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Analysis of Impact of the Economic Benefits on the Play-to-Earn Game: Evidence from Axie Infinity

Play-to-Earn 게임에서 경제적 이익의 영향 분석: Axie Infinity 사례 연구

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ABSTRACT

At the peak of the cryptocurrency boom in 2017, the first blockchain game, CryptoKitties, came out. Since then, there has been a race to make games that are better and more original. The experts believe this is the future of gaming since younger generations are more immersed in the gaming and cryptocurrency ecosystem. In this research, I use a theoretical model to analyze the relationships among the cryptocurrency, the non-fungible token (NFT) market, and the number of players in Axie Infinity, one of the most popular Play-to-Earn (P2E) games. An empirical analysis with data from the popular P2E game confirms the findings that the trading NFTs and the rise of the cryptocurrency benefit the users and operators. Moreover, there are positive correlations between the number of daily active users, the trading volume of NFTs, and the price of the cryptocurrency. The results of this empirical research clearly suggest that the economic benefits plays a significant role in the virtual world.

Keyword : Blockchain, Virtual economy, Cryptocurrency, Non-Fungible Tokens, Playto-Earn game **Student Number :** 2021-29946

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CHAPTER 1. INTRODUCTION

1.1. Research Background

Traditional gaming models typically follow the principles of free-to-play, play-towin, and pay-to-play, wherein any in-game items bought or upgrades paid for do not translate into tangible economic profit. This is primarily due to the nontransferable nature of these in-game purchases. Enhanced game assets are confined to the specific gaming universe they are a part of, suggesting that they hold no value in real-world economic terms. Nevertheless, the introduction of blockchain technology has profoundly reshaped the gaming industry's monetization tactics. Developers have begun to devise unique ways to monetize games that provide players with actual economic returns corresponding to their gaming skills and time investment. Blockchain's immutable ledger allows for secure transfer of in-game assets into the real world, where they can be traded for cryptocurrency, thereby assigning real-world value to these formerly intangible assets.

The advent of the play-to-earn (P2E) model, a disruptive business model driven by blockchain technology, Non-Fungible Tokens (NFTs), and cryptocurrency, marks a major shift in the gaming industry. NFTs, unique cryptographic assets, establish ownership of digital commodities on the blockchain. They serve as distinctive in-game items such as skins, trading cards, or characters, and their uniqueness drives their value. P2E games employ utility

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tokens, which function as native currencies on decentralized platforms. These platforms offer various benefits to players, including secure peer-to-peer transactions and the facilitation of smart contracts. Renowned utility tokens such as Ether, Filecoin, and GameCredits finance a wide array of activities, including game purchase, development, and consumption. These platforms raise funds by selling tokens to investors and prospective users. In the P2E model, the more players participate, the more in-game assets they can accumulate. This, in turn, enhances the value of these assets due to the network effect. Thus, participants stand to earn rewards that can be converted into real-world value. This novel approach not only revolutionizes the gaming experience for players but also redefines the economic dimensions of the gaming industry.

In play-to-earn game economy, players and developers work together in a similar manner to business partners. The players' role in the economy is to possess valuable assets and share them via trade. This should increase the number of participants in the game. Users can contribute to the growth of the P2E game economy by playing the game, completing tasks, and earning rewards. As more players join the game, the demand for in-game rewards or cryptocurrency increases, which can drive the value of these rewards up. This, in turn, can attract more players to the game, creating a positive feedback loop that can fuel the growth of the economy. Simultaneously, developers can contribute to the growth of the P2E game economy by creating new contents and improving existing ones.

By creating engaging and rewarding gameplay experiences, developers can attract more players to their games, which can help to increase the demand for in-game rewards or cryptocurrency. Additionally, developers can create new features or items that players can purchase using the in-game rewards or cryptocurrency, which can further increase the value of these rewards. In fact, as the popularity of the game's NFT collection grows, so does the developers' profit. For instance, as producing NFTs has a cost, developers recoup the cost from transaction fee earnings. The original creator earns money from the transaction fee every time an NFT is exchanged. For instance, if a royalty fee for a character NFT is set at 5%, then the developer will profit indefinitely every time this NFT is sold to another player.

Overall, the growth of the P2E game economy depends on the ability of developers to create engaging gameplay experiences and the willingness of users to play and earn rewards within these games. As the popularity of P2E games continues to increase, it is expected to see even more innovation in this space, driving further growth and expansion of the economy.

1.2. Research Question

The P2E games combine two things that consumers desire: entertainment and the opportunity to earn money. It is already established that people play games to enjoy them (Egli and Meyers 1984; Greitemeyer et al. 2019; Holl et al. 2020).

Nevertheless, the presumption that gaming is solely for entertainment overlooks the potential of financial incentives as a potent driving force for player engagement. This prompts an investigation into how the allure of monetary gains could sway participation rates in P2E games.

The value of participating in the game to one user is positively affected when another user joins and enlarges the network. Concurrently, the current research endeavors to discern the impact of volatility in the cryptocurrency and NFT markets - components intrinsic to P2E games as trading currency and assets - on player participation. Understanding these spillover effects could shed light on how the macro dynamics of financial markets influence the microcosm of P2E games. Thus, variations in demand within the cryptocurrency and NFT markets could result in a corresponding increase, decrease, or no change in P2E game participation, ceteris paribus. In line with this, the focal research question this study seeks to address is: *How do the cryptocurrency and NFT markets impact the number of players in the P2E game*?

CHAPTER 2. LITERATURE REVIEW

2.1. Information Technology and Economic Value

In the ever-evolving digital landscape, the advent of Web 3.0, frequently denoted as the decentralized or semantic web, has initiated a series of profound economic implications, reshaping the way individuals engage with internet technologies, platforms, and digital economies. This transformation is particularly noticeable in the world of online gaming, where users globally engage in shared virtual worlds, shaping an intricate network of communication and information exchange (Curtis, 1992).

Scholars and policy makers have expressed a significant interest in the novel business models ushered in by digital platforms (Bakos & Bailey,1997; Parker & Van Alstyne, 2005). The impact of digitalization is evidenced in sectors like online food delivery, which has notably altered American dining and meal preparation behaviors (Babar et al., 2021). Similarly, the advent of gig-economy platforms has stimulated local entrepreneurial activities while providing stable employment opportunities to the under-employed (Burtch et al., 2016). An important area of technological influence is ride-hailing services, significantly shaping transportation-related decisions (Lee et al., 2019; Circella & Alemi, 2018). Moreover, the use of information and communication technology has enhanced economic growth (Farhadi et al., 2012). Our research aligns with recent studies

exploring the economic consequences of burgeoning technologies such as Artificial Intelligence (Brynjolfsson et al., 2019). Additionally, there has been exploration into how a digital, blockchain-based technology can transform traditional physical asset markets and induce economic effects (Kanellopoulos et al., 2021). Within this context, this study extends the existing body of literature concerning how the introduction of new services modifies individuals' behaviors and choices, focusing on the impact of P2E games on users' behaviors driven by tangible incentives or extrinsic motivation. The integration of real-world economic value into gaming environments challenges the traditional boundaries between work and leisure. Following Castronova's seminal works (2002, 2004), players must make strategic decisions balancing their in-game victories and real-world earnings. The players' choices might shift towards more gaming hours, potentially impacting other activities such as traditional work or leisure, presenting a new perspective for Information Systems (IS) researchers studying technologymediated work, and contributing to the discussions on the gig-economy. Table 1 serves as a valuable reference, showcasing relevant studies that delve into the impact of emerging technologies on individuals' behaviors and choices, as well as the economic value attributed to information technology.

Authors (Year)	Title	Journal	Key Findings
Bakos and Bailey (1997)	An Exploratory Study of the Emerging Role of Electronic Intermediaries	International Journal of Electronic Commerce	New emerging roles for electronic intermediaries has reshaped the traditional dynamics of commerce.
Brynjolfsson et al. (2019)	Does Machine Translation Affect International Trade? Evidence from a Large Digital Platform	Management Science	Introduction of machine translation system has significantly increased international trade on the platform.
Burtch et al. (2019) Lee et al. (2022) Babar et al. (2021)	Can You Gig It? An Empirical Examination of the Gig Economy and Entrepreneurial Activity Impact of Ride-Hailing Services on Transportation Mode Choices: Evidence from Traffic and Transit Ridership Cooking or Clicking: The Impact of Online Food Devlivery Platforms on Domestic Food Preparation	Management Science MISQ Academy of Management	Introduction of new services can affect peoples' habits and choices: transportation, local entrepreneurial activity, meal preparation activities and physical health, etc.
Kanellopoulos et al. (2021)	Do Non-Fungible Tokens (NFTs) Affect Prices of Physical Products? Evidence from Trading Card Collectibles	ICIS 2021 SSRN Electronic Journal	Introduction of NFTs affect the prices of their physical counterparts.

Table 1. Key Papers on IT and Economic Value

Web 3.0 and Play-to-Earn (P2E) games are intertwined, creating economic effects through their combination of blockchain technology, smart contracts, and decentralized finance. Notably, P2E games, such as Axie Infinity, empower players to earn digital tokens through in-game activities. These tokens, bearing real-world value, can be exchanged or sold, introducing a new income source. This

becomes even more crucial for players in developing countries where these earnings can surpass traditional income sources. Furthermore, P2E games allow players to own their in-game items, characters, or lands in the form of NFTs, marking a departure from traditional gaming models where all economic value is captured by the developer or publisher.

Overall, the emergence of P2E games initiates a novel paradigm potentially altering individuals' behaviors and choices significantly, making it a subject of keen interest to the IS literature. As P2E games continue to evolve, IS researchers are presented with ample opportunities to delve into the behavioral changes and decisions that these games instigate, enriching established IS literature streams.

2.2. Network Effect

The premise of network effects is that the value of a product or service increases with the number of its users. Contributing to the two-sided network externality literature, our research examines how the value of participating in the game to one user is positively affected when another user joins and enlarges the network. In this case economic theory suggests that the value of membership to one user is positively affected when another user joins and enlarges the network (Katz et al., 1994). The cryptocurrency market is heavily influenced by the network effect, which results from the volatility of cryptocurrency prices. Cong, Li, and Wang (2021) underscore the importance of a robust network effect within platform users. To investigate the interplay between user adoption and the responsiveness of token price to expectations for future growth on the platform, the researchers develop a dynamic model of crypto tokens. The supply and demand of cryptocurrency fluctuate frequently and are highly reliant on the number of users in the market. If more users join the platform, each benefits more from joining the platform and is willing to pay a higher token price. However, if investors lose confidence in the cryptocurrency, they may sell it, causing prices to drop. The network effect is at play when more people purchase cryptocurrency because everyone benefits from the rising price.

Additionally, more players can also lead to increased demand for in-game assets (such as NFTs), which can raise their market value and potentially lead to greater profits for players who earn, trade, or sell these assets. This economic potential can further fuel the game's growth and popularity. NFTs are akin to the art world, where possessing a famous piece of art does not provide much utility

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but is highly valued in our culture. This is why original and unique works of art are more expensive than replicas. While it may seem easy to take a screenshot of an NFT or own a copy of it on a computer, this does not account for the network effect. As more individuals participate in the NFT market, the value of owning the original piece increases, especially because blockchain technology provides public proof of ownership. Drawing on the network effect and the history of previous digital technologies that have relied on similar effects, it is possible to predict the future success of cryptocurrency and NFT-based platforms like play-to-earn games.

Network effects have been extensively studied in IS literature, particularly in the context of digital platforms and online communities. This stream of research has shown that network effects can drive the success of digital platforms. With P2E games, IS researchers have an opportunity to extend this literature in several ways. They can explore how network effects manifest in the unique context of P2E games, where traditional gameplay and economic activity intertwine. They can also investigate how network effects interact with other factors, such as game design or economic conditions, to influence the success or failure of P2E games. Moreover, P2E games can provide a setting to study new forms of network effects, such as those arising from blockchain technology. For instance, how does the transparency and immutability of blockchain affect network effects? Or how do cross-game or cross-platform networks, enabled by blockchain interoperability, influence the dynamics and impacts of network effects? These are just some of the exciting questions that IS researchers could explore in this emerging field.

2.3. Spillover Effect

Economic changes in the real world, such as cryptocurrency market fluctuations or broader economic conditions, can directly impact the perceived profitability and attractiveness of P2E games, affecting both player engagement and developer investment. IS literature has examined how economic conditions influence technology adoption and use, and P2E games provide a unique context to extend this research. A spillover effect is a phenomenon that broadly refers to the impact of events in one setting on events in a different, seemingly independent setting (Rutherford, 2013). Thus, this study adds to the literature on spillovers across twosided platforms (Seamans and Zhu 2014, Zervas et al. 2017, Krijestorac et al. 2020), since P2E games, cryptocurrency market, and the NFT market are all examples of two-sided platforms where buyers and sellers meet to trade. Our research established whether the cryptocurrency as well as the NFT market have an impact on the users participating in P2E games, which in turn helps to understand the spillover effect of the larger platform on the smaller platform. Consequently, depending on how much demand fluctuates in the cryptocurrency and NFT market (due to their spillovers), the number of participants in P2E games can increase, decrease, or not change at all, ceteris paribus. In all these ways, P2E

games provide an exciting new context for IS researchers to explore spillover effects. Understanding these effects can provide insights for game developers, players, and policymakers, as well as contribute to broader theories about the role of digital technologies in society.

Apart from its academic contribution, our work has practical implication in online gaming industry. Due to the fast growth of gaming NFT market and P2E games, incumbents in video game industry must comprehend them in order to position themselves more effectively. Even though, P2E game is still a relatively new concept, it has the potential to reshape more than just the gaming landscape. As technology has the potential to fundamentally alter how individuals interact with and perceive traditional socioeconomic organizations such as financial institutions, marketplaces, and governments (Weforum, 2021).

CHAPTER 3. HYPOTHESIS DEVELOPMENT

In the rapidly evolving landscape of cryptocurrency, non-fungible tokens (NFTs), and play-to-earn (P2E) games, the dynamic of two-sided markets is an inherent characteristic. These platforms, which facilitate interaction and trade between buyers and sellers, may demonstrate a spillover effect where a larger market can influence a smaller one. This study aims to explore the impact of these wider markets, particularly the cryptocurrency and NFT markets, on player participation in general P2E games.

The cryptocurrency market, with Bitcoin as its most prominent representative, often influences the overall sentiment towards crypto-related activities. When Bitcoin's price increases, it frequently sparks an upsurge in interest and investment in the broader cryptocurrency space. Thus, a growing Bitcoin price could indirectly heighten the number of players in P2E games by escalating the general interest in crypto-related activities. In this light, we propose the following hypothesis:

Hypothesis 1: The cryptocurrency market is positively associated with the number of players in the play-to-earn game.

Recognizing the potential economic benefits offered by P2E games via NFT trading and the prospect of network effects increasing the value of in-game assets (also in the form of NFTs), we posit that these factors may significantly impact player participation in P2E games.

Hypothesis 2: The net NFT market is positively associated with the number of players in the play-to-earn game.

The gaming asset market within any P2E game primarily comprises NFTs unique to that platform. These NFTs typically represent in-game assets, such as characters, land, and items. As such, the trading volume of these NFTs can serve as an accurate representation of the level of economic activity within the game, thus providing insights into the game's popularity and player engagement. Therefore, it can be reasonably expected that a thriving gaming asset market in a P2E game contributes to the expansion of its player base. Hence, we hypothesize a positive relationship between the two.

Hypothesis 3: The play-to-earn gaming asset market is positively associated with the number of players in the play-to-earn game.

CHAPTER 4. METHODOLOGY

4.1. Data Collection

To analyze the participants in P2E game, data on the number of players in Axie Infinity was gathered from a public gaming source. The collected data was subsequently analyzed on a weekly basis. This specific time frame was chosen due to its ability to capture routine behaviors commonly associated with entertainment experiences. Drawing inspiration from examples such as people eagerly watching their favorite TV series aired on a weekly basis or indulging in hobbies during specific time frames each week, this approach sought to uncover similar patterns within the context of Axie Infinity's player engagement (Ma et al., 2014). The resulting dataset encompassed weekly observations spanning from May 2021 to July 2022. Within this dataset, several key variables were analyzed, including the sales of Axie Infinity NFTs, the total number of NFT sales, and the price of Bitcoin in US Dollar.

The volume of NFT sales serves as a valuable indicator of the overall activity and dynamism within the NFT market. Higher sales volumes suggest a robust and active market, which is likely to attract more participants, including potential players for P2E games. Therefore, the NFT data was sourced exclusively from the NonFungible Corporation, a reputable entity known for providing comprehensive NFT market data. Notably, the information obtained from the NonFungible Corporation exclusively focused on the Ethereum blockchain, which accounts for the vast majority of NFT transactions worldwide, ensuring a representative view of the NFT market's dynamics.

The sales volume of game-specific assets (in this case, Axie Infinityspecific NFTs) is used as an independent variable. The data for Axie Infinity NFTs was gathered from CryptoSlam, a prominent NFT aggregator known for its comprehensive coverage of NFT sales across multiple platforms. This allowed for a holistic view of the Axie Infinity NFT ecosystem, encompassing the various transactions and activities taking place within it. In order to gain insights into the cryptocurrency's market performance, information regarding the price of cryptocurrency was gathered from coingecko.com. By incorporating this data, we assessed any potential correlation between the price of BTC and player behaviors within Axie Infinity.

4.2. Description of Variables

Our dependent variable in this analysis is the weekly active users of Axie Infinity. We chose this metric as it directly reflects player engagement and investment in the game. The weekly active users of Axie Infinity are determined by aggregating the number of daily active users (DAU) over each week. DAU represents the total count of individuals who have actively engaged with the game by launching it at least once during a 24-hour period. By summing up the DAU figures for each day of the week, the weekly active user count is established.

The independent variables of interest encompass the weekly price of Bitcoin, the overall sales volume of NFT, and the specific volume of Axie Infinity NFT transactions. The Bitcoin price is determined weekly and signifies the trading value of Bitcoin in relation to the US Dollar during that specific week. Similarly, the NFT sales volume is a weekly measure, reflecting the aggregate volume of NFTs traded in the market within a given week. The sales volume of Axie Infinity NFT is also a weekly metric, exclusively accounting for the trading volume of Axie Infinity's own NFTs. A comprehensive overview and description of all the variables utilized in this study is presented in Table 2.

No.	Variables		Description
1	Dependent	Players in Axie Infinity	Weekly aggregate of daily active users (DAU) in Axie Infinity
2		Bitcoin Price	Weekly Bitcoin price in US Dollar
3	Independent	NFTs Sales Volume	Weekly sales volume of NFTs in US Dollar
4		Axie Infinity NFTs Sales Volume	Weekly sales volume of the Axie Infinity- specific NFTs in US Dollar

Table 2. Description of Variables

4.3. Empirical Model

The autoregressive distributed lag model (ARDL) is used to explore the link among the number of participants in the P2E game, cryptocurrency, and NFT market. The ARDL is an econometric tool used to analyze the relationship between variables in time series data. It is particularly useful when the variables under study are non-stationary, meaning they exhibit a trend or random walk over time. In the context of exploring the link among the number of participants in the P2E (playto-earn) game, cryptocurrency, and NFT market, the ARDL model can help to estimate the long-run equilibrium relationship between these variables, while also accounting for short-run dynamics and possible feedback effects.

These diagnostic tests are essential for ensuring the reliability and validity of the ARDL model's estimations (Pesaran, 1999). Initially, a unit root test is performed on each variable to assess their stationarity properties. This test helps determine whether the variables exhibit stable, non-trending behavior or possess a unit root, indicating non-stationarity. Thus, to address potential non-stationarity in the time series data and to meet the requirements of the ARDL model, transformations were applied to the variables under investigation. Specifically, logarithmic transformations were implemented on all variables to stabilize variance and to make the series more closely approximate normal distributions. This transformation has the added benefit of allowing results to be interpreted in terms of percentage changes, which is often more intuitive in economic contexts.

Subsequently, first differences were computed for the dependent variables that are non-stationary, that is, to ensure that the statistical properties of the variables such as mean and variance do not change over time. This step is critical for valid inference in the ARDL model, as non-stationary series can lead to spurious regression results. Furthermore, lags of the dependent variable were included in the ARDL model. The inclusion of lagged dependent variables as regressors is a common practice in time series analysis, especially in ARDL models. This allows for the specification to account for dynamics in the response variable that are not explained by the current values of the explanatory variables. By including lagged dependent variables, the model can capture autocorrelation or 'memory' effects, where past values of the series influence its current and future values. It essentially allows the model to acknowledge that changes in the number of active players in a P2E game are dependent not only on current market conditions but also on past player behavior.

The Akaike information criterion (AIC) is utilized to identify the optimal number of lags that should be included in the model. This step is crucial as it ensures that the model captures relevant past information while avoiding overfitting. Then, in each equation of the ARDL model, we analyze the correlation and potential causality between the dependent and independent variables. This analysis helps uncover the relationships and interactions between the variables of interest. Furthermore, autocorrelation is assessed to understand the presence of any serial correlation in the data, which can impact the reliability of the model's estimations. Thus, given that all variables are log-transformed, the coefficients can be interpreted as elasticities. We will focus solely on the short-run dynamics, avoiding the examination of long-run relationships. Consequently, the proposed first-differenced ARDL model takes the following form in equation 1:

$$lnPlayer_{t} = \alpha + \Sigma \beta_{i} lnPlayer_{t-i} + \Sigma \gamma_{1i} \Delta lnBTC_{t-i} + \Sigma \gamma_{2i} \Delta lnNFT_{t-i} + \Sigma \gamma_{3i} lnAXS_{t-i} + \varepsilon_{t}$$

$$(1)$$

To determine causality between variables, the Granger causality test is employed. This test explores whether changes in one variable precede changes in another variable. If past values of one variable significantly impact the other variable, it is said to "Granger-cause" the latter (Granger, 1969). By applying the Granger causality test, researchers can establish causal relationships between the variables, with the direction of causality determined by the relative timing of the variables.

CHAPTER 5. ANALYSIS AND RESULT

5.1. Descriptive Statistics

Table 3 shows the descriptive statistics of each variable. As shown in Table 3, we can see the mean, standard deviation, minimum, and maximum of the number of

active players, price of Bitcoin, NFT sales volume, and Axie Infinity-specific NFT sales volume.

Summary Statistics	Ν	Mean	St. Dev.	Min	Max
Number of Active Players	55	1,378,640	835,352	61,125	2,718,810
BTC Price (USD)	55	40,914.17	11,082	20,068	65,296
NFT Sales Volume (USD)	55	7.510e+8	6.0708e+8	3.254e+7	2.097e+9
AXS NFT Sales Volume (USD)	55	65,238,265	7.0910e+7	552,498	212,294,755

Table 3. Descriptive Statistics

	NumberofPlayers	BTC	NFT	AxieNFT
NumberofPlayers	1.0000000	0.4463817	0.2740848	0.7744634
BTC	0.4463817	1.0000000	0.8566783	0.5894505
NFT	0.2740848	0.8566783	1.0000000	0.5993599
AxieNFT	0.7744634	0.5894505	0.5993599	1.0000000

Table 4. Correlation Scores

5.2. Empirical Results

ARDL Model

In the ARDL model, the coefficients represent the change in the dependent variable resulting from a one-unit change in the independent variable, while accounting for lags. Since both dependent variable and independent variables are log-transformed, the interpretation is in terms of percentage changes. This is due to the mathematical property of logarithms where the difference in logs is equivalent to the log of the ratio, which in turn approximates percentage change for small changes.

Coefficients	Estimate
С	0.05652 (0.0619481)
lnPlayers _{t-1}	1.2473** (0.0014522)
lnBTC _{t-4}	0.19842* (0.01581)
lnNFT _{t-4}	-0.04225* (0.0160841)
$lnAXS_{t-2}$	0.0596* (0.0160841)
Adjusted R ²	0.9966
Prob. (p-value)	2.2e-16

Note: '.' p < 0.1, '*'p < .05, '**'p < 0.01

Table 5. Result of ARDL Model

Based on the model's result, $lnPlayers_{t-1}$ is statistically significant at the because the p-value of 0.0014522 is less than 0.05 (and less than 0.01). The coefficient indicates that a 1% increase in the number of players in the previous period (lag 1) is associated with an approximate 1.2473% increase in the number of players in the current period, all else being equal. The positive and significant coefficient for the number of players at lag 1 suggests a persistence effect, meaning that an increase in the number of players in one period tends to carry over into the next period. The coefficient of $lnBTC_{t-4}$ suggests that a 1% increase in the price of Bitcoin four periods ago is associated with an approximate 0.19842% increase in the number of players in the current period, all else being equal. The negative coefficient of $lnNFT_{t-4}$ suggests that a 1% increase in NFT sales volume leads to approximately a 0.04225% decrease in the number of players, four periods later. This is a relatively small effect, but it is statistically significant given the p-value of 0.0160841, which is less than the significance level of 0.05. The observed negative relationship between the sales volume of the NFT market and the number of players in Axie Infinity could be influenced by a variety of factors; however, this does not support hypothesis 2. One possible explanation is that when the overall NFT market is booming, potential and existing players might be allocating more of their resources (time and money) towards other NFT investments, reducing their engagement with Axie Infinity. Moreover, if there are high returns to be made in the broader NFT market, the opportunity cost of spending time playing Axie Infinity (which could otherwise be spent trading or investing in NFTs) could increase, leading to a decrease in the number of players. Possibly, increased sales volume in the overall NFT market could reflect the entry or success of competing games or platforms, drawing players away from Axie Infinity. Lastly, the coefficient of $lnAXS_{t-2}$ suggests that a 1% increase in the sales volume of Axie Infinity NFTs two periods ago is associated with an approximate 0.0596% increase in the number of players in the current period. According to this result, there appears to be a statistically significant positive relationship between the sales volume of Axie Infinity NFTs two periods ago and the number of players in the current period.

In summary, the ARDL model suggests complex dynamics in the number of players in Axie Infinity, with influences from NFT sales volume, the game's own past player count, and the price of Bitcoin. These results provide interesting insights into the factors that might influence the player count in a play-to-earn game like Axie Infinity.

Granger Causality Test

While the ARDL model can provide estimates of the magnitude and significance of the relationships between variables, the Granger causality test can provide additional evidence on the direction of influence between variables. Hence, the Granger causality test is used to determine whether one time series can be used to forecast another. In other words, it is a test of whether past values of one variable help predict future values of another variable, beyond what can be predicted by the past values of the second variable itself.

According to the result of the Granger Causality test, the price of BTC Granger-causes the number of weekly active users of Axie Infinity (p = 0.046), implying that past values of Bitcoin price provide statistically significant information for predicting the current number of weekly active users in Axie Infinity. The volume of NFT sales Granger-causes the number of weekly active users of Axie Infinity (p = 2.49e-12). The volume of Axie Infinity NFT sales Granger-causes the number of weekly active users of Axie Infinity (p = 0.01358). This also suggests that past values of NFT sales volume have statistically significant predictive power for the current number of weekly active users in Axie Infinity. Interestingly, the relationship also seems to work in the opposite direction, with the number of weekly active users of Axie Infinity Granger-causing the volume of Axie Infinity NFT sales (p = 0.005022). This implies that the past values of the number of weekly active users in Axie Infinity hold significant predictive power for the current volume of Axie Infinity NFT sales.

CHAPTER 6. DISCUSSION AND CONCLUSION

6.1. Discussion and Implication

This study aims to analyze the relationship between the cryptocurrency and NFT markets and the number of players in the P2E game to examine how the fluctuations in the markets encourage or discourage the players in the game. It experimentally evaluates a number of hypotheses using detailed data. The empirical results may indicate a strong influence of larger financial markets, such as those of cryptocurrencies and NFTs, on the engagement and decision-making of P2E game players. Variations in these markets, whether they are upward trends or downward spirals, can be powerful determinants in influencing participation in P2E games. Consequently, this relationship suggests a remarkable potential for market expansion in response to the growth of cryptocurrency and NFT markets.

In line with the network effect theory, as more players participate in the game, the value of the in-game assets increases, thereby attracting even more players. This could further increase the demand for the related cryptocurrencies and NFTs used or traded in these games, setting up a virtuous cycle of growth. However, an intriguing anomaly found in the study is the negative relationship between the NFT sales volume and the number of players in specific P2E games like Axie Infinity. This counterintuitive finding hints at the possibility of resource reallocation, where during a booming NFT market, players might be investing

more of their resources in other NFT ventures, consequently reducing their engagement in P2E games. Such findings exemplify the complex dynamics of the P2E games ecosystem, which intertwines gaming, cryptocurrencies, and NFTs. They also highlight the importance of further research to unpack these relationships and to better understand how they can shape the future of P2E gaming. The potential for shared prosperity between game developers and players in this burgeoning sector is enormous, and its implications are significant not only for the gaming industry but also for the broader digital economy.

The current research on the economic impact of P2E games, specifically Axie Infinity, provides several critical theoretical implications, which collectively serve to enrich the field of IS literature and contribute to understanding digital economies and user behavior in such contexts. First, this study contributes to the IS field by providing novel insights into the interplay between emerging technologies such as blockchain, cryptocurrencies, NFTs, and their influence on digital economic systems like P2E games. This research serves as one of the pioneering studies in this relatively unexplored area within the IS discipline, providing a valuable foundation for further investigations. Furthermore, this study elucidates the manifestation of network and spillover effects within the P2E gaming environment. By observing these phenomena in action, the research deepens the existing theoretical comprehension of these effects within digital platforms and markets, extending the prevailing knowledge of network and

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spillover effects to novel contexts. The potential of P2E models to function as a form of gig work also implies a significant contribution to the existing gigeconomy literature. This study illuminates the challenges and opportunities presented by gig work within digital environments, building upon the theoretical understanding of how such forms of work may be evolving in the digital era. Lastly, this study's exploration of P2E games within the context of the decentralized web, a core characteristic of Web 3.0, enhances our theoretical comprehension of the economic, social, and technical implications of decentralization.

Moreover, this study has practical implications for the online gaming sector. Numerous online gaming businesses have begun to offer their virtual goods straight to customers. Allowing wealth transfer (throughout the game market) may increase competition between operators and the market for identical commodities. In Castronova's seminar work 'On Virtual Economies,' virtual economy might be linked with real economy. Indeed, the gaming system has evolved as a result of the emergence of P2E games. More study is needed to determine whether the global economy's boundary between the virtual and real economies will collapse sooner than expected. Because of the fast expansion of the crypto and NFT markets and P2E games, not only existing gaming firms but also associated businesses must grasp these systems in order to develop more successful strategies in the future. Therefore, even though P2E game is still a relatively new concept, it has the potential to reshape more than just the gaming landscape as technology has

the potential to fundamentally alter how individuals interact with and perceive traditional socioeconomic organizations such as financial institutions, marketplaces, and governments.

6.2. Limitation

Some limitations inherent in this research must be noted. The empirical models employ a limited number of variables. Further exploratory research is needed to improve on them. Even though Axie Infinity is the one of the largest and most popular game in the P2E gaming market, the data sets are limited to those only from a single game. Consequently, the generalization of our findings may be hindered by this constraint. A downward trend in the markets could lead to biased results in empirical analysis due to confounding factors. For example, players may be more likely to stop playing the game during a bear market due to financial reasons, leading to an overestimation of the impact of the cryptocurrency and NFT markets on the game. Therefore, the highly volatile nature of cryptocurrency and NFT markets could lead to sudden and unpredictable changes that may not be captured in the model. This volatility could introduce significant noise into the data, potentially impacting the accuracy of the findings.

Behavioral factors can significantly influence the outcomes of P2E games. These factors encompass a broad range of elements that can alter a player's engagement level with the game. For instance, updates or changes to the game's

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mechanics, introduction of new features, or even external events like holiday seasons can greatly impact player behavior. During festive seasons, players may engage more with the game due to increased leisure time, leading to a temporary surge in the game's activity that doesn't necessarily reflect its usual trend. Furthermore, the release of new games in the market can also draw players away, affecting the overall engagement and profitability of the game under study. Neglecting these factors can potentially lead to a skewed understanding of the game's dynamics and its profitability over time.

6.3. Future Research

The virtual world is a fascinating topic for IS researchers and economists due to the fact that operators of virtual worlds have almost complete knowledge of their worlds, similar to gods. These economic systems grow at the speed of light on these planets. This creates an exceptionally fertile environment for microeconomic and macroeconomic study by academics, practitioners, and policymakers. We feel that this work represents a new horizon of analysis within this area of inquiry.

The findings of this research pave the way for numerous future studies, particularly within the emerging domain of play-to-earn games and the intersections of cryptocurrency and the NFT marketplaces. First, it is important to note that Axie Infinity represents only a single instance of play-to-earn gaming. Future investigations could mirror this study's methodology with different games of a similar nature, contrasting and comparing the outcomes. Such an approach would elucidate whether the identified relationships are consistent across games, or if unique dynamics are at play within individual games. Second, a deeper analysis of player behavior could yield valuable insights. Future studies might probe into the impact of in-game economic incentives on factors such as player retention, duration of gameplay, and in-game expenditure patterns. Third, local and global economic conditions could potentially exert influence over the dynamics of play-to-earn games. An avenue of exploration for future research could be examining how broader economic indicators, like unemployment rates, economic downturns, or policy shifts, can impact both player count and the NFT marketplace. Finally, an essential aspect to scrutinize is the long-term sustainability of play-to-earn models. Subsequent research could employ predictive modeling and forecasting techniques to anticipate future trajectories and evaluate the longevity of the play-to-earn paradigm.

국문초록

2017 년 암호화폐 열풍이 대유행하게 되면서, 최초의 블록체인 게임인 CryptoKitties 가 등장하였다. 이후, 더욱 우수하고 창의적인 게임 개발을 위한 경쟁이 이루어졌다. 전문가들은 젊은 세대가 게임 및 암호화폐 생태계에 대해 더욱 집중하고 있기 때문에 이것이 게임 산업의 미래를 대변한다고 믿고 있다. 이번 연구에서는 이론적 모델을 활용하여 가장 인기 있는 Play-to-Earn (P2E) 게임 중 하나인 Axie Infinity 의 암호화폐, 대체 불가능 토큰 (NFT) 시장 및 플레이어 수 간의 관계를 분석하였다. 이 연구는 인기 있는 P2E 게임의 데이터를 이용하여 경험적 분석을 실시하였으며, NFT 거래 및 암호화폐의 상승이 사용자와 운영자 모두에게 혜택을 제공한다는 결론을 도출한다. 또한, 일일 활성 사용자 수, NFT 거래량 및 암호화폐 가격 사이에는 양의 상관관계가 있음을 확인한다. 이러한 경험적 연구 결과는 경제적 이익이 가상 세계에서도 중요한 역할을 한다는 것을 명백히 보여준다.

주요어 : 블록체인, 가상 경제, 암호 화폐, 대체 불가능 토큰 (NFT), Play-to-Earn 게임 학번 : 2021-29946

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