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Methodological Framework as a Decision-Support Tool in Addressing NFTs and Blockchain Projects in the Tourism Industry

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Abstract: Non-fungible tokens (NFTs) are an emerging application of blockchain technology, with the potential to transform various industries, including tourism. Despite conceptual discussions that have highlighted opportunities and challenges associated with using NFTs—such as in digital souvenirs, ticketing systems, loyalty programmes, and conservation initiatives—there is a critical gap in the literature consisting of the lack of a structured methodological framework to empirically evaluate the impact of real-world NFT implementations. This study addresses this gap by proposing a conceptual model and methodological framework designed to assess NFT projects in the tourism sector. The framework integrates diverse data collection methods, advanced analytical techniques (including econometric analysis, natural language processing, and machine learning), and a technological workbench for tracking key performance indicators (KPIs). To demonstrate its applicability, the framework is applied to the Dalmatia NFT project, an exploratory application in cultural tourism. The considered example highlights the potential of NFTs to enhance tourism experiences while addressing challenges such as scalability, sustainability, and user engagement. This study concludes with insights into the framework's practical implications for stakeholders and outlines future research directions for empirical validation. By bridging the gap between theory and practice, this study aims to provide a robust foundation for effectively integrating NFTs into the tourism industry.

Keywords: non-fungible tokens (NFTs); blockchain technology; tourism innovation; sustainability in tourism; digital transformation

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1. Introduction

Non-fungible tokens (NFTs) and blockchain technology offer the potential to virtually represent any asset within the tourism sector. NFTs are characterised by their non-interchangeability, uniqueness, and indivisibility (Mofoken & Matima, 2018), making them distinct from other digital assets. Blockchain, on the other hand, ensures transparency regarding ownership, sale prices, and transaction histories. One of the key advantages of NFTs is their minimal spatial requirements, as they are stored in virtual "wallets," which simplifies the management of digital assets.

Furthermore, NFTs typically include smart contract provisions that allow the original creator to receive a percentage of the transaction price each time the asset is sold, ensuring

long-term revenue generation. Generally, NFTs are unique or part of a limited series and are labelled with a unique identification code, making each token distinct (Beckman, 2021). Therefore, purchasing an NFT grants ownership of the digital asset and provides the right to trade or sell it further, with all transactions securely recorded on the blockchain.

Building on Swan's projection (Swan, 2015), blockchain, the foundational technology behind NFTs, is anticipated to emerge as the "fifth disruptive computing paradigm", succeeding mainframes, personal computers, the Internet, and mobile/social networking. To grasp the transformative potential of blockchain technology, it is essential to revisit its core principles (Iansiti & Lakhani, 2017). First, blockchain operates as a distributed database where all participants can access and verify transaction records without relying on intermediaries. Second, transactions occur through peer-to-peer transmission, where communication is facilitated by a central node that disseminates information across the network. Third, blockchain ensures pseudonymous transactions, meaning that while all transactions are transparent and visible to anyone with access, participants' identities are pseudonymous. Fourth, blockchain guarantees the irreversibility of records; once transactions are recorded, they are immutable, with each new entry being cryptographically linked to the previous one. Lastly, the system is governed by computational logic, allowing blockchain transactions to be encoded and automated through smart contracts. This enables programmable transactions, enhancing the potential for autonomous and complex computational processes.

As articulated by Dogru et al. (2018), the advantages of blockchain technology can be encapsulated in four primary features: shared ledger, security, efficiency, and the implementation of smart contracts. Furthermore, blockchain-based digital marketplaces exhibit several distinctive characteristics, including reduced verification costs, a shared network infrastructure, the absence of intermediaries typically required in traditional two-sided markets, heightened competition, low barriers to entry, and minimised privacy risks (Onder & Gunter, 2022).

A blockchain functions as a distributed database that maintains a comprehensive record of all public transactions or digital events. This information is executed and shared among participants within the network. Notably, once recorded, the data cannot be erased but can be verified by most participants in the system, ensuring data integrity and reliability (Crosby et al., 2016). These foundational attributes underscore the transformative potential of blockchain technology in various sectors, particularly in enhancing transparency and operational efficiency.

In summary, non-fungible tokens (NFTs) represent digital assets that confer ownership and authenticity of unique items secured through blockchain technology. Unlike fungible assets, such as currency, which can be exchanged one-to-one, NFTs are characterised by their distinct and non-interchangeable nature. This unique attribute has facilitated the emergence of innovative applications across diverse sectors, including tourism. NFTs have proven applicable in various economic domains, such as the fashion industry (Santos & Sousa, 2024) and educational financial expenditures (Rani et al., 2023). Currently, NFTs are also prevalent within the sports, art, and music industries, where they serve multiple purposes, including the sale of records, issuance of event tickets, crowdfunding initiatives for musical projects (Folgieri et al., 2022a), and the auctioning of collectable items. The versatility of NFTs underscores their growing significance in reshaping economic interactions and enhancing user experiences across various fields.

The tourism sector, which focuses on unique experiences and personalised offerings, derives substantial benefits from integrating non-fungible tokens (NFTs). NFTs can facilitate the creation of digital souvenirs, streamline ticketing processes, enhance customer loyalty programmes, and bolster conservation initiatives by providing verifiable evidence of

donations (Folgieri et al., 2022b). Nonetheless, despite the theoretical discourse surrounding these opportunities, there is a noticeable deficiency in empirical research examining the practical implications of NFTs within the tourism context. This paper addresses this gap by applying the methodological framework developed in our prior study, offering a structured approach for evaluating NFT implementations in the tourism sector.

Despite the apparent advantages of NFTs and blockchain technology, their widespread adoption has been impeded. This resistance can be attributed, in part, to the technological challenges linked to their implementation, primarily stemming from a lack of expertise beyond specialised technology practitioners. Additionally, sustainability issues—detailed in subsequent sections—further complicate the landscape, making it challenging to establish appropriate metrics for assessing NFTs' positive or negative impacts across various sectors.

The primary objective of this paper is to apply the previously established practical framework, supported by technological and econometric methodologies, to facilitate a comprehensive evaluation of NFT and blockchain projects within the tourism industry. This will ensure an objective and precise assessment of the associated costs, benefits, and overall advantages.

By integrating advanced data collection, analytical techniques, and technological monitoring, the study aims to provide a conceptual design of a comprehensive decision-support tool that enhances economic viability, user engagement, and sustainability in NFT-based tourism projects. The value of this study resides in showing how the framework's effectiveness could be assessed through real-world applications, such as the Dalmatia NFT project (here presented as a possible preliminary case) (Carev, 2024), to guide future innovations in tourism, ensuring they align with ethical, environmental, and economic goals. Expectations from the application of the conceptual framework consist of the possibility to identify best practices for NFT adoption, mitigate potential challenges, and contribute to the broader digital transformation of the tourism sector.

The organisation of this paper is as follows: Section 2 presents a literature review concerning the application of NFTs and blockchain within the tourism sector; Section 3 briefly outlines the framework employed for evaluating the considered NFTs initiative; Section 4 introduces the initiative itself; and the discussion and conclusion provide a discussion and final considerations.

2. Literature Review

Emerging technologies such as blockchain and non-fungible tokens (NFTs), alongside impactful innovations including artificial intelligence (AI), machine learning (ML), and virtual reality (VR) (Gričar et al., 2023), are significantly shaping the evolution of the tourism sector. Notably, implementing NFT technology can transform the tourism industry by facilitating the decentralisation of operations, removing intermediaries, and establishing a reliable platform that fosters direct connections between tourists and service providers (I. A. Nastase et al., 2024).

Applying blockchain technology within the tourism landscape offers numerous opportunities, from consumer engagement to infrastructure management and financial operations. From the consumer perspective, functionalities such as peer-to-peer exchanges and smart contracts can be introduced, along with product and service categories that include both primary and secondary values. Regarding infrastructure management, considerations extend to physical assets and human resources. Furthermore, the financial sector can benefit from revenue generation strategies, including mining activities and national and international earnings accrual.

However, it is crucial to also account for associated costs, particularly those related to establishing a blockchain platform, ongoing support and specialised development of the

platform, and procuring necessary resources (Aghei et al., 2021). These factors collectively underscore the multifaceted implications of adopting blockchain technology in tourism.

According to existing literature, blockchain technology has the potential to confer substantial benefits to the tourism sector by enhancing competitive advantage, improving customer satisfaction, and optimising overall performance (Erceg et al., 2020). The multifaceted nature of blockchain facilitates various enhancements within tourism, including (i) an improved traveller experience through robust platform support, (ii) expedited and seamless cross-border payment processes, (iii) diversification that safeguards currency and bolsters the banking system, and (iv) a reduction in total operational costs by eliminating intermediaries and establishing a comprehensive record-keeping system for all processes involved.

Non-fungible tokens (NFTs) present numerous advantages to the tourism industry, such as enhanced marketing strategies, more engaging travel experiences, increased engagement rates, facilitation of repeat business, streamlined booking processes, and fostering customer loyalty, all of which contribute to effective brand building.

The integration of NFTs, virtual reality (Gričar et al., 2023; Folgieri & Buda, 2022), and augmented reality allows for innovative presentations of tourist destinations prior to actual visits, effectively influencing potential tourists through modern and interactive means. NFTs can serve various functions within hospitality settings, including check-ins, transactions, and redeeming loyalty points. The potential value of NFTs in the travel industry is extensive. To gain insight into the future of this travel technology, it is essential to examine how industry brands leverage NFTs to engage with customers and business partners, broaden brand awareness, and create new revenue streams.

For instance, Flybondi, a low-cost airline in Argentina, is pioneering the application of blockchain technology in its operations. The airline recently announced its intention to issue tickets as non-fungible tokens (NFTs), expanding customer capabilities by allowing them to sell or transfer these tokens to other travellers up to three days before their scheduled flight.

The applications of blockchain technology within the tourism and hospitality sector have been classified into various categories (Treiblmaier et al., 2020). These categories include (1) inventory management, (2) maintenance and tracking, (3) reservations and ticketing, (4) payments and tax compliance, (5) loyalty programmes and personalised marketing, (6) tokenisation and dedicated coins, (7) identity and credential management, and privacy, (8) baggage tracking, (9) smart contracts, (10) decentralised applications (DApps) for smart tourism, (11) disintermediation, and (12) coordination and competition. Specific use cases illustrate the implementation of blockchain in managing hotel inventory, tracking and tracing food supply chains, and handling reservations and ticketing processes.

Gretzel (2023) discusses the prospective mutual influence between blockchain technology and the tourism and hospitality industry, forecasting a synergistic relationship that will enhance both fields. Aysan et al. (2023) emphasise the significant potential of non-fungible tokens (NFTs) in establishing ownership rights linked to tangible goods and services. Since NFTs can be freely traded on the blockchain, an owner could transfer their right to a hotel room to another individual in an open marketplace. Early adopters of NFTs may capitalise on these transactions, as initial pricing often proves more advantageous than subsequent offers.

Moreover, the most pronounced effect of blockchain technology on the travel industry will likely be the increased disintermediation of traditional actors, a challenge that has intensified since the rise in online travel agencies (OTAs) in the early 2000s (Onder & Treiblmaier, 2022).

Tham and Sigala (2020) assert that the advantages of cryptocurrencies extend beyond their utility as payment mechanisms; they also have the potential to foster sustainable

tourism development by democratising participation in economic systems and redistributing economic power. Similarly, Picinini and Baptista (2022) emphasise that NFTs can play a pivotal role in establishing trust among tourists regarding the providers of a destination's tourism offerings. Consequently, non-fungible tokens (NFTs), enabled by blockchain technology, may partially transfer the principle of trust to technological infrastructures. This involves the creation of systems that prioritise transparency and traceability, address security concerns associated with blockchain, enhance the efficiency and reliability of financial transactions, and promote innovation through effective knowledge management (KM) strategies.

Furthermore, Ratna and colleagues (Ratna et al., 2024) posit that integrating blockchain technology, financial technology (fintech), and knowledge management can lead to new markets and opportunities within the tourism and hospitality sectors. However, it is important to note that most existing studies primarily focus on theoretical frameworks, with limited empirical evidence concerning NFTs' practical implementation and impact in the tourism context.

This review underscores a critical necessity for a comprehensive methodological framework that merges quantitative and qualitative approaches to evaluate the multifaceted effects of NFTs within the tourism industry. Drawing on previous works (Folgieri & Bait, 2014; Folgieri & Buda, 2022; Folgieri et al., 2022b; Gričar et al., 2023), a framework has been developed that can be utilised to assess the actual effectiveness of introducing NFTs within specific tourism initiatives. In this context, Section 4 presents a preliminary application of this framework to an initiative in the tourism sector, thereby providing a first evaluation of the efficacy of the proposed model.

3. Methodological Framework and Conceptual Model

The concept of the Internet of Value, along with its foundational technologies such as blockchain and application-related components like tokens, has yet to be fully integrated into marketing research. The attributes of this framework—such as value transfer and community building—and their impacts on customer satisfaction and loyalty, exist at a more advanced layer of the protocol stack, facilitating their incorporation into existing theoretical models and frameworks (Treiblmaier, 2023).

Patel (2021) emphasises that businesses can capitalise on these unique characteristics by crafting distinctive brand experiences that enhance brand awareness, encourage consumer interaction, and generate interest in their offerings. Furthermore, non-fungible tokens (NFTs) and the Metaverse provide an innovative avenue for monetising a country's cultural heritage without the need to sell physical assets, simultaneously promoting the research and education of human resources as an ancillary benefit (Shymaa, 2023).

Despite the clear advantages, notable criticisms are associated with NFTs, particularly concerning technical, ethical, and sustainability issues, where

- Technical challenges include concerns about blockchain scalability, the security of smart contracts, and interoperability between different platforms, which can hinder widespread adoption.
- Ethical issues arise from copyright infringement, market speculation, and the potential for money laundering, leading to concerns about fairness and transparency in NFT transactions.
- Sustainability concerns are primarily linked to the high energy consumption of proof-of-work blockchain networks, contributing to environmental degradation and raising questions about the long-term viability of NFTs.

To effectively engage in NFT projects, it is essential to employ a methodological framework that enables both pre- and post-evaluation of the initiative's effectiveness.

Consequently, the proposed practical methodology comprises three primary components: (i) data collection to gather sufficient information for assessing the initiative, (ii) analytical techniques to analyse the collected data, and (iii) a technological framework to facilitate ongoing monitoring and evaluation.

Data collection represents the initial step within this model. It highlights the necessity of compiling various data types for a comprehensive evaluation, including financial, visitor, user feedback, operational, and ethical/legal dimensions. Financial data are crucial for determining the economic viability and profitability of NFT initiatives in the tourism sector and should encompass revenue from NFT sales, implementation costs, and pricing strategies. Additionally, visitor data must be collected to gain insights into the demographics and behaviours of tourists participating in NFT initiatives. This includes demographic profiles, visitation details, familiarity with NFTs and blockchain technology, and operational data provided by NFT issuers and tourism operators utilising blockchain.

Based on the previous consideration, the paper focuses on the following research question: How can a methodological framework integrating data collection, analytical techniques, and technological monitoring enhance the effectiveness and sustainability of NFT-based tourism initiatives?

In fact, the model further advocates for collecting user feedback, which is essential for enhancing user experience and identifying potential areas for improvement. Both quantitative and qualitative feedback should be gathered, such as the following:

Awareness and understanding of NFTs and blockchain:

- Perceived Complexity/User-Friendliness: Ease of obtaining and understanding tourism-related NFTs.
- Sentiment Analysis: Public sentiment towards the concept of tourism NFTs and blockchain.
- Net Promoter Score: Willingness to recommend tourism NFTs.

User Experience with Purchasing/Using Tourism NFTs and Blockchain:

- Ease of Process: User-friendliness of signing up, purchasing through blockchain, and transferring NFTs.
- Ratings for Features: Feedback on the design, uniqueness, and exclusivity of NFTs.
- Feedback on Pricing/Value Proposition: Opinions on the cost and value of NFT offerings.
- Comments/Reviews on Use Cases: Specific feedback on digital souvenirs, ticketing, etc.

Motivations and Attitudes towards NFTs and blockchain:

- Perceived Benefits/Drawbacks: Opinions on NFT membership or loyalty programmes.
- Willingness to Pay: Interest in exclusive NFT experiences and rewards. Experience in blockchain.
- Concerns: Issues such as environmental impact, data privacy, and regulatory compliance.

The proposed methodological framework addresses the main considered variables, that is, technical, ethical, and sustainability challenges associated with NFTs through interrelated components. Specifically, Data collection captures financial, visitor, operational and user feedback data, providing insights into economic viability, user behaviour and perceptions of fairness and environmental impact. Furthermore, Analytical techniques process these data to identify patterns, such as transaction anomalies (addressing ethical concerns) and system inefficiencies (mitigating technical challenges), whilst the technological framework enables ongoing monitoring and evaluation, incorporating tools for real-time performance tracking, security audits, and sustainability metrics. The integration of the mentioned components ensures a holistic approach to addressing scalability, security,

ethical transparency, and environmental sustainability, thereby enhancing the long-term viability and adoption of NFT initiatives.

In our model, the collected data necessitates analysis through econometric methods such as regression analysis, time series analysis, and structural equation modelling to discern trends and relationships among variables. Additionally, artificial intelligence techniques contribute to data analysis, mainly through applications in sentiment analysis, which involve natural language processing (NLP) and machine learning (ML) algorithms. Content analysis and thematic coding are also instrumental in identifying recurring themes and evaluating the performance of NFT initiatives across various sectors, use cases, and target audiences. This comparison aids in generalising findings and discerning successful strategies for implementing NFTs in tourism.

The multi-dimensional data collection ensures a comprehensive evaluation of NFT initiatives.

The analytical approach incorporates advanced NLP techniques, including Aspect-Based Sentiment Analysis (ABSA) and multimodal sentiment analysis. Lexicon-based approaches, such as the Valence Aware Dictionary and sentiment Reasoning (VADER), can analyse social media data, online reviews, and user comments pertinent to tourism NFTs (Hutto & Gilbert, 2014). VADER is adept at capturing sentiment in concise, informal texts on social media platforms. Machine learning models, including Naive Bayes, Support Vector Machines (SVMs), and Bidirectional Encoder Representations from Transformers (BERT), can be utilised to develop sentiment analysis models tailored to the tourism and NFT contexts. Training these models on a corpus of tourism-related texts enhances their accuracy in detecting sentiments associated with NFT experiences.

ABSA can effectively identify specific aspects or features of NFT tourism applications, such as “Ease of Use”, “Value Proposition”, and “Environmental Impact”. Subsequently, using ABSA models, sentiment scoring should be applied to evaluate sentiments for each identified aspect. This methodology facilitates a nuanced understanding of user sentiments toward various components of NFT tourism initiatives, yielding granular insights into stakeholder perceptions and experiences.

Multimodal Sentiment Analysis combines multiple modalities, synthesising text, images, and videos to yield a comprehensive sentiment evaluation. For example, analysing user comments with images or videos depicting NFT-based tourism experiences can provide profound insights into user sentiment. To execute a multimodal analysis effectively, experts must develop models capable of processing and integrating diverse data sources, employing advanced deep learning techniques such as convolutional neural networks (CNNs) for image processing and recurrent neural networks (RNNs) for text analysis.

The reasons to adopt a multi-layered analytical approach are linked to the complexity of NFT and blockchain projects. Each technique serves a specific purpose and complements the others: the methodological techniques are interconnected and designed to provide a holistic evaluation of NFT initiatives, whilst the diversity of methodological techniques reflects the multi-faceted nature of NFT and blockchain projects. In fact, no single method can capture all these aspects effectively, which can be captured only by combining econometric, NLP, ML, and qualitative approaches.

The NFT Tourism Workbench presented in previous studies has been designed as a comprehensive platform for monitoring and evaluating NFT initiatives through key performance indicators (KPIs). This platform encompasses data integration and visualisation tools, benchmarking, comparative analysis, and scenario exploration, which are critical for forecasting future performance. It encompasses various KPIs, including financial metrics, visitor statistics, user experience indicators, and operational performance measures.

The framework further integrates data visualisation tools essential for amalgamating data from multiple sources and visualising performance metrics. Among these tools, D3.js has been selected, an open-source JavaScript library that facilitates the creation of dynamic, interactive data visualisations in web browsers. By embedding D3.js within the workbench interface, it is possible to enable the customisation of highly interactive visualisations tailored to specific analytical requirements.

Additionally, the framework incorporates benchmarking, comparative analysis, and scenario planning tools, which are vital for strategic decision-making and preparing for potential challenges. In this context, Python v-3.31 libraries such as sci-kit-learn and XGBoost 3.0.2. are adopted to leverage machine learning capabilities in predictive modelling, enabling the forecasting of future performance metrics, visitor trends, and potential adoption rates based on historical data and market variables.

To ensure comprehensive decision support, the workbench includes several key scenario planning and forecasting areas, specifically focusing on adoption rates, financial performance, visitor experience and engagement, and environmental impact assessments. Finally, ethical and legal compliance concerns have been addressed, including data privacy and adherence to regulatory standards, thereby ensuring responsible implementation of the framework.

The NFT Tourism Workbench aims to be a versatile and customisable platform, integrating various data sources and analytical tools to meet the specific needs of different tourism organisations. By combining advanced data visualisation, benchmarking, and scenario planning capabilities, the workbench provides a comprehensive decision-support tool, enabling organisations to anticipate potential challenges, identify opportunities, and proactively develop strategies to maximise the benefits and mitigate the risks associated with adopting NFTs within their respective contexts and target markets.

4. Explorative Example of Implementation for Cultural Tourism

Given the domain of possible research, an example of possible applications of NFT to cultural tourism experiences is provided to show how the mentioned techniques could be applied, following the designed framework. The following example presents an a priori evaluation of the Dalmatia NFT project, as it should be conducted prior to the launch of the project itself. It was not possible to perform any a posteriori evaluation due to the lack of official data, as often happens in the tourism industry. Far from being a criticism, it is just a fact that collecting homogeneous and significant data about a project is still hard, representing, in general, one of the limitations affecting the tourism industry in identifying effective promoting actions.

The Dalmatia NFT system has been considered since Splitsko-Dalmatinska County is becoming a leader in tourism presentation in the Metaverse and represents an interesting example of initiative for applying our framework. Started in 2022, the Dalmatia NFT system is part of the Tourism 3.0 project—a revolution in applying augmented reality technologies to present the tourist offerings of the destination.

It is used as a credential or digital certificate that confirms ownership of certain digital content, such as photographs, videos, audio recordings, or GIFs.

The system provides unique souvenirs for visitors to festivals or events in general. They receive a unique digital postcard or souvenir in their cryptocurrency wallet as memorabilia for attending the event.

The first step consisted of modelling Diocletian's Palace and creating NFTs, following a story about "the Dalmatians are coming home". The project's primary goal is to reach a younger audience using new technologies, presenting Dalmatia in a world that no one has used before.

During the project presentation, a virtual environment within the Sandbox Metaverse system was demonstrated, featuring content dominated by Split-Dalmatian County's cultural heritage.

Following the aims of the project, in this case, NFTs can (1) incentivise supply chain stakeholders to engage in more sustainable practices; (2) enhance customer willingness to pay for sustainable products; (3) provide anti-counterfeit measures; (4) support circular business model growth (Carev, 2024).

To test the project's limitations and strengths, the project has been broken down as follows:

1. Context and Objective Alignment

The Dalmatia NFT system, as part of the Tourism 3.0 project, aims to present Dalmatia using augmented reality and NFTs to reach a younger audience. This aligns well with the framework's focus on using NFTs for engagement and personalisation. NFTs serve as digital souvenirs or certificates that appeal to tech-savvy, younger generations, which complements the project's goal of modernising tourism marketing.

2. Economic and Operational Benefits:

NFTs like those used in the Dalmatia system have the potential to generate additional revenue streams through digital collectables. They also enhance customer engagement by offering memorable, personalised experiences like digital postcards. According to the framework, this could incentivise supply chain stakeholders to adopt more sustainable practices by providing verifiable anti-counterfeit measures and circular business models. However, the financial impact remains largely speculative without empirical revenue generation and return on investment.

3. Sustainability Concerns:

One of the limitations highlighted in the framework is sustainability. NFT minting is energy-intensive, potentially leading to increased carbon footprints, especially based on energy-inefficient blockchain protocols. This could undermine the environmental sustainability of initiatives like Dalmatia's. While the project successfully leverages technology for tourism marketing, future efforts might need to explore energy-efficient blockchain alternatives to mitigate negative environmental impacts.

4. User Engagement and Visitor Data Collection:

The Dalmatia project aims to use NFTs as unique digital souvenirs for festival attendees. According to the framework, collecting detailed visitor data (e.g., demographics, spending patterns, and motivations for NFT purchases) would be crucial for measuring user engagement.

5. Technological Adaptation and Challenges:

The Dalmatia project faces challenges in fully realising its potential due to a lack of broad technological expertise, which the framework also highlights as a common barrier to adopting NFTs. The system's success would depend on continuous adaptation to evolving blockchain technology and ensuring seamless integration with existing tourism systems.

Other limitations possibly faced by the Dalmatia project have been considered, such as:

- Energy Costs: The Dalmatia NFT system could be criticised for the high energy consumption involved in NFT transactions, particularly in light of sustainability goals.
- Data Collection and Analysis: Robust data collection on visitor engagement and financial outcomes is necessary to assess the full impact of the NFT system in line with the proposed framework.

- Cross-Context Adaptability: While the project is innovative, it may struggle with adaptability across different tourism sectors beyond digital souvenirs and postcards, requiring broader applications to fully realise its benefits.

Thus, while the Dalmatia NFT system demonstrates an innovative approach to tourism marketing, it must overcome technological, sustainability, and data-driven challenges to fully align with the methodological framework for maximising the impact of NFTs in tourism.

Considering the lack of data about the success of the initiative and given the purpose of our framework, practical both for a priori and a posteriori evaluation of an NFTs/blockchain-based project, the framework has been applied to generate guidelines that should have been followed before engaging the project to evaluate its benefits and challenges, so that they could serve on one hand as an example of application of the framework and on the other as a practical guideline to adopt our framework in projects as decision-making support to decide if start or not similar initiatives.

Given these premises, to apply the proposed framework for NFTs and blockchain in tourism to the Dalmatia NFT system and conduct an a priori feasibility study, its potential success must be assessed from various perspectives, including economic viability, technological feasibility, sustainability, and user engagement. This study aims to determine whether the system can achieve its objectives before full implementation based on the earlier framework. In the following, some basic elements about Economic Viability, Technological Feasibility, Sustainability and User engagement and Target Audience are explored.

Economic Viability: Revenue Generation Potential: NFTs in the Dalmatia system are used as digital souvenirs and tourist credentials, offering unique, verifiable digital content. According to the framework, such offerings can potentially increase customer engagement and generate new revenue streams, particularly among younger, tech-savvy tourists. However, for economic feasibility, it is crucial to assess:

- Market demand for NFTs in the tourism sector (especially in Croatia).
- Potential to monetise these digital assets through direct sales, secondary markets, or partnerships.
- Limitations: Although the Croatian tourism market is evolving, it may still be in the early stages of NFT adoption. The project's reliance on a new technology not yet widely embraced by all stakeholders could slow revenue generation.

Technological Feasibility: Strengths: NFTs provide a reliable means of verifying digital ownership and preventing counterfeit issues, aligning with the project's goal of offering unique digital experiences.

- Limitations: High gas fees on blockchain platforms like Ethereum could reduce user adoption, especially among tourists unfamiliar with blockchain. Additionally, limited blockchain expertise in the tourism industry poses a technological barrier, as the framework highlights the need for broader knowledge transfer to non-technical stakeholders.

Sustainability Considerations: Energy Efficiency and Environmental Impact: A significant concern highlighted in the framework is the energy consumption of blockchain technologies, particularly those using proof-of-work (PoW) mechanisms like Ethereum. The Dalmatia NFT system must address the following:

- Feasibility: The project could mitigate sustainability concerns by adopting energy-efficient blockchains (e.g., Solana or Tezos) that use proof-of-stake (PoS) or other low-energy consensus mechanisms.

Limitations: If the project continues using energy-intensive blockchains, it risks facing public backlash from sustainability-conscious tourists and stakeholders. The environmental

costs associated with minting and trading NFTs could outweigh the perceived benefits of the digital souvenirs.

User Engagement and Target Audience: Target Audience Feasibility: The primary goal of the Dalmatia NFT system is to reach younger audiences familiar with Metaverse technologies and cryptocurrencies. To evaluate this goal:

- Strengths: The integration with the Sandbox Metaverse and the use of NFTs as unique souvenirs align with younger generations' digital behaviours. This creates a clear value proposition for digital natives, enhancing customer willingness to engage with the platform.
- Limitations: Many tourists may still be unfamiliar with blockchain, NFTs, or cryptocurrency wallets. Educational efforts will be required to bridge the knowledge gap. The project must ensure a user-friendly onboarding process to avoid alienating non-technical users.

The project must also address important ethical and social considerations, particularly regarding transparency and ethical resource utilisation. Under the proposed framework, the Dalmatia NFT system should prioritise transparent practices concerning user data and digital ownership rights. Any lack of clarity surrounding the issuance, trading, or redemption of NFTs could erode trust in the system, undermining user confidence and engagement (Ahlawat et al., 2024).

Moreover, ethical considerations such as preventing data misuse and ensuring that NFTs enhance the overall user experience are paramount for the system's long-term viability. Implementing clear guidelines and practices prioritising ethical standards will be essential to foster a sustainable and trustworthy user environment (Liu et al., 2022). As such, these considerations should be integral to the design and execution of the Dalmatia NFT initiative, aligning with broader ethical imperatives within the realm of emerging technologies.

5. Discussion

Integrating non-fungible tokens (NFTs) and blockchain technology into the tourism sector marks a significant shift, emphasising the industry's digital transformation. The study's findings highlight the potential of NFTs to revolutionise tourism marketing by providing personalised and verifiable digital memorabilia. The Dalmatia NFT project represents a valuable example, aiming to engage a younger, tech-savvy audience while promoting cultural heritage through innovative methods. Existing literature discusses how NFTs offer unique opportunities to enhance brand awareness and foster customer loyalty (Patel, 2021; C. E. Nastase et al., 2022; I. A. Nastase et al., 2024). However, the project also reveals substantial challenges that must be addressed to fully exploit this technology's capabilities. One major challenge is the lack of empirical data to validate the theoretical framework proposed in the study. Although the Dalmatia project demonstrates the feasibility of NFTs as digital souvenirs, it also emphasises the difficulty of obtaining robust data on market adoption, user engagement, and financial returns. This observation aligns with the findings by Folgieri et al. (2022a), who noted that tourism projects often struggle to compile consistent and meaningful datasets, which hinders their evaluation effectiveness. This limitation highlights the need for a comprehensive evaluation before implementation to identify potential obstacles, including technological constraints, sustainability concerns, and market readiness.

Technological feasibility is a crucial factor to consider. The decentralised nature of blockchain technology offers significant advantages, such as transparency and traceability, as Crosby et al. (2016) and Onder and Gunter (2022) noted. However, the Dalmatia project illustrates the challenges of implementing this technology in an industry that may lack the technical expertise needed to fully utilise its capabilities. High transaction costs, limited

knowledge transfer, and user unfamiliarity with blockchain systems present significant barriers to adoption. User-friendly platforms, educational initiatives, and ongoing support are needed to overcome these challenges to ensure seamless integration with existing tourism infrastructures. Sustainability is also a pressing concern for blockchain-based initiatives, especially those that rely on energy-intensive proof-of-work mechanisms. This study highlights the environmental costs associated with minting NFTs, which could pose a significant obstacle, echoing the concerns raised by Carev (2024) about the carbon footprint of blockchain technologies. To address these issues, the Dalmatia project and similar initiatives must prioritise the adoption of energy-efficient blockchain protocols, such as proof-of-stake mechanisms, to align with global sustainability goals. Without these measures, the environmental impact of NFT projects could diminish their perceived value, particularly among stakeholders concerned about sustainability.

The economic viability of NFTs in tourism is an area that requires careful consideration. As highlighted in the study, NFTs have the potential to create new revenue streams through the sale of digital souvenirs and engagement in secondary markets. This aligns with the findings of Treiblmaier (2023) and Folgieri et al. (2022b), who emphasised blockchain technologies' revenue-generating opportunities. However, the success of these initiatives depends on market readiness, effective pricing strategies, and the willingness of stakeholders to invest in emerging technologies. The Croatian tourism market, while evolving, may still be in the early stages of embracing NFTs. Therefore, managing expectations and implementing targeted strategies to maximise economic returns is crucial. The Dalmatia NFT project, which focuses on younger, tech-savvy audiences, aligns strategically with demographic trends in digital consumption. C. E. Nastase et al. (2022) noted that targeting digital natives is a logical step for leveraging emerging technologies like blockchain. Integrating NFTs as digital souvenirs and augmented reality experiences positions the project as a forward-thinking initiative. However, broader adoption will require addressing user concerns regarding data privacy, security, and the complexity of blockchain systems. Educational outreach and simplified user experiences are essential in bridging the gap for non-technical users and facilitating wider acceptance of NFTs in tourism.

The methodological framework proposed in this study establishes a strong foundation for evaluating NFT and blockchain projects in tourism. By integrating econometric analysis, sentiment analysis, and technological feasibility assessments, the framework is a comprehensive decision-support tool for stakeholders. This approach aligns with the increasing focus on data-driven strategies in tourism management, as highlighted by Kwortnik and Thompson (2009). Additionally, the framework contributes to theoretical discussions by connecting conceptual ideas about NFTs with their practical applications in the tourism sector. It validates the potential of NFTs to enhance customer engagement and support sustainable business models, building on previous research by Onder and Treiblmaier (2022) and Folgieri et al. (2022b). However, the Dalmatia NFT project underscores the need for further empirical research to validate its findings and address existing limitations. Future studies should concentrate on gathering comprehensive data regarding financial performance, user adoption, and environmental impact. Longitudinal research would provide deeper insights into the long-term viability of NFTs in tourism, offering a clearer understanding of their potential to reshape the industry. Moreover, developing standardised sustainability metrics would allow for more accurate assessments of blockchain technologies, ensuring these technologies align with broader environmental objectives. Expanding the use of NFTs beyond digital souvenirs to include areas such as ticketing, loyalty programmes, and conservation initiatives could create new tourism innovation opportunities. These additional applications would not only diversify revenue streams but also enhance the overall value proposition of NFTs. It is crucial to address

ethical considerations, especially concerning data privacy and the equitable distribution of benefits, to build trust and ensure the long-term success of these projects. Implementing transparent practices and following ethical guidelines will build user confidence and promote responsible innovation.

6. Conclusions

The Dalmatia NFT system examined in this study is a significant example initiative for applying our framework to evaluate the advantages and disadvantages of an NFT and blockchain initiative within the tourism sector. The methodology has been implemented as an a priori decision-making tool, mainly due to challenges encountered in sourcing reliable information and data about the project's success.

Following our framework, the Dalmatia NFT project demonstrates potential as an innovative endeavour at the intersection of tourism and digital transformation. However, several limitations must be addressed for the project to achieve its objectives:

- The high transaction costs and energy consumption associated with blockchain platforms pose a significant threat to economic viability and environmental sustainability.
- A user-friendly interface and comprehensive educational resources are essential to engage a broader demographic beyond those already familiar with technology.
- Technological barriers and a lack of blockchain expertise within the tourism industry necessitate sustained support and adaptation to evolving technological landscapes.

To enhance its likelihood of success, the project should consider adopting energy-efficient blockchain solutions, integrating intuitive platforms tailored for tourists, and continuously assessing its environmental impacts. Ongoing refinements will ensure that the Dalmatia NFT system remains competitive while aligning with broader sustainability objectives within the tourism sector.

The economic potential of NFTs in tourism is significant, particularly in creating new revenue streams, enhancing visitor engagement, and supporting more sustainable practices through transparent, anti-counterfeiting measures. However, the actual financial returns are still largely speculative due to limited empirical data, especially in emerging markets like Croatia. Additionally, user adoption may be hindered by unfamiliarity with blockchain and NFTs, necessitating educational outreach to bridge this gap and facilitate smoother integration within tourism infrastructures.

Furthermore, sustainability is a key issue. The energy-intensive nature of specific blockchain protocols, like proof-of-work (PoW), could clash with global sustainability goals, suggesting a need for alternative, energy-efficient blockchain solutions.

Despite these challenges, the framework can serve as a decision-support tool, aiding stakeholders in evaluating whether to proceed with similar projects by providing clear financial feasibility, technological sustainability, and user engagement metrics. Continuous refinement of the framework, emphasising ethical and legal considerations, will be crucial for future applications.

This study highlights the need for further research into the real-world implications of NFTs in tourism, especially concerning data collection and energy consumption. Without robust, empirical evidence, the long-term viability of such projects remains uncertain, but the framework can be effective in evaluating whether or not to proceed with starting an NFT/blockchain project. The methodological framework can be easily adapted to evaluate any NFTs and blockchain initiatives in simple steps, guided by the designed methodology and following correct data gathering, ensuring the project's success while adhering to ethical and sustainable practices.

The NFT Tourism Workbench is designed as a multifunctional and adaptable platform that integrates diverse data sources and analytical tools tailored to the distinct requirements

of various tourism organisations. The workbench is a comprehensive decision-support instrument amalgamating sophisticated data visualisation techniques, benchmarking methodologies, and scenario planning functionalities. This enables organisations to anticipate potential challenges, identify strategic opportunities, and proactively formulate strategies to enhance the advantages and mitigate the risks associated with integrating NFTs in their specific contexts and target markets.

Such a workbench facilitates informed decision-making and aligns with contemporary tourism management trends, where data-driven approaches are increasingly recognised as essential for optimising operational efficiencies and fostering innovation (Kwortnik & Thompson, 2009). Furthermore, it underscores the importance of adaptability and foresight in navigating the evolving landscape of the tourism industry, particularly as emerging technologies like NFTs reshape traditional practices (Sigala, 2020).

In conclusion, the NFT Tourism Workbench represents a strategic tool for enhancing the resilience and sustainability of tourism organisations in an increasingly digitalised marketplace.

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