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Article

Opportunities and Barriers to the Adoption of Blockchain-Based Games in an Online Gaming Company in Thailand

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Abstract. This research aims to explore potential opportunities and barriers related to the adoption of blockchain-based games in an online gaming company in Thailand. The identified opportunities are classified under the benefits framework proposed by Shang and Seddon [1], and the identified barriers are classified under the Technology-Organisation-Environment (TOE) framework. Based on the knowledge and experience of experts in the case company, all the opportunities and barriers are then assessed using the concept of Failure Mode and Effect Analysis (FMEA), which is further improved using the Analytic Hierarchy Process (AHP) by assigning a relative weight to each element of the FMEA before being used to find the priority number (PN). Next, the Pareto principle is applied to reveal the critical opportunities and barriers. As a result, a total of 21 critical opportunities are revealed and categorised into 5 dimensions: 4 operational opportunities; 3 managerial opportunities; 7 strategic opportunities; 4 infrastructure opportunities; and 3 organisational opportunities, and a total of 19 critical barriers are revealed and categorised into 3 dimensions: 7 technological barriers; 6 organisational barriers; and 6 environmental barriers. The TOWS matrix is then used to formulate possible strategies for the case company to exploit the opportunities and address the barriers to the adoption of blockchain-based games. As a result, a total of 7 SO, 12 ST, 5 WO, and 1 WT strategies are proposed. Based on the PNs and the interview with experts, a roadmap including short-, medium-, and long-term action plans is also developed to facilitate the adoption of blockchain-based games.

Keywords: Blockchain-based games, opportunities and barriers, benefits framework, TOE framework, FMEA, AHP, Pareto, TOWS matrix, technology adoption.

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1. Introduction

1.1. Gaming Industry in Thailand

The Coronavirus disease (COVID-19) pandemic has posed significant challenges for many industries around the world such as trade, supply chain, finance, health, and education [2]. However, the opposite has been the case for the gaming industry. The Digital Economy Promotion Agency (DEPA) [3], established in 2017 by the Thai government to support the progress of the adoption of innovation and technology in Thailand, reports that the pandemic has become one of the key drivers of the gaming industry in Thailand because consumers' behaviour has shifted from offline activities to online activities. Gaming has become a means of how people spend time during lockdowns and social distancing and, as a result, a rise in revenue and engagement could be observed in all game segments. In 2020, the number of gamers in Thailand rose to more than 32 million [4], which was around 45% of the total population. In terms of video game revenue, Thailand is the second-largest in Southeast Asia and is ranked 20th globally [5]. Figure 1 represents the revenue of the video game market in Thailand, which is expected to have a compound annual growth rate (CAGR) of 9.76% from $US599.77 million in 2021 to $US870.26 million in 2026. The mobile game segment is the largest segment which is expected to account for over 63.5% of the total market volume in 2022 [6].

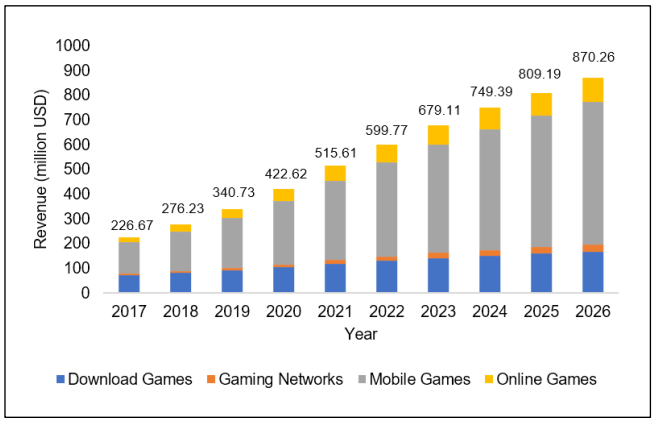

Fig. 1. Video game revenue by segment in Thailand (2017 - 2026) (Adapted from Statista [6]).

1.2. Blockchain Industry in Thailand

Figure 2 shows the result of a survey (n = 55) conducted by Deloitte [7] to study the effect of the COVID-19 pandemic on digital transformation in various industries in Thailand including energy, consumer, financial, technology, media, telecommunications, and healthcare sectors. As opposed to basic technologies (e.g. traditional web technology and mobile application), it can be seen that advanced technologies (e.g. blockchain, augmented reality (AR) or virtual reality (VR), and robotics) have been adopted by only a few companies. 47% of the companies in the study even have no plan to invest in blockchain technology. Therefore, it can be concluded that blockchain technology in Thailand is still in its infancy stage. A study of blockchain technology by Pongnumkul et al. [8] also suggests that the stage of blockchain technology adoption in Thailand is still considered early, but there is a rapid increase in numbers and industry varieties.

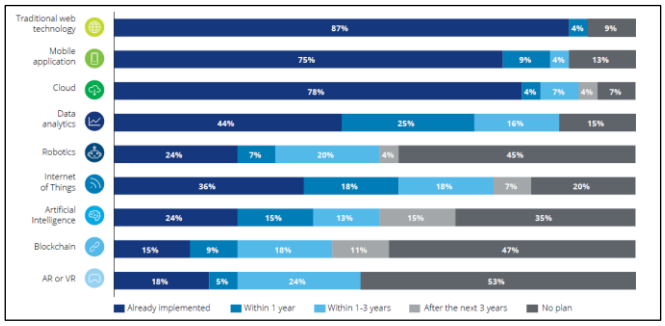

Fig. 2. Plan for digital technology implementation in organisations in Thailand [7].

Although the concept of blockchain technology is still new and not well-known to the general public, Thailand is praised as one of the most critical markets for blockchain in Southeast Asia [9]. The reason is that there is a wide range of discussions and initiatives about blockchain technology in many sectors in Thailand, some of which are as follows:

- The Bank of Thailand [10] has announced a press release stating that it is studying the possibility of developing Central Bank Digital Currency (CBDC) in Thailand;
- Siam Commercial Bank [11], one of Thailand's largest financial institutions, has partnered with Ripple, an enterprise blockchain solution, to expand its cross-border transfers for retail customers;
- A manual to guide how blockchain can be used for government services has been published by Digital Government Development Agency [12]; and
- National Electronics and Computer Technology Center (NECTEC) has developed a blockchain-based voting system that can be applied to local elections to reduce fraud and maintain data integrity [13].

Regardless of the stage of blockchain technology adoption, Fig. 3 shows an interesting fact that Thailand is ranked first globally at over 20% in terms of cryptocurrency ownership proportion among internet users aged 16 to 64 [14]. This means Thai people have shown a clear interest in digital currencies which, at the moment, are generally accepted as the main use case of blockchain technology.

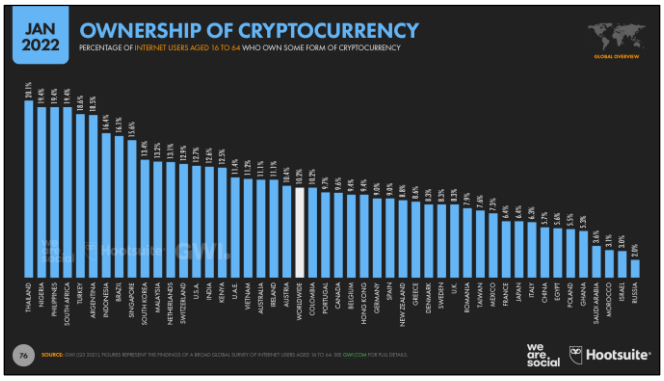

Fig. 3. Ownership of cryptocurrency [14].

1.3. The Connection Between Gaming Industry and Blockchain Technology

Blockchain technology, enabled by its underlying distributed ledger technology, has the potential to transform the online gaming industry with the development of non-fungible tokens (NFTs) and the "play-to-earn" (P2E) model. Because of blockchain-based games, players are introduced to new ways of earning income from playing games, thus redefining the value proposition of online games. According to Herrera [15], blockchain technology utilisation is currently being dominated by blockchain-based games with over 1.4 million unique active wallets accounting for almost half of the entire industry's usage. As a result, compared to other aspects of blockchain technology such as Decentralised Finance (DeFi), games have become one of the most popular use cases of blockchain technology, as shown in Fig. 4.

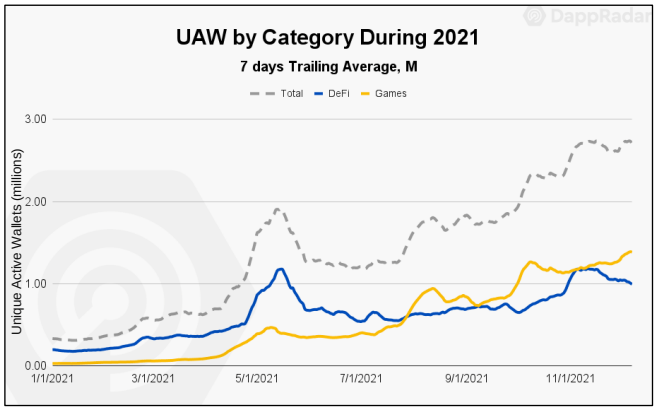

Fig. 4. Unique active wallets by category (2021) [15].

Figure 5 shows the aim of the Ministry of Industry in Thailand to promote the Thailand 4.0 policy, officially established in 2016, in which the digital economy is a part of the new S-curve industries [16]. Moreover, the Digital Economy Promotion Agency [17] has the desire to drive the growth of the digital content and gaming industry in Thailand. Blockchain-based games thus have a promising future in this context. However, considering the novelty of blockchain technology, there are barriers and risks related to the adoption and implementation of the technology in organisations [18].

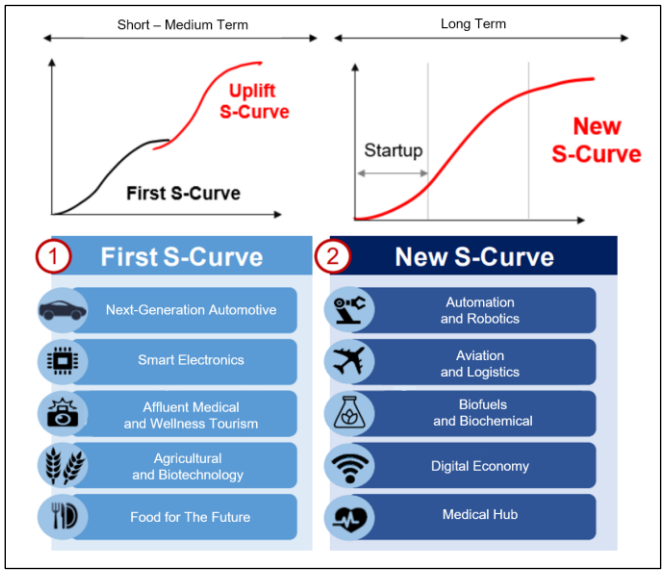

Fig. 5. Thailand's First S-curve and New S-curve (Adapted from OIE [19]).

1.4. The Company and Business Overview

This research will use an online gaming company that has one of its main offices located in Thailand as the case company, hereafter will be referred to as "the company" or "the case company". In addition to the Thai market, the company focuses on developing and publishing mobile and personal computer (PC) online games for the global markets. However, its most dominant region is Southeast Asia, which accounted for more than 60% of the company's total revenue in 2020. The monetisation model currently used by the company for its games is referred to as "free-to-play" (F2P), which means users can access, install, and play games for free with an option to spend real money through In-App Purchases (IAPs) in exchange for virtual currencies or goods [20]. F2P is one of the most popular business models for online gaming companies making up 80% of the total game revenue worldwide in 2018 [21]. With the success of its F2P model, the company to date has neither decided to start its journey in the blockchain industry nor engaged in any activities related to blockchain technology. Despite the fact that the F2P model is currently widely adopted by most developers and publishers in the online gaming industry, some of the well-known players, who also are offering their services to users in Thailand and could be considered direct competitors to the company, have started to realise the disruptive potential of blockchain technology and embark on the blockchain gaming landscape.

1.5. Research Contributions

The contributions of this research are as follows:

- This research contributes to the academic literature in the field of the blockchain industry and the

use of blockchain in the online gaming industry in which there are very limited studies.

- Given the nascent and fragmented state of blockchain standards, this research is believed to be the first academic study to explore the opportunities and barriers related to the adoption of blockchain-based games in an online gaming company in Thailand and propose strategies to exploit the opportunities and address the barriers.
- The findings of this research can be used and extended by online gaming companies and authorities to understand the potential values of blockchain-based games and the barriers that are preventing them from adopting blockchain-based games. This research also can help stakeholders develop strategies to maximise benefits and solve the challenges related to the adoption of blockchain-based games, which could introduce a new concept of the digital economy and a new form of value creation.
- The methodology of this research, which includes various theoretical frameworks and strategic planning tools and techniques (e.g. benefits framework, TOE framework, FMEA, AHP, Pareto analysis, and TOWS matrix), can be adapted to study the critical opportunities and barriers related to the adoption of other technologies in organisations in different sectors.

In the remaining sections of this research, Section 2 presents the literature review, followed by an explanation of the research methodology in Section 3. The result of the research is discussed in Section 4. Lastly, Section 5 is the discussion and conclusion.

2. Literature Review

2.1. Blockchain Technology

Blockchain technology, since its first real-world application in 2009 as a foundation of the first cryptocurrency called "Bitcoin" [22], has evolved into one of the most promising technologies in the world [23]. The blockchain, referred to as distributed ledger technology, acts as a decentralised database of records of all transactions that are shared among all members of the network [24]. To verify the validity of transactions in blockchains, a distributed consensus mechanism of the majority of participating members is used. Moreover, as each block in the blockchain is linked together, it is very difficult for anyone to modify information once it is published [25].

According to Attaran and Gunasekaran [26], there are 6 principles of blockchain technology as follows:

1. *Distributed Database*. Identical databases are replicated in a distributed manner and stored in many different locations. Each party can access the entire database. The data in the blockchain is not controlled by a single party. Transaction records can be viewed and verified directly by any parties without third-party intermediaries.
2. *Peer-to-Peer Transmission*. A centralised system is not required, and communication can happen directly between peers. On the same network, each node simultaneously can "store" and "forward" data to all other nodes.
3. *Transparency with Pseudonymity*. There is full transparency on transactions that occur between addresses to any parties who have access to the network. A change to one address will be updated for others. A unique alphanumeric address is assigned to each node on the blockchain. Each party can decide whether to remain anonymous or not.
4. *Irreversibility of Records*. A transaction record cannot be altered once it is put in the database, as it is connected to every transaction record that happened before it. Computational algorithms are used to make sure that the records are stored permanently in chronological order and visible to all other parties.
5. *Computational Logic*. Because the nature of the ledger is digital, algorithms can be used to automatically trigger transactions between nodes.
6. *Transaction Speed*. Without a need for human intervention, transactions on the blockchain are fully completed and verifiable in a matter of seconds.

The stages of blockchain evolution can be divided into 4 stages as follows:

- *Blockchain 1.0* [27] refers to the first application of blockchain technology related to decentralised digital currencies and digital payment systems. Blockchain is defined as the "Internet of Money" that connects finances, which is comparable to the "Internet of Things" (IoT) that connects devices. The most prominent application of the blockchain is Bitcoin, the first and largest digital currency, which utilises a Proof-of-Work (PoW) consensus mechanism where a new block in the blockchain is generated by solving a specific mathematical puzzle [28].
- *Blockchain 2.0* [23] refers to the development of applications beyond payments, transfers, and transactions of digital currencies using the blockchain and smart contracts. Smart contracts, featuring the same functions as traditional contracts, are computer programs defined by the code and can automatically execute the terms of contracts (i.e. whether to act or not act) in a transparent manner [25]. For this reason, trust between parties in making agreements can be removed using smart contracts. Examples of such applications are financial transactions (e.g. stock, derivatives, bonds, and futures) and legal agreements (e.g. contracts, land titles, and property titles).
- *Blockchain 3.0* [29] refers to the generation of blockchain that involves Decentralised Applications (DApps). DApps are built with back-end code that allows the creation of decentralised data storage and computing, running on a distributed network of computers that directly connects users and providers. Antonopoulos and Wood [30] describe a DApp as a web application that has smart contracts and is built on top of the blockchain. Raval [31] provides a stronger definition of a DApp as follows: 1) it must be an open-source application; 2) it must have internal currency necessary for the use of the application

(i.e. transaction fees); 3) it must have decentralised consensus; and 4) it must have no central point of failure as it runs on several different networks in a distributed fashion.

- *Blockchain 4.0* [29] is a recent and emerging evolution of blockchain technology, which refers to the progression that there is a combination of blockchain technology with other advanced technologies such as Artificial Intelligence (AI). Blockchain 4.0 allows blockchain technology to be used in business to respond to industry demands [32]. The integration of blockchain with different technologies helps solve complex problems and fulfil business needs because it can provide data accuracy and improve the data recording process. An example of a successful use case is CognitiveScale, an AI startup based in the United States, which uses blockchain for storing the results of an AI application for regulatory compliance in financial markets [33].

2.2. Blockchain Technology in the Online Gaming Industry

The online gaming industry is one of the industries that could potentially be disrupted by blockchain technology. The reason is blockchain technology offers developers and players, as never before, new ways of interacting with gaming platforms. Moreover, gamers could be considered early adopters of blockchain technology, as they already have been familiar with the uses and the concept of virtual currency models, which have a similar function to cryptocurrencies in blockchains [26].

2.2.1. Ethereum

From a technical perspective, Antonopoulos and Wood [30] describe Ethereum as "a deterministic but practically unbounded state machine, consisting of a globally accessible singleton state and a virtual machine that applies changes to that state". This, in essence, means that Ethereum is an open-source and decentralised blockchain network in which smart contracts can be executed. Ethereum is well-known for its ability to host DApps, which are composed of smart contracts [23], [29]. The executions of smart contracts are processed by Ethereum Virtual Machine (EVM), which runs on the computers of all participants on the network. For this reason, Ethereum is also known as "a distributed state machine in which rules for computing a new valid state from block to block are determined by the EVM" [33]. "Ether", often referred to as "ETH", is the native cryptocurrency used by the Ethereum network for transaction fees when executing smart contracts. The programming language used for writing smart contracts in Ethereum is called "Solidity".

2.2.2. Non-fungible tokens (NFTs)

A non-fungible token (NFT) is a token standard originally introduced by the Ethereum Request for Comments (ERC) 721 proposal on the Ethereum blockchain [30]. Unlike standard cryptocurrencies (e.g. Bitcoin) in which all tokens are equivalent and indistinguishable, each NFT is unique, distinct, and not interchangeable. Smart contracts in the blockchain can track the transfer of ownership and prove the existence of NFTs. NFTs thus have properties that are traceable, indivisible, verifiable, irreplaceable, unique, and tradable [35]

The opposite side of NFTs is fungible tokens, which are designed based on the ERC-20 standard. The ERC-20 standard is a uniform Application Programming Interface (API) for smart contracts used for creating fungible tokens within the Ethereum blockchain. The majority of Ethereum-based tokens are based on the ERC-20 standard with properties that are non-unique and interchangeable [30].

2.2.3. Play-to-earn

Digital games that are designed and built using the blockchain (and its underlying technologies) are referred to as "blockchain-based games" [36]. Blockchain-based games thus essentially are DApps that have NFTs as digital assets (i.e. in-game items such as decorative items and characters). With blockchain technology and the properties of NFTs, the concept of digital scarcity can be created [35], [37]. As a result, a new business model "play-to-earn" [38], also referred to as "P2E", has emerged in the online gaming industry, which also could be considered a new paradigm of how human input can be converted into capital. In the P2E model, players can earn financial incentives for playing and progressing in blockchain-based games. According to Binance Academy [37], there are two primary ways in which players can earn financial incentives: 1) earning in-game currencies by, for example, completing daily challenges or missions; and 2) earning or trading in-game items which are NFTs. The P2E model and the properties of NFTs have allowed blockchain-based games to surpass $US4.5 billion in terms of NFT trading volume, accounting for over 20% of the total revenue from all NFTs in the blockchain industry in 2021 [15].

A prime example of a game operating under a P2E model is "Axie Infinity", released in 2018 by Sky Mavis, which is a game studio based in Vietnam. Axie Infinity is one of the most successful and most well-known Ethereum-based games, having managed to reach daily active users of 1.8 million, daily transactions of $US33 million, and a total sales volume since the game launch of over $US2.8 billion in October 2021 [39]. In the game's ecosystem, players can collect virtual pets called "Axies", which essentially are NFTs that players can purchase, own, or trade through the game's marketplace, and battle them in turn-based strategy gameplay (see Fig. 6). Each player

needs to have three Axies to form a team to play the game. In contrast to the traditional business model such as the F2P model where the revenue is generated by IAPs, the revenue generated in Axie Infinity is primarily coming from charging a 4.25% transaction fee for every transaction made by its players on its NFT marketplace and when players breed new Axies [41]. Figure 7 shows that Sky Mavis has earned over 99% of its cumulative revenue of more than $US1.3 billion in just 6 months after the launch of the Ronin network, which is an Ethereum-linked sidechain developed to decrease transaction costs for its players [42].

Fig. 6. Axie Infinity's gameplay [40].

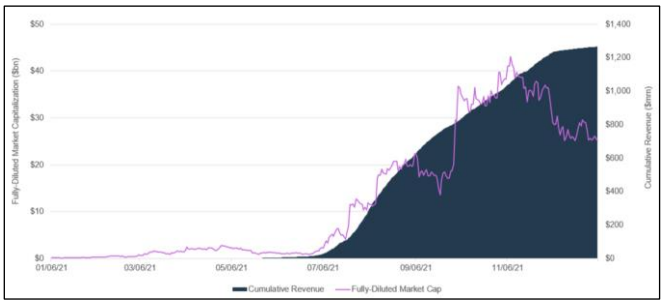

Fig. 7. Axie Infinity's revenue and market capitalisation growth (1 June 2021 – 6 January 2022) [42].

Axie Infinity has a complex P2E economy, as it involves two main cryptocurrencies: "Axie Infinity Shard (AXS)" and "Smooth Love Potion (SLP)", both of which can be purchased or sold through major cryptocurrency exchanges (designed to function like shares) and can be earned through participating in the game.

1. Axie Infinity Shard (AXS), is an ERC-20 governance token with the purpose of aligning the incentives between players and game developers through user-generated content initiatives. Players can receive AXS tokens as rewards for interacting with Axie Infinity in various activities such as staking their tokens, playing the game, and participating in governance votes. The total supply of AXS is 270,000,000, 21% of which is gradually allocated to Sky Mavis over a span of 4.5 years, and 15% of which is distributed through a process called Initial Coin Offering (ICO), which is a public and private sale of AXS tokens [42].

2. Smooth Love Potion (SLP), is an ERC-20 token mostly serving as the utility token rewarded to players after spending a certain amount of time in the game such as completing in-game missions and winning battles. Another use case of SLP is breeding new Axies, which is a process in which SLP tokens will be burned to create new a new Axie. The total supply of SLP is unlimited.

Most of Axie Infinity's players are from emerging countries that are severely affected by the COVID-19 pandemic such as the Philippines, Brazil, and Venezuela. It is reported that the game is able to create a new digital economy for its players, transforming their time and skills from playing P2E games into income [39], [43], [44]. According to a survey (n = 1,103) conducted in the Philippines by Balthazar [45], 32% of the respondents are ready to quit their current jobs if P2E games allow them to earn enough income. Because of the high demand and popularity of Axie Infinity, different types of retail stores in the Philippines (e.g. food and beverages, travel, healthcare) have accepted SLP as a form of payment or provided discounts for customers who are willing to pay for their products or services using SLP [46], [47].

2.2.4. Web 3.0

The World Wide Web, since its inception in 1989 by Tim Berners-Lee [48], has continuously evolved until now. Web 3.0 is the most recent evolution of the internet (see Fig. 8).

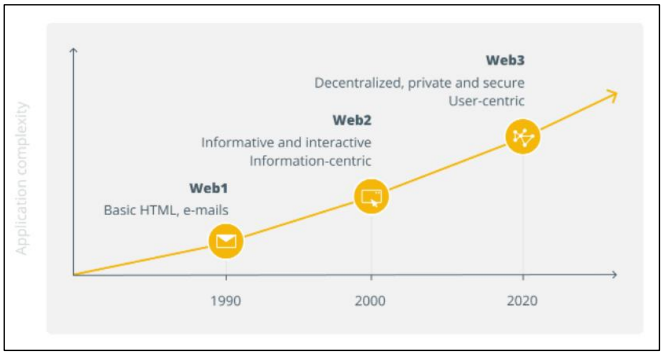

Fig. 8. The evolution of the Internet [48].

Web 1.0: Read-Only refers to a platform in the earliest generation of the internet evolution through which information or content could be published in a static or read-only form. Most participants are users, while there are only a few developers. There also is no interaction between the websites and users [50].

Web 2.0: Read-Write refers to interactive social websites [32]. Web 2.0 improves how humans can interact with the internet, as it allows greater social interactions (e.g. view, create, share, and edit) among collaborative parties such as users and developers [50]. Most of the current social media websites with user-generated content on the internet are Web 2.0 applications. According to Tekisalp [51], with Web 2.0 architecture, while users would have little to no control over their data, developers would be the only person dictating who may have access to servers, user data and track records, and how long the content should be kept in a database. Many cases of social media bans in

recent years from companies such as Facebook [52], YouTube [53], and Twitter [54] are great examples of this.

Web 3.0: Read-Write-Own usually refers to the semantic web that has blockchain as an underlying technology [32], [55], [56]. However, according to Ethereum Foundation [57], Web 3.0 is simply another term for DApps. It is believed that Web 3.0 can revolutionise how data is structured in the back end, how agreements are settled, and how value is exchanged [58], as it is a decentralised ecosystem that is built so that both developers and users can make changes in both the front end and the back end. According to Tekisalp [51], Web 3.0 architecture enabled by public ledgers would introduce a brand new infrastructure layer, interactions, functionalities, and requirements to both developers and users. As a result, the following features would be available with Web 3.0 applications:

1. Applications can store some (or all of the content) and logic on the blockchain, which will become transparent and accessible to the public; and
2. Users would be able to have direct control over their content and logic on the blockchain. Accounts or privileged APIs would not be needed to interact with data on the blockchain.

Table 1 represents a comparison of Web 2.0 (i.e. traditional games) and Web 3.0 (i.e. blockchain-based games) in 3 main aspects: platform characteristics, user interaction, and commercials.

2.2.5. The metaverse

The metaverse is currently a major trend in the blockchain and cryptocurrency industry, if not the entire technology industry, although its definition is still varied and themes of how it is or will eventually turn into are still emerging [42]. Davis et al. [60] describe the metaverse as immersive and three-dimensional virtual spaces that have the representation of avatars, the use of software agents, and real-world metaphor as the means of how people interact with each other in a way that there are no physical limitations. Marr [61] describes the metaverse as a shared, persistent, three-dimensional virtual world. JPMorgan [59] describes the metaverse as a place where physical and digital lives are merged, resulting in the creation of a unified and virtual community for people to work, play, transact, and socialise. Facebook recently changed its company name to Meta in an attempt to announce a new direction in building the metaverse [62]. As the world's leading social media platform, it believes that the metaverse is a collection of multiple virtual worlds that allow users to build and explore with other people who are not there with them physically [63].

According to Newzoo [64], the main enablers and drivers of the metaverse are as follows:

1. The growth of immersive technologies (e.g. AR and VR, live streaming technologies, and cloud technologies;
2. The expansion of decentralised infrastructure (i.e. blockchain);
3. The emergence of cross-platform development and online social multiplayer platforms;
4. The accessibility of content creation and user-generated content;
5. The growth of games as social media; and
6. The advancement of hardware, network infrastructure (e.g. 5G), spatial computing, visualisation, and AI.

The concept of the metaverse is also connected with Blockchain 4.0 in the sense that blockchain is applied to the business and is incorporated with other advanced technologies which, in this case, are AR and VR hardware. The metaverse in the global market is expected to reach $US678.8 billion by 2030 with a CAGR of 39.4% [65]. It is reported that every industry (e.g. e-commerce, real estate, media, entertainment, etc.) would take part in the metaverse because there are so many business opportunities in this virtual space, and they will be likely to use game-as-a-platform to create social activities and connect with their users [64]. One of the current leaders in the virtual world is "The Sandbox" [66], which is a metaverse project built on the Ethereum blockchain where users can build, own, and monetise their NFT assets through the P2E model. "SAND" is the ERC-20 native token used to interact with its ecosystem. Examples of traditional companies who have entered the metaverse space by collaborating with The Sandbox are as follows:

- HSBC, one of the world's largest financial services, has announced a partnership with The Sandbox to acquire a plot of digital land, which will be used for co-creating new experiences with its customers [67];
- Gucci, an Italian luxury fashion brand, has purchased a plot of land to expand its virtual fashion experiences as part of the Gucci Vault project, which is an experimental online store that has already listed, for example, a collection of Gucci-themed NFTs [68];
- Adidas, a sportswear giant, revealed a collaboration with The Sandbox and announced that it has owned a parcel of virtual land called "adiVerse" [69]; and
- SCB [70], a bank in Thailand, has announced through a press release that one of its subsidiaries "SCB10X" will be launching its virtual headquarters in The Sandbox (see Fig. 9) to foster virtual community and explore the new frontier for the digital economy.

Fig. 9. SCB 10X's Headquarters in The Sandbox (Adapted from SCB 10X [71]).

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Table 1. Comparison of Web 2.0 and Web 3.0 in the online gaming industry (Adapted from JPMorgan [59]).

		Web 2.0	Web 3.0
	Examples of game titles	• Second Life • Fortnite • World of Warcraft	• Axie Infinity • Decentraland • The Sandbox
Platform Characteristics	**Platform structure**	• Owned by the game developers • Decision-making is based on shareholder value	• Governed by the community or decentralised autonomous organisation (DAO) • Participation enabled through native governance tokens • User consensus is used for making decisions
	Data storage	• Centralised	• Decentralised
	Platform format	• PC • Mobile • Console • AR, VR	• PC • Mobile (in development) • AR, VR (in development)
	Payments infrastructure	• Regular payments such as credit/debit cards	• Cryptocurrency wallets
User Interaction	**Ownership of digital assets**	• Leased within a specific platform where assets are purchased	• Truly owned (in the form of NFTs)
	Portability of digital assets	• Unable to be transferred to other platforms	• Transferable • Cross-blockchain compatible (in development)
	Content creators	• Game developers	• Game developers • Community
	Activities	• Socialisation • Livestreaming • Multiplayer gaming • Electronic sports (esports) competition	• Same activities as Web 2.0 • P2E gaming
	Identity	• In-game avatars	• Self-sovereign and interoperable identity • Anonymous private-key-based identities
Commercials	**Means of Payments**	• In-game virtual currencies	• Cryptocurrencies
	Revenue creation	[Example F2P model] • For every IAP, App Store earns 30% and game developers earn 70%	• Developers can earn revenue from transaction fees and directly from NFT sales • Users can earn financial incentives from in-game participation through the P2E model • Creators can earn through royalties on secondary trades of NFTs

2.3. Studies on Opportunities for the Adoption of Blockchain-Based Games

It should be logical to say that the benefits of adopting blockchain-based games for online gaming companies will come from the properties of the underlying technology (i.e. blockchain). There are many opportunities related to the adoption of blockchain-based games that could be brought to the online gaming industry for both game developers and players, all of which are summarised in Table 2 based on many different sources including academic literature, articles, websites, blogs, and survey papers.

2.4. Studies on Barriers to the Adoption of Blockchain-Based Games

Despite a rapid increase in recognised opportunities for the adoption of blockchain-based games, the blockchain industry is still in its infancy and is new to the online gaming industry. Although there are clear benefits and new experiences enabled by blockchain-based games that online gaming companies could offer to their users, not all of them will immediately enter into such uncharted territories as the blockchain and cryptocurrency industry. There are many potential barriers that are hampering the adoption of blockchain technology, particularly for traditional online gaming companies, all of which are summarised in Table 3.

2.5. Related Tools

2.5.1. Benefits framework

To have a complete and systematic understanding of potential opportunities for the adoption of blockchain-based games, a comprehensive framework for classifying those opportunities is necessary. Shang and Seddon [1] propose a framework for classifying Enterprise Resource Planning (ERP) benefits from a business perspective, which is divided into 5 dimensions: operational, managerial, strategic, infrastructure, and organisational benefits. It is believed that Shang and Seddon's [1] benefits framework is suitable to be used for classifying potential opportunities related to the adoption of blockchain-based games in an online gaming company in Thailand for the following 2 reasons:

1) Structure. The framework is used for classifying and evaluating the benefits of enterprise systems, which can be used as a guide for this research, which is an explorative study. The framework can also help classify the opportunities for the adoption of blockchain-based games in the case company into proper dimensions: operational, managerial, strategic, infrastructure, and organisational benefits.

2) Academic proof. The framework can be used to show a comprehensive overview of the enterprise systems' benefits from a managerial perspective. It also is used and refined by many researchers for academic literature related to ERP and information systems [81], [82]. Moreover, a study by Fosso Wamba et al. [83] shows that the framework can be used to evaluate the value of blockchain technology in the supply chain industry.

2.5.2. Technology-Organisation-Environment (TOE) framework

The Technology-Organisation-Environment (TOE) framework [84] explains how the three dimensions of an organisation's context affect the adoption and implementation of technology. According to Baker [85], each dimension in the TOE framework can be described as follows:

- The technology context refers to the availability and the characteristics of technological innovation. Analysing both existing technologies in the organisation and the innovation that is not currently in use can set limits on the scope and rate of technological change to which the organisation could adapt and change in the future.
- The organisational context mainly refers to the resources of the organisation such as organisational size, the level of available resources, and internal communication processes.
- The environmental context includes the market structure, government regulation, and support infrastructure.

The TOE framework can help investigate factors that have an impact on the adoption of innovation at the organisational level in a wide range of technologies and contexts in different industries [85]. Moreover, it is evident that the framework could be applied to identify the challenges to the adoption of blockchain technology in different industries: food supply chain [86], government and public service [87], and energy sector [88]. Therefore, to investigate potential barriers that could affect the adoption of blockchain-based games in an online gaming company in Thailand, the TOE framework is considered a suitable tool.

2.5.3. Failure Mode and Effect Analysis (FMEA)

According to Henley and Kumamoto [89], Failure Mode and Effect Analysis (FMEA) is constructed using a forward logic, which is also known as an inductive analysis. FMEA is a formal design methodology originally used to improve design and production processes by identifying potential weaknesses, resulting in being able to pinpoint basic faults at the component level and determining the effects. Many industries (e.g. military, aerospace, automobile, power plants, software, healthcare, and catering) have adopted FMEA as a tool for assessing the reliability and safety of various processes and phases of the product life cycle [90]. Sharma and Srivastava [90] also state that the most effective way of using FMEA is to

Table 2. Literature review on opportunities for the adoption of blockchain-based games.

Supporting Studies	Opportunities for the Adoption of Blockchain-Based Games
Al-Jaroodi and Mohamed [72]	• Transparency and full control over virtual assets for players • No restrictions for players on platforms where virtual assets can be used (i.e. cross platforms), which can improve flexibility and video game experiences • Introduction of new reward mechanisms between developers and players • Improved security related to virtual asset ownership on gaming platforms (e.g. illegal trading, hacking, stealing) • Secure and faster payment method between developers and players
Attaran and Gunasekaran [26]	• Transparency and decentralised control of virtual assets • Reduction of fraud and lost revenue from duplicated virtual assets, hacking and stealing • Promoting credibility, accountability, and good behaviour within the gaming ecosystem resulting from records on the blockchain • Improvement of the games from receiving user feedback and reviews through incentive mechanisms • Parallel gaming universe (i.e. players can use characters and items across several platforms) enabled by smart contracts • Unrestricted and permissionless gaming economies for developers (e.g. developers are allowed to use free economies to generate revenue by charging fees or selling virtual assets) • Proof of limited supply and asset scarcity • Potential for democratising the gaming industry (e.g. development of governance and voting features)
Besançon et al. [73]	• Improved trust between developers and players • Game server's cost reduction using peer-to-peer (P2P) networks • Better ownership management of virtual assets (e.g. crafting and trading of in-game assets with other players) • Facilitation of co-creation activities (e.g. the governance and user-generated content of the game)
BGA [74]	• Asset ownership for players • New reward systems for players • New revenue streams for developers (e.g. P2E, sale and open trading of digital assets, revenue-sharing model) • Decentralised project ownership • Transparency • Collaborations among stakeholders • Creativity and gameplay • Provable fair game mechanics • Improved data security • Convenient data management • Lower transaction costs
BITKRAFT [75]	• Healthier game economies • Better unit economics • Better economic alignment • Robust network assurances from public blockchains • Prevention of value leakage lost to peripheral markets
Kalra et al. [76]	• Real-time prevention against cheating and distributed denial-of-service (DDoS) attacks • Increased robustness of online games using the P2P architecture
Nha [77], Nystrom and Sun [42]	• New monetisation models • Opportunity for expanding user base globally
Pfeiffer et al. [78]	• Protection against forgery, non-tampering of in-game collectables • Game crime (i.e. black market) restriction • P2P trade (where developers can earn commissions) • Possibility of cross-platform worlds for virtual assets (e.g. characters, weapons, and tokens) • Transparency of the game mechanics (e.g. distribution of in-game points, badges, and achievements) • Privacy protection • Tokenised esports tournaments • Establishment of game ecosystems on blockchain

Table 3. Literature review on barriers to the adoption of blockchain-based games.

Supporting Studies	Barriers to the Adoption of Blockchain-Based Games
Attaran and Gunasekaran [26]	• Scalability limitations (e.g. slow network speed, high transaction fees, and network congestion during high traffic) • Sustainability issues of blockchain-based games • Traditional games' advantages (e.g. superior gameplay and graphics)
Besançon et al. [73]	• Lack of full control over the content in some aspects (i.e. unwanted content is more difficult to be censored) • Technological complexity • Lack of interoperability between game engines and blockchains • Data storage issues
BGA [74]	• Regulatory uncertainty • Poor user experience and gameplay quality • Lack of standardisation • Lack of education or understanding of blockchain-based games • Shortage of technical experts • Implementation challenges • Lack of on/off ramps (i.e. being able to conveniently convert between fiat money and cryptocurrencies) • Technology limitations • Lack of interoperability • Resistance from industry incumbents • Niche market, insufficient market size
BITKRAFT [75]	• Blockchain trilemma (i.e. decentralisation, scalability, security) • Speed • High and volatile transaction fees • Environmental impact • High switching costs for traditional developers • Limitations on game design • Less control of game economies • Poor user experience in managing virtual assets
McKinney et al. [79]	• Intellectual property issues related to NFTs • Regulatory risks • Tax treatment
Mozuch [80]	• Investor risk, unconvincing return on investment (ROI) • Blockchain-based games' development challenges • Public relations and the possibility of community backlash
Nha [77]	• Shortage of suitable developers who know both games and blockchain technologies • Market pressure for products, which compromises quality
Pfeiffer et al. [78]	• Lack of technological knowledge to distinguish different blockchain networks and to decide which network to rely on • Low social acceptance of blockchain technology • Blockchain tokens are not yet mainstream • Lack of knowledge on which data in the gaming environment should be stored on the blockchain • Know-your-customer (KYC) and anti-money laundering (AML) regulations

consider using it from the beginning of the design stage, process control, operation, and throughout the life cycle of products or services. By developing FMEA, it is believed that the severity or the chance of occurrence of failure modes can be prevented or avoided and that the risks can be prioritised. A failure mode is a way in which a component or process might fail to meet its design intent. After each failure mode is identified, a cross-function team is often established to determine its effect on the whole system [91].

In the standard FMEA process, each failure mode is evaluated by considering the risk priority number (RPN), which is the multiplication of the probability of occurrence (O), the severity of the failure (S), and the probability of the failure being detected (D) (see Fig. 10). A numeric scale from 1 to 10 is usually used to rate and evaluate each of the three risk factors in the standard FMEA. Failure modes that have greater RPN values should be prioritised first as they are generally considered more important [92].

$$\text{Risk Priority Number (RPN)} = \text{Occurrence (O)} \times \text{Severity (S)} \times \text{Detection (D)}$$

Fig. 10 RPN Calculation Source (Adapted from Sharma and Srivastava [90]).

According to Pillay and Wang [93], FMEA is suitable to be used as part of quantitative analysis, meaning it can predict the likelihood of failure modes and identify the critical part that could negatively and severely affect the systems. The purposes of using FMEA are as follows:

- Analysing the system to assess the effects of failure modes;
- Identifying the potential points of failure; and
- Improving or developing processes to reduce or eliminate the chance of occurrence of failure modes.

Figure 11 illustrates the process that would normally be required for carrying out an FMEA.

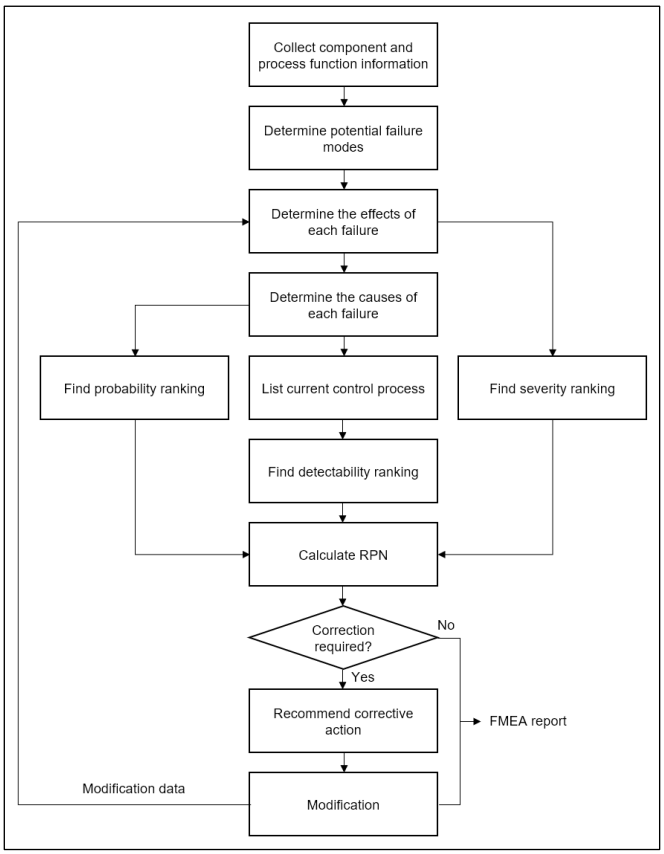

Fig. 11. Standard FMEA procedure (Adapted from Pillay and Wang [93]).

2.5.4. Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP), introduced by Saaty [94], is a decision-making method that is designed to solve multiple criteria problems by helping the decision-makers to be able to prioritise each factor and arrange them in a hierarchical form. In addition to typical decision-making, it is found that there are many different applications of AHP in various industries, some of which are forecasting, planning and development, benefit-cost analysis, selection, allocations, and priority and ranking [95]. There are 4 steps for applying the AHP, according to Saaty [96], [97], as follows:

1. *Design of a hierarchy for the problem*. The top level of the hierarchy is the goal of the problem (i.e. the objective of the decision-maker). The second level is the criteria that contribute to the goal. The bottom level usually is the list of alternatives.

2. *Construction of a pairwise comparison matrix*. This step is to arrange a matrix from all the elements in the second level using a pairwise comparison scale (see Table 4). By rating a scale ranging from 1 to 9, the judgements of decision-makers are used to determine which element dominates the other. In a group decision-making setting, the geometric mean can be used to calculate the average score on each pairwise comparison because it is rated on a ratio scale [98].

Table 4. Relative scale measurement source (Adapted from Hummel et al. [98].

Scale	Verbal Judgments
1	Equally important
2	Equally to moderately more important
3	Moderately more important
4	Moderately to strongly more important
5	Strongly more important
6	Strongly to very strongly more important
7	Very strongly more important
8	Very strongly to extremely more important
9	Extremely more important

3. *Derivation of priorities*. According to Ishizaka and Lusti [99], one of the common methods used for the derivation of priorities (i.e. "the priority vector" or "the principal eigenvector" [96]) from a pairwise comparison matrix in the AHP is called the "mean of normalised values". This can be done if a pairwise comparison matrix is considered consistent, as shown in Eq. (1), which could be determined when the rules of transitivity (see Eq. (2)) and reciprocity (see Eq. (3)) are satisfied.

$$A=\begin{bmatrix} p_1/p_1 & \cdots & p_1/p_j & \cdots & p_1/p_n \\ \cdots & 1 & \cdots & \cdots & \cdots \\ p_i/p_1 & \cdots & 1 & \cdots & p_i/p_n \\ \cdots & \cdots & \cdots & 1 & \cdots \\ p_n/p_1 & \cdots & p_n/p_j & \cdots & p_n/p_n \end{bmatrix} \quad (1)$$

$$a_{ij}=a_{ik}\cdot a_{kj} \quad (2)$$

$$a_{ij}=\frac{1}{a_{ji}} \quad (3)$$

where i, j and k are any alternatives of the matrix

Also, in a consistent pairwise comparison matrix, all the comparisons a_{ij} follow Eq. (4).

$$a_{ij}=\frac{p_i}{p_j} \quad (4)$$

where p_i is the priority of the alternative i

The demonstration of the calculation process of the mean of normalised values comprises 3 steps as follows:

1. Given the pairwise comparison matrix, as shown in Eq. (1), the first step is to find the sum of all the elements of column *j*, as shown in Eq. (5).

$$\frac{p_1}{p_j}+\cdots+\frac{p_i}{p_j}+\cdots+\frac{p_n}{p_j}=\frac{\sum_{i=1}^{n} p_i}{p_j} \quad (5)$$

2. The next step is the normalisation of column *j*, which is calculated by dividing Eq. (4) by Eq. (5), as shown in Eq. (6).

$$\frac{\frac{p_i}{p_j}}{\frac{\sum_{i=1}^{n} p_i}{p_j}}=\frac{p_i}{p_j}\cdot\frac{p_j}{\sum_{i=1}^{n} p_i}=\frac{p_i}{\sum_{i=1}^{n} p_i} \quad (6)$$

3. The last step is to derive the priority by finding the mean of the elements of row *i*, as shown in Eq. (7).

$$\left(\frac{p_i}{\sum_{i=1}^{n} p_i}+\ldots+\frac{p_i}{\sum_{i=1}^{n} p_i}\right)\cdot\frac{1}{n}=\frac{n\cdot p_i}{\sum_{i=1}^{n} p_i}\cdot\frac{1}{n}=\frac{p_i}{\sum_{i=1}^{n} p_i} \quad (7)$$

4. *Logical consistency*. In the AHP, there could be inconsistency in making decisions because it is common that decision-makers may not give precise estimations, especially if they need to deal with intangible elements [97]. For this reason, it is important to determine whether the decisions in the pairwise comparison matrix are consistent or not by calculating the consistency ratio (CR). If the CR is 0.1 or less, the problem is accurately structured in the pairwise comparison matrix, and the estimate of the priority vector is acceptable. However, if the CR is greater than 0.1, an attempt to improve consistency should be considered, as it means the responses of the decision-maker are inconsistent or random.

There are 5 steps for the calculation of CR, adapted from Al-Harbi [100], as follows:

1) Multiplying the pairwise comparison matrix by the priority vector (i.e. eigenvector)

2) Dividing each resulting value from (i.) by their respective eigenvector element

3) Calculating the principal eigenvalue (λ_{max}) by finding the mean of resulting values from (ii.)

4) Calculating the consistency index (CI), as shown in Eq. (8)

CI Calculation:

$$CI=\frac{\lambda_{max}-n}{n-1} \quad (8)$$

where n is the size of elements in the matrix.

5) Calculating the consistency ratio (CR), as shown in Eq. (9).

CR Calculation:

$$CR=\frac{CI}{RI} \quad (9)$$

where RI is the random consistency index.

The random consistency index is shown in Table 5.

Table 5. Random consistency index source (Adapted from Al-Harbi [100]).

Size of Matrix (n)	Random Consistency
1	0
2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49

2.5.5. Pareto diagram

According to Grosfeld-Nir et al. [101], the Pareto principle, also referred to as the 80/20 rule, states that approximately 80% of the total wealth is from 20% of the population. The Pareto principle has shown that it can be applied to many managerial scenarios: roughly 80% of profits are generated from 20% of the projects; roughly 80% of a company's revenue is generated from the top 20% of customers. Figure 12 shows a Pareto diagram where critical attributes can be revealed, as there is a clear illustration that 20% of the attributes account for around 80% of relative frequency. As a result, it is believed that a Pareto diagram is a useful tool that can represent a summary of practical information, show critical attributes, and help set priorities.

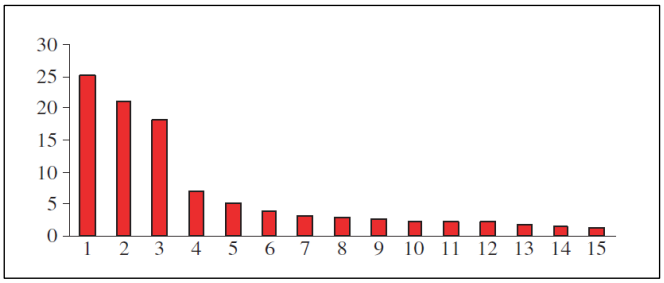

Fig. 12. Pareto diagram [101].

2.5.6. TOWS matrix

According to Weihrich [102], the TOWS matrix (see Fig. 13) is a conceptual framework used for formulating strategies in which external factors (i.e. threats and opportunities) are matched with internal factors (i.e. weaknesses and strengths). The TOWS matrix could be considered a variation of the SWOT (strengths, weaknesses, opportunities, and threats) analysis [103]. After all the factors are identified, they can be used in combination to formulate strategies, which are divided into 4 different types as follows:

1. *Strengths and Opportunities (SO)*. The SO strategies can be used by the organisation to exploit its strengths and respond to opportunities.
2. *Strengths and Threats (ST)*. The ST strategies examine how the organisation's strengths can be used to deal with external threats.
3. *Weaknesses and Opportunities (WO)*. The WO strategies aim to counter weaknesses by maximising opportunities.
4. *Weaknesses and Threats (WT)*. The WT strategies focus on how the organisation can minimise both weaknesses and threats.

TOWS Matrix		Internal	
		Strengths	Weaknesses
External	Opportunities	SO Strategies	WO Strategies
	Threats	ST Strategies	WT Strategies

Fig. 13. The TOWS matrix (Adapted from Weihrich [102]).

2.5.7. Integrated approach to quantifying opportunities and barriers

Academic studies by many scholars have proven that FMEA can be used in combination with other problem-solving, strategic planning, and management tools. Some examples are as follows:

- Can and Erbiyik [104] use FMEA and Pareto analysis in their study for analysing risks related to the use of aerial images in landslide analysis;
- Held and Brönnimann [107] investigate incidents of electrical vehicles' batteries catching fire by using FMEA in combination with fault tree analysis (FTA) to analyse the failures and design experiments; and
- Sutrisno et al. [108] develop a decision-making model for corrective action options by integrating FMEA with SWOT analysis.

Moreover, in the context of technology adoption, an academic study by White [109] has shown that the concept of FMEA (and RPN value) can be used to prioritise the potential application and benefits of blockchain technology in addition to its traditional objective of identifying and evaluating failure modes of products or processes and their effects. It is also found that FMEA is used to investigate and prioritise trust barriers to online shopping in a study by Rasty et al. [110].

As for the TOE framework, it also has been used in conjunction with other tools and theories, some of which are as follows:

- Alkhalil et al. [111] propose a model to explore the complexity of the decisions related to the migration of existing resources to cloud computing based on the concept of the TOE framework and the diffusion of innovation (DOI) theory; and
- Tripopsakul [112] studies the factors influencing the adoption of social media as a business platform in Thailand by using an integrated model between the TOE framework and the technology acceptance model (TAM).

It can be seen that different strategic techniques can be integrated and used in combination with each other. Therefore, in this research, the concept of FMEA will be used in conjunction with the AHP in a way that each element of the FMEA, namely Likelihood (L), Impact (I), and Control (C), will be weighted by the resulting priority vector (i.e. relative weights) from the AHP. The reason is that each element of FMEA is expected to have a different effect from the others, for which the AHP will be able to help determine the weight. The resulting value, referred to as the priority number (PN), then will be used to prioritise the opportunities (categorised under the benefits framework) and the barriers (categorised under the TOE framework) that are related to the adoption of blockchain-based games in the case company. After that, the Pareto diagram will be used to find critical opportunities and barriers. The TOWS matrix will then be used to formulate strategies to respond to all those factors, which will be followed by a suggested roadmap with action plans required for the adoption of blockchain-based games. All these methods will be discussed in detail in the following sections.

3. Research Methodology

The methodology of this research is shown in Fig. 14

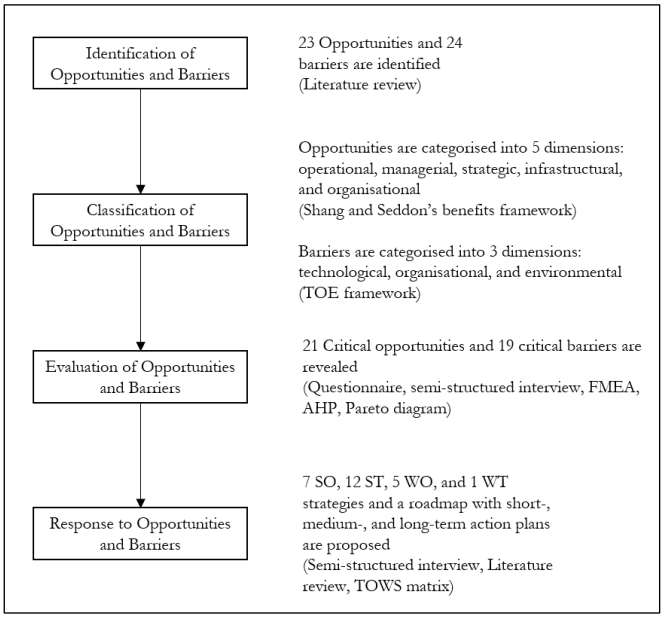

Fig. 14. Research methodology overview.

3.1. Identification of Opportunities and Barriers

To have a broad understanding of how blockchain technology is connected to the online gaming industry, the

first step of this research is to conduct a literature review to find out the current applications and use cases of blockchain technology in the context of the online gaming industry. Not only can the literature give a broad understanding of how blockchain can be applied to the online gaming industry, but it also shows the fundamental functions of blockchain technology, the characteristics of blockchain technology, and how blockchain technology works. The understanding of the core concept of blockchain technology in the online gaming industry can be used as a foundation for the rest of the research, which studies potential opportunities and barriers related to the adoption of blockchain-based games.

The main source of data for opportunities and barriers related to the adoption of blockchain-based games in this research is the literature. However, it is expected that there are very limited academic studies on the topic of this research. One of the main reasons is due to the fact that Cryptokitties, which is highly regarded as the first blockchain-based game, was just released in late November 2017 [113]. This confirms that the applications of blockchain in the online gaming industry (i.e. blockchain as the supporting technology of online games) are still in the infancy stage. For this reason, after having finished a review of the literature, an additional list of opportunities and barriers related to the adoption of blockchain-based games in the company will be proposed in this research, resulting in a more comprehensive list of opportunities and barriers ready to be used in the next steps of the research.

3.2. Classification of Opportunities and Barriers

This step is to categorise all the identified opportunities and barriers into systematic groups. All the identified opportunities and barriers will be consolidated by removing the duplicate ones and combining those that are similar in meaning and terminology. Given the novelty of blockchain technology, it is clear that the nature of this research will be exploratory [72], [109], [114], [115]. Thus, it is necessary to have academic theories and frameworks that can function as a structure of this research to categorise all the opportunities and barriers. The list of all identified opportunities will be categorised into 5 dimensions: operational, managerial, strategic, infrastructural, and organisational. This structure is constructed by adopting the benefits framework that is originally used for classifying ERP benefits proposed by Shang and Seddon [1]. The benefits framework can help conceptualise the business values of blockchain-based games from a managerial perspective and provide a generic and systematic model for this research. As for the list of all identified barriers, they will be classified into specific categories based on the TOE framework, which includes 3 dimensions: technological, organisational, and environmental.

3.3. Evaluation of Opportunities and Barriers

This step is designed to evaluate each of the identified opportunities, which are categorised under the benefits framework, and each of the identified barriers, which are categorised under the TOE framework. Experts at the case company, who have sufficient knowledge of blockchain technology as well as understand its potential and use cases in the online gaming industry, will be invited to participate in a questionnaire that will ask them to assign a score to each factor related to the adoption of blockchain-based games in the company. There are 3 criteria for the selection of experts, proposed by Wang et al. [115], which are used in this research: 1) roles and responsibilities of the participants; 2) knowledge and experience in the industry; and 3) time and willingness of the participants.

A 5-point Likert scale questionnaire will be sent to a group of experts to assign a score to each opportunity and barrier factor ranging from 1 to 5 in 3 elements: Likelihood (L), Impact (I), and Control (C) (Table 6 – Table 11). The questionnaire is separated into 2 main parts: opportunities and barriers. In terms of opportunities, there are a total of 5 tables including 4 operational opportunities, 3 managerial opportunities, 9 strategic opportunities, 4 infrastructure opportunities, and 3 organisational opportunities. In terms of barriers, there are a total of 3 tables including 9 technological barriers, 8 organisational barriers, and 7 environmental barriers. The questionnaire of this research is based on the concept of individual sensemaking, adapted from Wang et al. [115]. This means the questionnaire will be sent to a group of experts, each of whom will provide individual evaluations, which will allow them to fully develop their interpretations of the blockchain as the underlying technology of blockchain-based games and potential opportunities and barriers resulting from the adoption in the company. Moreover, this individual approach can mitigate the polarisation effect and cognitive biases, which would often occur in traditional Delphi studies [116]. However, given the technical complexities and the preliminary stage of blockchain-based games, the questionnaire will be conducted in a face-to-face setting. The experts thus will be able to raise any questions that they may have when filling out the questionnaire.

Table 6. Criteria used for rating likelihood (L) for opportunities.

Score	Description	Likelihood (L)
1	Very Low	Less than 1% chance. The opportunity is very unlikely to occur.
2	Low	Between 1-10% chance. The opportunity is unlikely to occur.
3	Moderate	Between 10-33% (1/3) chance. The opportunity may occur sometimes.
4	High	Between 33-67% (2/3) chance. The opportunity is expected to often occur.
5	Very High	More than 67% (2/3) chance. The opportunity is very likely to occur and will always occur.

Table 7. Criteria used for rating impact (I) for opportunities.

Score	Description	Impact (I)
1	Very Low	The opportunity will have a very minimal positive impact on the business.
2	Low	The opportunity will have a minor positive effect on the business.
3	Moderate	The opportunity may cause a considerable positive effect on the business.
4	High	The opportunity will cause a significant positive effect on the business.
5	Very High	The opportunity will cause an extensive and long-term positive effect on the business.

Table 8. Criteria used for rating control (C) for opportunities.

Score	Description	Control (C)
1	Very Low	The company is very unlikely to identify a strategy to seize and realise the opportunity and is unable to control the causes and consequences of the opportunity.
2	Low	The company is unlikely to identify a strategy to seize the opportunity with a low chance of realising the opportunity and controlling the causes and consequences of the opportunity.
3	Moderate	The company may be able to identify a strategy to seize the opportunity with a moderate chance of realising the opportunity and controlling the causes and consequences of the opportunity.
4	High	The company can identify a strategy to seize the opportunity with a high chance of realising the opportunity and controlling the causes and consequences of the opportunity.
5	Very High	The company has an effective strategy to seize and realise the opportunity with full control over the causes and consequences of the opportunity.

Table 9. Criteria used for rating likelihood (L) for barriers (Adapted from Abdelgawad and Fayek [117]).

Score	Description	Likelihood (L)
1	Very Low	Less than 1% chance. The barrier is very unlikely to occur.
2	Low	Between 1-10% chance. The barrier is unlikely to occur.
3	Moderate	Between 10-33% (1/3) chance. The barrier may occur sometimes.
4	High	Between 33-67% (2/3) chance. The barrier is expected to often occur.
5	Very High	More than 67% (2/3) chance. The barrier is very likely to occur and will always occur.

Table 10. Criteria used for rating impact (I) for barriers.

Score	Description	Impact (I)
1	Very Low	The barrier will have a very minimal negative impact on the business.
2	Low	The barrier will have a minor negative effect on the business.
3	Moderate	The barrier may cause a considerable negative effect on the business.
4	High	The barrier will cause a significant negative effect on the business.
5	Very High	The barrier will cause an extensive and long-term negative effect on the business.

Table 11. Criteria used for rating control (C) for barriers (Adapted from Abdelgawad and Fayek [117]).

Score	Description	Control (C)
1	Very High	The company has an effective strategy to detect or control the causes and consequences of the barrier.
2	High	The company can identify a response with a high chance of detecting or controlling the causes and consequences of the barrier.
3	Moderate	The company may be able to identify a strategy with a moderate chance of detecting or controlling the causes and consequences of the barrier.
4	Low	The company is unlikely to identify a strategy with a low chance of detecting or controlling the causes and consequences of the barrier.
5	Very Low	The company is very unlikely to identify a strategy capable of detecting or controlling the causes and consequences of the barrier.

A semi-structured interview with the same group of experts will then be conducted after all of them have responded to the questionnaire. Unlike the individual format of how the questionnaire is conducted, the semi-structured interview will be in a group format designed to last approximately 60 minutes. It is believed that the group interview, which often includes the sharing of ideas and insights, can provide a better representation and understanding of the issues [100]. Despite involving experts from many different roles and responsibilities, the interview in this research is believed to be effective because of the nature of the company, which is a flat organisational structure [118] with minimal hierarchical layers, and the culture of the company, which supports the involvement of employees in decision-making and encourages direct and open communication in the workplace, thereby making all opinions equally important. A reasonable balance can also be achieved because the interview will be set up in a way that each expert can share his opinion and give feedback on other persons' viewpoints, and all participants will be consistently asked for their engagement in the interview.

To further evaluate the opportunities and barriers, the concept of the FMEA will be adapted and applied in this research. The scores of Likelihood (L), Impact (I), and Control (C) of each opportunity and barrier from all the experts will be imported to Microsoft Excel for the calculation to find the mean value of Likelihood (L_M), the

mean value of Impact (I_M), and the mean value of Control (C_M). After that, unlike the traditional FMEA method in which all three elements are considered equally important, the concept of AHP (i.e. priority vector) in which each relative weight is multiplied by the average of each respective FMEA element will be used for calculating the priority number (PN) by finding the sum of all the resulting values (see Fig. 15). It is believed that the improved method of PN calculation as demonstrated in this research would be able to better reflect the different influence of each element on the decisions related to the adoption of blockchain-based games in the company compared to the traditional FMEA method, as the group of experts' AHP preferences based on their real-world knowledge and experience are used to build the relative scale measurement, which consequently is used to determine the relative weights required for the calculation.

$$\text{Priority Number (PN)} = (L_M \times W_L) + (I_M \times W_I) + (C_M \times W_C)$$

where W_L, W_I, and W_C are relative weights of L_M, I_M and C_M, respectively.

Fig. 15 Priority number calculation (Adapted from Aslani et al. [119]).

The ranking of each opportunity and barrier based on the PN can be used to compare and prioritise all the opportunities and barriers. A certain factor, either an opportunity or a barrier, is considered more important if the value of its PN is higher compared to others. After all the opportunities and barriers have been prioritised by the ranking of PN, Pareto diagrams will be drawn to reveal the most critical opportunities and barriers, which will result in a proper display of the most significant factors that could facilitate (i.e. opportunities) or hinder (i.e. barriers) the adoption of blockchain-based games in the company.

In the traditional FMEA method, which is a common risk analysis technique, a numerical value is assigned to each risk associated with the cause of a failure in three elements: Occurrence (O); Severity (S); and Detection (D). By multiplying these three elements together, the risk priority number (RPN) can be calculated. As a result, the risky elements can be targeted and prioritised based on the resulting RPNs. However, it can be seen that there are deviations in terms and definitions from the elements of the traditional FMEA used in this research as follows:

- Likelihood (L) is comparable to Occurrence (O) from the traditional FMEA method;
- Impact (I) is comparable to Severity (S) from the traditional FMEA method;
- Control (C) is comparable to Detection (D) from the traditional FMEA method; and
- Priority Number (PN) is comparable to Risk Priority Number (RPN) from the traditional FMEA method.

It is believed that these deviations are necessary to be used in this research due to the following 2 reasons:

1. This research does not only study the barriers related to the adoption of blockchain-based games in the company but also the opportunities. Thus, it is important to have common terms (i.e. Likelihood (L), Impact (I), Control (C), and Priority Number (PN)) that can be used throughout all the steps of the research for both opportunities and barriers. The method of how each opportunity is assessed in this research using FMEA is also supported by White [109] where the potential applications of blockchain technology are prioritised by using the concept of FMEA.
2. The change from Detection (D) to Control (C) could be considered a major shift in the definition. However, the opportunities and barriers in this research, which are identified through the study of the adoption of blockchain-based games in the company, could not be measured in the same way as how Detection (D) is defined in the traditional FMEA. Moreover, it is argued by Abdelgawad and Fayek [117] that the traditional definition of Detection (D) is ambiguous and difficult to understand. They thus define this element as "the ability of the company to come up with a risk response strategy to detect and control the root causes and consequences of the risk event".

3.4. Response to Opportunities and Barriers

Once the critical opportunities and barriers have been identified and prioritised, a set of possible strategies on how the company can respond to those factors should be developed. The reason is that the strategies not only can help address the barriers to the adoption and mitigate the risks, but also can act as guidance on how the company could effectively implement blockchain-based games and, as a result, the potential benefits can be realised from the adoption. The strategies based on the literature review and the feedback from the semi-structured interview with the group of experts will be proposed. The TOWS matrix will be used as a framework for formulating strategies in response to those critical opportunities and barriers. Moreover, to help the company make informed decisions about the adoption of blockchain-based games, a roadmap which is divided into short-, medium-, and long-term action plans will also be proposed. Similar to the identification process of opportunities and barriers, it is expected that the relevant studies are limited. Therefore, the experts' feedback from the semi-structured interview will also be used to fill the literature gap.

4. Result and Analysis

4.1. Background of the Company and Experts

The company is a leading online gaming company and has one of its offices located in Thailand. The company, since its inception, has been generating revenue from a common business model called F2P. The company can be considered a traditional online gaming company

because it has been mainly relying on the F2P model. Moreover, the company has not integrated blockchain technology into its products or systems. To understand the reason behind why this is the case, a group of experts are invited to participate in the questionnaire and the semi-structured interview. The target participants of this research are in senior or managerial positions in the company with at least 5 years of experience in the field. They thus can be considered experts in the online gaming industry because of their wealth of knowledge and experience. The experts are deliberately selected so that this research would have representatives from many different roles and responsibilities of the company. They are also selected only if they have sufficient knowledge of blockchain technology and have an understanding of the utilisation of blockchain in the online gaming industry. In total, 7 experts (see Table 12) are invited, and all of them agree to participate in the questionnaire and the semi-structured interview.

Table 12. Summary of experts.

Expert	Organisational Role/Responsibility	Location
1	Regional Product Manager (Mobile)	Thailand
2	Senior Strategic Operations (Mobile)	Thailand
3	Senior Marketing Team Lead (PC)	Thailand
4	Product Manager (Mobile)	Thailand
5	Senior Marketing Specialist (Mobile)	Thailand
6	Senior Product Manager (Mobile)	Thailand
7	Revenue Team Lead (Mobile)	Thailand

4.2. Demonstration of Research Findings

4.2.1. Identification and classification of opportunities and barriers

The literature is used as the primary source to identify both opportunities and barriers. There are, however, 6 additional factors extracted during the identification process as follows:

3 Opportunities are later categorised in the organisational dimension under the benefits framework:

- *Facilitation of business learning*. To capitalise on the emergence of blockchain technology, the development of requisite knowledge and skills (e.g. foundational technology, distributed ledger technology, laws and regulations, markets and economics, industrial design, and blockchain standards [120]) is needed for the adoption. Thus, employees have an opportunity to develop new skill sets and competencies by adopting blockchain-based games in the organisation.
- *Support for organisational changes*. To realise the benefits of technology adoption, organisations need to embrace changes and have a collaborative environment [121].
- *Employee engagement*. Native cryptocurrencies of blockchain-based games adopted by the company can be used to perform a similar function as stock options, which could be considered monetary incentives affecting employees' engagement [122].

2 Barriers, which later are categorised in the environmental dimension under the TOE framework:

- *Lack of policy framework*. One of the well-known use cases of Blockchain is in financial services [123], [124]. A guideline for blockchain technology adoption in financial services has been released by the Bank of Thailand [125]. However, there is no regulatory framework from the government to promote blockchain technology in the online gaming industry.
- *Lack of investment incentives*. The public sector in Thailand has realised the potential impact of blockchain technology and accepted that it is one of the emerging megatrends [3]. Although it is also reported that a plan for investment incentives (e.g. corporate income tax exemptions) is being considered by the Board of Investment of Thailand through "Category 5.10 Development of Software, Digital Platform or Digital Content" to attract foreign investors [126], there is still a lack of incentives from the government for online gaming companies to adopt blockchain as the underlying technology of online games.

1 Barrier, which later is categorised in the technological dimension under the TOE framework:

- *Absence of successful development and implementation of blockchain-based games in Thailand*. Most of the current well-known developers who operate blockchain-based games are not from Thailand, and most projects in the Thai market are still in the early stage or are not developed by major game developers in the industry. Thus, there are no practical examples to be used as guidance for the development and implementation of blockchain-based games in Thailand for the company. As a result, there is a total of 23 opportunities (see Table 13) and 24 barriers (see Table 14) identified in this research.

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Table 13. Classification of opportunities under the benefits framework.

Dimension	Opportunity	Explanation
Operational	Improved payment process	Blockchain enables a secure and faster payment method between developers and players.
	Prevention of value leakage	There is a reduction in fraud and lost revenue from duplicated virtual assets, hacking, stealing, and economic activities on grey markets.
	Sever cost reduction	Game server costs can be reduced by using P2P networks.
	Lower transaction costs	Transaction costs can be reduced as intermediaries are removed.
Managerial	Improved credibility, accountability, and behaviour within the gaming ecosystem	The gaming community and ecosystem can be improved, as all activities are recorded on the blockchain and visible to everyone.
	Ownership management of digital assets	Trading features are part of blockchain by nature, in contrast to traditional games where developers need to create additional features and databases for this purpose.
	Better unit economics	Customer lifetime value and acquisition costs can be improved by revenue-sharing models between developers and players.
Strategic	Increased sense of ownership	NFTs enabled by smart contracts and blockchain technology help increase a sense of ownership and control over digital assets for players.
	New business models	The P2E model can be a new business model or revenue stream for online gaming companies.
	Improved customer feedback	Incentive mechanisms can encourage constructive feedback from players.
	Digital scarcity	The concept of verifiable scarcity and limited supply can increase the desirability of digital assets.
	Customer co-creation	Players are allowed to be involved in governance or voting features on some aspects of the game on a decentralised network; NFTs facilitate user-generated content of the game; value is exchanged and transferred through tokens.
	Improved trust	Trust between developers and players can be established by smart contracts.
	New reward systems for players	The P2E model can provide financial incentives for players to play the games.
	Global user base	Blockchain networks provide an opportunity for expanding the user base globally.
	Privacy protection	Data privacy of players can be protected by self-sovereign identity.
Infrastructure	Transparency	Data stored on the blockchain is transparent and verifiable.
	Cross-chain infrastructure	There is a potential for cross-platform compatibility for digital assets.
	Improved data security	Blockchain helps improve the security of data or virtual assets, as they are stored on a distributed ledger system.
	Defence against cyberattacks	Cyberattacks such as DDoS attacks can be prevented by the P2P architecture.
Organisational	Facilitation of business learning	Employees' skills are broadened by adopting blockchain-based games in the organisation.
	Support for organisational changes	Organisational structures and processes are needed to be changed; higher collaboration and coordination between different business units.
	Employee engagement	Employees have a chance to own native cryptocurrencies of blockchain-based games, which can function as a form of incentives and increase engagement.

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Table 14. Classification of barriers under the TOE framework.

Dimension	Barrier	Explanation
Technological	Limitations of blockchain technology	Blockchain trilemma (i.e. scalability, security, decentralisation) is not yet to be solved, causing issues such as high and volatile transaction fees, slow network speed, and security concerns.
	Sustainability issues of blockchain-based games	There are challenges in building and sustaining economies within blockchain-based games.
	Lack of technological knowledge to distinguish different blockchain networks	There are many blockchain networks in the market; there are challenges in deciding which network to rely on.
	Blockchain as the underlying technology of online games is still questionable	It is still uncertain whether blockchain technology will be an integrated part of the online gaming industry.
	Traditional games still have an advantage over blockchain-based games	The maturity of technology required for developing traditional games can provide better graphics and gameplay quality compared to blockchain-based games.
	Absence of successful development and implementation of blockchain-based games in Thailand	Blockchain is new to the gaming industry; there are no best practices for blockchain-based games' development and implementation in the market.
	Blockchain technology complexity	The lack of stable development tools, interoperability, and standardisation of blockchain technology prevents the adoption of blockchain-based games.
	Poor user experience	The use of blockchain could be a hindrance to the adoption of blockchain-based games (e.g. lack of on/off ramps for players to conveniently convert between fiat money and cryptocurrencies).
	Data storage issues	Lack of knowledge on which data in the gaming environment should be stored on the blockchain.
Organisational	Uncertain ROI	There is a risk for investors in terms of stability, predictability, and growth of blockchain-based games.
	High switching costs	There are high switching costs associated with integrating blockchain technology into existing games or changing the business model.
	Lack of proper resources and capabilities	The adoption of blockchain-based games poses challenges in terms of financial resources, technical experts, etc.
	Business process transformation	The adoption of blockchain-based games would introduce new business models; organisational changes will happen.
	New governance models	In contrast to the centralised structure of traditional games, governance tokens provide holders with voting power in some aspects of blockchain-based games; the concept of DAOs or decentralised decision-making in the gaming ecosystem is still questionable.
	Current business models are still profitable	Changes are not necessary, as the F2P business model is still profitable.
	Lack of full control over the content	Blockchain is immutable; data stored on the blockchain is difficult to be censored.
	Lack of understanding by top management	Managers are not aware of how blockchain-based games work or the potential benefits they could bring to the organisation.
Environmental	Lack of education or understanding of blockchain-based games	There are common misconceptions that the concept of blockchain-based games is a Ponzi scheme or scam.
	Low social acceptance of blockchain-based games	Blockchain-based games are not yet fully accepted by the general public; opportunities for players to use blockchain and cryptocurrencies are still limited; blockchain gaming is a niche market.
	Regulatory uncertainty and legal considerations	It is uncertain how to deal with know-your-customer (KYC) and anti-money laundering (AML) regulations required for developing blockchain-based games; there are issues related to the intellectual property of NFTs and tax treatment for players and developers.
	Public relations and the possibility of community backlash	There is a possibility that changing the value proposition would create a negative sentiment.
	Environmental impact of blockchain technology	PoW blockchains require significant energy usage and have a negative impact on the environment.
	Lack of policy framework	There is no regulatory framework from the government to promote blockchain technology in the online gaming industry.
	Lack of investment incentives	There is a lack of incentives from the government for online gaming companies to adopt blockchain-based games.

4.2.2. Evaluation and classification of opportunities and barriers

The evaluation process is separated into 4 parts: 1) application of FMEA; 2) application of AHP; 3) calculation of priority number; and 4) Pareto analysis, all of which will be discussed in turn.

4.2.2.1. Application of FMEA

To apply the FMEA method, all the identified opportunities and barriers are used to create a 5-point Likert scale questionnaire, which is distributed to a group of experts to assign a score ranging from 1 to 5 to each opportunity and barrier in three elements: Likelihood (L), Impact (I), and Control (C). The criteria used for scoring each factor and the description for both opportunities and barriers are shown in Table 6 – Table 11. Most of the experts take approximately 20-30 minutes to fill out the questionnaire. All the responses of each factor from the experts are then transferred to Microsoft Excel to find the mean values of Likelihood (L_M), Impact (I_M), and Control (C_M), which can be obtained by calculating the averages of Likelihood (L), Impact (I), and Control (C), respectively.

4.2.2.2. Application of AHP

The RPN in the traditional FMEA method is obtained by multiplying all three elements together. This method is fairly straightforward and simple to understand; however; some issues often occur with this approach to calculating the RPN value to define the most critical factors for which corrective actions are immediately needed. For example, as the same weight for all three elements is considered in the traditional FMEA method, there are drawbacks in the way in which the RPN is calculated and in the way in which the results are interpreted because the effect of each element is not the same [127]. As a result, the priorities for developing corrective actions could be wrong. The AHP is, therefore, adapted and used in this part of the research to make the traditional FMEA method a more suitable decision-making tool by assigning a relative weight to each element of the FMEA before being used for the calculation of priority number (PN). The AHP in this research consists of 4 steps as follows:

1) Design of a Hierarchy for the Problem

The objective of applying the AHP is to determine the relative weights of FMEA elements, each of which is expected to have a different effect on the decisions to adopt blockchain-based games in the company. All three elements of FMEA are the criteria considered for the design of the AHP.

2) Construction of a Pairwise Comparison Matrix

The semi-structured interview with the group of experts is used for understanding the group preferences in terms of which element in the FMEA is considered more important and how each element contributes to the decisions related to the adoption of blockchain-based games in the company. The method of aggregating experts' preferences in this research is adapted from Hummel et al. [98]. This means the experts are individually asked to make pairwise comparisons of the FMEA elements by verbally assigning a score from 1 to 9 (see Table 4). After that, the geometric mean is used to calculate a group score on each pairwise comparison. A relative scale measurement (see Fig. 16) is then constructed based on the group scores, which can be interpreted as follows:

- Impact (I) is moderately more important than Likelihood (L) (score 3);
- Impact (I) is strongly more important than Control (L) (score 5); and
- Likelihood (L) and Control (C) are equally important (score 1).

Element	Scale																	Element
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
I							3											L
I					5													C
L									1									C

Fig. 16. AHP preferences of the group of experts.

The group preferences of the FMEA elements are used for creating a pairwise comparison matrix, as shown in Table 15.

Table 15. Pairwise comparison matrix.

Element	I	L	C
I	1.0000	3.0000	5.0000
L	0.3333	1.0000	1.0000
C	0.2000	1.0000	1.0000

3) Derivation of Priorities

There are 3 steps of the "mean of normalised values" approach to finding a priority vector of a pairwise comparison matrix as follows:

i. Based on the pairwise comparison matrix (see Table 15), the first step is to find the sum of all the elements of the columns, as shown in Table 16.

Table 16. Sum of columns.

Element	I	L	C
I	1.0000	3.0000	5.0000
L	0.3333	1.0000	1.0000
C	0.2000	1.0000	1.0000
Total	1.5333	5.0000	7.0000

ii. The next step is the normalisation of the columns. This can be done by dividing each element of the matrix

by its respective sum of the columns, as shown in Table 17 and Table 18.

Table 17. Normalisation of columns (1).

Element	I	L	C
I	1.0000 / 1.5333	3.0000 / 5.0000	5.0000 / 7.0000
L	0.3333 / 1.5333	1.0000 / 5.0000	1.0000 / 7.0000
C	0.2000 / 1.5333	1.0000 / 5.0000	1.0000 / 7.0000

Table 18. Normalisation of columns (2).

Element	I	L	C
I	0.6522	0.6000	0.7143
L	0.2174	0.2000	0.1429
C	0.1304	0.2000	0.1429
Total	1.0000	1.0000	1.0000

iii. The calculation of the mean of each row is the last step required for deriving the priority vector (see Table 19), which can be done as follows:

Table 19. Priority vector calculation.

Element	I	L	C	Priority Vector
I	0.6522	0.6000	0.7143	0.6555
L	0.2174	0.2000	0.1429	0.1867
C	0.1304	0.2000	0.1429	0.1578

4) Logical Consistency

Following the calculation method of the consistency ratio (CR) in Section 2.5.4, the CR is 0.0252 (the principal eigenvalue (λ_{max}) is 3.0292 and the consistency index (CI) is 0.0146). As the CR value is less than 0.1, the judgements can be considered consistent and acceptable.

4.2.2.3. Calculation of PN

From the AHP calculation of the priority vector, the relative weights are W_L =0.1867, W_I =0.6555, and W_C=0.1578. The PN for each opportunity and barrier is then can be calculated (see Fig. 15). The results are shown in Table 20 – Table 27.

Table 20. Operational opportunities ranked in descending order of PN.

Operational Opportunity	PN
Improved payment process	3.52
Lower transaction costs	3.49
Prevention of value leakage	3.43
Sever cost reduction	3.41

Table 21. Managerial opportunities ranked in descending order of PN.

Managerial Opportunity	PN
Better unit economics	4.08
Ownership management of digital assets	3.65
Improved credibility, accountability, and behaviour within the gaming ecosystem	2.42

Table 22. Strategic opportunities ranked in descending order of PN.

Strategic Opportunity	PN
Increased sense of ownership	4.50
Customer co-creation	4.50
New reward systems for players	4.46
Global user base	4.34
Digital scarcity	4.05
New business models	3.98
Improved customer feedback	3.50
Improved trust	3.41
Privacy protection	2.78

Table 23. Infrastructure opportunities ranked in descending order of PN.

Infrastructure Opportunity	PN
Improved data security	4.10
Transparency	4.08
Defence against cyberattacks	4.07
Cross-chain infrastructure	3.83

Table 24. Organisational opportunities ranked in descending order of PN.

Organisational Opportunity	PN
Employee engagement	4.17
Facilitation of business learning	3.88
Support for organisational changes	3.53

Table 25. Technological barriers ranked in descending order of PN.

Technological Barrier	PN
Poor user experience	4.30
Blockchain technology complexity	4.28
Sustainability issues of blockchain-based games	4.20
Traditional games still have an advantage over blockchain-based games	3.99
Lack of technological knowledge to distinguish different blockchain networks	3.93
Absence of successful development and implementation of blockchain-based games in Thailand	3.69
Limitations of blockchain technology	3.65
Data storage issues	2.71
Blockchain as the underlying technology of online games is still questionable	2.59

Table 26. Organisational barriers ranked in descending order of PN.

Organisational Barrier	PN
Uncertain ROI	4.35
Current business models are still profitable	4.29
Lack of understanding by top management	3.95
High switching costs	3.81
New governance models	3.77
Lack of proper resources and capabilities	3.24
Lack of full control over the content	3.01
Business process transformation	2.48

Table 27. Environmental barriers ranked in descending order of PN.

Environmental Barrier	PN
Regulatory uncertainty and legal considerations	4.69
Lack of education or understanding of blockchain-based games	4.37
Low social acceptance of blockchain-based games	3.99
Public relations and the possibility of community backlash	3.91
Lack of policy framework	3.47
Lack of investment incentives	3.07
Environmental impact of blockchain technology	2.93

PNs can be used to prioritise the factors related to the adoption of blockchain-based games in the company and determine which one is more critical when compared to others. Although the AHP is used in this research to determine the relative weights of each element of the FMEA, the relationship between each factor in the same dimension and the relative weights of different dimensions (i.e. operational, managerial, strategic, infrastructure, and organisational dimensions for opportunities; technological, organisational, and environmental dimensions for barriers) on their effects related to the adoption of blockchain-based games in the company are not studied in this research. Thus, the opportunity and barrier factors are ranked in descending order of PN only in the dimension they belong to, and each dimension is independent of another.

In terms of opportunities, assuming that all the factors have the same weight, it can be found that infrastructure opportunities (average PN = 4.02) are ranked highest by PN, followed by strategic opportunities (average PN = 3.95), organisational opportunities (average PN = 3.86), operational opportunities (average PN = 3.46), and managerial opportunities (average PN = 3.38), respectively. Both of the highest-ranked opportunities by PN are from the strategic dimension: increased sense of ownership (PN = 4.50); and customer co-creation (PN = 4.50).

In terms of barriers, assuming that all the factors have the same weight, it can be found that environmental barriers (average PN = 3.78) are ranked highest by PN, followed by technological barriers (average PN = 3.70) and organisational barriers (average PN = 3.61), respectively. The highest-ranked barrier by PN is from the environmental dimension: regulatory uncertainty and legal considerations (PN = 4.69).

By doing this, it is believed that the study of the opportunities and barriers in this research would be more systematic based on robust academic frameworks (i.e. the benefits framework and the TOE framework) and that all the critical opportunities and barriers can be easier to understand and prioritised, resulting in a better representation of which aspects of the company in which the action plans are immediately needed in order to promote the adoption of blockchain-based games. The opportunities with higher PNs are expected to occur more often, have a more positive impact on the business, and the opportunity event is more manageable by the company when adopting blockchain-based games. The barriers with higher PNs are expected to occur more often, have a more negative impact on the business, and the risk event is more difficult to be controlled by the company when adopting blockchain-based games.

4.2.2.4. Pareto analysis

This part of the research is to apply the Pareto principle to each category of opportunities and barriers after the FMEA and AHP techniques have been used to calculate the PNs. By the use of a Pareto diagram in each category, the critical opportunities and barriers can be revealed, thus representing the most significant factors needed to be prioritised. The following 4 steps are used in this research for the Pareto analysis:

1. Calculate the PN% of all factors in their respective dimensions;
2. Calculate the cumulative PN% of all factors in their respective dimensions;
3. Draw a Pareto diagram for each dimension to determine critical factors (i.e. 20% of the factors with the highest PN% should account for 80% of the cumulative PN% in each category); and
4. If the 80/20 rule cannot be applied, the critical factors are all those that reach the cumulative PN% of 80% [128].

After applying the Pareto diagrams for each dimension of opportunities and barriers, it is found that there is no dimension in which 20% of the factors with the highest PN% account for 80% of the cumulative PN%. As a result, all the factors that reach 80% of the cumulative PN% of 80% are used to determine the critical factors. Table 28 summarises all 21 critical opportunities using the benefits framework: 4 operational opportunities, 3 managerial opportunities, 7 strategic opportunities, 4 infrastructure opportunities, and 3 organisational opportunities. Table 29 summarises all 19 critical barriers using the TOE framework: 7 technological barriers, 6 organisational barriers, and 6 environmental barriers.

Table 28. Critical opportunities under the benefits framework.

Dimension	Opportunity
Operational (OP)	Improved payment process (OPO_1)
	Lower transaction costs (OPO_2)
	Prevention of value leakage (OPO_3)
	Sever cost reduction (OPO_4)
Managerial (M)	Better unit economics (MO_1)
	Ownership management of digital assets (MO_2)
	Improved credibility, accountability, and behaviour within the gaming ecosystem (MO_3)
Strategic (S)	Increased sense of ownership (SO_1)
	Customer co-creation (SO_2)
	New reward systems for players (SO_3)
	Global user base (SO_4)
	Digital scarcity (SO_5)
	New business models (SO_6)
	Improved customer feedback (SO_7)
Infrastructure (I)	Improved data security (IO_1)
	Transparency (IO_2)
	Defence against cyberattacks (IO_3)
	Cross-chain infrastructure (IO_4)
Organisational (OR)	Employee engagement (ORO_1)
	Facilitation of business learning (ORO_2)
	Support for organisational changes (ORO_3)

Table 29. Critical barriers under the TOE framework.

Dimension	Barrier
Technological (T)	Poor user experience (TB_1)
	Blockchain technology complexity (TB_2)
	Sustainability issues of blockchain-based games (TB_3)
	Traditional games still have an advantage over blockchain-based games (TB_4)
	Lack of technological knowledge to distinguish different blockchain networks (TB_5)
	Absence of successful development and implementation of blockchain-based games in Thailand (TB_6)
	Limitations of blockchain technology (TB_7)
Organisational (OR)	Uncertain ROI (ORB_1)
	Current business models are still profitable (ORB_2)
	Lack of understanding by top management (ORB_3)
	High switching costs (ORB_4)
	New governance models (ORB_5)
	Lack of proper resources and capabilities (ORB_6)
Environmental (E)	Regulatory uncertainty and legal considerations (EB_1)
	Lack of education or understanding of blockchain-based games (EB_2)
	Low social acceptance of blockchain-based games (EB_3)
	Public relations and the possibility of community backlash (EB_4)
	Lack of policy framework (EB_5)
	Lack of investment incentives (EB_6)

4.3. Response to Opportunities and Barriers

In this section, to respond to the critical opportunities and barriers, the TOWS matrix is a strategic planning tool used for formulating strategies by matching external factors (i.e. opportunities and threats) with internal factors (i.e. strengths and weaknesses). It is found that the internal factors of the company include 8 internal strengths: 1) in-depth knowledge and understanding of online gaming business, 2) strong reputation in its main regions, 3) research and development (R&D) and technological capabilities, 4) relationship with local authorities, 5) partnership and collaboration with global game studios, 6) large user base in its main regions, 7) resilient business and ability to adapt quickly, and 8) ability to raise capital; and 1 internal weakness: limited operating history of publishing games globally. All these 9 internal factors (i.e. 8 internal strengths and 1 internal weakness) are added to the 21 critical opportunities (Table 28) and the 19 critical barriers (see Table 29) to give a comprehensive view of all the factors affecting the adoption of blockchain-based games in the company required for conducting the SWOT analysis, which consequently is used as a basis for formulating strategies based on the TOWS matrix.

Table 30 shows the SWOT analysis for the adoption of blockchain-based games in the company, including 8 strengths (i.e. 8 internal strengths), 6 weaknesses (i.e. 1 internal weakness, 1 technological barrier, and 4 organisational opportunity), 21 opportunities (i.e. 4 operational opportunities, 3 managerial opportunities, 7 strategic opportunities, 4 infrastructure opportunities, and 3 organisational opportunities), and 14 threats (i.e. 6 technological barriers, 2 organisational barriers, and 6 environmental barriers).

4.3.1. Strategies

The company's strengths, weaknesses, opportunities, and threats in the context of the adoption of blockchain-based games are first considered. After that, possible strategies are determined based on the TOWS matrix by matching external factors with internal factors. The proposed possible strategies for the company to seize the critical opportunities and address the critical barriers, which include 7 SO, 12 ST, 5 WO, and 1 WT strategies as follows:

Table 30. SWOT analysis for the adoption of blockchain-based games.

Internal Factors	**Strengths (S)**	S_1	In-depth knowledge and understanding of the online gaming business
		S_2	Strong reputation in its main regions
		S_3	Research and development (R&D) and technological capabilities
		S_4	Relationship with local authorities
		S_5	Partnership and collaboration with global game studios
		S_6	Large user base in its main regions
		S_7	Resilient business and ability to adapt quickly
		S_8	Ability to raise capital
	Weaknesses (W)	W_1	Limited operating history of publishing games globally
		W_2	Lack of technological knowledge to distinguish different blockchain networks (TB_5)
		W_3	Lack of understanding by top management (ORB_3)
		W_4	High switching costs (ORB_4)
		W_5	Current business models are still profitable (ORB_2)
		W_6	Lack of proper resources and capabilities (ORB_6)
External Factors	**Opportunities (O)**	O_1	Improved payment process (OPO_1)
		O_2	Lower transaction costs (OPO_2)
		O_3	Prevention of value leakage (OPO_3)
		O_4	Sever cost reduction (OPO_4)
		O_5	Better unit economics (MO_1)
		O_6	Ownership management of digital assets (MO_2)
		O_7	Improved credibility, accountability, and behaviour within the gaming ecosystem (MO_3)
		O_8	Increased sense of ownership (SO_1)
		O_9	Customer co-creation (SO_2)
		O_{10}	New reward systems for players (SO_3)
		O_{11}	Global user base (SO_4)
		O_{12}	Digital scarcity (SO_5)
		O_{13}	New business models (SO_6)
		O_{14}	Improved customer feedback (SO_7)
		O_{15}	Improved data security (IO_1)
		O_{16}	Transparency (IO_2)
		O_{17}	Defence against cyberattacks (IO_3)
		O_{18}	Cross-chain infrastructure (IO_4)
		O_{19}	Employee engagement (ORO_1)
		O_{20}	Facilitation of business learning (ORO_2)
		O_{21}	Support for organisational changes (ORO_3)
	Threats (T)	T_1	Poor user experience (TB_1)
		T_2	Blockchain technology complexity (TB_2)
		T_3	Sustainability issues of blockchain-based games (TB_3)
		T_4	Traditional games still have an advantage over blockchain-based games (TB_4)
		T_5	Absence of successful development and implementation of blockchain-based games in Thailand (TB_6)
		T_6	Limitations of blockchain technology (TB_7)
		T_7	Uncertain ROI (ORB_1)
		T_8	New governance models (ORB_5)
		T_9	Regulatory uncertainty and legal considerations (EB_1)
		T_{10}	Lack of education or understanding of blockchain-based games (EB_2)
		T_{11}	Low social acceptance of blockchain-based games (EB_3)
		T_{12}	Public relations and the possibility of community backlash (EB_4)
		T_{13}	Lack of policy framework (EB_5)
		T_{14}	Lack of investment incentives (EB_6)

4.3.1.1. SO strategies

There are 7 SO strategies as follows:

1. O_1 O_2 S_6 (see Table 31)

Table 31. SO strategies (1).

Opportunities (O)	
O_1	Improved payment process (OPO_1)
O_2	Lower transaction costs (OPO_2)
Strengths (S)	
S_6	Large user base in its main regions

In terms of financial processes, using blockchain technology and P2P networks as the payment system for blockchain-based games would allow the company to be able to reduce costs, have a faster settlement, and more secured payment across different regions in which it operates, as it would be relying on a P2P network and there would be no intermediaries [129].

2. O_8 O_9 O_{10} O_{12} O_{18} S_1 S_6 (see Table 32)

Table 32. SO strategies (2).

Opportunities (O)	
O_8	Increased sense of ownership (SO_1)
O_9	Customer co-creation (SO_2)
O_{10}	New reward systems for players (SO_3)
O_{12}	Digital scarcity (SO_5)
O_{18}	Cross-chain infrastructure (IO_4)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business
S_6	Large user base in its main regions

A new reward system for players could be introduced by the P2E model, which would allow for new interaction and collaboration between the company and its players. As a result, customer co-creation activities [130] can be created and enhanced, as all the stakeholders in the ecosystem including both developers and players could turn into the creators of value. The concept of a sense of ownership and scarcity also could be created by the properties of NFTs [131]. NFTs also come with a potential for cross-chain compatibility, which will give a whole new experience for players interacting with the virtual worlds. An expert stated, "The P2E model and NFTs definitely would be an introduction of new gaming experiences to our players and change how our digital content is currently being provided." With its online game business knowledge, the company should deploy features enabled by blockchain-based games to enhance the service offerings that are currently being provided to its players.

3. O_3 O_6 O_{15} O_{17} S_1 S_3 (See Table 33)

Table 33. SO strategies (3).

Opportunities (O)	
O_3	Prevention of value leakage (OPO_3)
O_6	Ownership management of digital assets (MO_2)
O_{15}	Improved data security (IO_1)
O_{17}	Defence against cyberattacks (IO_3)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business
S_3	Research and development (R&D) and technological capabilities

By incorporating blockchain technology (using R&D and technological capabilities) into the online gaming business (using the business expertise) of the company, it is believed that blockchain can provide an additional layer of security for digital assets, prevent illegal activities in black markets, and reduce illegal copies of digital assets. Blockchain is more resilient to cyberattacks compared to traditional servers [132]. Moreover, smart contracts help ensure and verify transactions when digital assets are traded [133].

4. O_{16} S_1 S_2 (See Table 34)

Table 34. SO strategies (4).

Opportunities (O)	
O_{16}	Transparency (IO_2)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business
S_2	Strong reputation in its main regions

With blockchain technology, the distribution and management of digital assets will be transparent and verifiable. An expert stated, "We can use blockchain to introduce the tokenisation of digital assets, which will allow them to be tracked and traced by everyone. This could be considered an add-on feature to online games [enabled by blockchain technology]." Moreover, the data stored on the blockchain and smart contracts can be used to solve the transparency and trust issues of loot boxes [134], which are used by game developers as one of the main monetisation methods. There also has been increased scrutiny from customers and regulators and a request for transparency [135], [136]. The reputation of the company can be enhanced as a result of increased transparency, which is achievable by incorporating blockchain technology into its online gaming business.

5. O_{20} O_{21} S_3 S_7 (See Table 35)

Table 35. SO strategies (5).

Opportunities (O)	
O_{20}	Facilitation of business learning (ORO_2)
O_{21}	Support for organisational changes (ORO_3)
Strengths (S)	
S_3	Research and development (R&D) and technological capabilities
S_7	Resilient business and ability to adapt quickly

The company can improve business learning by adopting blockchain-based games and new technology in the organisation. The company's technological capabilities and employees' skills will be enhanced. This is also aligned with the concept of dynamic capabilities [137], which is defined as the company's ability to seek and integrate new competencies and adapt its resources to rapidly address external changes.

6. O_{14} O_{19} S_1 S_6 (See Table 36)

Table 36. SO strategies (6).

Opportunities (O)	
O_{14}	Improved customer feedback (SO_7)
O_{19}	Employee engagement (ORO_1)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business
S_6	Large user base in its main regions

The tokenisation model introduced by blockchain-based games can be used to improve engagement not only for internal stakeholders (e.g. employees) but also for external stakeholders (e.g. players and investors). The reason is that financial incentives can be provided by using native tokens of blockchain-based games. All the experts agreed that there is a high chance that the idea of using native tokens as incentives for employees could increase employee engagement and positively affect the online gaming business processes of the company. By leveraging the company's existing user base, special incentive mechanisms also can be developed to improve customers' feedback and behaviour on the platforms [138].

7. O_7 S_1 S_6 (See Table 37)

Table 37. SO strategies (7).

Opportunities (O)	
O_7	Improved credibility, accountability, and behaviour within the gaming ecosystem (MO_3)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business
S_6	Large user base in its main regions

Online games are the place in which many players with diverse backgrounds meet virtually. As data (e.g. players' interactions, history, and transaction records) is stored in a public and immutable manner on the blockchain, players are encouraged to have good behaviour in the community [138]. The blockchain combined with the company's knowledge of community management could be used to foster a good gaming ecosystem.

4.3.1.2. ST strategies

There are 12 ST strategies as follows:

1. T_1 S_1 S_3 S_5 (See Table 38)

Table 38. ST strategies (1).

Threats (T)	
T_1	Poor user experience (TB_1)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business
S_3	Research and development (R&D) and technological capabilities
S_5	Partnership and collaboration with global game studios

It is uncommon for players to fully enjoy the full features of blockchain-based games without necessary activities such as interacting with a cryptocurrency exchange, setting up a wallet, swapping tokens, and transferring tokens [139]. As a result, poor user experience has been one of the main barriers to the adoption of blockchain-based games. The company could mitigate this challenge by collaborating with leading developers in the industry to develop a solution that would allow players to participate in the P2E ecosystem without the need for them to directly interact with the blockchain and that is easy for them to understand. This approach has been used by major game developers such as Netmarble, which is in a strategic partnership with Klaytn Foundation in developing the MARBLEX wallet system [140], allowing players seamless interaction with its blockchain-gaming ecosystem.

2. T_2 S_3 (See Table 39)

Table 39. ST strategies (2).

Threats (T)	
T_2	Blockchain technology complexity (TB_2)
Strengths (S)	
S_3	Research and development (R&D) and technological capabilities

Blockchain could be considered a complex technology, especially for a company that has no prior

knowledge and experience with it. It is found that the lack of interoperability and standardisation is hindering the adoption of blockchain at the enterprise level in financial services where assets are moved between different stakeholders [141]. The online gaming industry is no different, as there are transactions and digital assets that are always needed to be verified and moved between players' accounts and servers. Although there is still a need for robust standards and mature development tools for blockchain-based games, the industry has been able to create promising standards in recent years. Examples of these are the ERC-20 standard, which is designed for the creation and use of tokens; and the ERC-721 standard, which represents the standardisation of NFTs. Both of them allow interoperability between DApps within the Ethereum blockchain [142]. There are also other initiatives around development tools for game developers such as Enjin [143], Ankr [144], and Arkane [145], which provide software development kits (SDKs) and APIs that come with support for popular game development tools (e.g. Unity and Unreal Engines) for the integration of blockchain-based games. The company thus should focus more on R&D for blockchain that can function as the underlying technology of online games to study how the technology has evolved and find suitable development tools.

3. T_3 S_1 (See Table 40)

Table 40. ST strategies (3).

Threats (T)	
T_3	Sustainability issues of blockchain-based games (TB_3)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business

Sustainability is one of the main issues of blockchain-based games. According to Glover [146], most P2E games are known for their unstable tokenomics (a portmanteau of "token" and "economics") and repetitive gameplay. It is believed that the primary reason for this is that most existing companies in the blockchain industry have not had experience with game development; however, this could change as more game industry veterans are getting involved. Luton [147] suggests that there are, in essence, three elements to consider when designing a P2E model: 1) mechanics, which are enabled by blockchain technology and are related to how tokens are transferred in and out of the ecosystem; 2) motivations, which are needed to be aligned between developers, players, and investors; and 3) systems, which describe how mechanics and motivations are connected together. The company thus should leverage its online gaming business know-how to address the sustainability issues in developing blockchain-based games.

4. T_4 S_1 S_3 (See Table 41)

Table 41. ST strategies (4).

Threats (T)	
T_4	Traditional games still have an advantage over blockchain-based games (TB_4)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business
S_3	Research and development (R&D) and technological capabilities

As traditional games have been in the industry for a longer time compared to blockchain-based games, it is obvious that all the supporting technologies and development tools would be at a more mature stage, hence a better production quality in terms of graphics and gameplay. However, a focus on the R&D for blockchain technology in combination with online game business knowledge should help the company to be able to develop high-quality blockchain-based games. This could be observed from the fact that there currently are blockchain-based games in development with a promise of high graphics and gameplay quality. Examples of these are Illuvium, a role-playing game developed on the Ethereum blockchain [148]; Star Atlas, a massively multiplayer online game developed on the Solana blockchain [149]; and League of Ancients, a multiplayer online battle arena game developed on Binance Smart Chain [150].

5. T_5 T_7 S_1 S_3 S_7 (See Table 42)

Table 42. ST strategies (5).

Threats (T)	
T_5	Absence of successful development and implementation of blockchain-based games in Thailand (TB_6)
T_7	Uncertain ROI (ORB_1)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business
S_3	Research and development (R&D) and technological capabilities
S_7	Resilient business and ability to adapt quickly

Although there is an absence of successful development and implementation of blockchain-based games in Thailand, the company can use its business knowledge, fast and nimble organisation, and technological expertise to set up a pilot project for blockchain-based games. Implementing a small-scale pilot project is considered an efficient initiative to carry out innovation and would allow the company to realise benefits in terms of quality, time, cost, scope, risk, and resources [151]. Moreover, the data received from pilot projects would allow the company to predict the ROI and

give an understanding of where the potential cause of failures might be, thereby being able to come up with corrective actions when deciding to actually scale up the projects.

6. T_6 S_3 (See Table 43)

Table 43. ST strategies (6).

Threats (T)	
T_6	Limitations of blockchain technology (TB_7)
Strengths (S)	
S_3	Research and development (R&D) and technological capabilities

Blockchain trilemma (i.e. scalability, security, decentralisation) has been known as the limitations of blockchain technology [152]. A prime example of this is high transaction fees during high traffic of Ethereum-based games, resulting in an 87% decrease in active users [153]. However, there are many initiatives proposed to solve the limitations, including Layer 1 (i.e. the main blockchain networks) and Layer 2 solutions (i.e. secondary networks or technology operating on top of the existing blockchains). An example of Layer 1 solutions is Ethereum 2.0 [154], also known as Consensus Layer, which is aimed to make the Ethereum blockchain more scalable, more secure, and more sustainable by changing its consensus mechanism from Proof-of-Work (PoW) to Proof-of-Stake (PoS). Examples of Layer 2 solutions are nested blockchains, state channels, and sidechains [155]. These blockchain solutions have seen immense growth in recent years. Thus, an investment of the company in R&D could help provide a better understanding of blockchain technology and blockchain-based games.

7. T_8 S_1 (See Table 44)

Table 44. ST strategies (7).

Threats (T)	
T_8	New governance models (ORB_5)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business

One of the organisational structures established in the blockchain and cryptocurrency space is DAO, which is operated by distributed ledger technology and smart contracts with an aim to reduce human intervention in the decision-making process within organisations [156]. According to Dion [157], compared to traditional organisational structures, DAOs have the following five characteristics: 1) tokenised governance model; 2) decentralisation by design; 3) automated process using smart contracts; 4) transparency; and 5) ease of capital formation. Because of the decentralisation element of DAOs, various groups of stakeholders would be able to play a part in supporting Web 3.0 game development activities such as aligning a development direction and enabling community input and ownership.

An expert, however, stated, "The idea of democratised decision-making is interesting, but from a game development perspective, I am not sure that it would create the best outcome for the game and its community." He also proceeded and said, "It is easier [for players] to play the game than it is to decide the right direction for the game development." Thus, the company could still mainly rely on its business knowledge and experience in the online gaming industry to develop blockchain-based games. However, it can mitigate this challenge by, for example, hosting open discussions with its players in the community or responding to their feedback to make sure that they are heard and seen. An example of this kind of initiative from a major game developer in the industry is World of Warcraft's Community Council by Blizzard Entertainment [158], in which players are gathered to have open lines of communication with developers through the form of live chats.

8. T_9 T_{13} S_4 (See Table 45)

Table 45. ST strategies (8).

Threats (T)	
T_9	Regulatory uncertainty and legal considerations (EB_1)
T_{13}	Lack of policy framework (EB_5)
Strengths (S)	
S_4	Relationship with local authorities

The most critical barrier to the adoption of blockchain-based games in the company is regulatory uncertainty and legal considerations. To develop and publish blockchain-based games, there are many regulatory aspects to be considered, some of which are even yet to be established or settled by the authorities in Thailand. Some examples are the changes to tax regulations [159], the ban on NFTs and meme-based tokens [160], and no official rules and regulations about blockchain-based games for game developers, players, and investors. To overcome this challenge, the development of policies and regulatory frameworks by the government is necessary. It is also possible for the company to be one of the representatives of the online gaming industry to arrange a meeting with regulators and related stakeholders to find out where the potential challenges in the adoption of blockchain-based games could be solved by regulatory frameworks or policies issued by the government.

9. T_{10} S_1 S_2 S_5 (See Table 46)

Table 46. ST strategies (9).

Threats (T)	
T_{10}	Lack of education or understanding of blockchain-based games (EB_2)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business
S_2	Strong reputation in its main regions
S_5	Partnership and collaboration with global game studios

As most of the current blockchain-based games' economies are driven by speculative activities, blockchain-based games are sometimes viewed as Ponzi schemes or scams [161], [162]. Moreover, most companies developing blockchain-based games in the industry are newly established or not well-known in the online gaming industry. The company's game business knowledge and collaboration with its global game studio partners can be used to develop blockchain-based games that have sustainable P2E business models. The sustainable business model and the reputation of the company and global studios could help overcome this challenge. The company also could make a public announcement to educate its players on how the business models of blockchain-based games work.

10. T_{11} S_1 S_3 S_6 (See Table 47)

Table 47. ST strategies (10).

Threats (T)	
T_{11}	Low social acceptance of blockchain-based games (EB_3)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business
S_3	Research and development (R&D) and technological capabilities
S_6	Large user base in its main regions

Although blockchain gaming still is a niche market and is not reachable by the general public, the industry in the first quarter of 2022 grew by 2,000% from that of 2021 [163]. This indicates that the blockchain gaming industry is growing very rapidly. To further gain acceptance, the company should use its business knowledge and invest in R&D to develop supporting solutions in the ecosystem of blockchain-based games that can solve user experience problems. Moreover, the company could leverage its existing user base to publish new blockchain-based games and pave the path to mass adoption.

11. T_{12} S_1 (See Table 48)

Table 48. ST strategies (11).

Threats (T)	
T_{12}	Public relations and the possibility of community backlash (EB_4)
Strengths (S)	
S_1	In-depth knowledge and understanding of the online gaming business

Integrating an element of NFTs into existing games has shown a possibility of community backlash for some game developers. The reason is that players believed that the integration of NFTs is just another method for game developers to earn more profits without actually making the game more enjoyable [164]. The company could use its experience in the online gaming business to predict and align its players' expectations with the P2E models and NFT features when developing blockchain-based games. Market research also could be conducted before developing blockchain-based games to understand players' expectations.

12. T_{14} S_8 (See Table 49)

Table 49. ST strategies (12).

Threats (T)	
T_{14}	Lack of investment incentives (EB_6)
Strengths (S)	
S_8	Ability to raise capital

An expert stated, "Investment incentives from the government would be one of the key accelerators for the adoption of blockchain-based games in the company." The government should incentivise online gaming companies, which are part of the digital economy in accordance with the Thailand 4.0 policy, to adopt blockchain as the underlying technology of online games. This process could be done in conjunction with all the necessary regulatory frameworks and policies. However, another expert stated, "It is believed that we have enough cash to deploy blockchain-based games in the company, and we can raise money to fund the development of blockchain-based games if it is necessary. We have raised a few rounds of funding in the past." Thus, the company also could use its financial strength to overcome the investment incentive challenge.

4.3.1.3. WO strategies

There are 5 WO strategies as follows:

1. O_4 O_{11} W_1 (See Table 50)

Table 50. WO strategies (1).

Opportunities (O)	
O_4	Sever cost reduction (OPO_4)
O_{11}	Global user base (SO_4)
Weaknesses (W)	
W_1	Limited operating history of publishing games globally

Blockchain networks that anyone in any part of the world has access to can easily help the company expand its user base to a global scale at a potentially lower cost than traditional game servers, given that it is a one-off purchase for each activity in the blockchain compared to the recurring cost of running and expanding servers in traditional online games. Costs of executing smart contracts (i.e. transaction fees) in the blockchain also could be transferred to executors [73].

2. O_{13} W_5 (See Table 51)

Table 51. WO strategies (2).

Opportunities (O)	
O_{13}	New business models (SO_6)
Weaknesses (W)	
W_5	Current business models are still profitable (ORB_2)

While it is true that the current F2P business model where game developers earn revenue through IAPs is still profitable, it has been proven that the P2E model can be an additional source of income by collecting transaction fees that occur on the blockchain. A study by Levy and Barnes [165] reveals that over two-thirds of the revenue of Thetan Arean, a blockchain-based game combining both F2P and P2E models, are from transaction fees on the blockchain, albeit experiencing a fluctuation over time. It is always a good idea for the company to not rely solely on a single business model and to find new revenue streams in such a highly competitive environment as the online gaming industry.

3. O_5 W_4 (See Table 52)

Table 52. WO strategies (3).

Opportunities (O)	
O_5	Better unit economics (MO_1)
Weaknesses (W)	
W_4	High switching costs (ORB_4)

According to Alroumi [166], blockchain-based games and the P2E model can lower the player acquisition cost for game developers. P2E games are known for their characteristics that can provide financial incentives for players, thus generating word of mouth and reducing marketing costs. Moreover, blockchain-based games can encourage high player spending compared to F2P games. The reason is that spending within the game can be considered a form of investment opportunity. Because of the decreased player acquisition cost and increased customer spending, the P2E model provides game developers with an alternative business model that could provide long-term economic benefits to the company, thereby offsetting the high switching costs of blockchain-based games.

4. O_5 O_{11} O_{13} W_3 (See Table 53)

Table 53. WO strategies (4).

Opportunities (O)	
O_5	Better unit economics (MO_1)
O_{11}	Global user base (SO_4)
O_{13}	New business models (SO_6)
Weaknesses (W)	
W_3	Lack of understanding by top management (ORB_3)

Because of the nature of the P2E model, some part of the monetary value will be transferred to players. It could be difficult for the management to switch their current monetisation model where all the sales on the platform will go towards the company. To make blockchain-based games a part of the company's business strategy, the management team needs to believe that there will be greater tangible benefits which would be worth the time and effort as a result of adopting blockchain-based games. The benefits that the company would get immediately are the new P2E business model, which would act as an additional revenue stream; untapped markets on a global scale; and higher average revenue per player (ARPU) resulting from the revenue sharing model. The company also could put more effort into the R&D for blockchain-based games to study the technology and the potential benefits that it could bring to the organisation.

5. O_{10} O_{11} O_{13} W_6 (See Table 54)

Table 54. WO strategies (5).

Opportunities (O)	
O_{10}	New reward systems for players (SO_3)
O_{11}	Global user base (SO_4)
O_{13}	New business models (SO_6)
Weaknesses (W)	
W_6	Lack of proper resources and capabilities (ORB_6)

To mitigate the financial challenges, according to Binance Academy [167], one of the available options for

raising venture capital and project funding in the blockchain and cryptocurrency space is called ICO, which is a process that allows the company to raise funds through the use of cryptocurrencies. How ICOs work is often compared with how traditional companies raise funds through Initial Public Offering (IPO); however, ICOs are less regulated than capital markets [168]. This fundraising strategy can be used in the early development stages of blockchain-based games to get financial support from early investors around the globe who are interested in the product and service offerings of the company.

4.3.1.4. WT strategies

There is 1 WT strategy as follows:

1. T_2 T_5 W_2 W_6 (See Table 55)

Table 55. WT strategies (1).

Threats (T)	
T_2	Blockchain technology complexity (TB_2)
T_5	Absence of successful development and implementation of blockchain-based games in Thailand (TB_6)
Weaknesses (W)	
W_2	Lack of technological knowledge to distinguish different blockchain networks (TB_5)
W_6	Lack of proper resources and capabilities (ORB_6)

An expert stated, "We currently do not have enough knowledge to cope with blockchain technology, as our core competencies are in developing and publishing traditional online games." To minimise the company's weaknesses for the lack of technical knowledge and capabilities combined with external threats that there is no successful development of blockchain-based games in Thailand and that blockchain technology is complex, an acquisition of a blockchain-based gaming development company could be considered as part of the company's strategic options. This approach is based on the diversification strategy – horizontal integration from Ansoff's [169] product-market strategies. The company will have access to new products and services (i.e. blockchain-based games and related services) in a new market (i.e. blockchain and cryptocurrency industry), and the company would be able to increase its blockchain technology capabilities.

4.3.2. Roadmap

After having formulated all the possible strategies, a roadmap with action plans should be developed to help the company plan the investments, allocate resources, and make informed decisions about the adoption of blockchain-based games. Given the nature of the online gaming industry and the blockchain technology that is constantly evolving at a rapid pace, the roadmap is divided into short-, medium-, and long-term action plans over a period of 6 years from 2022 to 2027 (see Table 56). There are 2 approaches to developing action plans on the roadmap. First, the PNs of all the opportunity and barrier factors are considered. Factors with higher PNs mean they are considered more important, and immediate responses are required. If there is an alignment with the strategies discussed earlier, actions in response to those factors are then proposed as part of the short-term action plans. Second, the knowledge and experience of the experts from the semi-structured interview is used in combination with the literature for the development of the roadmap. Because of the time constraints, economic limitations, and legal considerations, the implementation of the proposed action plans falls outside of the scope of this research. Based on Table 56, suggestions for short-, medium-, and long-term projects to promote the adoption of blockchain-based games in online gaming companies in Thailand are as follows:

4.3.2.1. Short-term action plan

Resolve the Regulatory Uncertainty. Regulatory uncertainty is the main concern that online gaming companies face when deciding to adopt blockchain-based games. The government and regulators need to have clear frameworks and policies that can support the adoption of blockchain-based games. When players earn cryptocurrencies from blockchain-based games, they will recognise ordinary income based on the fair market value of the tokens, and capital gain (or loss) will be incurred when they disposed of those tokens depending on the price that has changed. Thus, tax implications that are currently unclear should be clarified for all stakeholders including online gaming companies, players, and investors. Moreover, NFTs as digital assets pose challenges in terms of intellectual property for online gaming companies [79]. There should be clear ownership rules and boundaries to help them protect their intellectual property rights. There also should be know-your-customer (KYC) and anti-money laundering (AML) regulations for online gaming companies to comply with to mitigate possible financial crimes [170].

Build a Small-Scale Pilot Project for Blockchain-Based Games. In the first phase of the roadmap, a small-scale pilot project should be built. The purpose of the pilot project is to test the developing and publishing processes of a blockchain-based game and consequently gain the knowledge and data required for successful implementation. The actions to set up the pilot project should include the identification of the goals, the design of the project with estimated time and costs, and the establishment of a team with appropriate training and resources to operate the project. Acquiring new talented employees with adequate skills and qualifications to join the team could also be considered. The result and feedback obtained from the project should be used to evaluate the failures and design improvement plans before

deploying blockchain-based games on a larger scale. In this phase, knowledge and data gained from this phase should also be shared between regulators and online gaming companies to plan suitable regulations required for the successful implementation of blockchain-based games.

Table 56. Action plans for the adoption of blockchain-based games.

Phase 1	Phase 2	Phase 3
Short-Term Action Plan (2022-2023)	**Medium-Term Action Plan (2024-2025)**	**Long-Term Action Plan (2026-2027)**
• Make blockchain-based games a part of the company's business strategy • Put effort into R&D to study the technology behind blockchain-based games and the immediate benefits of adopting blockchain-based games • Develop the utilisation plan for the tokenisation model and financial incentives of blockchain-based games for both internal and external stakeholders • Search for partners in the industry to develop a platform required for interacting with the ecosystem of blockchain-based games • Focus on R&D for blockchain-based games to find suitable development tools • Develop a small-scale pilot project for blockchain-based games • Develop a fundraising plan for the development of blockchain-based games • Explore the potential of using the P2E model as a new business model for the company • Regulators to plan the development of regulatory frameworks and policies • Release a series of educational content to educate the public about blockchain-based games • Study the tokenomics of blockchain-based games and how to develop a sustainable P2E business model	• Assess the ROI based on the pilot project and develop an improvement plan • Scale up the project to serve the existing user base • Integrate the company's knowledge and technological capabilities into improving graphics and gameplay for high-quality blockchain-based games • Assess additional opportunities for adopting blockchain-based games (e.g. cross-chain compatibility, management of digital assets, prevention of value leakage) • Develop a platform for players to participate in blockchain-based games • Conduct market research to understand players' expectations • Continue to invest in R&D for blockchain technology robustness • Establishment of official rules and regulations about blockchain-based games for game developers, players, and investors	• Fully publish blockchain-based games as part of the company's product and service offerings • Continue to invest in R&D for the development of related technologies to further improve blockchain-based games • Explore long-term benefits of adopting blockchain-based games (e.g. support for a better gaming ecosystem, long-term business learning, and organisational changes) • Policy frameworks to support the adoption of blockchain-based games for online gaming companies • Investment incentives for online gaming companies to adopt blockchain-based games

Design a Sustainable P2E Model. One of the key features of blockchain-based games is the P2E model. However, according to Nystrom [171], the current P2E model has 3 main flaws: 1) blockchain-based games are too reliant on the "pay-to-win" game dynamic (i.e. the practice of paying money that gives players a significant advantage over others); 2) huge upfront investment in NFTs is required for players to play blockchain-based games, which is a barrier to entry for potential players, thus further enhancing the pay-to-win game dynamic; and 3) blockchain-based games are not enjoyable, and players are motivated only by financial incentives. As a result, these routine actions make the P2E model unsustainable in the long term. The sustainability of the P2E model is, therefore, the main challenge that the company as one of the leading online gaming companies in the industry needs

to overcome. The company should use its business expertise and study the existing blockchain-based games in the market to create a P2E model that can sustain a competitive environment and has a robust economy.

4.3.2.4. Medium-term action plan

Scale up the Pilot Project for Blockchain-Based Games. The second phase of the roadmap is to scale up the pilot project. The purpose of this phase is to utilise the knowledge and experience gained from testing the pilot project in the first phase of the roadmap to extend the project to serve the existing user base of the company, which will provide the company with more knowledge and data on a larger scale. There also should be an evaluation of the commercial potential of the P2E model of blockchain-based games by assessing the ROI and the revenue-generating model.

Develop a Platform for Blockchain-Based Games. Online gaming companies must overcome user experience challenges in designing blockchain-based games. The objective of this phase should be to focus on how players can participate in the ecosystem of blockchain-based games in a seamless manner without the need to directly interact with blockchain technological complexities. A platform should be developed and integrated into blockchain-based games to provide, for example, the process of on-ramps and off-ramps, which can facilitate the exchange between fiat money and cryptocurrencies. The company could also collaborate with other leading developers in the industry to build such a platform.

4.3.2.2. Long-term action plan

Fully Publish Blockchain-Based Games. The last phase of the roadmap is the full deployment of blockchain-based games as part of the company's product and service offerings. The blockchain-based games in this phase are improved from the second phase to have higher quality in terms of graphics, gameplay, and monetization model with more reliable underlying blockchain technology. There is still a need for continuous R&D to keep up with constantly changing technology and to mitigate risks in deploying blockchain-based games as well as maximise the long-term benefits of blockchain-based games on a larger scale. Moreover, it is expected that there will be policy frameworks and investment incentives from the government to support the adoption of blockchain-based games for online gaming companies in Thailand.

5. Discussion and Conclusion

5.1. Discussion

Blockchain-based games, which mainly include the use of NFTs and cryptocurrencies to create a new digital economy and a new business model called "P2E", are a potential disruption to the value proposition of online games and how developers and players communicate and interact with each other, thereby posing great challenges to traditional companies in the online gaming industry. Although blockchain-based games are evolving and growing fast [172], they are still in an early stage. There are limited studies regarding the potential opportunities and challenges of blockchain-based games, especially from a managerial perspective. This research thus aims to close the literature gap and study potential opportunities and barriers related to the adoption of blockchain-based games in an online gaming company in Thailand, as well as suggest how it can seize the opportunities that blockchain-based games could offer and overcome the barriers that prevent the adoption of blockchain-based games.

This research studies the applications of blockchain technology in the online gaming industry. It is found that blockchain can be used as the underlying technology of online games, also known as blockchain-based games. Blockchain-based games are part of DApps or Web 3.0 applications. Ethereum is the most recognised blockchain used for hosting blockchain-based games. Moreover, many elements of blockchain technology are utilised in blockchain-based games. Some examples are NFTs that can be used as digital assets for blockchain-based games, which introduce the concept of digital scarcity and increase a sense of ownership; Smart contracts that are used to verify transactions and the transfers of the ownership of digital assets, hence improving transparency and traceability; and cryptocurrencies that are used as a means of payment and financial incentives for participating in blockchain-based games, hence the creation of the new business model "P2E". The Metaverse, which is an emerging theme in the blockchain industry, is a futuristic concept of virtual worlds where physical and digital lives are converged. Blockchain and Web 3.0 applications are expected to play an important part in building future virtual spaces where people will have new forms of social interactions and digital economies.

This research also identifies potential opportunities and barriers related to the adoption of blockchain-based games in an online gaming company in Thailand. To achieve this objective, potential opportunities and barriers are identified based on the literature review. However, there are 6 additional factors, which are 3 opportunities and 3 barriers, proposed in this research. As a result, a total of 23 opportunities and 24 barriers are identified in this research.

Next, all the identified opportunities and barriers are classified. Shang and Seddon's [1] benefits framework is used for classifying the opportunities. All 23 opportunity factors are categorised into 5 dimensions:

- 4 Operational opportunities;
- 3 Managerial opportunities;
- 9 Strategic opportunities;
- 4 Infrastructure opportunities; and
- 3 Organisational opportunities.

The TOE framework is used for classifying the barriers. All 24 barrier factors are categorised into 3 dimensions:

- 9 Technological barriers;

- 8 Organisational barriers; and
- 7 Environmental barriers.

The opportunities and barriers related to the adoption of blockchain-based games in an online gaming company in Thailand are then assessed. There are 4 main steps used to evaluate the opportunities and barriers: 1) application of FMEA; 2) application of AHP; 3) calculation of PN; and 4) Pareto analysis.

1. The concept of the FMEA process is used in this research. Each opportunity and barrier comprises 3 elements of FMEA, which are: Likelihood (L), Impact (I), and Control (C). A 5-point Likert scale questionnaire is sent to a total of 7 experts at the online gaming company in Thailand to assign a score ranging from 1 to 5 to these elements of each factor based on the given criteria.

2. To improve the FMEA process in this research, the AHP is used to determine the relative weights of each FMEA element. The reason is that each of these elements might have a different effect on the company's decision to adopt blockchain-based games. AHP's preferences are obtained from the group interview with the same group of experts who agree to participate in the questionnaire.

3. The PN of each opportunity and barrier is calculated by finding a sum of all FMEA elements after being multiplied by their respective relative weights. The resulting PNs can be used to determine which factors are more important. The factors with higher PNs mean that they are more important. In terms of opportunities, the highest-ranked dimension by PN is infrastructure, followed by strategic, organisational, operational, and managerial, respectively. Two opportunities with the highest PN are from the strategic dimension: *increased sense of ownership* and *customer co-creation*. The properties of NFT used as digital assets in blockchain-based games can help improve the strategic outcome of the company in a way that players would have an increased sense of ownership over the digital assets. The reason is that the use of blockchain technology and NFTs can represent proof of ownership, introduce scarcity, and ensure the traceability of digital assets [173]. Enabled by blockchain technology, tokenisation is described as the future of co-creation [174]. The reason is that tokens, which are transferable and exchangeable, represent a measurable unit of value and provide incentives for stakeholders to participate in the networks, thereby promoting collaboration and collective decision-making. In terms of barriers, the highest-ranked dimension by PN is environmental, followed by technological and organisational, respectively. The barrier with the highest PN is from the environmental dimension: *regulatory uncertainty and legal considerations*. This means it is clear that the adoption is affected by concerns about how the authorities in Thailand may impose legislation or restrictions that could affect the blockchain industry and blockchain-based games and no clear regulations in many aspects of the blockchain industry in Thailand. The result of this research that regulatory uncertainty is the main challenge to the adoption of blockchain-based games also correlates with the result from a survey conducted by BGA [74], although the respondents live in many different geographical locations.

4. Lastly, the Pareto principle is applied in this research to find critical opportunities and barriers. As a result, out of a total of 23 opportunities, there are 21 critical opportunities:

- 4 Operational opportunities;
- 3 Managerial opportunities;
- 7 Strategic opportunities;
- 4 Infrastructure opportunities; and
- 3 Organisational opportunities.

Out of a total of 24 barrier factors, there are 19 critical barrier factors:

- 7 Technological barriers;
- 6 Organisational barriers; and
- 6 Environmental barriers.

Possible strategies and a roadmap with an action plan to exploit the opportunities and address the barriers to the adoption of blockchain-based games in an online gaming company in Thailand are also proposed. The TOWS matrix is the tool used for formulating strategies by matching external factors with internal factors of the company. It is found that the company has 9 internal factors (i.e. 8 internal strengths and 1 internal weakness), which are used in combination with 21 critical opportunities and 19 critical barriers to create the strategies that can serve as guidance for the company on how to respond to the critical opportunities and barriers related to the adoption of blockchain-based games. As a result, a total of 7 SO, 12 ST, 5 WO, and 1 WT strategies are proposed in this research. A roadmap including short-, medium-, and long-term action plans to promote the adoption of blockchain-based games in the company is also proposed. The action plans are developed based on the PNs and the experts' feedback from the interview.

5.2. Limitations of the Research

This research has a few limitations as follows:

- There is limited prior academic literature on the topic of this research, which studies opportunities and barriers to the adoption of blockchain-based games. Although this research is able to extract additional factors (see Section 4.2.1), there possibly could be other factors that are not included in this research.
- The findings of this research are based on a questionnaire and an interview with a group of experts from one of the online gaming companies operating in Thailand. This research thus may not be able to represent the entire industry. Representatives from different companies could have different viewpoints on factors related to the adoption of blockchain-based games.
- This research does not include the perspectives of other stakeholders who could influence the adoption of blockchain-based games such as the government and financial regulatory authorities when developing the strategies and the roadmap.
- Limitations of quantitative analysis in this research should also be considered.

5.3. Conclusion

Blockchain has a disruptive impact on many sectors, one of which is the online gaming industry. The reason is that blockchain-based games can revolutionise the online gaming industry by introducing players and developers to new ways of interacting with each other and changing the value proposition of playing games. The findings of this research have shown that blockchain-based games could be developed so that they benefit from the features of blockchain technology by including the use of DApps, smart contracts, and NFTs. Blockchain-based games and blockchain technology as a whole are still in their preliminary stage but are constantly evolving. Thus, the future of blockchain-based games is yet to fully unfold. There has been an increasing number of industry veterans and practitioners stepping into the blockchain industry by developing blockchain-based games and integrating blockchain features into their product and service offerings. In years to come, as blockchain-based games are being adopted and experimented on, not every project will succeed, and there will be rises and falls of many projects along the way. However, one thing is certain: blockchain will introduce interesting years of R&D and innovation to the online gaming industry. The successful implementation of blockchain-based games in the online gaming industry eventually could be one of the key reasons for the mass adoption of blockchain technology.

This research proposes possible strategies that could be used as guidance to promote the adoption of blockchain-based games in online gaming companies in Thailand. How the opportunities could be exploited and how the barriers could be addressed are also discussed in this research. Following the proposed strategies, there are further actions to be made by all the relevant stakeholders including online gaming companies, the government, and authorities to facilitate the adoption of blockchain-based games. The findings of this research are beneficial to online gaming companies in such a way that a comprehensive view of the critical opportunities and barriers is clearly shown from a managerial perspective. Moreover, the proposed strategies and the roadmap with action plans can shape the path of strategic development, design of strategic decisions, planning, and frameworks, and provide suggestions for the successful adoption of blockchain-based games not only for the case company but also for other online gaming companies in the industry.

The findings of this research offer significant insights into the opportunities, barriers, and strategies for the adoption of blockchain-based games; however, the research methodology could be extended. Although the semi-structured interview format in this research could be considered appropriate for an explorative study, alternative methods such as a Delphi study could be used during the identification and evaluation processes of opportunities and barriers for a more organised approach to collecting and analysing experts' opinions, which could result in a more in-depth understanding of the research subject and more robust findings. Moreover, all opportunities or barriers may not be equally important in real-life and their influence on the adoption of blockchain-based games may not be the same. As there could be different strategies for technology adoption, the change in the priority of one opportunity or barrier may relatively affect another. Thus, the methodology of future studies could be designed so that the relationships between each factor in the same category, the relative weights of different categories, and their effects on the adoption of blockchain-based games are considered.

By using this research as a foundation, the scope of future studies could be extended in a way that more traditional online gaming companies and other stakeholders (e.g. representatives from the government and authorities) could be included throughout all the steps of the research. Their opinions also could be used to fill the literature gap and could be considered when developing the strategies and the roadmap to serve as a guiding tool in facilitating the adoption of blockchain-based games.

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