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A multi-criteria approach to rating Metaverse games

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***Abstract*— Non-Fungible Tokens (NFTs) took the already profitable gaming industry to a whole new level. Before that, people would pay to buy games, and there were also some in-game purchases. But now every item in games is an NFT, and different NFTs have different prices. A lot of users consider NFT metaverse games an investment opportunity. Therefore, it is vital to evaluate these metaverse games and rate them to find the most attractive investment opportunities. In this paper, we develop a framework for rating NFT metaverse games by considering their various risks and potential upsides through the PROMETHEE II method. Specially, we design a flip ratio that can take into account both the opportunity to flip another cryptocurrency and the risk of being flipped by another cryptocurrency. Our new flip ratio could be a very useful measure of risk-opportunity analysis. We also analyze the crash risk of NFT game tokens' prices through a non-parametric value at risk analysis, which is compatible with the volatile nature of cryptocurrency prices.**

Keywords*— *Non-Fungible Tokens, PROMETHEE II, Metaverse, Flip Ratio, Non-Parametric Value at Risk

I. INTRODUCTION

The global gaming market was valued at USD 173.70 billion in 2020, and it is expected to reach a value of USD 314.40 billion by 2026, registering a compound annual growth rate (CAGR) of 9.64% over 2021-2026. These platforms are attracting more than hundreds and thousands of new visitors in online traffic. Video gaming trends have experienced a massive surge in players and revenue recently. Companies like Microsoft, Nintendo, Twitch, and Activision have all reached new heights in player investment [1]. The emergence of e-commerce in the gaming world has become a natural thing with this rapid development of the game industry [2]. However, conventional gaming platforms are now faced with a new rival, NFT games. They may not be as much fun, but people can earn money from them. Instead of just paying to have fun NFT gamers are now playing to earn money (play-to-earn). Actually, conventional games like poker also provide the option of play-to-earn, and you can usually observe both extrinsically-motivated and intrinsically-motivated players in most conventional games [3]. However, NFT games' business plans are mainly concentrated on play-to-earn players. Therefore, in this paper, we are evaluating NFT games from the extrinsically-motivated players' point of view. Furthermore, our research is different from studies that are focused on categorizing players, as we are trying to suggest new evaluation tools for specific types of players. In other words, we are more concentrated on games' specifications than the players' specifications, which have been covered in previous studies [4, 3]. Lowry et. al. [4] extended the Hedonic-motivation systems (HMS) model to study players' motivations and Penttinen et. al. [3], through the use of such models, showed that there are very few differences between extrinsically-motivated and intrinsically-motivated players. Since play-to-earn players also have financial motivations, we believe that our findings would be useful to them.

We can define a Non-Fungible Token (NFT) as a cryptographically unique, indivisible, irreplaceable, and verifiable token that represents a given asset, be it digital, or physical, on a blockchain [5]. NFTs can represent objects like art, collectibles, and in-game items. In fact, people can attach private files or unlockable content to NFTs [6], which is very useful for providing online services (sending a file or a password to customers), but these are the lesser-known capabilities of NFTs, and most people know NFTs through their use in NFT games or collectibles [5]. The public attention toward NFTs has exploded in 2021 when their market experienced record sales, but little is known about their overall structure and evolution of them [7]. NFTs are widely used in NFT games and the metaverse. Metaverse and NFT games also overlap to some extent because metaverse can also be a place to play. However, it can cover more activities than just playing. For example, it can serve as a place for social experiments such as virtual concerts, meetings, and conferences. NFT-based metaverses can offer users new ways to play, invest, gather, and interact — and to earn from it all. Further, while development on the myriad singular metaverse platforms is highly noteworthy, it's the potential for the various metaverse games to interact and interoperate with one another that could drive the budding blockchain gaming ecosystem into a pillar of the global economy [8]. Metaverse technology is fairly specialized, and the industry is still in its early stages; once again we are like the internet in 1996. The term "metaverse" as a whole refers to any kind of activity that can be done in a virtual universe. It spans from social interactions to providing different services and playing games. In this paper, we focus on the metaverse games based on blockchain technology.

Since NFT games are a new phenomenon that provides a platform for both playing and earning money, it is crucial to evaluate and rate them to find the most attractive NFT games. However, to the best of the authors' knowledge, only a few studies have evaluated NFT games; therefore, providing a framework to do so can be very helpful. As Davis [9] mentioned, the harsh truth about NFT games (and the metaverse in general) is that they are not a good fit for most investors.

Although the adoption of NFTs in the gaming world comes with benefits, it also presents significant obstacles to overcome. Most notably, NFTs need to be made more appealing and intuitive to mainstream consumers who might not be technically oriented. And because NFTs possess intrinsic value, there's a risk that some will be used predominantly as speculative assets. This potentiality could

motivate players to purchase in-game assets with the hope of selling them for future profit, instead of using the assets within the gaming ecosystem as intended. Despite these challenges, the potential for profit within the gaming industry will motivate more non-blockchain-focused brands to experiment with NFTs, likely by forming partnerships with third-party blockchain projects that have the technical expertise needed to bring their vision to life. Simultaneously, the broader success of gaming Dapps will likely play a role in further catalyzing NFT infrastructure improvements and driving the development of innovative solutions that unlock mainstream adoption [10].

Since most of the blockchain projects' business models are more complicated than conventional firms', evaluating and rating these projects can provide a lot of valuable information to investors. However, at the time of performing this research, only a few analysts were evaluating and rating these projects, and most of them did not provide a reliable scientific analysis. Boreiko and Vidusso [11] reviewed the new ecosystem built around Initial Coin Offerings (ICOs) and studied the roles of the ICO aggregators, listing, and rating agencies. They found that rating data seemed to vary considerably across different rating websites and seemed not to be of great quality, so investors should treat such ratings with caution.

In this paper, we first take a look at the evolution of NFTs and NFT games and their specifications as Fintech. Then we explain our research methodology, which entails determining the proper criteria for evaluating NFT games and explaining the PROMETHEE II approach used to rate our sample NFT games. Next in the Data and Findings section of our paper, we provide the sample data and the output of our model, and finally, in the Conclusion section, we draw our conclusion about NFT games and how readers of this paper can use our methodology to rate other cryptocurrency projects and how they can interpret the results.

Non-fungible tokens (NFTs) differ from fungible tokens in two important aspects: Every NFT is unique and also it cannot be divided or merged. This new form of the token was first introduced with the ERC-721 standard in late 2017. ERC-721 variates significantly from the ERC-20 standard as it extends the common interface for tokens by additional functions to ensure that tokens based on it are distinctly non-fungible and thus unique. For practitioners, these distinct properties of NFTs enable a variety of new use cases. It particularly improves the tokenization of individual assets which is not feasible with fungible tokens, as they cannot digitally represent uniqueness. Thus, practitioners have conducted a multitude of experiments using NFTs to represent both digital goods such as virtual gaming assets, digital artwork, and software licenses as well as physical assets such as luxury goods and cars [12]. NFTs are powered by Smart Contracts. A smart contract is a self-executing contract or set of rules between two or more parties being directly written into the system and exists across the blockchain network [13]. NFTs are minted (i.e., created) through smart contracts that assign ownership and manage the transferability of the NFTs. When someone creates or mints an NFT, they execute code stored in smart contracts that conform to different standards, such as ERC-721. This information is added to the blockchain where the NFT is being managed [14]. ERC-998, which is an extension to the ERC-721 standard that adds the ability for NFTs to own other NFTs and tokens, was also introduced in 2018. Several extensions to ERC-721 have been developed in recent years and each one comes with special utilities (ERC-1155, ERC-223, ERC-827, ERC-777, ERC-1137, ERC-875, ERC-865). Since ERC-721 is based on Ethereum, Binance Smart Chain (BSC) has developed its own NFT standards. As the NFT markets grow, most smart chains are developing their own NFT standards. Moreover, to overcome Ethereum's currently high gas fee (minting and transaction fees) problem, OpenSea.io, which is one of the major NFT marketplaces, has collaborated with Polygon blockchain to enable minting NFTs with zero gas fees. Mintable.app has also started supporting Immutable X to provide zero gas fee minting. These types of blockchains that support zero gas fees are called layer-2 blockchains.

The first application based on NFTs to reach widespread adoption was a virtual online game called CryptoKitties. The game took up more than 70% of the transaction capacity of the Ethereum network at one point and the most expensive NFT that represents ownership of such a cat was sold for over USD 100,000 in late 2017. Over 100 similar digital collectibles such as virtual card games or unique original digital art have been created by the community in the past year and the number is expected to grow further [12].

As the popularity of the NFTs increased, so did their markets. Mukhopadhyay & Ghosh [15] reviewed the NFT marketplace from several aspects. They reported that the NFT marketplace can be categorized into two levels. One is at the project level and another is at the ownership level. At the project level, the NFT market can be segregated into 6 main segments - Art, Collectibles, Sports, Utility, Metaverse, and Games. At the ownership level, the NFT market is segmented into Primary and Secondary Market. Leading platforms like Opensea.io, Rarible.com, WazirX, Binance, and Mintable.app facilitate players to mint, trade, buy, and auction NFTs via Metamask wallet account that links the platform and cryptocurrency exchanges with fiat currency banking entities. Art and collectibles capture the major market segments because game NFTs are mostly traded at the games' internal marketplaces. Kireyev [16] also reported that an increasing trend in NFT prices may not be entirely attributed to an increase in the "value" of NFTs but could also be attributed to marketplace design improvements. According to Kireyev [16], NFT collections that are offered by two different marketplaces can exhibit significantly different market statistics because of differences in bidding costs rather than differences in inherent value. However, Kireyev [16] did not study NFT games and concentrated on NFT collections. Some NFT marketplaces such as the Mintable.app are now providing the ability to mint and trade NFTs with zero gas fees, however, purchasing Axi Infinity NFTs from its marketplace requires a gas fee. Some of the conventional games also have marketplaces to buy game items. Before the era of e-commerce, online gamers often relied on forums or even direct contact with the seller. Hence, fraudulent acts were

usually carried out by unscrupulous individuals. However, after the appearance of e-commerce in the gaming world, those problems began to vanish [2]. Now, NFTs have provided a secure way of selling and purchasing items in NFT games marketplaces.

Structurally, coins and tokens markets, as well as NFTs markets, can be classified into Decentralized Exchanges (DEX) and Centralized Exchanges (CEX). However, we can categorize games' NFT items markets as internal marketplaces that are managed exclusively within each game (e.g., https://market.decentraland.org/), or platform marketplaces that enable games developed on the same platform to trade their NFT items on a shared marketplace (e.g., https://enjinx.io/eth/marketplace).

Before we start with the evaluation of NFT games we discuss how these projects are closely related to financial technology so we could evaluate them from a financial point of view.

"Financial technology" or "Fintech" refers to the use of technology to deliver financial solutions. The term's origin can be traced to the early 1990s and referred to the "Financial Services Technology Consortium", a project initiated by Citigroup to facilitate technological cooperation efforts [17]. According to the Financial Stability Institute (FSI) of the Bank for International Settlements (BIS), fintech activities can be found in the following financial services categories: (i) deposits and lending; (ii) capital-raising and alternative sources of funding; (iii) asset management, trading, and related services; (iv) payments, clearing and settlement services; (v) insurance; and (vi) crypto-assets. Furthermore, FSI considered creating, distributing, storing, or exchanging crypto-assets, using them for investment or payment purposes, or as a reference in financial products as financial activities related to crypto-assets [18]. Although, FSI acknowledges that crypto-assets are part of Fintech activities they do not concentrate on particular types of crypto-assets and instead focus on the regulatory aspects of Fintech.

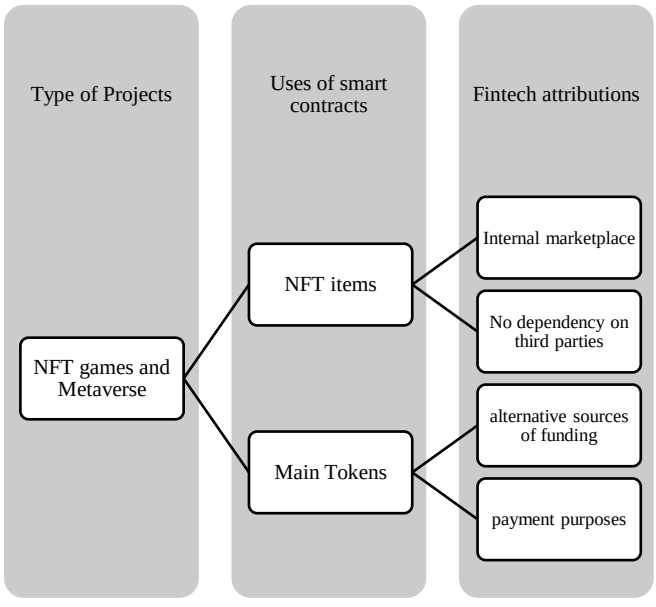
Moreover, The FSI report prepared by Ehrentraud et al. [18] mentioned that most crypto-assets could also be classified under the other categories of financial services, depending on their underlying economic function, rights attached and business model features, however, crypto-related services involve a range of unique approaches with quickly evolving use cases. This is also the case for NFT game projects because they also use utility tokens to cover the financial aspects of their business such as capital-raising and alternative sources of funding.

Lu [19] further studies how blockchain creates opportunities for Fintech: (1) utilizing the security, reliability, and immutability of the underlying infrastructure, and (2) implementing the functionalities of smart contracts. Although he discusses the importance and functionality of smart contracts in Fintech, he does not elaborate more on the different types of smart contracts or NFTs, and how they are used in Fintech. However, he suggests that in the near future we can expect the development of blockchain platforms to address the finance-specific needs of new marketplaces. Therefore, NFT games that provide an internal marketplace for their NFT items and use blockchain to address their finance-specific needs can be classified as Fintech. Other researchers such as Ali et al. [20] and Queiroza & Wamba [21] also emphasize the importance of smart contracts in empowering Fintech projects with new financial tools. Panisi [22] goes further and emphasizes the importance of smart contracts to fintech and electronic markets. According to him, blockchain and smart contracts aim at decreasing monitoring and enforcement costs. Thus, blockchain and smart contracts can free financial institutions from relying on post-trade financial market infrastructures and improve market efficiency in the clearing, settlement, and transaction management.

Among the researchers who have worked on this subject, Kong & Lin [23] state that NFTs serve as a novel investment vessel in this Fintech era. However, they concentrate on CryptoPunks collectible NFTs as one of the earliest and the most valuable NFT projects and do not consider other types of NFT projects such as NFT games.

As the literature review showed, researchers have identified smart contracts as examples of Fintech, but have not specifically focused on NFTs and NFT projects to precisely define their roles in the field of Fintech. As mentioned before, NFTs are used in several areas, the two main areas of which are collectibles and NFT games/ Metaverse. Most collectibles projects only sell their NFT collections and have no other connections with smart contracts. Yuga Lab, for example, which sells its CryptoPunks collection as NFTs, did not have a token until 2022, and then issued its token, ApeCoin, to finance its Metaverse project, not its collectibles project. However, NFT games and metaverses are more related to Fintech because they use smart contracts in two ways, for a variety of purposes that are defined by FSI as examples of Fintech. Fig. 1. shows what aspects of Fintech NFT games and metaverses cover:

Fig. 1. Metaverse characteristics that make them a type of Fintech



Source: Author's.

Analysts have used various methodologies to evaluate different cryptocurrency and blockchain projects. Cheah & Fry [24], through performing an econophysics methodology, reported that Bitcoin exhibits speculative bubbles and found empirical evidence that the fundamental price of Bitcoin is zero! which is a controversial opinion among market participants. They took into account the Bitcoin price and did not consider other characteristics of a cryptocurrency project; therefore, their methodology may not be suitable for a comprehensive evaluation of NFT projects. In another study, Urquhart [25] through a variety of robust tests reported that Bitcoin is an inefficient market but may be in the process of moving towards an efficient market. By performing the Ljung-Box autocorrelation of returns test, Runs and Bartels test of returns independency, and a variance ratio test they investigated if the Bitcoin price follows a random walk hypothesis. Similar to Cheah & Fry [24], Urquhart [25] also only concentrated on the price of Bitcoin. However, Blockchain projects are very diverse and even the NFT ecosystem is already extremely broad. Consequently, the due diligence process is necessarily different depending on the particular asset type [15]. Therefore, in this paper, we aim to provide a more in-depth analysis of NFT games.

Specifically, in the context of NFTs, Franceschet [26] adapted Kleinberg's authority/hub Hyperlink-Induced Topic Search (HITS) method to rate artists and collectors in a major crypto art marketplace. In his study, HITS method is developed to rate and rank artists and collectors in art systems. Artists create and sell artworks, they are the sources of art. Collectors buy and pull together artworks, they have some sense of where good art is. Franceschet [26] applied the proposed rating method to the marketplace of SuperRare, which is among the most important crypto art galleries by popularity and volume of exchanged artworks. His thesis in the art setting is: "A leading artist sells to leading collectors and a leading collector buys from leading artists." According to Franceschet [26] HITS method establishes a rating for artists coupled with a rating for collectors independently from the characteristics of NFT artworks, which can be hard to measure. However, in this paper, we aim to measure different characteristics of NFT game projects. Dowling [27] also performed a study on NFT pricing. His work is more concentrated on the pricing of NFT items within the games than pricing the games themselves. He tests the market efficiency of NFT Lands in Decentraland (a metaverse game that is also included in our study sample) which are traded as NFTs. To do so, he performs an automatic variance ratio (AVR) test, an automatic portmanteau (AP) test, and a Domínguez and Lobato (DL) consistent test. According to him, the NFT Lands market can be characterized as an inefficient market with a rapid rise in prices. He does not provide a framework for evaluating NFT Lands and determining their value in comparison to other virtual lands, rather, he investigates their market efficiency. Ante [28] who analyzed NFT markets on Ethereum smart chain through a (cointegrated) vector autoregression (VAR) model also reported that NFT markets are immature or even inefficient. Moreover, Ante [29] reported that (larger) cryptocurrency markets affect the growth and development of the (smaller) NFT market, but there is no reverse effect. In another study, Dowling [30] also tested if NFT pricing is related to cryptocurrency pricing. Through a wavelet coherence analysis that indicates co-movement between the two sets of markets, he reported that cryptocurrency pricing behaviors might be of some benefit in understanding NFT pricing patterns. He studied Decentraland, CryptoPunk, and Axie Infinity NFTs. Since both Decentraland and Axie Infinity are categorized as NFT games we have included them in our study too. CryptoPunk is not a game or metaverse, therefore, we did not include it in our study. Again, his study is focused on Decentraland and Axie Infinity's NFTs and not the whole projects, and also, he studies the crypto markets macrostructure and does not provide a framework for investment decision making. Since we intend to perform a comprehensive evaluation and fundamentally analyze NFT games our study is focused on different aspects of NFT games to be able to evaluate them from various aspects, and not just their NFTs. Moreover, instead of taking a macrostructure view and testing crypto markets' efficiency, we try to provide a framework for investment decision-making.

NFT games or generally all the blockchain-based projects are riskier than simple non-financial companies and they always have a tokenomics (economics of crypto tokens) aspect that has to be investigated thoroughly. Therefore, as explained in the previous subsection, it is safe to say that they can all be categorized as Fintech projects to some extent. As mentioned before, Kong & Lin [23] also considered NFTs as alternative investments in the Fintech era and reported that token scarceness and subjective judgments of aesthetics are crucial determinants for explaining a large portion of NFTs price premiums. Analysts use different multicriteria methodologies to rate conventional financial institutes. Some of the most commonly applied techniques include Data Envelopment Analysis (DEA), Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), ELimination Et Choix Traduisant la REalité (ELECTRE), VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), and Preference Ranking Organization METHod for Enrichment of Evaluation II (PROMETHEE II) [31].

The PROMETHEE family of outranking methods include, among others, PROMETHEE I (partial ranking) and PROMETHEE II (complete ranking). It is an outranking method for a finite set of alternative actions to be ranked and selected among conflicting criteria [32]. Various analysts have used PROMETHEE II for rating financial institutes and non-financial institutes. PROMETHEE II is also applied in cryptocurrency studies. Researchers such as Kądziołka [33] and Aljinović et al. [34] employed the PROMETHEE II methodology in the field of cryptocurrencies. Kądziołka [33] used the PROMETHEE II method to create a ranking of cryptocurrency exchanges. Cryptocurrency exchanges can surely be categorized as Fintech; however, their characteristics are very different than NFT projects. Therefore, while Kądziołka [33] shows that the PROMETHEE II method is appropriate for ranking cryptocurrency Fintech we have to develop special criteria to be able to use it for ranking NFT projects. Moreover, we go further than ranking projects and provide a framework for

rating them. Aljinović et al. [34] use PROMETHEE II for cryptocurrency portfolio selection and cite "incorporating criteria that, to the best of our knowledge, have never been used before in portfolio optimization" as one of their contributions to the existing literature. We also develop special criteria that, to the best of our knowledge, have never been used before in blockchain project evaluations. Aljinović et al. [34] study sample consists of nine cryptocurrencies: Bitcoin, Dash, Ethereum Classic, Ethereum, Litecoin, Monero, Neo, Stellar, and Ripple, which none of them are NFT game projects. Similar to Kądziołka [33], Aljinović et al. [34] study also does not provide a rating framework.

According to Ulengin et al. [35], the PROMETHEE II has at least 3 advantages: (i) being user-friendly, (ii) success in applications to real-life planning problems, and (iii) completeness of rankings. Also, Papathanasiou & Ploskas [36], who compared and modeled several Multiple Criteria Decision Aid (MCDA) methods including TOPSIS, VIKOR, PROMETHEE, SIR, AHP, and Goal Programming, state that PROMETHEE provides decision-makers with much richer information at the expense of a more complex preference modeling. They also mention that PROMETHEE has the GAIA visual descriptive model and also can be programmed in Python. Moreover, while PROMETHEE I only allows for partial ranking, PROMETHEE II allows for both partial and complete ranking of alternatives. Therefore, using PROMETHEE II can improve the usability, and flexibility of our research, to be applied to other types of cryptocurrencies, by professionals and also by less educated cryptocurrency investors.

II. RESEARCH METHOD

To produce a comprehensive analysis, we utilize a combination of generic cryptocurrency measurements, such as a token's market cap, alongside NFT games' unique criteria, such as the number of users, or the simplicity of entry to the game (free-to-play vs. pay-to-play). Below is a complete list of the selected criteria.

TABLE I. EVALUATION CRITERIA

Criteria		**Measuring method**	**Criteria Code**	**Preference**
Upside potential	White Paper	Most Recent Updated Date	WP	MIN
	Green Paper	1 if has a green paper, 0 if not	GP	MAX
	Scientific References	Number of citations to the project based on Google Scholar	SF	MAX
	Ease of Entrance	0 if free-to-play, 1 if pay-to-play	FREE	MIN
	Relative Market Value	The main token market cap, divided into the number of token holders	MATH	MIN
		The main token market cap, divided into the number of Twitter followers	MATW	MIN
Risks	CertiK Rank	CertiK's assigned rank, based on security score	CER	MAX
	Value at Risk	Non-Parametric 100-day Value at Risk	VaR	MIN
Hybrid	Flip Ratio	Distance from flipping the next higher-ranked coin compared to the distance from being flipped by a lower-ranked coin	FLIP	MIN

Source: Author's.

To perform a comprehensive evaluation, we tried to find a criterion that could measure both the upside potential of NFT games and their risks. Therefore, we put our criteria into two categories: upside potential and risks. We also designed a specific flip ratio that takes into account both the potential of flipping a higher-ranked token and the risk of being flipped by another token. That is why we put our special flip ratio in a hybrid category.

A. FLIP Ratio

Coin flipping, in a general sense, means flipping a coin to randomly determine the outcome of a binomial variable. In this sense, it is commonly used in statistics and probability studies. However, in cryptocurrency markets, flipping is a term that is commonly used to describe a situation where the market cap of a cryptocurrency exceeds the market cap of another one (usually a coin that used to have a higher market cap). In other words, flipping is when a cryptocurrency surpasses another cryptocurrency in market value. For example, if Ethereum ever beats Bitcoin to become the biggest cryptocurrency based on its market cap, we can say that Ethereum flipped Bitcoin; or from the opposite point of view, we can say Bitcoin got flipped by Ethereum. Since market dominance is an important measure of the weight of each cryptocurrency in the market, flipping is important to market participants. More dominant cryptocurrencies tend to have more influence on the market dynamics. Typically, the dominant coin becomes the market leader. Moreover, sometimes there is a competition between the holders of similar coins to surpass each other. For example, if Shiba Inu ever flips DogeCoin, it would be huge news for meme coins' holders.

As mentioned above, "The Flippening" is a special term in the cryptocurrency market that refers to "Market Dominance" [37, 38]. For example, one of Bitcoin's risks is to be flipped by Ethereum [39, 40], after which it may quickly lose its publicity and that would lead to a decrease in the number of Bitcoin holders. Therefore, being flipped pulls investors out of the cryptocurrency. The reverse is also true, a cryptocurrency, which gains more dominance by flipping other coins, also gains more market attention and a larger investor base. Flipping news is spread among the cryptocurrency community, and cryptocurrency project developers use this news for their marketing purposes.

"Market Dominance" is well documented in analyzing other, conventional, markets [41, 42, 43].

Thus, our FLIP ratio measures the potential for gaining more market dominance in proportion to the risk of losing market dominance. Our new flip ratio compares the chance of a coin flipping another coin to the chance of the same coin getting flipped by another coin. To the best of our knowledge, no similar ratio has been formulated in other studies or used by cryptocurrency market participants in their investment decisions. Although, there is a "Flippening Index" provided by https://www.blockchaincenter.net/en/flippening/ that plots the Ethereum market capitalization graph as a percentage of Bitcoin market capitalization.

We modeled our special flip ratio as follow:

$$FLIP = \frac{\#(N-1)\ coin's\ market\ Cap - \#(N) coin's\ market\ Cap}{\#(N) coin's\ market\ Cap - \#(N+1) coin's\ market\ Cap} \quad (1)$$

Where:

- #(N): coin's rank based on its market cap (e.g., Bitcoin is ranked as #1, Ethereum is ranked as #2, etc.)
- Market cap: coin's current market price multiplied by the number of coins in circulation as provided by websites like Coinmarketcap.com

B. Value at Risk

We use Value at Risk (VaR) as an important measure of the market risk of NFT games' main tokens. Unlike measures such as variance or CAPM Beta, non-parametric value at risk analysis is compatible with the volatile nature of cryptocurrencies and the large leptokurtosis of their price movements, which also shows that they do not follow a normal distribution. Cryptocurrencies' returns not only are more volatile and riskier than traditional currencies but also exhibit heavier tails behavior and violate the assumption of normality [44].

VaR can be calculated with different meths. There are three types of VaR: parametric VaR, simulated VaR, and non-parametric VaR. One significant advantage of non-parametric VaR is that we can calculate it based on the historical performance of cryptocurrencies rather than assuming a distribution probability. Therefore, we can work with actual scenarios that happened in the past. They may not happen again, but they are more realistic than other assumptions [45].

VaR calculates the maximum expected loss, over a given period and given a specified level of confidence. Generally, given $\alpha \in [0, 1]$, and a reference instrument r, the VaR_α at level α of the final net worth X with distribution P, is mathematically defined as [46]:

$$VaR_\alpha(X) = -inf\{x|P[X \leq x.r] > \alpha\} \quad (2)$$

In the historical non-parametric VaR approach, we calculate VaR directly from past returns. In this paper, we calculate VaR using 100 daily returns and set the level of confidence at 95%. Since we are using daily returns, we are finding the worst daily shocks in the past 100 days of a cryptocurrency's price movements.

C. White Paper and Green Paper

White papers and green papers are where a project explains its business and draws its road map. The white paper is more about what a project has achieved and is capable of doing now or in the near future. The green paper is more ambitious and focused on long-term developments. However, both of them should give a good explanation of the project and enlighten the readers about it. Since both of these papers do not have a very strict format, evaluating them is subjective. Therefore, we take their last updated date as a more objective criterion that shows how committed the project runners are to updating their white paper. Moreover, since many projects do not have green paper, we consider the existence of green paper as an advantage. To the knowledge of the authors, white paper and green paper specifications have not been used as factors in evaluating cryptocurrencies.

D. Scientific references

One other factor that we look into is the scientific importance of projects, and we measure it by the number of scientific references to the project, its white paper, and its green paper. It shows how innovative a project might be and how much it is covered by researchers. From an investor's perspective, whether a project has a scientific background can help to determine whether a team with a new idea is behind it, or whether the project, probably, is another copycat. This can at least help investors avoid projects that may be scams or rug pulls. Also, researchers usually study projects that at least have some data to review and are worth reviewing. Moreover, since there is no such thing as "analysts' coverage" for cryptocurrencies, "researchers' coverage" can be used instead. We use Google Scholar in this regard. Although relevant data are not summarized anywhere, Google Scholar's database is essentially a part of a popular WWW search engine, which means that there are no limits on the languages covered, keywords allowed per search, and list of covered journals, provided for the latter that an electronic edition exists [47]. To the knowledge of the authors, scientific references have not been studied in the process of evaluating cryptocurrencies.

E. Ease of Entrance

Playing most NFT games entails buying some NFTs to start with. We consider this a barrier to entry. However, some games offer the option of starting from scratch and playing to earn your first NFT item. We consider the free-to-play option an advantage. Although some studies reported that the free-to-play option may not be attractive because, inevitably, players have to pay to be able to play properly. People think it's unethical that some games give the illusion of a free-to-play option whereas if you want to practically play the game, you have to pay to unlock the game's main features. However, big, well-known games usually do not pursue this unethical path [48]. In general, the literature analysis revealed that the advantages of free-to-play over pay-to-play remain unproven, and each of these tactics has its own unique strengths and weaknesses [49].

F. Relative Market Value

Relative Market Value is a type of relative analysis that we use in our model to link the project's main token's market cap to one of its most important measures of performance, which is the number of players, or more comprehensively, its popularity. Generally, there are two types of cryptocurrencies: those meant to fund a specific project and those designed for general or non-specific uses [50]. In the present paper, by "project's main token" we mean the one that is meant to fund the NFT game project. Analysts and market participants sometimes call the first type of cryptocurrency "coins" and the second type of cryptocurrency "tokens" or, in our case, "utility tokens", which give their holders consumptive rights to access a product or service [51]. However, these categories may overlap now that cryptocurrencies can serve multiple purposes. Besides, since the market cap of all types of cryptocurrencies is calculated in the same way, we do not need to differentiate between coins and tokens when we are only using their market cap and may use both names interchangeably. Moreover, since most of the projects do not announce their exact number of players, we use two measures that together can be a good representative of a game's popularity. One measure is the number of the game's token holders, and the other measure is the game's official Twitter account followers. Almost all cryptocurrency companies are using social media as an advertising tool [52]. Therefore, Twitter followers can be used as a measure to determine the effectiveness of marketing costs in increasing games'

popularity. According to Park and Lee's [52] findings, measuring the social media presence of a cryptocurrency can lead to a more accurate evaluation. Li et al. [53] also state that the number of followers on Twitter and Reddit can reflect how many people support the cryptocurrency. Ong et al. [54] also used Twitter followers and market capitalization, among other measures, to provide an overall rank for alternative cryptocurrencies. They stated that a currency without users will not have any value and a strong indicator of a coin's strength is reflected in its community support. To measure community support, several metrics can be used as a proxy such as Twitter followers.

Regarding the number of token holders, other researchers have also used a similar measure to estimate game players. For example, in the Harris [55] study, games' user counts were determined by the number of unique wallets that showed any kind of interaction with a smart contract from the games. Our two relative market value ratios are defined as below:

$$MATH = \frac{token\ market\ cap}{Number\ of\ token\ holders} \quad (3)$$

$$MATW = \frac{token\ market\ cap}{number\ of\ Twitter\ followers} \quad (4)$$

The number of users can also be viewed as an indicator of the level of adoption of the game among people. In the cryptocurrency context, the level of adoption refers to how much a cryptocurrency is known to people or is used by people. The level of adoption shows how cryptocurrencies have found their way into ordinary people's lives. Shahzad, Xiu, Wang, & Shahbaz [56] discussed how gaming can be related to the adoption of bitcoin, although they didn't study the games themselves.

G. CertiK Rank

CertiK is a verification platform to examine smart contracts and blockchain ecosystems. CertiK checks if they are bug-free and hacker-resistant. Moreover, hybrid approaches to the verification of smart contracts are proposed and used in the CertiK project [57]. Here we use Certik's assigned ranks, if any, for NFT games to evaluate them based on their security. Certik mostly evaluates projects built on Binance Smart Chain and Polygon, but since there are a lot of different smart chains now, we couldn't find any security analysis agencies that would cover all of them. Moreover, CertiK is a pioneer in the area of cryptocurrency security evaluation.

Ratings are an important factor when analyzing stocks and bonds. In the field of company analysis, rating scores assigned by rating agencies refer to the companies' credit risk. If the rate of a company changes, it will have a huge effect on its stock price and its bond yields. However, since cryptocurrency projects are mainly not registered as companies, and their capital structure is not clear, they are not rated by rating agencies. Therefore, there are other agencies like CertiK that assign a security score to these projects. Hence, CertiK scores are about the operational risk of cryptocurrency projects rather than their credit risk. Security has always been a critical part of evaluating online games. The emergence of online games fundamentally changed the security requirement for computer games. In the new context, copy protection is not, at least not the only, security issue anymore. Though online games, on the other hand, are commonly regarded as one of the distributed E-Commerce applications, they have their own unique security challenges [58].

Regarding blockchain games, Min & Cai [59] assert that blockchain games are still suffering from security issues due to immature blockchain technologies and their unsophisticated developers.

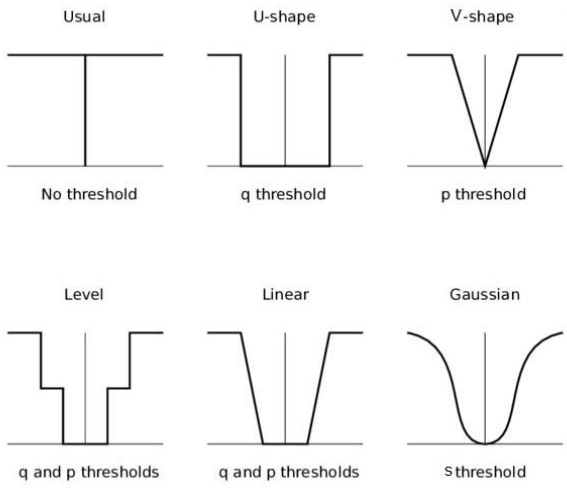
H. PROMETHEE II

As demonstrated in Table I, the specified criteria are conflicting; some of them are preferred to be higher while others are preferred to be lower. Therefore, after calculating these measures, we use the PROMETHEE II method to combine these conflicting criteria and rate NFT Games by comparing their strengths and weaknesses against each other. We follow the Doumpos & Zopounidis [60] approach in implementing the PROMETHEE II method for rating financial institutions. The evaluation of NFT games in the context of the PROMETHEE II method is based on pairwise comparisons. In particular, for each pair of games *(i,j)* the pairwise preference index $P(x_i,x_j)$ is computed, where $x_i=(x_{i1}, x_{i2}, ..., x_{in})$ is the vector with the description of the game *i* on *n* evaluation criteria. The $P(x_i,x_j)$ is defined as the weighted sum of pairwise partial preference indices $\pi_k(x_{ik}, x_{jk})$ as follows:

$$P(x_i, x_j) = \sum_{k=1}^{n} w_k \pi_k(x_{ik}, x_{jk}) \quad (5)$$

where w_k is the weight of criterion *k* and $\pi_k(x_{ik}, x_{jk})$ is the corresponding pairwise partial preference index. $\pi_k(x_{ik}, x_{jk})$ measures (on a scale of 0 to 1) the strength of the preference for the game *i* over game *j* on criterion *k*. It is a function of $x_{ik} - x_{jk}$ determining the comparative performances of the games on criterion *k*. Brans & Vincke [61], the developers of the PROMETHEE method, proposed six types of preference functions, namely: usual, U-shape, V-shape, Level, Linear, and Gaussian. Fig.2. depicts these functions and their required thresholds [62].

Fig. 2. PROMETHEE method six types of preference functions



Source: Binnekamp's.

A popular choice for quantitative data is the Gaussian function used by Doumpos & Zopounidis [60], Gökalp [63], and Paksoy & Traş [64] for rating financial institutions:

$$\pi_k(x_{ik}, x_{jk}) = \begin{cases} 0 & if\ x_{ik} \le x_{jk} \\ 1 - exp\left[-\frac{(x_{ik}-x_{jk})^2}{2\sigma_k^2}\right] & if\ x_{ik} > x_{jk} \end{cases} \quad (6)$$

where $\sigma_k > 0$, which has to be selected by the user, defines the inflection point of the preference function. The gaussian and Linear functions are more suitable if the criteria have a continuous numerical scale (such as FlIP, MATW, and MATH) and if we want to introduce an indifference threshold [65]. However, while the Linear function needs two thresholds, the Gaussian function only needs one, therefore, we are less dependent on the user's judgment.

Now, if we consider a set of M games for evaluation, the results of all the pairwise comparisons are aggregated into a net performance index $\emptyset(x_i)$ as follows:

$$\emptyset(x_i) = \frac{1}{M-1}[\emptyset^+(x_i) - \emptyset^-(x_i)] \quad (7)$$

$$\emptyset^+(x_i) = \sum_{j \neq i} P(x_i, x_j) \quad (8)$$

$$\emptyset^-(x_i) = \sum_{j \neq i} P(x_j, x_i) \quad (9)$$

Where Equation (8) represents the outranking character of the game *i* over all the other games and Equation (9) represents the outranking character of all games in the sample over game *i*. Thus, the net performance index $\emptyset(x_i)$ in Equation (7) combines the strengths and weaknesses of a game compared to its competitors in an overall evaluation measure. The net performance index $\emptyset(x_i)$ ranges from -1 to 1, with higher values associated with higher-performing NFT games.

To build a rating model, we can transform $\emptyset(x_i)$ into a 4-level rating scale via the following function:

$$V(x_i) = \begin{cases} 1 & if\ \emptyset(x_i) = \emptyset^M \\ 1 + 4\frac{\emptyset^M - \emptyset(x_i)}{\emptyset^M - \emptyset^L} & if\ \emptyset^L < \emptyset(x_i) < \emptyset^M \\ 5 & if\ \emptyset(x_i) = \emptyset^L \end{cases} \quad (10)$$

where $\emptyset^L = min\{\emptyset(x_i)\}$ and $\emptyset^M = max\{\emptyset(x_i)\}$.

With this transformation, the games' rates will range on a scale from 1 (best performance) to 5 (worst performance). Now, we can specify the associated ratings as follow:

TABLE II. TRANSFORMED NET PERFORMANCE INDEX INTERVALS AND THEIR ASSIGNED RATINGS

Overall score interval	Assigned rating
$\mathbf{1 \le V(x_i) \le 2}$	AAA
$\mathbf{2 < V(x_i) \le 3}$	AA
$\mathbf{3 < V(x_i) \le 4}$	A
$\mathbf{4 < V(x_i) \le 5}$	BBB

Source: Author's.

It is worth mentioning that our rating framework gives a good insight into the relative value of different projects. As cryptocurrencies have very complex structures, performing an absolute valuation and driving the intrinsic value of projects is a very sensitive subject and it is susceptible to a lot of considerations, even for very well-known cryptocurrencies like Bitcoin, therefore, most of the evaluations of cryptocurrencies are based on relative valuations. Furthermore, rating and ranking are considered as two different types of categorizations because ranking is based on sorting projects but rating assigns each project to a prespecified category

III. DATA AND FINDINGS

Our sample consists of NFT games on the top 100 cryptocurrencies ranked by their market capitalization, according to coinmarketcap.com (accessed on December 21, 2021). We selected projects that were tagged with "gaming" by coinmarketcap.com and provided at least one NFT game.

At the time of our study, there were 6 NFT games in the top 100 cryptocurrency projects. Some of these projects are games themselves, and some of them are platforms that developers can build their own games on them. We used their 100 days of historical prices up to Dec. 25 2021 to calculate their VaR and relative market value and Flip ratio. Table III describes the sample data.

TABLE III. SAMPLE DATA DESCRIPTION

Project	The Sandbox	Axie Infinity	Decentraland	Gala	Bora	Enjin
Main Token	SAND	AXS	MANA	GALA	BORA	ENJ
White Paper Latest Update	Aug-20	Dec-20	Aug-17	null	May-18	Sep-17
Google Scholar Results	22	53	241	0	0	46
Existence Of a Green Paper	No	No	No	No	No	No
CertiK Rank	1	null	14	null	null	null
Value At Risk	-0.10543	-0.08339	-0.11245	-0.1387	-0.1421	-0.0983
Main Token's Market Cap (million USD)	4,813	6,004	6,144	3,120	924	2,726
Higher Ranked Token's Market Cap (Million USD)	5,013	6,140	6,467	3,291	939	2,823
Lower Ranked Token's Market Cap (Million USD)	4,765	5,857	6,140	3,023	902	2,710
Free-To-Play	yes	NFT-Required	yes	yes	yes	yes
Number Of Token Holders	85,155	46,248	181,827	72,767	23,562	158,279
Twitter Followers	646,916	805,329	410,834	212,918	16,578	441,393

Sources: Author's, coinmarketcap.com, twitter.com, scholar.google.com, certik.com, decentraland.org, axieinfinity.com, sandbox.game, boraecosystem.com., enjin.io

"Null" in the "White Paper Latest Update" row of Table III means the project does not have a white paper, and in "CertiK Rank" row it means that the project has not been ranked by Certik.

As presented below, Table IV outlines the calculated criteria.

After calculating the criteria, we use Visual PROMETHEE Academic Edition software to rate NFT games. In calculating the Gaussian preference function, if we choose a low value for σ_k, it means that the preferences will be reinforced for small deviations. Now because determining the σ_k value is a subjective decision; we choose a small value to take into account the small deviations between projects in their ratings. Therefore, we set $\sigma_k = 0.5\%$ for all criteria. We also weigh all 9 criteria equally, however, in the "sensitivity

analysis" subsection we perform a sensitivity analysis and discuss how changing the criteria's weights and σ_k may change the results.

TABLE IV. CRITERIA DESCRIPTION

Criteria		Criteria Code	Preference	Minimum	Maximum	Average	Standard Deviation
Upside potential	White Paper	WP	MIN	391	1,603	1,073	579.62
	Green Paper	GP	MAX	0	0	0	0.00
	Scientific References	SF	MAX	0	241	63	101.74
	Ease of Entrance	FREE	MIN	0	1	0	0.41
	Relative Market Value	MATH	MIN	17,227	129,838	53,248	39641
		MATW	MIN	6,177	55,744	17,738	19011
Risks	CertiK Rank	CER	MAX	1	14	8	9.19
	Value at Risk	VaR	MIN	-0.1421	-0.0834	-0.1134	0.02
Hybrid	Flip Ratio	FLIP	MIN	0	1	1	0.23

Source: Author's.

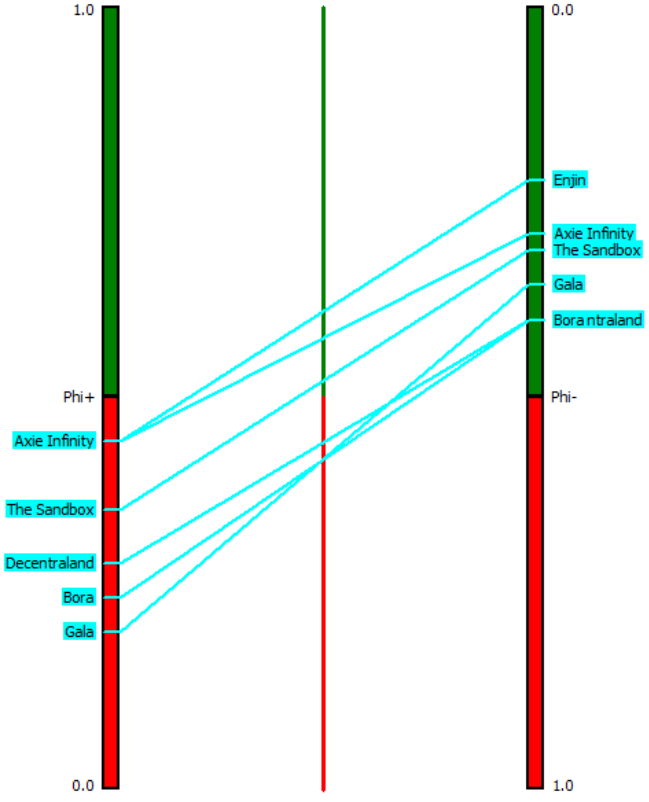
We calculated NFT games' partial performance scores and net performance index values, using Equations (8), (9), and then (7). Table V shows the partial performance scores and net performance index values.

TABLE V. PARTIAL PERFORMANCE SCORES AND NET PERFORMANCE INDEX VALUES

NFT games	$\emptyset(\mathbf{x_i})$	$\emptyset^+(\mathbf{x_i})$	$\emptyset^-(\mathbf{x_i})$
Enjin	0,2222	0,4444	0,2222
Axie Infinity	0,1538	0,4444	0,2906
The Sandbox	0,0462	0,3573	0,3111
Decentraland	-0,1111	0,2889	0,4000
Bora	-0,1556	0,2444	0,4000
Gala	-0,1556	0,2000	0,3556

Source: Author's.

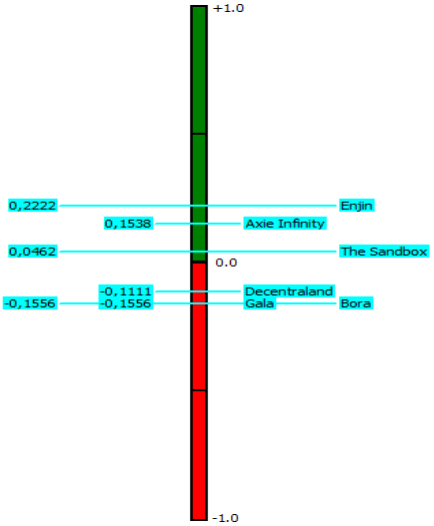
Fig. 3. PROMETHEE I partial preference ranking



Source: Author's, via Visual PROMETHEE Academic Edition software

Fig. 3., is useful to understand the partial preference ranking of games under consideration. The left column in Fig. 3. corresponds to the $\emptyset^+(x_i)$ values and the right column to the $\emptyset^-(x_i)$ values. If one game has the highest $\emptyset^+(x_i)$ and the lowest $\emptyset^-(x_i)$, as in our case, we can say it is the best game based on both $\emptyset^+(x_i)$ and $\emptyset^-(x_i)$; In our case, Enjin is ranked as the best performing game according to $\emptyset^+(x_i)$ values and $\emptyset^-(x_i)$ values. On the other hand, Gala is ranked as the worst-performing project according to $\emptyset^+(x_i)$ values, but according to $\emptyset^-(x_i)$ values, Bora and Decentraland are both the worst performing games. In this case, projects are incomparable based on their partial performance. Therefore, we have to look into their net performance.

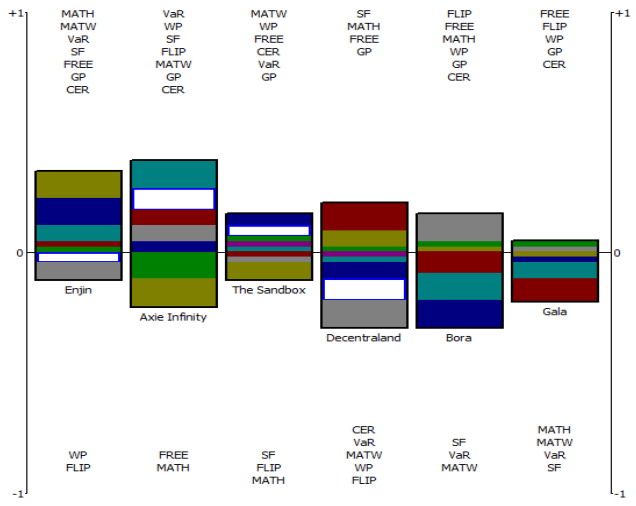
Fig. 4. PROMETHEE II complete ranking



Source: Author's, via Visual PROMETHEE Academic Edition software

Fig. 4. illustrates the PROMETHEE II complete ranking. In this figure, the game on the top (bottom) of the column has the highest (lowest) $\emptyset(\boldsymbol{x_i})$ value, so it is ranked as the best (worst) game. In PROMETHEE II complete ranking, all games are comparable. In our case, according to their $\emptyset(\boldsymbol{x_i})$, Enjin is ranked as the best performing game and Bora and Gala are both ranked as the worst-performing games. It is also worth mentioning that Enjin has its own NFT standard (ERC-1155) and therefore it has more potential to grow as a platform.

Fig. 5. Strengths and weaknesses



Source: Author's, via Visual PROMETHEE Academic Edition software

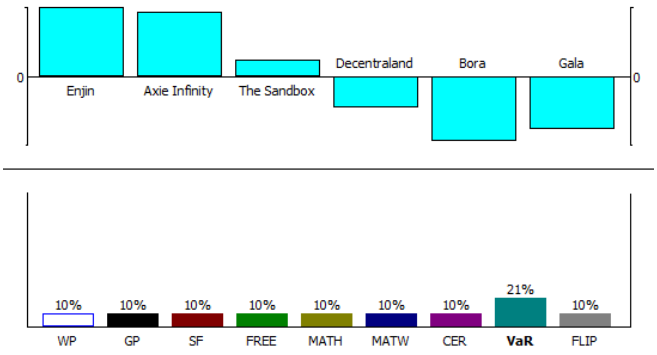
Fig. 5. shows the complete ranking in more detail. In Fig. 5., a bar is drawn for each game. The different slices of each bar are colored according to the criteria. Each slice is proportional to the contribution of a criterion to the $\emptyset(x_i)$ of the game. Positive (upward) slices correspond to good features while negative (downward) slices correspond to weaknesses. This way, the balance between positive and negative slices is equal to the $\emptyset(x_i)$. Games are ranked from left to right according to the PROMETHEE II Complete Ranking. In our case, all the games showed some weaknesses. Enjin weaknesses are based on its outdated white paper (WP) and high FLIP ratio. On the other hand, even though Axie Infinity performed well based on several criteria, its very high MATH ratio and the fact that it is not a free-to-play game prevented it from becoming the best NFT game.

A. Sensitivity analysis

In Aljinović et. al. [34] study, the weights of the chosen criteria were estimated using Saaty's AHP method. However, here we perform a set of sensitivity analyses to objectively investigate the importance of each criterion in ranking the NFT games. After that, we also perform a sensitivity analysis on σ_k.

Since value at risk is an important criterion that shows games token's price crash risk, we can double its weight and see how it would affect our ranking. As Fig. 6. depicts, in this case, Enjin would still remain the best NFT game.

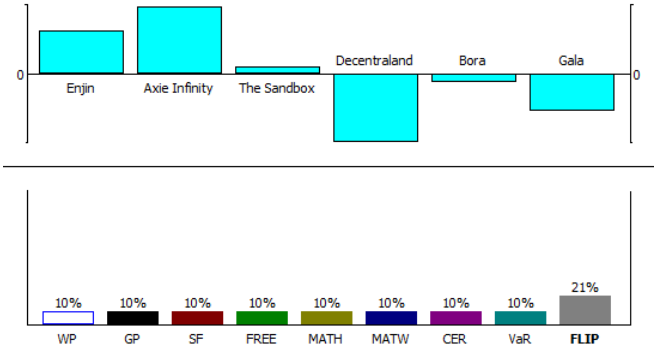
Fig. 6. Ranking, if we assign a higher weight to VaR



Source: Author's, via Visual PROMETHEE Academic Edition software

However, as Fig. 7. shows, if we double the weight of the FLIP ratio, Axie Infinity would surpass Enjin and become the best-performing game.

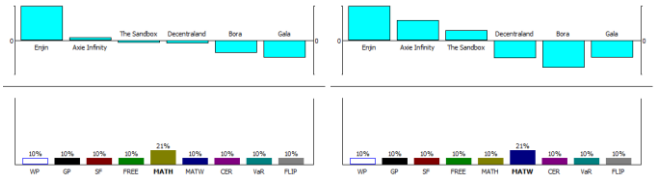
Fig. 7. Ranking, if we assign a higher weight to FLIP



Source: Author's, via Visual PROMETHEE Academic Edition software

From the relative market value point of view if we double the weight of MATH and MATW, in both cases Enjin would still remain the best-performing NFT game.

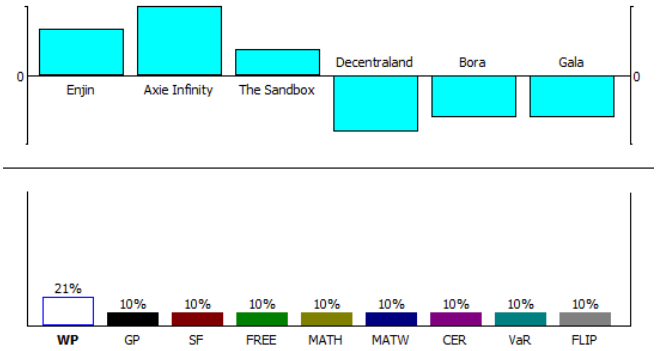
Fig. 8. Ranking, if we assign a higher weight to MATH or MATW



Source: Author's, via Visual PROMETHEE Academic Edition software

It is obvious that since none of the games had a green paper, this criterion does not affect the ranking. Based on our sensitivity analysis doubling the weight of SF, FREE and CER wouldn't change Enjin's rank as the best-performing game. Only if we double the weight of WP, it would make Axie Infinity the best game.

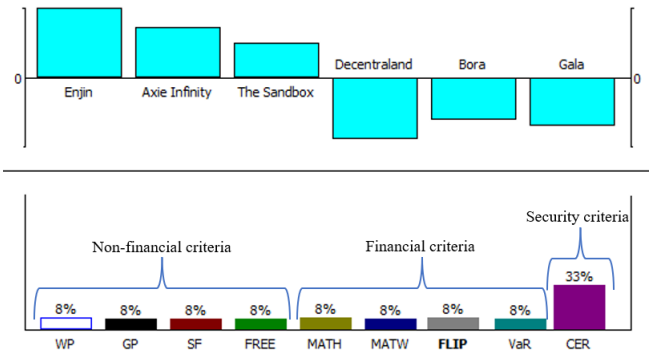
Fig. 9. Ranking, if we assign a higher weight to WP



Source: Author's, via Visual PROMETHEE Academic Edition software

We may also group our criteria into three equally weighted groups of non-financial, financial, and security criteria. We may consider WP, GP, SF, and FREE as non-financial criteria, MATH, MATW, VaR, and FLIP as financial criteria, and CER as security criteria. We also weigh the criteria in each group equally. Therefore, each group's weight would be around 33% and each criterion in each group would be weighted accordingly. Based on this scenario, Enjin would still remain the higher-ranked NFT game.

Fig.10. Ranking, if we group the criteria into three equally weighted categories



Source: Author's, via Visual PROMETHEE Academic Edition software

As we mentioned before, we chose a small inflection point for our Gaussian preference function. Now, to see the effect

of increasing σ_k on the results we rerun the model using $\sigma_k = 1\%$. If we compare the results depicted in Table VI with Table V, we can see that if we set $\sigma_k = 1\%$ the distance between projects net performance indexes values increases, however, their ranking will not change and Enjin will still remain the best performing game.

TABLE VI. NET PERFORMANCE INDEX VALUES IF $\boldsymbol{\sigma_k = 1\%}$

NFT games	$\emptyset(\mathbf{x_i})$
Enjin	0.2221
Axie Infinity	0.1551
The Sandbox	0.0449
Decentraland	-0.1080
Bora	-0.1532
Gala	-0.1609

Source: Author's.

Moreover, as Table VII shows, since we already chose a small inflection point, further decreasing σ_k will not change the ranking.

TABLE VII. NET PERFORMANCE INDEX VALUES IF $\boldsymbol{\sigma_k = 0.1\%}$

NFT games	$\emptyset(\mathbf{x_i})$
Enjin	0.2222
Axie Infinity	0.1363
The Sandbox	0.0637
Decentraland	-0.1111
Bora	-0.1556
Gala	-0.1556

Source: Author's.

B. The final rating

Finally, we transform the net performance values through Equation (10) and rate them according to our rating scale specified in Table II. The assigned ratings are as follows:

TABLE VIII. ASSIGNED RATINGS

NFT games	$\mathbf{V(x_i)}$	**Assigned ratings**
Enjin	1.00	AAA
Axie Infinity	1.72	AAA
The Sandbox	2.86	AA
Decentraland	4.53	BBB
Bora	5.00	BBB
Gala	5.00	BBB

Source: Author's.

As presented in Table VIII, 50% of the games are rated as BBB. Only one game is rated as AA and about 33% of the games under consideration are rated as AAA, which means they have a more attractive risk-potential profile than the others.

IV. CONCLUSION

The cryptocurrency market has grown significantly in recent years. One of the segments of this market, the NFT games market, has recently attracted a lot of attention with the popularity of NFTs as well as the development of metaverse. However, as mentioned in the literature review, many studies have reported that the NFT market cannot be categorized as an efficient market [28, 27]. Market efficiency has three main aspects: operational efficiency, informational efficiency, and allocation efficiency [66]. Although the use of blockchain technology has had a significant impact on improving the operational efficiency of the NFT games market, in terms of informational efficiency, NFT games market participants still face many ambiguities, due to the complexities of the NFT games projects. Poor information efficiency, in turn, has led to poor allocation efficiency. Therefore, to improve the efficiency of the NFT games market, we need to improve its informational efficiency, and consequently its allocation efficiency. Fundamental analysis, by refining data and turning it into information, helps market participants to comprehend this information and reflect it on prices, thus increasing market informational efficiency. Therefore, in this study, our focus is on selecting various data that is freely available to market participants. Then, by providing solutions to turn this data into decision criteria, we try to help investors make informed decisions. We also showed that most previous studies have focused on the games' NFT items themselves and also on market efficiency, rather than providing tools for evaluating and making investment decisions [28, 27, 30], whereas, we focus on the whole project from an investor perspective and provide a framework for comparative analysis and rating that could aid investors in their investment decisions.

Coins and tokens are often traded on Decentralized Exchanges (DEX) and Centralized Exchanges (CEX). Trading statistics of these markets are usually available. Similar to the coins and tokens markets, there are also NFT CEXs and DEXs that have grown significantly in recent years. However, in these markets, collectibles and other types of NFTs are mostly traded rather than games' NFT items. NFT games have internal marketplaces where their NFT items are traded, and each of these marketplaces has its own structure. Like tokens markets, market statistics for NFT CEXs and DEXs are also available, but due to the internal nature of NFT games marketplaces, not much information is published about them. However, games' main tokens are traded on CEXs and DEXs and can be compared. Accordingly, the focus of this study was on comparable data.

Since cryptocurrency projects have a very complex structure, are unregulated, and most importantly, do not publicize much information about their activities, evaluating them and determining which one is a more attractive investment opportunity is a difficult task.

After modeling the best criteria to evaluate and rate NFT games, we defined a 4-level rating scale (from AAA to BBB) to find the most attractive NFT games. Our findings show that 50% of the NFT games in the top-100 cryptocurrencies are rated as BBB, and investing in them needs rigorous due diligence. It is worth mentioning that we conducted a relative rating, so when we assert that a game rated as AAA performed well, we mean it performed well compared to the other games under consideration. Suppose we want to make an absolute rating. In that case, we should determine some thresholds for each criterion value, but determining these thresholds is a subjective matter, and we wanted to avoid making subjective judgments in our rating as much as possible.

Our research is different from other studies that are focused on players or the social and recreational aspects of games, as we are trying to evaluate and rate NFT games from an investment point of view.

Our comprehensive rating framework could be beneficial to cryptocurrency analysts and investors. In particular, the new FLIP ratio that we introduced could be a very constructive measure in all cryptocurrencies' ratio analyses. When performing ratio analysis, analysts try to use tailored

ratios that are suitable for the nature of each business. Unfortunately, up until now, there aren't many ratios that are modeled explicitly for cryptocurrency analysis. Therefore, we hope that introducing this new FLIP ratio can help other analysts develop a set of tailored ratios for cryptocurrency ratio analysis.

The non-parametric historical VaR that we used in this paper is also suitable for analyzing other types of cryptocurrencies. Also, we tried to take into account the adoption of games by considering Twitter followers.

Moreover, since we used free information that is available to all market participants, our proposed rating framework can also help evaluate various types of cryptocurrency projects. Analysts can modify our framework by choosing different criteria or changing the weights of each criterion and conducting their own customized cryptocurrency rating. They can also modify our framework and transform it into an absolute rating framework.

We suggest that analysts also add CVaR as another measure of risk for further research and define more ratios for relative analysis. Moreover, we considered the free-to-play option as a positive point for NFT games. However, the literature review has shown that the outcome of pursuing a free-to-play strategy over a pay-to-play scheme is not that straightforward and requires more research.

Our study contributes to the literature in three ways: First, we expand the studies on evaluating blockchain projects from a financial point of view by specifically concentrating on the NFT game and Metaverse. We add to the literature by providing evidence that NFT game projects and Metaverse can be categorized as Fintech. To the best of our knowledge, our paper is the first study that evaluates NFT game projects and Metaverse as types of Fintech, from a financial point of view.

Second, we add to the literature in the field of fundamental analysis by demonstrating the power of ratio analysis, which is an equity fundamental analysis method, in the evaluation of blockchain-based projects. For the first time, our study presents ratios that fit the characteristics of blockchain-based projects, especially NFT games and Metaverse.

Third, we add to the literature on the flexibility and applicability of the PROMETHEE II method in evaluating and ranking blockchain-based projects. We also show how to convert PROMETHEE II output into ratings.

The following limitations should be considered in interpreting and using the results of this study:

- The results of this study may change by changing the assumptions made to determine the weight of our criteria.
- Other information about NFT metaverse games may be available that may affect the results of the research.
- Apart from PROMETHEE II, there are other MCDA methods, which were also mentioned in the manuscript, and each has its own advantages and limitations, and using them may lead to different results.

According to our findings and also the mentioned limitations, we suggest that in future studies, methods such as the Delphi or AHP methods be used to determine the weight of the criteria. We also suggest that more data be used to evaluate projects. For example, the smart chains' gas fees can be considered one of the barriers to entering an NFT game.

Moreover, the time of establishment of metaverse projects can be taken into consideration, because older projects have more opportunities to attract the audience. In the present paper we performed a cross-sectional analysis, however, time analysis is also one of the approaches to analyzing financial ratios.

Finally, we suggest that the results of using other MCDA methods be compared with PROMETHEE II to determine whether a change in the method can make a significant difference to the results

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