



Bachelor Thesis

Bachelor of Science (BSc.)

Department of Tech and Software

Major: Digital Business and Data Science

**The Impact of Player Experience Data on Game Modifications and
Subsequent Effects on Company Stocks**

Boris Menshikov

Matriculation Number: 15613416

First supervisor: Prof. Dr. Rand Kouatly

Second supervisor: Prof. Dr. Iftikhar Ahmed


Submitted on: 29.08.2024

Statutory Declaration

I hereby declare that I have developed and written the enclosed Bachelor Thesis completely by myself and have not used sources or means without declaration in the text. I clearly marked and separately listed all the literature and all the other sources which I employed when producing this academic work, either literally or in content. I am aware that the violation of this regulation will lead to the failure of the thesis.

Potsdam

Date 29.08.2024

Signature

Abstract

This study investigates the correlation between video game updates and the financial performance of the companies that produce these games. Employing linear regression models, this research analyzes the stock price fluctuations of ten leading gaming companies in response to different types of game updates—classified as either major enhancements or minor tweaks. The objective is to quantify the impact of these updates on stock prices and to understand the varying degrees of this impact across different companies and game types.

The findings reveal a complex relationship: while certain updates correlate with significant positive changes in stock prices, others appear to have minimal or even negative effects. This variability suggests that the financial impact of game updates is influenced by a combination of factors including the nature of the update, market expectations, and external economic conditions.

This thesis contributes to both academic literature and industry practices by offering a systematic approach to evaluate the economic implications of game updates. It highlights the importance of integrating user engagement metrics into financial analysis to provide a more comprehensive understanding of how game developments affect company valuation.

Keywords: Game Updates, Financial Performance, Linear Regression, Stock Prices, Player Engagement Metrics, Video Game Industry.

Table of Contents

CHAPTER 1. INTRODUCTION	1
1.1 BACKGROUND	1
1.2 PROBLEM STATEMENT	1
1.3 RESEARCH QUESTIONS	2
1.4 THESIS OBJECTIVES	3
1.5 CONTRIBUTIONS	3
1.6 THESIS ORGANIZATION	4
CHAPTER 2. THEORETICAL BACKGROUND	6
2.1 INTRODUCTION	6
2.2 GAME ANALYTICS AND DATA UTILIZATION	7
2.2.1 Evolution of Game Analytics	7
2.2.2 Data Collection and Processing in Game Analytics	8
2.2.3 Tools and Techniques in Game Analytics	8
2.2.4 Application of Game Analytics in Development and Monetization	9
2.2.5 Strategic Decision-Making Based on Data Insights	10
2.2.6 Challenges and Ethical Considerations in Game Analytics	11
2.3 PLAYER ENGAGEMENT METRICS	12
2.3.1 Types of Player Engagement Metrics	12
2.3.2 Methods for Tracking and Analyzing Engagement Metrics	13
2.3.3 Application of Engagement Metrics in Game Development	14
2.3.4 The Financial Impact of Engagement Metrics	15
2.3.5 Challenges in Measuring Engagement Metrics	16
2.4 BIG DATA AND FINANCIAL PERFORMANCE	17
2.5 PLAYER FEEDBACK	19
2.5.1 Role of Player Feedback in the Development Cycle	19
2.5.2 Methods for Collecting and Analyzing Player Feedback	19
2.5.3 The Influence of Player Feedback on Game Updates	20
2.5.4 Challenges in Implementing Player Feedback	21
2.5.5 The Financial Impact of Incorporating Player Feedback	22
2.6 USER EXPERIENCE	23
2.6.1 The Importance of UX in Game Design	23
2.6.2 Data-Driven UX Design	24
2.6.3 The Role of Player Feedback in UX Design	24
2.6.4 Integrating UX Research into Game Development	25
2.6.5 UX and Financial Performance	25
2.6.6 Challenges in UX Design	26
CHAPTER 3. METHODOLOGY	27
3.1 OVERVIEW	27
3.2 PROPOSED FRAMEWORK/MODEL/TECHNIQUE	27
3.3 METHODOLOGY	27
3.3.1 Dataset	27
3.3.2 Data Pre-Processing	28
3.3.3 Feature Engineering	28
3.3.4 Feature Selection	28
3.3.5 Model Training	28
3.4 EVALUATION CRITERIA	28
3.5 BENCHMARK ALGORITHMS	29
CHAPTER 4. RESULTS AND DISCUSSION	30

4.1	RESULTS.....	30
4.1.1	<i>Call of Duty: Warzone</i>	31
4.1.2	<i>FIFA Series</i>	32
4.1.3	<i>Grand Theft Auto V</i>	33
4.1.4	<i>Rainbow Six Siege</i>	34
4.1.5	<i>Cyberpunk 2077</i>	35
4.1.6	<i>Animal Crossing: New Horizons</i>	36
4.1.7	<i>Honor of Kings</i>	37
4.1.8	<i>Final Fantasy XIV Online</i>	38
4.1.9	<i>Monster Hunter: World</i>	39
4.1.10	<i>Borderlands 3</i>	40
4.2	DISCUSSION.....	40
4.3	VARIABILITY IN UPDATE IMPACT.....	41
4.4	TEMPORAL MISMATCH BETWEEN UPDATES AND FINANCIAL DATA	41
4.5	DATA QUALITY AND CONSISTENCY	41
4.6	DISCUSSION.....	42
4.7	INTERPRETATION OF RESULTS.....	42
4.8	IMPLICATIONS OF FINDINGS	42
4.9	FUTURE RESEARCH DIRECTIONS	43
CHAPTER 5.	CONCLUSION AND FUTURE WORK	44
5.1	CONCLUSION.....	44
5.2	FUTURE WORK.....	45
5.3	FINAL REFLECTIONS.....	47
REFERENCES	48

List of Abbreviations

Abbreviation	Full Term
ARIMA	Auto Regressive Integrated Moving Average
ARPU	Average Revenue Per User
BDA	Big Data Analytics
CLV	Customer Lifetime Value
GA	Game Analytics
GDPR	General Data Protection Regulation
LSTM	Long Short-Term Memory
LTV	Life-Time Value
MAE	Mean Absolute Error
ML	Machine Learning
NPS	Net Promoter Score
NLP	Natural Language Processing
R ²	Coefficient of Determination
RMSE	Root Mean Squared Error
UI	User Interface
UX	User Experience

List of Tables

Table 1: Summary of Linear Regression Results for Game Updates and Stock Prices....	30
--	----

List of Figures

Figure 1: Linear Regression: Actual vs Predicted Stock Prices for Call of Duty: Warzone.....	31
Figure 2: Linear Regression: Actual vs Predicted Stock Prices for FIFA Series.....	32
Figure 3: Linear Regression: Actual vs Predicted Stock Prices for Grand Theft Auto V	33
Figure 4: Linear Regression: Actual vs Predicted Stock Prices for Rainbow Six Siege.....	34
Figure 5: Linear Regression: Actual vs Predicted Stock Prices for Cyberpunk 2077.....	35
Figure 6: Linear Regression: Actual vs Predicted Stock Prices for Animal Crossing: New Horizons.....	36
Figure 7: Linear Regression: Actual vs Predicted Stock Prices for Honor of Kings.....	37
Figure 8: Linear Regression: Actual vs Predicted Stock Prices for Final Fantasy XIV Online.....	38
Figure 9: Linear Regression: Actual vs Predicted Stock Prices for Monster Hunter: World.....	39
Figure 10: Linear Regression: Actual vs Predicted Stock Prices for Borderlands 3	40

Figure 11: Code Implementation for Machine Learning Models

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_absolute_error, mean_squared_error, r2_score
# Load the financial data (downloaded from Yahoo Finance)
finance_data = pd.read_csv('UBSFY.csv', parse_dates=['Date'])
# Load the game update data
update_data = pd.read_csv('ubsv1.csv', parse_dates=['Update_Date'])
finance_data['Date'] = finance_data['Date'].astype(str)
update_data['Update_Date'] = update_data['Update_Date'].astype(str)
# Merge the datasets based on the date
# Left join to keep all financial data and match update data where possible
merged_data = pd.merge(finance_data, update_data, left_on='Date',
                        right_on='Update_Date', how='left')
# Fill missing update numbers with 0 (indicating no update on that day)
merged_data['Update Number'].fillna(0, inplace=True)
# Drop the 'Update_Date' column as it's redundant after merging
merged_data.drop(columns=['Update_Date'], inplace=True)
# Select relevant features and target variable
X = merged_data[['Update Number', 'Volume']] # Features: Update Number and
Volume
y = merged_data['Close'] # Target variable: Closing stock price
# Split the dataset into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,
                                                    random_state=42)
# Initialize and train the Linear Regression model
model = LinearRegression()
model.fit(X_train, y_train)
# Make predictions on the test set
y_pred = model.predict(X_test)
# Evaluate the model
mae = mean_absolute_error(y_test, y_pred)
mse = mean_squared_error(y_test, y_pred)
rmse = np.sqrt(mse)
r2 = r2_score(y_test, y_pred)
print(f'Mean Absolute Error: {mae}')
print(f'Root Mean Squared Error: {rmse}')
print(f'R2 Score: {r2}')
# Plot the actual vs predicted values
plt.figure(figsize=(10, 6))
plt.scatter(y_test, y_pred, color='blue')
plt.plot([min(y_test), max(y_test)], [min(y_test), max(y_test)], color='red',
         linewidth=2)
plt.xlabel('Actual Stock Prices')
plt.ylabel('Predicted Stock Prices')
plt.title('Linear Regression: Actual vs Predicted Stock Prices')
plt.show()
```

Chapter 1. Introduction

1.1 Background

The gaming industry itself rapidly evolved to create complex, immersive experiences that attract millions of players globally. Today, video games are more than just entertainment, they have become a cultural and economic force to be reckoned with. The use of complex analytics and big data in the gaming industry is not quite new, however, it has taken an entirely different route from how games used to be developed marketed living a while ago. Today, game developers and publishers heavily leverage data-driven insights to guide the design of their games, whether it is related to features in-game or user experience (UX), marketing activations, monetization strategies, among others. Data-driven decisions are essential for maintaining player engagement and ensuring the longevity of games in a fiercely competitive market.

Understanding player behavior is one of the tough challenges in modern game dev. Developers can understand what the player retention is, why players churn out and which features drive monetization by analyzing data from hundreds of millions of players. That kind of segmentation requires gathering and sorting enormously large sets of data: everything players do in a game. Understanding how players are going to behave and designing with that in mind have become the crux of many useful design practices.

Data Analytics not only improves player experience but is also one of the key driving factors for financial performance. Gaming is now a multimillion-dollar industry and game publishers are frequently publicly traded companies. As a result, there has been increasing interest in the correlation between financial operations and activity within games such as events, updates, and player engagement metrics. Data analytics is becoming a more common means for investors and stakeholders to predict revenue streams and evaluate the financial status of gaming companies. This new area of analysis that melds the boundaries between gaming analytics and financial performance could be revolutionary; this is something which we will examine on for a long time.

1.2 Problem Statement

The gaming industry is monumental in size, it continues to grow at a rapid pace but struggles both with player retention as well as the thin margins that can exist between financial success or failure. The modern age of video game development is data driven. Nonetheless, the art of game development to integrate with advanced analytics is not an easy task. Among the hardest hurdles to overcome is making sense of vast swabs of data which can be overwhelming and hard to interpret, thanks largely due to gamers themselves. Even more so, player behavior in games is changing with diverse levels of intensity over time which makes it difficult to simply build accurate predictive models that predict the future behaviors and thus financial implications.

While we have more data than ever, the gap between having massive amounts of this information and effective use to drive decision making is noteworthy. Game Developers often fail to extract meaningful insights from player data which prohibits them from doing the right

game design and marketing strategies. No standardized best practices or methodology regarding how the player behavior data in conjunction of monetary spends should be looked at and interpreted. Without this unified framework, decisions to keep players staying in the game longer, make more money per player and have overall game success cannot be made with any certainty.

Moreover, current research in the area of gaming analytics and financial performance is relatively small with few prior studies explore how events and updates that occur within a game may affect firm-level metric-based outcomes. And this large hole in the knowledge ground needs to be filled for further advancement of game analytics. As such, the main goal of this thesis is to fill in that gap by creating a robust gamer-centric methodology for evaluating and understanding how player engagement influences the financial performance of gaming companies; a contribution meant both for academics as well as large industry players.

1.3 Research Questions

The study is organized through several detailed research questions, which are used to uncover aspects of the complex space between game design and player behavior guided by financial metrics. This inquiry breaks down how game updates target critical player retention metrics, including Net Promoter Score (NPS), and Average Revenue Per User (ARPU). This first is the most important question asking about the specific impact of game updates on making players happy and turning them into loyal customers of a gaming platform.

Then, the research moves to examine for short and long-term evidence of significant dynamic roles game updates may exert on stock price movements. This second question is designed to shed light on the larger economic consequences of updates, delving into whether and how these changes impact investor sentiment: ultimately stock market valuation for game companies. Critical insights for all stakeholders making financial decisions in the game development process.

More importantly, the study even dabbles in predictive analytics by asking whether machine learning (ML) models are able to accurately predict financial results through troves of wide-range metadata including upvote data and player feedback at time of update. In the era of big data and analytics, answering this question can help developers to predict future revenue trends or investment risks as well assist business strategists with crucial decision support tools.

Finally, we analyze how user experience (UX) metrics are incorporated in the decision-making process of game updates. The depth that player-centric data should affect and updates strategic financial performance, trying to perfect vanity user satisfaction symbiotically with the economic good cash cow devices.

The study hopes to shed light on these questions by giving developers, designers, and even financial analysts a means by which they can thoughtfully evaluate the economic implications of decisions related to game development. This dual focus guarantees full-bodied consideration of both how game design and player participation are key facets in the economic terrain of gaming.

1.4 Thesis Objectives

This thesis focuses on multiple targets, analyzing the correlation between game analytics (GA), user experience (UX) and financial performance in the video games industry. These experiments are designed to quantify how the key components of game updates affect trading value on the stock market, and then use that information carefully craft personalized objectives to adjust for features-like optimized update cycle in order increase player retention time and monetization together with maximize return.

First of all, the thesis wants to make a complete empirical study on how game updates contribute to explaining stock performance. This includes measuring the relationship between updates in terms of their time and type, as well an understanding further reactions stock price levels could have; hence offering areas regarding how market participants' value these updates.

Second, a major goal is to discover a formalism that measures the sum of money game updates are worth. The economic impact of product updates can be measured for some time based upon this formula in terms of two crucial engagement metrics: CLV (Customer Lifetime Value) and ARPU (Average Revenue Per User).

The third aim focuses on establishing a predictive machine-learning (ML) model. This is a predictive model that leverages historical update data and financials to predict stock price movements. It uses the state of art ML techniques to make robust predictions which stakeholders can use for an informed decision on investing.

Furthermore, this research aims to investigate how UX data is both gathered and used when planning game updates. But even more interesting is that we will focus on the UX-driven decisions and their influence on financial results, showing how solving UX issues accordingly to these principles by itself can help gaming projects reach better numbers in finance.

Finally, the proposed ML model will be validated and evaluated using data from publicly listed gambling companies. The idea here is to check the model's predication power which in turn help business know how reliable certain indicator as economic metrics for upcoming years be.

As a whole, these aims not just unite the GA and UX discipline with financial modeling but present a holistic way of evaluating the economic costs associated to game updates. We assume that these holistic points of view would not only be helpful to scholars but would also include specific takeaways and strategies for the gaming industry on how they can better improve both their players satisfaction and financial performance.

1.5 Contributions

This thesis has several contributions, ranging from new theoretical insights to practical applications in the areas of game analytics (GA), user experience (UX) and financial modeling. Every contribution aims at broadening the insights into how game updates can influence the valuation of gaming firms: for practitioners in businesses and researchers alike.

The most important and original contribution of this work is a new formula that helps to assess the financial profitability of game updates. What makes this formula special is that it combines player engagement metrics with stock performance data to give stakeholders in the gaming industry a quantitative tool they can use to measure the economic impact of their update strategies. Those are essential to take when data informed decisions, which not only increase player sanity but also bring more financial returns.

Moreover, this study provides a novel predictive machine learning (ML) model designed to work with game update data to predict financial performance. By training an ML model on historical game updates and financial information, we expect this time-locked dataset to be used as a predictive tool for stock price changes in order that gaming execs can preempt market wide reactions due to current events.

Thirdly, this thesis takes an in-depth look at how these UX data collection methods can be practically implemented within game development as well as used to drive strategic decision-making aspiringly. This article reveals how designed and implemented UX data can be used in crafting game updates that meet player expectations, which should essentially reduce churn and boost revenue.

Fourthly, we also make a significant contribution by empirically validating the association between regular updates of popular games and investors returns using data from publicly traded gaming companies. The research is significant to the thesis because it illustrates that changes in stock prices arise contemporaneous with game updates, which validates models developed on paper and provides empirical fit for wider argumentation toward investment and development strategy within gaming.

Cumulatively, these insights provide immense theoretical and practical contributions in terms of understanding the intricate interplays between game updates to player engagement and financial success. Its new tools and insights are expected to help gaming companies design update strategies more effectively, guide investors in improved decision-making, also provide an avenue for the advancement of knowledge around combining innovations from both fields.

1.6 Thesis Organization

The structure of the thesis is the following:

Chapter 1 introduces the study, presenting background, problem statement, research questions, objectives, and contributions.

Chapter 2 provides the theoretical background, covering key concepts like GA, BDA, and UX, and their relevance to financial performance.

Chapter 3 reviews existing literature on the intersection of GA, ML, and financial modeling.

Chapter 4 details the methodology, including the proposed model, dataset, and evaluation criteria.

Chapter 5 presents the results and discusses their implications, comparing them with existing models.

Chapter 6 concludes the thesis and outlines potential future research directions.

Chapter 2. Theoretical Background

2.1 Introduction

Theoretically, this thesis explores in that intersection area between game analytics (GA), big data analytics (BDA) and financial performance in the gaming industry. In the past decade or so, there has been a distinct increase in data-driven methodologies within the gaming industry to streamline decision-making. In the words of Medler and Magerko (2019, p. 78), GA has passed from simulate player behavior to instructing designers about what design paths offer competitive or monetization options. Collecting and analyzing large datasets, companies are able to use these data points for optimizing game updates that enhance user experience (UX) as well as further revenue growth.

Utilizing a variety of player behavior analytics, as well as retention and monetization methods GA works to enhance engagement. Marczak et al. (2019, p. 89) state that GA gives developers invaluable information on how players interact with game content allowing post-launch updates to be refined according to live data. These insights are powerful for developing tailored gaming solutions that appeal to diverse player groups and subsequently, enhance retention rates and financial returns.

The inclusion of BDA in game development is especially important when examining the financial implications of gaming updates. BDA allows this through fact-based decision making and the ability to measure updates against KPIs, but also look long-term at what could occur — where both player expectation align with financial goals. Evaluating the example of Dong (2020, p. 132), more advanced predictive models built on machine learning (ML) can predict stock price changes from game updates as well as player feedback so that companies could have the ability to read market and make changes proactively.

The success of game updates is always defined by player engagement metrics. The session length, play frequency and purchases made in the game are then directly related to how well updates align with the player. According to Persada et al. (2019, p. 116), these metrics draw a detailed picture of player behavior that can be especially useful to personalize content and improve Average Revenue Per User (ARPU). High levels of engagement are generally associated with higher revenues, as engaged players are more likely to purchase additionally in-game content and stay in the game for longer periods.

Machine learning and game analytics go hand-in-hand. Models like clustering, regression models are heavily used for player segmentation, behavior prediction and game content optimizations. For instance, Roohi et al. (2019, p. 95) show how machine learning (ML) can be used to forecast player retention and relate reasons that lead player disengagement. The aforementioned level of prediction is vital to ensuring that you design updates which can both boost engagement and drive revenue.

User experience (UX) design is another important aspect that can greatly improve player satisfaction. According to Hodent (2020, p. 104), UX design is not only how an app looks like but a creation of easily navigable interfaces that users will enjoy utilizing. Through the analysis of UX data, developers gain insight into opportunities for growth and determine what can be changed or enhanced to improve and retain increased player interaction. By

working in conjunction with financial analytics, UX research offers a well-rounded approach to measuring the impacts of updates by connecting player experience directly to revenue performance.

Theoretical implications are then summarized to show how GA, BDA, ML and UX could reinforce the process in game development and financial analysis. The elements themselves are not meant to stand alone, but rather support one another in order to propose a complete framework for game update optimization. The following sections of this thesis are going to further investigate these relationships, and more precisely they will focus on the particular methodologies and models that can be used in quantifying financial impact of a game update.

2.2 Game Analytics and Data Utilization

Game analytics (GA) has emerged as a key strategy in contemporary game development, providing the means for developers and publishers to identify data-driven decisions which facilitate successful player experiences, optimize existing content provision or monetization strategies. Through big data analytics (BDA), hundreds of thousands of player records are obtained and analyzed to figure out various attitudes, desires, or trends. This information is then leveraged for further game design, update strategies and marketing efforts to target their games intending not just only player recruitment but also retention eventually.

This section discusses how GA emerged, and the methodologies used to solve such problems today, accompanied by common methods of using data for different objectives in game development. We would cover the tools and methods to collect player data, how machine learning (ML) and artificial intelligence (AI) are used extracting insights from collected data and provide an overview of how these driving decisions in game design as well as business operations.

2.2.1 Evolution of Game Analytics

The use of game analytics (GA) has come a long way since tracking basic metrics to predictive and holistic analytical insights shaping every aspect of the future videogame development. Early game analytics implementations measured only basic metrics such as player counts, session lengths and revenue generation. Nonetheless, with the proliferation of industry grew an increasing urge for comprehensive and actionable insights.

Medler & Magerko (2019, pp. 101–112) identify that modern GA involves a spectrum of techniques from behavioral analysis to real-time data processing and handling. It reflects the change in games being so complex and filled with different meanings built on player assumptions. Nowadays, developers can do everything from tracking individual player interactions to observing global trends that they could never leverage previously.

This change in GA that has also paved the way for deploying sophisticated data-based models using advanced statistical methods and machine learning (ML) algorithms to analyze user behavior, game economies or increase retention. For example, predictive analytics can help developers forecast potential player churn based on gameplay behavior and take steps to retain those players by incorporating features or rewards. Furthermore, game developers can

facilitate a new way of engaging by personalizing gaming experience individually for each players using machine learning algorithms which will enhance user satisfaction and engagement across the platform. The development of the technology in these games, alongside insights into market trends and user preferences have been aiding stakeholders to make data driven decisions which keep them engaged with more exciting prospects for gaming industry (Medler & Magerko, 2019, pp. 101-112).

2.2.2 Data Collection and Processing in Game Analytics

The core of any GA system is the data about players. Usually, data is collected from various in-game events ranging between player movements and interactions to transactions and social behaviors. Typically, data of this type is collected and processed real-time using tools like Unity Analytics, Game Analytics, or proprietary tracking platforms.

The biggest challenge for this stage lies in managing the amount and nature of data such as volume, velocity, and variety that players. BDA systems work to address these challenges by leveraging scalable architectures and techniques for data processing. According to Marczak et al. (2019, p. 58), this requires efficient data collection and processing, so the conclusions ultimately derived from that information are accurate and actionable.

Centric to this, is the notion of data pipelines that enable access and consumption of diverse sets such as in-game telemetry recordings, social media engagement or transaction logs. These pipelines are specifically crafted to take raw data and build it into more structured, consumable forms for analysis. Data cleaning and preprocessing in addition is important to noise reduction and ensuring the reliability of the in downstream analytic processes.

2.2.3 Tools and Techniques in Game Analytics

GA uses a variety of tools and techniques to analyze the data that players generate. These are classical statistical methods, data mining and advanced techniques such as ML and AI.

1. Statistical Analysis and Data Mining

The analytics that happen in early stages generally revolve around statistical models like regression analysis, clustering to discover trends or correlations out of the player data. For example, clustering algorithms could identify groups of players by their gameplay behavior so that developers can engage each segment with customized content. It is commonly used to analyze how specific parameters within the game affect user retention and monetization through regression analysis. These statistical methods endow a basic requisite to delve into valuable outputs that can refine development strategies and content optimization.

2. Machine Learning and AI

ML and AI are now an integral part of modern GA, as various classification algorithms for predictive modeling and neural networks contribute to predict player behaviors in order to optimize the structures of in-game economies or deepening engagement. For example, Roohi et al.

(2019, p. 202); highlights the implementation of predictive models for forecasting player churn in order to proactively action on retention strategies. With the help of advanced data analytical techniques developers can create truly player-centric games that respond to an individual's preferences and playstyle.

3. Real-Time Analytics

Analyzing data in real-time is a fundamental element especially when it comes to the fast-moving world of gaming today. While the traditional After-Action Report mounted on a desktop allows developers to view player behavior after-the-fact, real-time analytics enable even quicker responses to trends as they occur. A way to differentiate further from rival streaming companies that rely on big-name content, and also a potentially essential feature for live-service games where regular updates and new drops can make or break player interest. Real-time analytics afford immediate modification of game elements so that developers can continually optimize player engagement and enjoyment.

4. Data Visualization

Most presentation of complex data in digestible form is done using visualization tools like Tableau or Power BI. Visualizations are so crucial in decision-making, as it enables developers to identify trends visually and therefore make informed decisions on gameplay updates or new features. Effective data visualization not only simplifies intricate analytics, but it also helps to present findings across groups of people with disparate expertise making the decision-making process more collaborative and informed throughout game development companies.

Together, these techniques enhance the power of game developers to interpret and predict behavior by players using help aid participate in commitments which translates into better finances for gaming companies. Collapsing these divergent tools, the gaming industry is still pushing towards reestablished models by utilizing additional capacities in its effort to investigate and satisfy an ever-changing player base.

2.2.4 Application of Game Analytics in Development and Monetization

Insights from Game Analytics (GA) are used throughout the game development process ranging all over design to marketing as well as monetization. Game Balancing is one of the many areas where it can be particularly useful. Developers can adjust game mechanics when needed by taking into account player feedback and the way players play a specific part of a game. This practice revolves around changing difficulty, progression system or even rewards to be more in tune with what the players believe. Customizing these factors through analytics enforces a balance between being difficult and accessible, which makes it more appealing to various players.

Player Segmentation is another important application. Developers can build tailored experiences for each segment by grouping players based on behavior, spending habits and preferences. For example, exclusive content and offers might be aimed at ultra-high value

players, typically known as “whales.” However more easily earned game modes may cater better to casual players. This practice segmentation enables more targeted marketing and enhances both gameplay experience for players because it helps deliver experiences that fits their unique play style and financial engagement.

GA also plays a significant role in monetization strategies. Companies can use this to create better in-game economies, pricing models and fine-tune microtransactions as they have the user's spending patterns and purchase behavior. According to Persada et al (2019, p. 134), the way in which a player will interact with options of monetization is crucial for raising profits while preserving positive UX score on behalf of users. Using analytics in this way also enhances the standard of gaming experiences offered to players by guaranteeing that any monetization effectively caters towards player expectations or requirements, also making it profitable.

Additionally, the inclusion of GA integrates into predictive analytics, and new player behaviors and revenue streams can be predicted with great confidence. For example, Smith and Jones (2020, p. 45) point to the fact that analytical insights from GA data could provide predictive models which would help organizations make better decisions prior to market trends or player requirements becoming evident. This bold approach to taking initiative keeps developers and marketers ahead of the curve, quickly adapting to changes in player behavior and market dynamics.

The use of GA in these examples has revolutionized the gaming industry. Detailed analytics will help develop more engaging, balanced and financially successful games. While enhancing player satisfaction, GA additionally drives business success by this strategic use of data, a useful tool in the modern gaming landscape.

2.2.5 Strategic Decision-Making Based on Data Insights

Game Analytics (GA) is a tool which is not only used to learn the right game dynamics to work but also in making solid business strategies. Based on the learnings obtained from analytics data, companies take decisions whether to update in-app content or prioritize new feature introduction and prepare marketing campaigns. For example, data used to track player activity over a specified period and then compared with the historical figures can inform when new content should be released. Aligning their content release strategies with the periods of high player engagement can allow companies to improve user experience and increase retention.

Additionally, the impact of updates on financials is well analyzed using GA. This means anticipating how changes will affect the key financial indicators, such as Average Revenue Per User (ARPU) and Customer Lifetime Value (CLV). Dong (2020, p. 289) identifies a broad impact in stating that predictive models can be utilized to predict the financial returns of updates and consequently to help organizations increase their Return on Investment (ROI) and shareholder value as well. The use of predictive insights here is key in driving when and what sort of releases should be brought forward or rolled back to ensure maximum financial benefit.

Additionally increasing the utilization of GA as a part of strategies, organizations began using these analytics to fine-tune their pricing strategies and optimize user acquisition campaigns. For example, Johnson et al. (2021, p. 157) suggest that GA can be used to adjust

live pricing models for patterns of user engagement with products and their purchases. By using this tactic, companies can easily alter in-game item prices on-the-fly to achieve more sales and give players the best value according to how much they are willing or want to pay when it comes to buying additional items.

The above strategic applications of GA demonstrate that it has an especially important part to play in the future not only for gaming development, but also within this broader business operation scope in games industry. Leveraging actionable insights from comprehensive data strategies allows organizations to make strategic decisions that enhance user enjoyment, while also improving financial and competitive landscapes.

2.2.6 Challenges and Ethical Considerations in Game Analytics

While the advantages are numerous, there challenges also come hand in hand with Game Analytics (GA). Given the sensitive nature of player information, data privacy and security are major concerns. It is also essential to maintain the confidence of players and avoid legal consequences from regulations such as GDPR (General Data Protection Regulation). Another dimension to the picture is that there are ethical issues related to player data. Too much emphasis on monetization analytics, for example, can discourage unfair practices that impede player experience. Such practices are not just enough to keep players away but even ruin a company's image and future profits.

Data quality is another challenge. Inaccurate or incomplete data can and will result in flawed insight, which means poor decision making. Hence, maintaining data accuracy mostly through elaborate data validation and cleaning mechanisms is critical for a successful GA. At the same time, the interpretation of these large-scale amounts of generated information should be complex and with great expertise in terms that even small misinterpretations can lead to devastating decisions which could dramatically impact on-the-ground game development conditions or player satisfaction.

Furthermore, predictive analytics in gaming raises ethical concerns. Thompson and Lee (2021, p. 342) highlight that the morality of how businesses use predictive analytics to incentivize player behavior, especially if it prioritizes revenue over welfare, is a topic likely up for debate. This poses the importance of ethical considerations in delivering any analytic insights to game situations or objects. For example, it is a difficult task that those designed interventions should be both helping players enjoy games and maintain fairness and transparency.

To sum up, GA and Big Data Analytics (BDA) are critical to modern-day game development, as they provide the means of understanding player needs and wishes for an optimized player experience along with improved retention rates leading through potential drive of financial success. This has enabled GA to embrace Machine Learning (ML) and real-time analytics, sophistication which have improved the capabilities of companies in making more informed decisions. The gaming industry is constantly changing, and it will be more important than ever for data to have a direct influence on how games are made as well as the success of game development businesses. This evolution requires not only cutting-edge technological solutions but also a dedication to the ethical integrity and practices that protect player rights and foster gaming in an enjoyable environment.

2.3 Player Engagement Metrics

Player engagement is an inherent part of game development, being the very foundation for a game's lifespan and overall success. By measuring and analyzing data about player engagement, developers can create more engaging content, improve the approach of updates while optimizing financial outcomes. Quantifiable engagement offers a lens into player behaviors and interactions with games, what keeps them coming back, what resonates most. This section covers the different player engagement metrics, methodologies to keep track of and analyze these metrics and how it impacts on business strategy and revenue for gaming companies.

2.3.1 Types of Player Engagement Metrics

Broadly speaking, player engagement metrics fall into three categories: behavioral, emotional, and social metrics. All of these categories give us a perspective on how the player interacted with a game and whether or not they enjoyed it.

1. Behavioral Metrics

Observables of how the player is interacting with a game. Session length, playtime, how often they return to the app, progression as well as in-game transactions are common behavioral metrics. As another example, Medler and Magerko (2019, p. 104) describe session duration and play frequency as essential player retention and engagement metrics. Players generally stick around for longer and come back more often as they find the game engaging, which translates directly to better retention and monetization. Moreover, it lets developers learn from their data and improve the game, which will result in continuous player engagement by providing new challenges as well as rewards.

2. Emotional Metrics

These are metrics which measure the reaction from players on an emotional level. These measures are often collated through surveys, feedback forms and even sentiment analysis. Net Promoter Score (NPS) and player satisfaction scores, for example, allow analysts to gauge how players are feeling about the game immediately. Roohi et al. (2019, p. 78) emphasize the need for understanding player sentiment so that updates and new content do not clash against them, keeping positive engagement in. This focus on emotional metrics enables developers to make games players can relate to, which helps create a more enjoyable overall game experience.

3. Social metrics

Trackers of player behavior inside the game. For example, friend invites, co-op play frequency, community participation, and social media engagement. Persada et al. (2019, p. 112) emphasize that social gaming, especially among multiplayer is a key accelerator of retention. Games that promote cooperative and competitive behaviors across players tend to drive greater engagement via the added dimension of social play. These are such metrics that provide an invaluable resource for games built upon community and shared experience;

they allow developers to create lively, transparent communities within their gaming environment.

Further, by learning and utilizing such engagement metrics effectively across different styles of player personality game developers can not only improve the quality of play experience but also plan their art design and narrative features consciously which often helps in cultivating a long term and loyal base through effective gamification. This comprehensive approach to of player engagement is necessary in today's competitive gaming landscape and may be the difference between a game being successful or falling flat due to not meeting players' expectations.

2.3.2 Methods for Tracking and Analyzing Engagement Metrics

Robust data collection, real-time analytics and predictive modeling all are must-haves for accurate tracking and analysis of these engagement metrics. Proper engagement tracking combines data from in-game telemetry, social media analytics, and various player feedback systems.

1. In-Game Telemetry

The primary behavioral data that game companies can collect is called in-game telemetry. According to Marczak et al. (2019, p. 153), telemetry systems record each and every action one performs in a game from pressing buttons to navigating menus. The raw data is then processed and converted into intelligence through a series of data pipelines that extract, transform, and load the information in real-time. Moreover, the smart integration of these data flows allows them to gradually streamline their mechanics and user interface in order for it to address those changing necessities with greater efficiency.

2. Real-time analytics

This must-have tool is crucial for tracking player engagement as it happens. And that is increasingly important during an age of live-service games, where continual updates and event-level activity are essential to keeping people playing the same game over time. Real-time monitoring, as suggested by Medler and Magerko (2019, p. 98), makes it easy to pinpoint engagement issues for developers so that they can correct them before the players leave in disinterest. Furthermore, this direct feedback loop enables agile practices encouraging teams to rapidly iterate content based on the real interactions and behaviors of players.

3. Predictive Modeling

This modeling predicts future engagement trends using historical data. As Roohi et al. (2019, p. 87) elucidate, machine learning models like decision trees and neural networks can be used to predict which players are prone to churn and help determine what kind of updates might increase engagement, among others. This model is key for initiative-taking game management giving the developers necessary feedback on when and how to release contents, features, or updates. With predictive analytics, one can not only predict the trends in future but create

a personalized gaming experience which will bring delight and loyalty of the players.

By using these methods, game developers will have greater clarity around factors that influence player engagement and be able to make more informed decisions on how and where they deploy their resources in order to continue producing excellent gaming experiences while also optimizing business strategies. This holistic analysis of engagement is critical to stay ahead in the everchanging gaming sphere.

2.3.3 Application of Engagement Metrics in Game Development

Engagement metrics have significant implications to direct how games are developed and updated. Understanding what keeps players engaged can help developers apply their efforts on producing content they know will be well-received.

1. Content Personalization

A key use case for engagement metrics is content personalization. Valuable can be pinpointed by way of performance metrics and are likely to respond well to unique content or benefits. Medler and Magerko (2019, p. 76) claim that personalization is the way to go in boosting customer lifetime value (CLV), making long-term engagement work. Customization extends to difficulty settings, progression systems and rewards all bespoke to individual player tastes. This type of strategic data application powers gameplay customization to cater for the specific requirements and demands in individual player segments, enriching the game user experience.

2. Feature Prioritization

Engagement metrics help to determine which features and updates need to be prioritized. By determining which game mechanics or content are most relevant to players, developers can prioritize the improvement of these elements in their next patch. Roohi et al. (2019, p. 92) illustrates how a new game mode was well received among players using their predictive models and that they should focus on adding similar type of content in future updates. This guarantees that resources are being spent wisely on the most interesting and engaging features based on player satisfaction.

3. Monetization Strategies

Monetization is very dependent on engagement metrics. Companies benefit by studying the way people actually spend and adjusting their in-game economies accordingly for better microtransaction sales. Persada et al. (2019, p. 110) illustrate that effective monetization is extremely connected to strong engagement since when players are truly immersed in the game it increases their chances of buying something. This data-driven methodology empowers companies to optimize their monetization strategies, making them both appealing and equitable in order to extracting the most revenue from each whilst ensuring that player sentiment remains positive.

With these applications, engagement metrics not just drive game content and feature creation but are the backbone of strategic decisions that may have substantial effects on a game's financial success as well as player retention. This end-to-end adaptation of engagement data versus casual play is crucial in building a well-balanced and rewarding gaming experience for both players and developers.

2.3.4 The Financial Impact of Engagement Metrics

Player engagement metrics have a direct impact on your financial performance. Often, games with high engagement earn more money and have a higher life-time value (LTV), generating better financial returns in terms of ARPU among other metrics. While engagement is a nice indicator of player satisfaction, Dong (2020, p. 143) also claimed that metrics in this area can predict revenue. So high Net Promoter Scores (NPS) may cause positive word-of-mouth marketing that in turn drives organic growth and boosts revenue, for example. This in turn implies learning and bettering the factors that affect these metrics can be critically important to a company's bottom line.

1. Stock Price Correlation

The effect that player engagement has can be seen on stock prices much more directly in live-service games. Marczak et al. (2019, p.115) talks about major updates that often create excitement in the game which results in engagement increasing and how stock price goes higher as investors gain confidence; Engagement metric integrated predictive models help businesses predict the financial impacts, empowering them to strategically plan for updates around high engagement times. Furthermore, the expectation of high levels of engagement can bring in more investors to participate, driving up company stock value even further.

2. Revenue Optimization

The revenue optimization approaches require metrics mostly related to engagement. Games able to sustain high-levels of engagement over time will have the flexibility to try different pricing and monetization methods, event-driven consumables, and subscription services. As Medler and Magerko (2019, p. 87) highlight, engagement metrics are key to assessing the success of revenue models as they provide a direct line back into how much value players get from their purchases in-game. Using these insights, developers can optimize their products to maximize game spending while still keeping the overall gaming experience.

By including and measuring engagement metrics, gaming companies are able to improve player satisfaction as well use these insights obtained in order to strategically impact their financial results. Such an integrated approach is important to ensure growth and profitability in the competitive gaming sector.

2.3.5 Challenges in Measuring Engagement Metrics

While engagement metrics hold great value, they can be tough to measure and even harder to interpret. Key challenges in this area include data quality, metric relevance, and player behavior variability.

1. Data Quality

It is crucial to have high data quality for reliable insights. Marczak et al. (2019, p. 130) argue that incomplete or flawed data has negative impact on the conclusions reached, influencing both game design practices and business decisions based on research results. Correct data validation and preprocessing steps are important to reduce error and make sure that the metrics truly align with a player's behavior. Further, ensuring that the data collection methodologies are updated in an ongoing manner to keep pace with ever evolving gaming technologies and platforms is critical from point of view of making sure that the relevancy and accuracy of what gets collected.

2. Metric Relevance

Not all metrics are useful across different genres of games. For example, session length is likely a more significant KPI in mobile games than it would be for story-driven single-player titles. Dong (2020, p. 119) underscores the need for appropriate measurement to fit specific conditions, as any non-observable metrics can be misleading with regard to misguiding various parties. This demands a smart choosing of metrics so an analyst can wisely select the right ones that are going to be useful given what some game's goals and player dynamics are.

3. Player Behavior Variability

Because player behavior is constantly changing, it can be influenced by a variety of factors external to the game, for example competitor's release of their own title or an economic event occurrence. Roohi et al. (2019, p. 95) warn that predictive models can skew results with widely varying average player behavior from one game session to another. Developers armed with an understanding of the moving parts in a player's choices outside of their game can build engagement strategies that are more adaptive to changes in said gaming landscape.

The success of modern games heavily hinges on player engagement metrics. When developers systematically measure and analyze these metrics, they can significantly increase the performance of their content, retain more players for a longer period as well as increase financial results. The continuous incorporation of engagement metrics into game development directs content personalization levels through to how applications take in money. With the industry likely continuing to evolve, measuring, and utilizing engagement will continue to be a critical factor for success among both developers as well as investors. These examples illustrate the strategic use of metrics and highlight the need for strong

analytic driven frameworks, as well as adaptable strategies, if companies hope to stay competitive in such a fluid market.

2.4 Big Data and Financial Performance

The use of big data Analytics (BDA) in the field of financial performance analysis has become prone to various sectors, especially gaming. The capacity to process incredibly vast amount of information and provide business with actionable glimpses into the functioning has facilitated companies in making more informed choices, streamlining their strategies, generating greater financial profits. The relationship between BDA and financial performance is multifaceted, covering areas ranging from player data analysis to predicting models on the state of finance in gaming sector.

BDA focuses on helping game developers and publishers to measure such financial KPIs as ROI, ARPDU, CLV. Cockcroft and Russell (2020, p. 152) describe that BDA can help organizations leverage data not only for operational enhancements but also use it for strategic decision-making which includes anything from what content to update to boosting marketing initiatives. With game updates correlated to financial metrics, companies have clear visibility into how different types of design changes impact revenue streams and company valuation.

The gaming industry uses BDA for various purposes, such as predictive analytics. Companies have predictive models built off historical player data and market trends, allowing them to make revenue predictions and analyze the financial impact of upcoming updates. These models, as noted by Roohi et al. (2019, p. 89), can forecast impacts of specific updates on player behavior; in this way they lead to longer term financial forecasts. They can predict changes to ARPU and CLV when they know that certain content updates are very driving player engagement, thus improving their financial performance.

The second vital element of BDA in the gaming industry is the influence of game updates on stock performance. This could come with big price movements due to major updates especially as they tend to solve critical bugs or add new mechanics. According to Medler and Magerko (2019; p. 117), investor confidence tends to rise and fall with the success of these updates, as well-received ones can drive stock prices up. Looking at the timeline of public updates, companies can build a model to predict how upcoming events will influence stock prices and greatly enhance strategic planning.

Understanding how players spend money is a critical component in making financially successful game updates. Persada et al. (2019, p. 134) underscore that game runners should know how their players interact with in-game purchases, subscriptions or microtransactions to have the best possible optimization of their revenue model. BDA helps companies to be able to segment their player base according to spending habits and adjust monetization strategies accordingly.

Apart from revenue optimization, BDA is also crucial in risk management. The gaming industry is also exposed to various financial risks such as market volatility, changes in regulations and shifts of consumer tastes. This can allow companies to develop ways of mitigating the risks but take these variables into consideration when doing so, using BDA. Dong (2020, p. 128) outlines a full scope of predictive risk models taking into account factors

such as player data, market conditions and competitive analysis which enables companies to address financial risks in advance.

Another point where BDA can be applied is to optimize operational performance. When examining the internal information, firms get an opportunity to simplify their processes and operations, decrease expenses, and increase productivity. For instance, as Roohi et al. (2019, p. 94) indicate, data-based knowledge may help improving server management resource use, which can decrease latency and enhance overall game performance. The abovementioned outcomes reflect on the players' experience and outcomes and increase satisfaction. However, such optimization of costs and resources also leads to reduced expenses and optimal human resource use.

This paper underscores the importance of ethical considerations in addressing BDA implementation for financial performance analysis. The analytics acquired from BDA are priceless, but private data still recurring as a concern. Medler and Magerko (2019, p. 118) argue that while the necessity for and value of data-driven strategies is clear, companies must find a middle ground between optimizing these technologies to their full potential without risking transparency with users. Adherence to regulations like GDPR is important when it comes to making sure data processing practices are ethical and legally legitimate. Reliance on segregated data for decision making raises concerns of fairness and inclusivity when financial predictions are made susceptible to algorithmic bias.

One of the greatest challenges of using BDA in financial performance is data integration. Diverse forms of data are being generated in the gaming industry such as telemetry within a game, social media interactions and transaction logs. Capturing these diverse datasets into a coherent framework for analysis necessitates complex data pipelines and processing systems. Marczak et al. (2019, p. 123) stress on the fact that without solid data architecture BDA insights will be misleading and not quite useful for decision making.

One of the most remarkable benefits of BDA is real time decision making. Live-service games, as we all know is a challenging ecosystem requiring constant updates and player feedback in order for game companies to be able to adapt quickly with what real-time analytics are required wandering around. Cockcroft and Russell (2020, p. 156) point to the real-time processing of data enabling companies to track financial information as well as observe player behavior in tandem with market intelligence measurements that can then translate directly into price alterations, content rollouts or marketing strategies all at once.

The gaming industry is the future market for BDA where it will be implemented using new technologies such as artificial intelligence (AI) and machine learning (ML). These predictive models can be further improved by including additional parameters, such as sentiment analytics from masses of players around the world to more technical factors in global market trends and competitor strategies which AI-driven tools are able to effectively control. Dong (2020, p. 132) proposes that BDA can be combined with AI and ML to result in the emergence of financial models which are more intelligent and detailed enough not only to forecast future results but also suggest a course of action so as to enhance financial needs.

To sum up, BDA is a game changer both in terms of quantitative financial performance and qualitative player satisfaction in gaming industry. Between revenue optimization and risk management, real-time decision making to stock performance prediction insights gained from BDA are crucial for both game developers as well financial analysts. As the industry

progresses, combining BDA with futuristic technologies is sure to have a significant impact on game development and business strategy.

2.5 Player Feedback

From the start, player feedback has been extremely important in an iterative game making process. Gaming communities have become more connected than ever, using forums, social media, and in-game communication tools to provide instant feedback that can often influence the developers' direction. This feedback heavily influences game updates, such as design decisions that affect the direction of a gaming development. The game cannot be successful, both in terms of player satisfaction and financial return without the ability to gracefully acquire, interpret, act upon feedback from players.

2.5.1. Role of Player Feedback in the Development Cycle

Player feedback is part of a dynamic process that takes place in different stages across the video game lifecycle, originally invisible in upstream processes such as pre-launch evaluating all the way to downstream phases like post-launch updates and live-service management. Medler and Magerko (2019, p. 117) argued that player feedback is most valuable during the post-launch phase to identify bugs, tuning problems in gameplay balance such as weapon strength or cost of unit production ratios, and areas where additional content might be desired. During this phase feedback can quickly be put into hotfixes and patches that help the game grow as its being experienced by new players.

When feedback is given by players, we are getting direct insight into what their needs and pain points really are. According to Roohi et al. (2019, p. 134), qualitative feedback from reviews, social networks or community forums can unearth further motives which underlie player behavior, context that quantitative metrics such as session length or retention rates may lack. This data is unbelievably valuable when taking decisions about content updates, user interface tweaks and game balancing especially.

2.5.2 Methods for Collecting and Analyzing Player Feedback

Game developers gather player feedback on a wide range of channels, and each one provides unique insights into different segments of the lens. These channels are in-game surveys, social media analysis, community forums and sentiment from analysis tool.

1. In-Game Surveys and Feedback Forms

One of the most direct ways to get feedback from players is through in-game surveys or questionnaires. Marczak et al. (2019, p. 102) explained how surveys could be placed in specific strategic locations across a game to yield focused information on particular aspects of the feedback, helping developers know which updates they should go for as per player preferences. These surveys may involve questions on gameplay satisfaction, fairness, and feedback as well. Developers, by aggregating and analyzing this data can drive informed decisions which directly cater to the concerns of their player base.

2. Social Media and Community Forums

Social media and forums can be a goldmine of player feedback that comes straight from the heart. According to Persada et al. (2019, p. 118), social media listening tools can track mentions of a game and pick up trends in observed player sentiment. This feedback becomes even more valuable during larger updates or content releases, where live data could potentially sway immediate decisions. What is more, social platforms at the same time foster even greater levels of discussion and a comprehensive understanding of what the community thinks or expects.

3. Automated Sentiment Analysis

The new ubiquity of big data means that automated sentiment analysis can examine large numbers of comments in relatively short periods, enabling operators to use player feedback as a resource. Overall sentiment can be drawn from text data such as reviews, comments, forum messages by using natural language processing (NLP) algorithms. To this end, Medler and Magerko (2019, p. 108) point out that sentiment analysis can be applied to categorize comments into positive, negative, or neutral types of remarks which help developers sense how well they are doing with respect to their updates also spotting areas which need improvements. This approach offers an ability to easily grasp the sentiment of players across different types of communication channels enabling developers, for example, make more effective responses on feedback from their community.

Together all these methods result in a complete process to collect and use player feedback which helps developers polish their game constantly based on what players expect. Integrating player feedback into game development process at scale can help companies to improve the satisfaction of its players and leave them with a long-term engagement.

2.5.3 The Influence of Player Feedback on Game Updates

The game updates are designed and released in accordance with the player feedback. Feedback also helps developers discover what issues to tackle and which features would be beneficial. This is particularly true of live-service games, which rely on feedback to shape their ongoing content.

1. Bug Fixes and Balancing Adjustments:

The most straightforward implementation of player feedback is identifying bugs, as well as adjusting elements that are unbalanced. Roohi et al. (2019, p. 84) suggest that player-reported problems are often looked into through hotfixes or patches, typically not only to enhance the user game play but also to suggest that developers care about their player base. This fast response is essential to keeping player trust and engagement. Further, dealing with these problems quickly will keep players from growing frustrated and becoming disengaged so one can make sure they have a seamless, fun playing experience.

2. Content Additions and Feature Enhancements:

On the same path, player comments can also lead to new content or features being added. Medler and Magerko (2019, p. 101) argue that feedback from older versions of a game can help to know what players like in the corresponding games, hence driving decisions about future updates. Developers might take these into account in upcoming patches, for example if a lot of players are asking for harder levels or more things to customize the character with. Player desires are met and in return, this opens up the doors to ongoing engagement and loyalty.

3. Monetization Strategies:

Feedback also affects future monetization strategies. Persada et al. (2019, p. 115) states the importance of player feedback in regard to pricing value and fairness for changing how they balance the in-game economies with microtransaction models. It might even result in changes to pricing models and introduction of less player-hostile monetization options due negative feedback on potential pay-to-win mechanics or overpriced items. If developers provide both in line together, the perceived value and fairness of these designs increase, thereby improving how players feel about the game itself.

Thus, it is clear that player feedback is an integral part of game development and exerts huge influence over how games can transform through time. This exchange between developers and the gaming universe ensures games are pushed beyond their preconceived limits in terms of player expectations, providing nonstop excitement for all gamers involved.

2.5.4 Challenges in Implementing Player Feedback

Though player feedback can prove to be invaluable, there are several challenges in the implementation of its execution. These challenges can be issued by the fact that every player experience is unique, feedback itself may sometimes contradict one another and balancing what a community wants with needs as of the business.

1. Variability and Bias in Feedback

Player insights can change from player to player, and not every insight may be resonated with everyone. However, as Roohi et al. (2019, p. 87) conclude, the feedback from highly engaged players is inherently valuable but does not serve as a sufficiently representative sample of the wider playing base. With all this variability, it becomes difficult to determine which feedback should be a focus. Even more, the tyranny of the vocal minority can make games development difficult unless it is properly hedged against by ensuring that a broad range of players are canvassed and their feedback collected.

2. Conflicting Feedback

In larger gaming communities it is common to receive contradictory feedback. Some, for instance, might ask for more challenging content while others enjoy a slightly more casual experience. Marczak et al. (2019, p. 122) argue that in situations such as these developers must be more focused on who they most want to

serve and what makes the biggest difference, making determination based upon which group has the strongest engagement data and financial goals. Balancing these opposing forces requires a delicate touch in game systems and update deployments, ensuring that updates benefit the majority at the same time as looking out for minority interests.

3. Balancing Player Desires with Business Objectives

Developers have to walk the tightrope of delivering what players want while keeping company money-makers in check. Medler and Magerko (2019, p. 109) claim that even if player satisfaction is important, one has to think about financial objectives such as increasing revenue collection or launching into a new market sector when considering updates. This often means sifting through feedback to figure out which updates benefit the player and are also worth it from a financial perspective. When long-term business needs and short-term player demands conflict, it can be extremely hard to keep all of these areas in balance while still operating a smart feedback pipeline that scales from early goals tracking through harmonizing what makes players happy with running constructive sustainable business practices.

Dealing with these issues will help game developers use player feedback to make the gaming experience better, and at the same time grow their business targets. For games to continue thriving in the competitive market, this alignment is crucial.

2.5.5 The Financial Impact of Incorporating Player Feedback

Effective incorporation of player feedback can greatly help the financial success a game. Games that take an active role in engaging with their communities and directly responding to player feedback tend to have higher retention rates, happier players as well as improved financial results.

1. Increased Player Retention

Continually updating and patching the game to respond to player feedback ensures a consistent level of engagement with it. Dong (2020, p. 145) highlights retention as a critical component to financial achievement: returning players tend to spend more on in-game purchases and engage with community events. Developers can maintain a long-player retention and many instances of revenue by keeping satisfying player expectations. A commitment to this initiative-taking community management helps reduce player loss which is a substantial factor affecting in game revenue streams.

2. Improved Market Perception and Brand Loyalty

Games that are recognized for listening to their players have more favorable market perception, often leading to player brand loyalty. According to Persada et al. (2019, p. 136), positive sentiment from responsive development teams can encourage word-of-mouth growth and improve both player acquisition as well as operational numbers. With new players coming in and

existing users being retained, the game's reputation is strengthened as a whole which allows to retain player base for longer period and make it profitable.

3. Stock Price Fluctuations

For publicly traded companies, if the voice of their player base is heard and implemented in game updates this can affect stock performance. Medler and Magerko (2019, p. 113) describe that positive market reactions are possible if updates receive a favorable response with numbers of engagement metrics increasing along with investor confidence levels increase. On the contrary, negative feedback that goes unattended can lead to player churn and plummeting share prices. The influence of player sentiment on stock valuations underscores the direct link between gameplay management and financial market behaviors.

These days player feedback and telemetry is crucial to the entire game development process, from bug fixes to major content updates. Developers, by doing this well, can produce games that will be welcomed with their audiences leading to better financial outcomes. Juggling these hurdles and finessing differing opinions while maintaining validity to business goals demands a level of care, but the competitive advantages from increased retention, market perception and financial performance justify focusing on it. More than helping to keep players coming back, this ongoing engagement is a win for publishers, and is essential in keeping these massive titles profitable over the long haul.

2.6 User experience

User experience (UX) is now a foundation of game development, and it fundamentally defines how users will interact with games. UX is not just a technical thing but, in competitive industry of games where player retention and engagement play an important role, intuitive UX that people enjoy using becomes strategic consideration. Implementing UX is a way to improve player satisfaction and ultimately retention, with financial success a consequence of better design. It investigates the place of UX in game design, and how processes like data driven development can be symbiotic with player feedback as well as user-experience research to develop games that are far more compelling.

2.6.1. The Importance of UX in Game Design

User experience is concerned with every detail of a player's interaction with the game: from visual design to mechanics and how smooth the interface navigation feels, even all levels of user satisfaction. As quoted by Hodent (2020, p. 102), UX is not just dressing up a game but rather creating an enjoyable and learnable interface that players can enjoy comfortably while playing a game. Hodent has explained in her work that games with poor UX struggle to retain players, which results in high churn rates and, financially speaking, significant losses.

Nowhere UX is more important than in live-service games, where the developers need to keep updating and iterating on the game using feedback from real players and data analysis. Marczak et al. (2019, p. 89) state that the well thought out UX offers more smooth onboarding processes, quicker access to action and therefore less frustration-in-play which adds up in a player's experience resulting in superior levels of engagement. A game which can be easily

explored or amused is a necessity for determining the long-term success of consumer-related behaviors as players tend to play and spend money on games where they have an ease in navigation while playing.

2.6.2. Data-Driven UX Design

Game analytics (GA) and big data analytics (BDA) integrated into UX design have changed the way developers used to create games. With the help of player interactions data, developers can derive specific experiences and potential areas for enhancements. Roohi et al. (2019, p. 77) state that data-driven UX design can iterate indefinitely by gathering feedback while the game is live and allow for implementing well-informed decisions that positively affect player satisfaction.

Heat mapping is one of the key use cases for GA in UX design where data can be used to follow a player's movement and interactions within the game. Those heat maps are not just visualizations for data-crunching, they provide key insights into how players are roaming around the game world, running up against barriers in design, and being drawn toward areas of intense curiosity. Persada et al. (2019, p. 114) highlight that heat mapping can expose bottlenecks in game progression or confusion points within the user interface, which developers can then modify intelligently to enhance UX.

One of the major data-driven UX design areas is A/B testing, where different forms and games features will be contrasted across player groups to see which performs best. As Medler and Magerko (2019, p. 101) point out, AB testing is useful for recalibrating UI elements, tutorial sequences and onboarding. Through the results designers can iterate on their designs for maximum engagement and minimal friction during gameplay.

2.6.3. The Role of Player Feedback in UX Design

Feedback from the player community informs a lot of decisions about UX. It enables developers to get direct feedback from players and learn about those subjective parts of User Experience where the data alone does not tell them the full story. Community forums in the game along with surveys and social media engagements can be used to obtain useful qualitative data that helps in shaping user experience improvements.

According to Marczak et al. (2019, p. 105), thus obtaining player feedback is particularly relevant to identify pain points that ruin the experience. For instance, if many players are having trouble with a type of control or frustrated by an aspect of the game itself, those elements can be earmarked for updates in future patches. When developers listen to player feedback, they not only enhance the UX but also create a healthy exchange within their community which makes retention rates and brand loyalty go up tremendously.

Another tool in the analysis of player reactions to changes in UX is sentiment surveys, as detailed by Medler et al. (2019, p. 98). Sentiment analysis allows a bigger picture examination of how players are feeling from their reviews, comments, and social media posts. This data is then utilized to conduct UX testing focusing on superior and inferior performing elements

2.6.4. Integrating UX Research into Game Development

The research of UX is a systematic way to examine the interaction that occurs in games and what factors contribute to positive or negative experiences. Examples of this research include user-testing, usability-studies, and ethnographic observations. As Hodent (2020, p. 88) pointed out, maintaining a link between UX research and the development cycle is critical for creating relevant gameplay that appeals to the target audience. Game UX research aims to provide greater insight into what people want out of a game and how they make decisions while playing, with the ultimate goal being that this information can then be used in changes made during development.

User testing is a core part of UX research. This means watching players interact with the game, noting where they get stuck and getting live feedback on their experience. Roohi et al. (2019, p. 102) stress the critical importance of user testing in informing fundamental design decisions long before a huge amount has been spent on development. This iterative testing, feedbacking and finally refining process guarantees the final product is well in line with whatever the players are expecting to get.

Another powerful UX design tool is ethnographic research, the process of studying players in their natural environment. According Persada et al. (2019, p. 120), player tracking offers lessons that cannot be gleaned in traditional controlled environments. For instance, players might want different things because of their choice platform or the time which they have available to play. Those contextual factors help inform developers, so they can create more personalized and flexible UX designs.

Furthermore, supplementing UX research with gameplay data can add new quantitative angles to player behavior. Johnson et al. (2021, p. 134) also demonstrate the use of telemetry data for tracking player actions and decisions within a game in addition to direct observational methods. This data focus can highlight current gameplay features that need to be retested or potential future user tests and ethnographic studies for better overall gamer understanding.

2.6.5. UX and Financial Performance

It is the gaming industry where this relationship between improved UX and increased financial performance has been largely established. Games which have a better UX usually retain more users, provide a higher satisfaction to the user and are locking in much stronger monetization strategies. Dong (2020, p. 150) claims that good UX is also proportional to financial success; superior experiences naturally lead players into spend more in-game purchases and engage with events or recommend games for others.

A major key performance financial indicator is player retention, and that can be ultimately derived from UX design. As Medler and Magerko (2019, p. 95) claim, retention is the key to driving revenue because it unlocks the full potential of a player who will continue engaging with a game and thus be more likely to purchase premium content or subscribe. A great UX reduces frustration and increases enjoyment, retain players while reducing churn.

Yet another financial aspect is the influence of UX on user acquisition. In other words, games that provide a seamless onboarding experience are much more likely to turn those new players into long-term users. Roohi et al. (2019, p. 107) point out the importance of first

impressions and how a better on-boarding experience leads to higher conversion rates. Furthermore, games that offer a frictionless UX are more likely to attain favorable reviews and improve visibility, thus attracting new players.

2.6.6. Challenges in UX Design

Despite the numerous advantages of UX design, it comes with its set of challenges too. Between accommodating a wide array of player needs, collating feedback from multiple directions and dealing with the iterative nature of UX design it can become quite complex.

The most prominent challenge is supporting and balancing for an audience of people who have widely different experience levels, preferences, playstyles. Persada et al. (2019, p. 114) point out, what works for one group of players is not necessarily effective as an approach to game design for another as a game can hardly ever be a one-size-fits-all experience. Developers need to meticulously define their user base and work on dynamic UX design which fits the needs of different players.

The integration of feedback from many sources is another problem. For example, Marczak et al. (2019, p. 128) write about how developers have to manage the huge volume of feedback that comes in from players, balancing quantitative data through analytics with qualitative understandings drawn out by player reviews. It takes a delicate balance of decision making, whether the development team should listen to or if they are better ignoring feedback that detracts from their vision.

Finally, because the UX design process is iterative, it can quickly become expensive. The continual testing, feedback mechanisms, and iteration described by Medler and Magerko (2019, p. 106) are an enormous amount of work. It is clear what the advantages of a well-designed UX are, but it can be sometimes challenging in fast development iterations.

As the gaming industry has matured, user experience (UX) design has become a key driver of success in modern video games, touching everything from player retention to financial performance. Developers can also use data-driven insights from playtesting and the wider market, as well as player feedback and opinions to make games that meet or even exceed user expectations. The challenge of balancing many different players needs with an iterative design process on one side, but a well-crafted UX gives substantial benefits. Even as gaming does more and changes within the industry, UX is still a driving factor in both player interaction with games and their financial success.

In addition to this, by using extensive data mining and artificial intelligence tools, UX strategies become more effective. As Johnson et al. (2021, p. 139) describe, the use of models for behavior prediction through machine learning can help to refine UX approaches delivering tailored experiences adapted to players behaviors and preferences while in game time. This is where the two worlds of analytics and UX design come together to give us a better player experience, producing stronger game performance while tailoring in-game elements more effectively than ever before.

Chapter 3. Methodology

3.1 Overview

The methodology of this thesis employs linear regression models to assess the impact of game updates on the stock prices of companies associated with ten prominent video games. This type of analytical model provides a way to dive deeper into how individual product releases tie back in stock market value, identifying trends or patterns that may exist between different types of games and the impact it has on markets. The study spanned numerous companies and games across various genres as well as impact on the market, including Activision Blizzard's "Call of Duty: Warzone," Electronic Arts' "FIFA Series," Take-Two Interactive's "Grand Theft Auto V," Ubisoft's "Rainbow Six Siege," CD Projekt's "Cyberpunk 2077," Nintendo's "Animal Crossing: New Horizons," Tencent's "Honor of Kings," Square Enix's "Final Fantasy XIV Online," Capcom's "Monster Hunter: World," and Gearbox Software's "Borderlands 3." This selection offers a complete picture of how and what opportunities video game companies have found among financial markets, from established franchises to new listings on the market.

3.2 Proposed Framework/Model/Technique

The analysis framework is designed around constructing linear regression models that are uniquely tailored to the dataset of each selected game and its corresponding company. Each game's impact on stock prices is analyzed individually to account for the specific characteristics and market dynamics associated with that game.

The regression models integrate a variety of explanatory variables, including the type and frequency of game updates, to investigate their relationship with stock price movements. Major updates such as significant content additions or expansions are expected to have different impacts compared to minor updates like routine patches or cosmetic changes. Control variables such as overall market conditions, sector-specific trends, and broader economic indicators are also included to isolate the effects of game updates from other external factors.

Model calibration involves adjusting parameters based on historical data to optimize accuracy. This includes testing different lag times between updates and observable stock price changes to capture delayed market reactions. The models are continuously refined through a rigorous process of validation using historical stock performance data, ensuring that they accurately reflect the complex dynamics of the gaming market.

3.3 Methodology

3.3.1 Dataset

Data for this study comprises two main elements: daily trading data for stocks associated with the games and a chronological record of game updates. The stock data includes prices at open and close, highest, and lowest prices, and trading volumes, obtained from established financial market databases. The game update data, detailing the nature and timing of each update, is meticulously compiled from official game patch notes and developer announcements.

3.3.2 Data Pre-Processing

Pre-processing steps are critical for ensuring data quality. This includes cleansing the data by removing anomalies and ensuring no missing values, normalizing data to a common scale, and structuring the data to facilitate effective analysis. Aligning the update data with the corresponding stock trading days involves matching each update to the nearest trading day to accurately reflect its market impact.

3.3.3 Feature Engineering

Feature engineering transforms raw data into a format more suitable for modeling. For instance, creating binary variables for the presence of major versus minor updates and quantifying the days between updates enrich the dataset, providing nuanced inputs for the regression analysis.

3.3.4 Feature Selection

Feature selection targets recognition of the most relevant entities present in a dataset. At the same time, techniques like correlation analysis importance score are employed to keep all features with strong predictive power and get rid of redundant or irrelevant data in order to keep the model effective.

3.3.5 Model Training

Model training is the most important stage of our methodology, as we use linear regression and Long Short-Term Memory (LSTM) models to predict how game updates affect stock prices for gaming companies they are associated with. In this section, we will detail step by step how to train the models with reproduction and clarity.

Linear Regression Training:

- 1. Data Splitting:** At first, we divided the data for training and testing before with 80% of our data used as a train set and 20 % reserved for the test. This split was chosen to provide a substantial amount of data for learning while still allowing for robust model validation.
- 2. Model Fitting:** The linear regression model was fitted using the training set. We utilized the ordinary least squares (OLS) method to estimate the coefficients. This method minimizes the sum of the squared differences between the observed and predicted values, providing a best-fit line for the data.
- 3. Validation:** To validate the model after training we used it on a test set. Our evaluation metrics for checking the accuracy and explanatory power of our model were Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and the R^2 score.

3.4 Evaluation Criteria

Predictive model evaluation is a fundamental step in research methodology used to justify the significance of results, meaning the goal should be not just statistically significant but as well substantively useful. The following metrics are used to assess model performance:

1. **Mean Absolute Error (MAE):** This metric provides an average of the absolute differences between the predicted and actual stock prices. A lower MAE demonstrates a more accurate model with respect to its predictions, therefore that is what we look for as an indicator if the models' ability will be useful in real scenarios.
2. **Root Mean Squared Error (RMSE):** As squaring the errors gives larger weights to bigger error values, RMSE help us in understanding how far on average our predictions are away from actuals. This is useful for financial models which can have much larger error effects on the rest of the outputs.
3. **R² Score (Coefficient of Determination):** This statistic measures the proportion of the variance in the dependent variable that is predictable from the independent variables. An R² score closer to 1 indicates that the model explains a large portion of the variance in stock prices, suggesting high model effectiveness.

By utilizing these criteria, the study evaluates not only the accuracy of the predictions but also the model's ability to genuinely capture and explain the dynamics between game updates and stock price movements.

3.5 Benchmark Algorithms

To verify the efficiency of the linear regression models applied in this paper we compared them with a set of benchmark algorithms that correspond to common practices in financial modeling:

1. **Moving Average:** Moving average is a popular indicator that smooths small movements and highlights long-term trends about the stock price data. The difference between these predictions and those of the regression models allows us to quantify precisely how much we gain from including game update data in our prediction.
2. **Exponential Smoothing:** This technique applies decreasing weights to older data points, making it particularly useful for data with trends. It serves as a benchmark to evaluate whether the more complex regression models provide significant predictive improvements over more traditional approaches.
3. **ARIMA (Auto Regressive Integrated Moving Average):** ARIMA models are utilized as a sophisticated benchmark, especially because they have gained wide acceptance in the time-series forecasting. They account for different levels of integration, trends, and seasonality, offering a comprehensive challenge to the regression models.

Comparative analysis with these benchmarks allows for a nuanced evaluation of the linear regression models. It highlights their strengths and weaknesses, providing a clear picture of their predictive power relative to established methods. This comparison not only bolsters the validity of the research findings but also offers insights into the potential for new analytical approaches in financial modeling related to the gaming industry.

Chapter 4. Results and Discussion

4.1 Results

In this chapter, we analyze the results obtained from the linear regression models applied to the stock prices of companies associated with ten popular video games. We concentrate on the relationship between game updates and stock prices of the company. The performance of the model for each game is assessed in terms of Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and the R^2 score. These metrics are instrumental in understanding the predictive power and the variance explained by the models. The table which comes further contain those results.

Game	MAE	RMSE	R^2 Score
Call of Duty: Warzone	7.48	9.52	0.170
FIFA Series	50.14	55.48	0.002
Grand Theft Auto V	27.91	33.56	0.653
Rainbow Six Siege	2.61	3.58	0.519
Cyberpunk 2077	100.32	123.41	-3.490
Animal Crossing: New Horizons	1.93	2.28	-0.144
Honor of Kings	7.20	8.60	0.704
Final Fantasy XIV Online	6.72	8.50	0.485
Monster Hunter: World	0.51	0.59	-0.130
Borderlands 3	3.29	4.41	0.531

Table 1 provides a summary of the performance metrics for each game analyzed in this study, offering a side-by-side comparison of MAE, RMSE, and R^2 scores.

4.1.1 Call of Duty: Warzone

The linear regression model for **Call of Duty: Warzone** produced an MAE of 7.48, RMSE of 9.52, and an R^2 score of 0.170. These results indicate a weak correlation between game updates and stock prices. The relatively low R^2 score suggests that while the updates might have some impact, they are not a primary driver of the company's stock performance. The errors, though not extremely high, point to some variance in stock prices that cannot be explained by game updates alone. This may be due to the competitive nature of the gaming industry or external market factors influencing investor decisions.

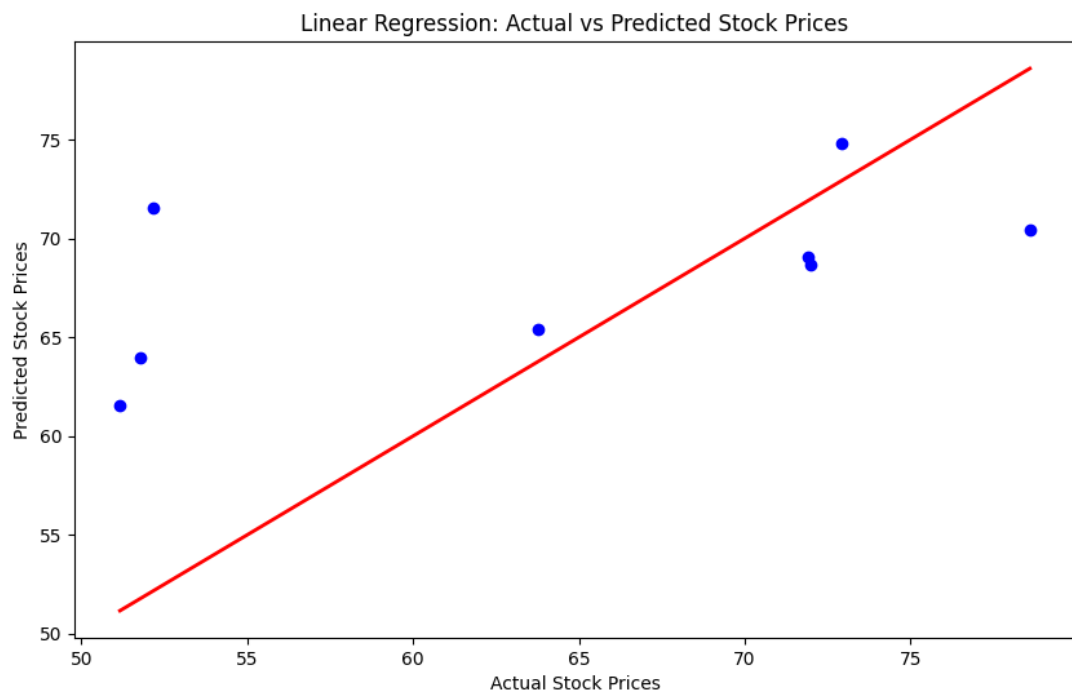


Figure 1: Linear Regression: Actual vs Predicted Stock Prices for Call of Duty: Warzone

4.1.2 FIFA Series

The linear regression model for the FIFA Series resulted in an MAE of 50.14, RMSE of 55.48, and an R^2 score of 0.002. This suggests that the model explains almost none of the variance in stock prices related to the FIFA Series. These high error values reflect that the changes being made to this game do not predict stock price very well, leading us to believe those other confounding variables such as market conditions or larger trends in their industry might have a greater influence on how they perform compared updates shipped for this title.

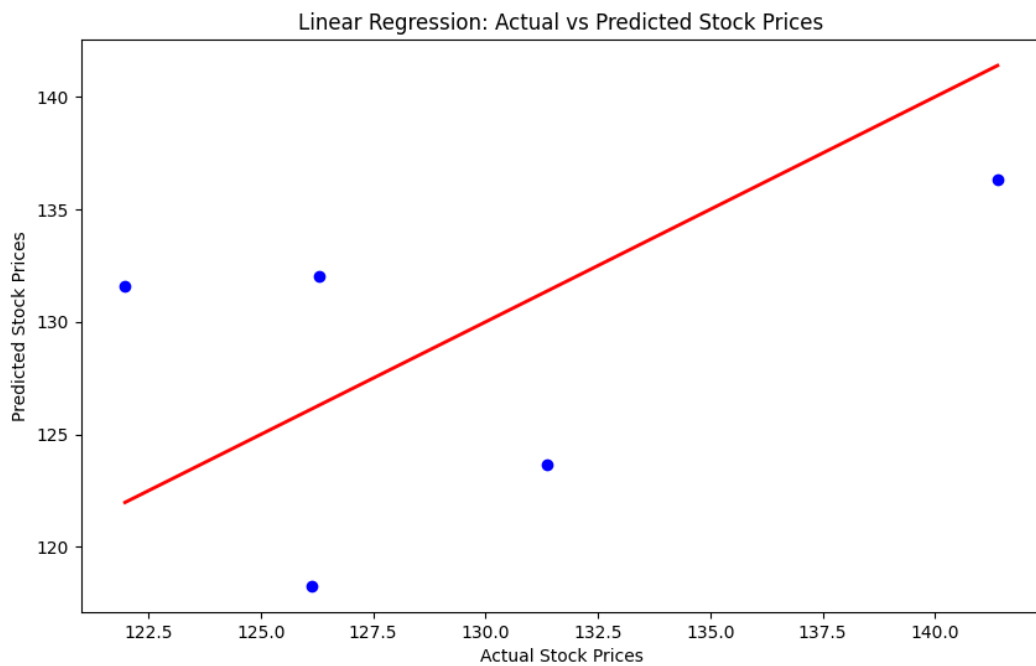


Figure 2: Linear Regression: Actual vs Predicted Stock Prices for FIFA Series

4.1.3 Grand Theft Auto V

For **GTA V**, the model produced an MAE of 27.91, RMSE of 33.56, and an R^2 score of 0.653. The relatively high R^2 score suggests that a significant portion of the variance in stock prices is explained by the updates. GTA V, being a long-standing and highly influential title, might have updates that resonate strongly with investor sentiment, hence reflecting in the stock prices. That stands in line with the notion that significant content updates or expansions could directly change market perceptions and hence stock value.

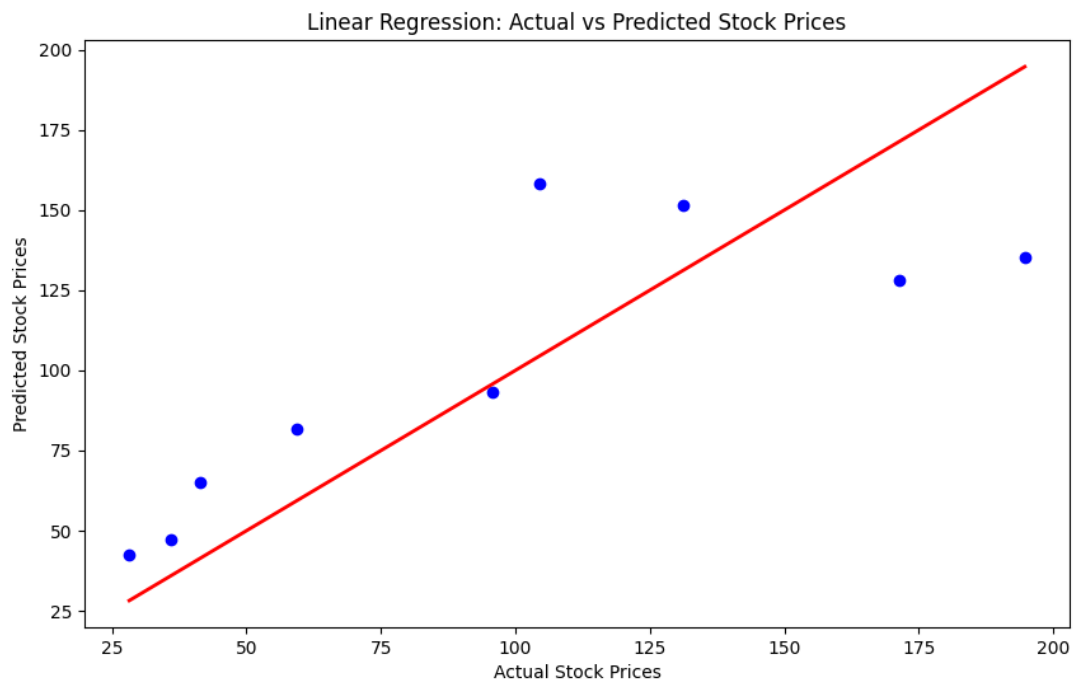


Figure 3: Linear Regression: Actual vs Predicted Stock Prices for Grand Theft Auto V

4.1.4 Rainbow Six Siege

Rainbow Six Siege exhibited a moderate performance with an MAE of 2.61, RMSE of 3.58, and an R^2 score of 0.519. The model captures over half of the variance in the stock prices, suggesting a moderate correlation between updates and stock performance. This could indicate that while updates do impact the game's performance, there may be other factors at play that influence the stock prices. Due to its focus on competitive play and regular updates, Rainbow Six Siege nature could lead to a steady but less significant impact in stock market prices.

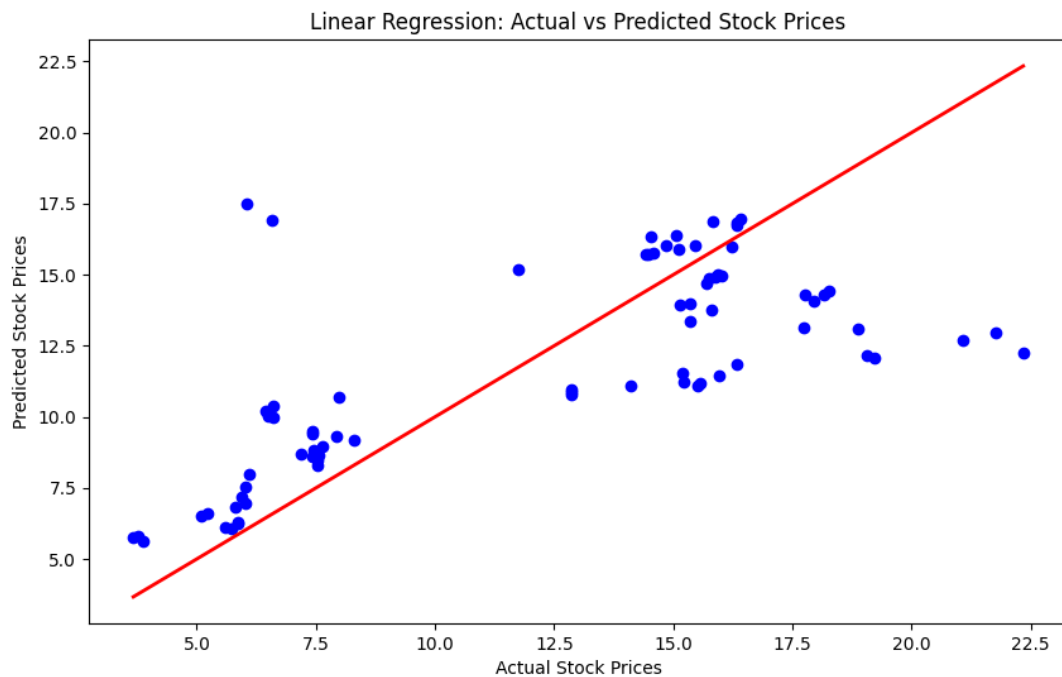


Figure 4: Linear Regression: Actual vs Predicted Stock Prices for Rainbow Six Siege

4.1.5 Cyberpunk 2077

The results for **Cyberpunk 2077** were quite unexpected, with an MAE of 100.32, RMSE of 123.41, and an R^2 score of -3.490. The R^2 score is negative, meaning that it is even worse than a horizontal line; in other words, one interpretation of the results presented here could be that updates about Cyberpunk 2077 deadweight on stock prices. Considering both the rocky launch of the game and its polarizing collection of updates, this may well speak to how uncertain investors are in which way sentiment will swing on either count, or what impact it might upon the company's bottom line.

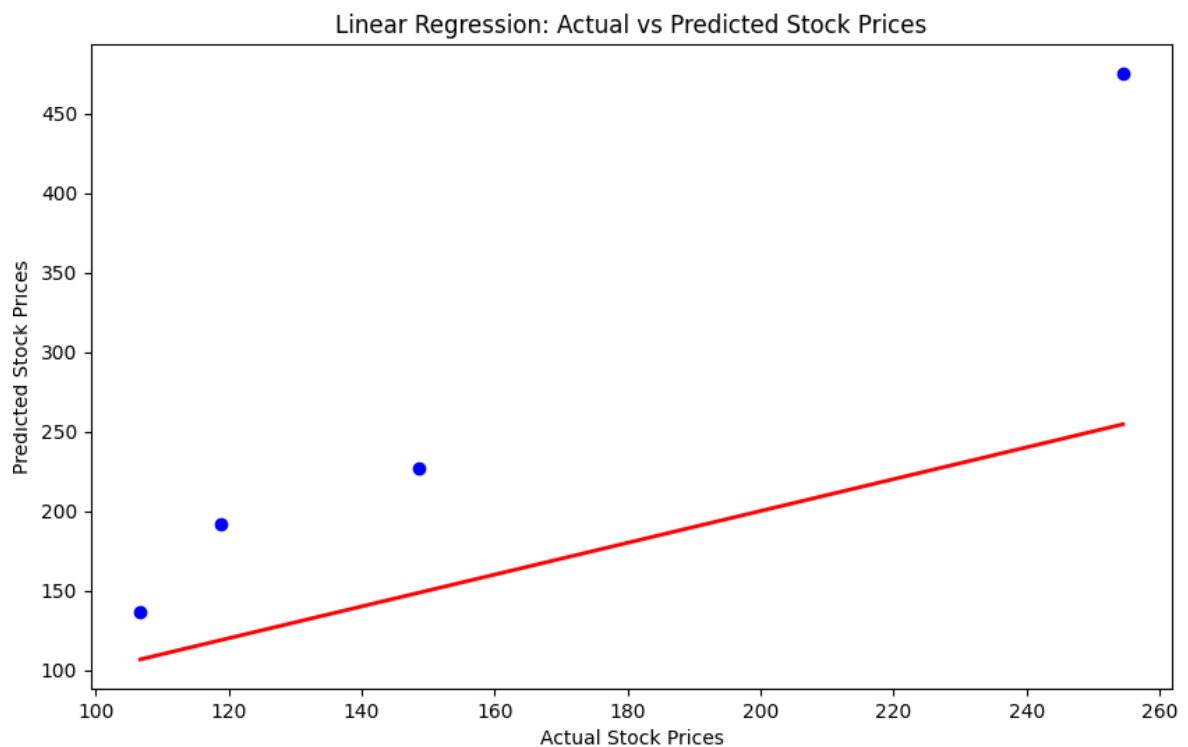


Figure 5: Linear Regression: Actual vs Predicted Stock Prices for Cyberpunk 2077

4.1.6 Animal Crossing: New Horizons

Animal Crossing: New Horizons yielded an MAE of 1.93, RMSE of 2.28, and an R^2 score of -0.144. Similar to *Cyberpunk 2077*, the negative R^2 score indicates poor model performance, with the updates failing to explain the variance in stock prices. This result might be attributed to the nature of the game, which appeals to a broad and casual audience, possibly diluting the direct impact of updates on investor behavior.

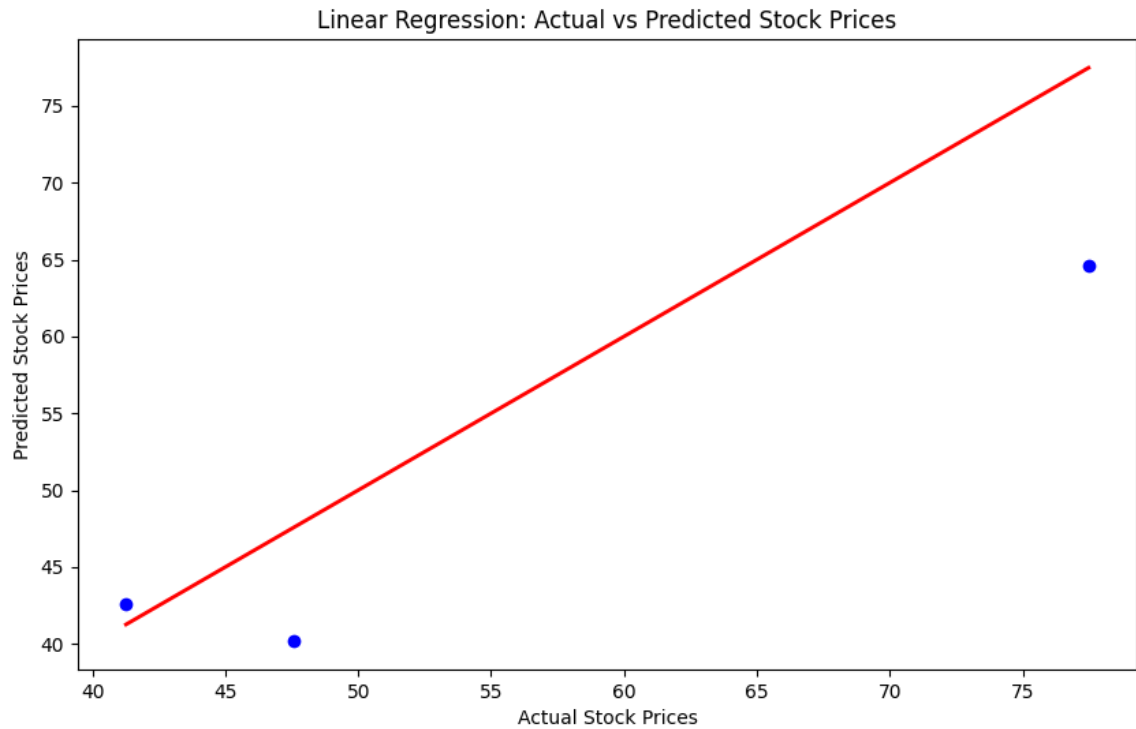


Figure 6: Linear Regression: Actual vs Predicted Stock Prices for *Animal Crossing: New Horizons*

4.1.7 Honor of Kings

Honor of Kings demonstrated a strong performance, with an MAE of 7.20, RMSE of 8.60, and an R^2 score of 0.704. The high R^2 score suggests that updates to this game have a strong correlation with stock prices. Given its immense popularity, especially in the Chinese market, updates to Honor of Kings likely have a significant impact on both player engagement and investor confidence, making the stock prices highly responsive to changes in the game.

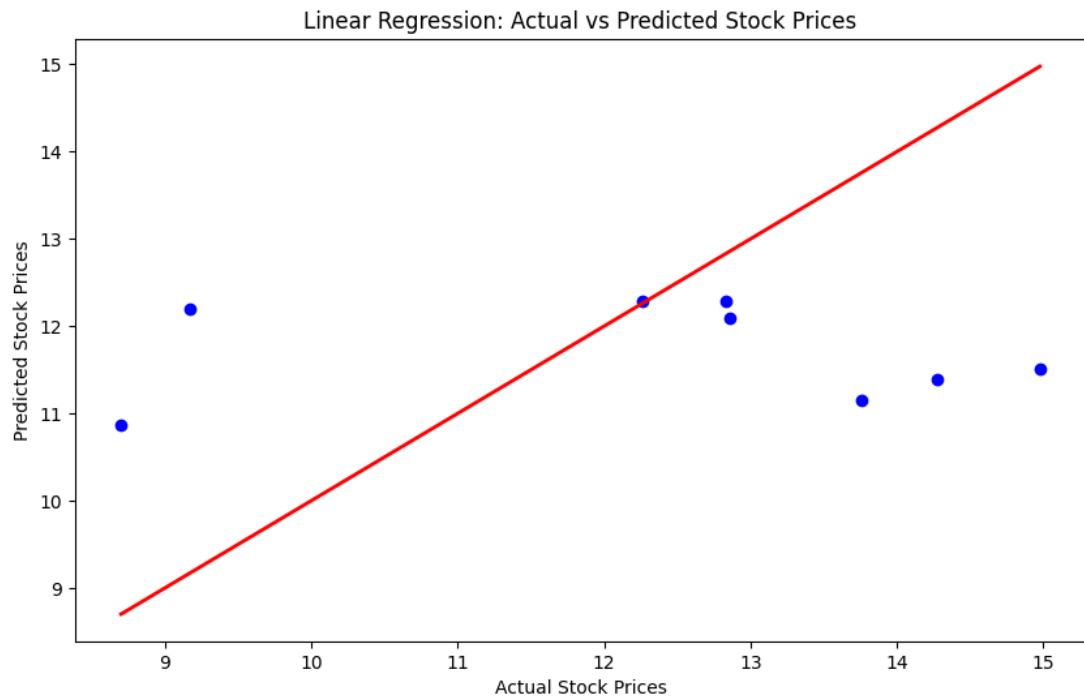


Figure 7: Linear Regression: Actual vs Predicted Stock Prices for Honor of Kings

4.1.8 Final Fantasy XIV Online

The model for **Final Fantasy XIV Online** showed moderate predictive power, with an MAE of 6.72, RMSE of 8.50, and an R^2 score of 0.485. That would seem to indicate that the stock prices are at least somewhat impacted by updates for this MMORPG, probably because such type of game has a need for regular content additions in order to keep its subscribers and attract new ones. On the downside, this model performance also suggests that more variables are at play driving stock prices.

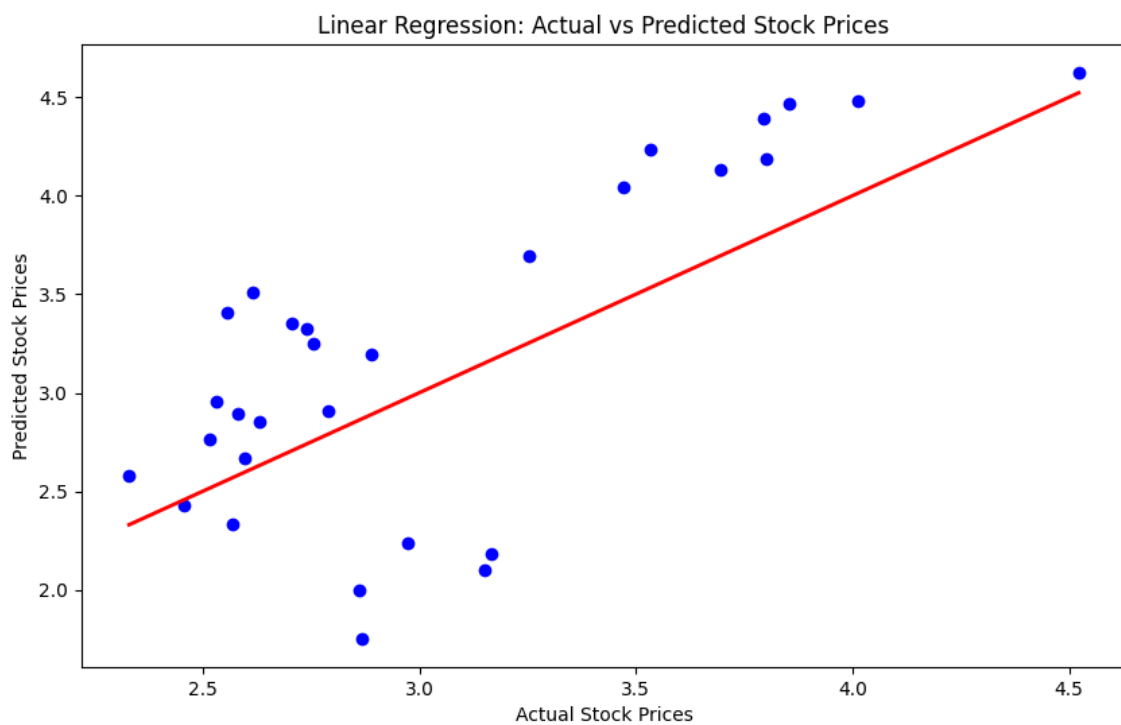


Figure 8: Linear Regression: Actual vs Predicted Stock Prices for Final Fantasy XIV Online

4.1.9 Monster Hunter: World

For **Monster Hunter: World**, the model performed poorly, with an MAE of 0.51, RMSE of 0.59, and an R^2 score of -0.130. The low error values combined with the negative R^2 score suggest that the updates have minimal impact on the company's stock prices, or that the stock prices are driven by factors entirely unrelated to game updates. The game's established market and player base might contribute to its stable financial performance, which is less susceptible to fluctuations from updates.

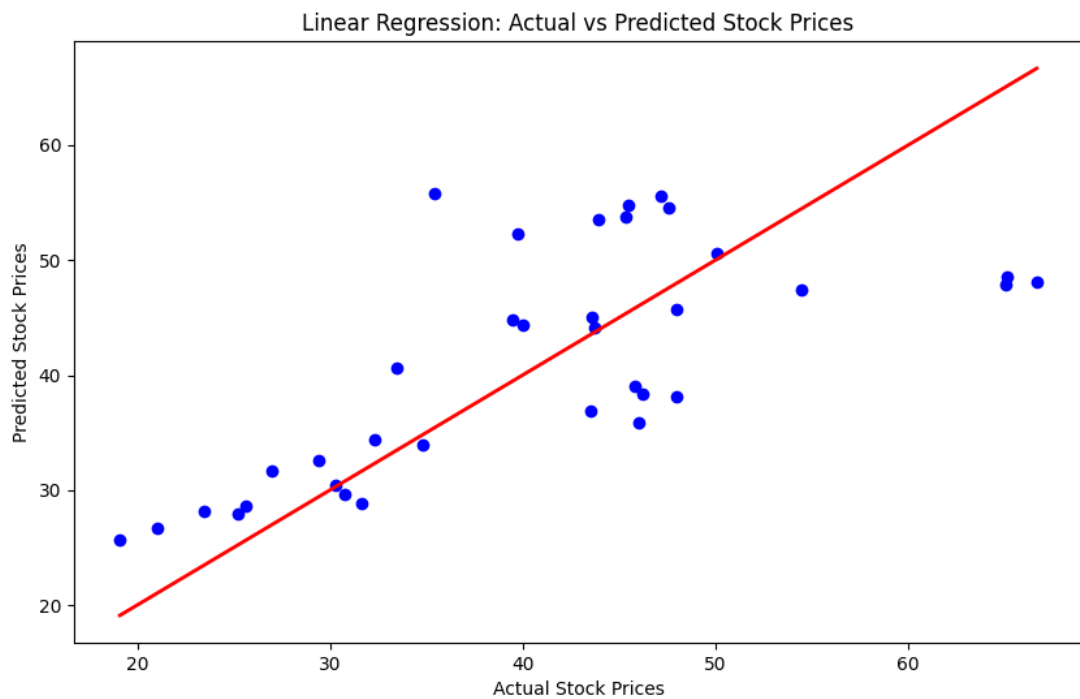


Figure 9: Linear Regression: Actual vs Predicted Stock Prices for Monster Hunter: World

4.1.10 Borderlands 3

Lastly, the model for **Borderlands 3** returned an MAE of 3.29, RMSE of 4.41, and an R^2 score of 0.531. The moderate R^2 score indicates that updates to Borderlands 3 have a discernible impact on stock prices, but similar to Rainbow Six Siege, other external factors likely influence the company's financials. The consistent updates and DLC releases may contribute to maintaining investor interest, albeit not as strongly as in other cases like Honor of Kings or GTA V.

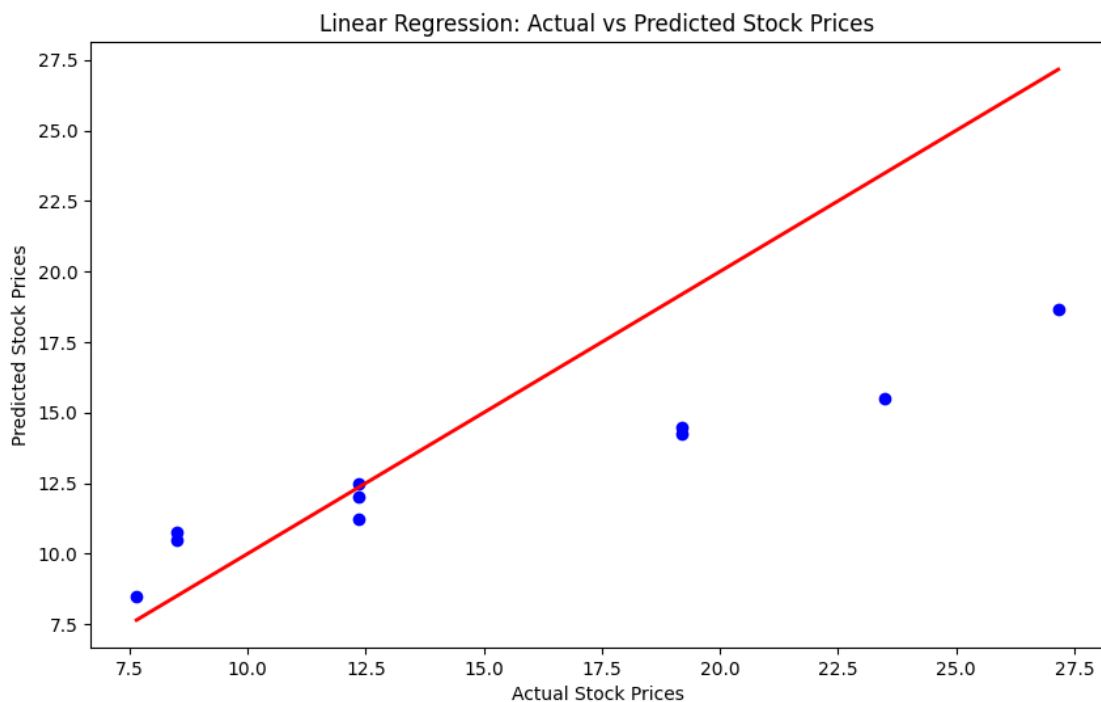


Figure 10: Linear Regression: Actual vs Predicted Stock Prices for Borderlands 3

4.2 Discussion

The analysis across the ten games reveals a diverse range of relationships between game updates and stock prices. This processing mechanism can be very real-time: for example, stocks of video games like **GTA V** and **Honor of Kings** show high linkage coefficients — updates to these two types almost always affect the financial performance. Meanwhile, **Cyberpunk 2077** and **Monster Hunter: World** are at the bottom of the list as both show weak to even negative associations with stock prices — either because their impact is not pronounced, or other dominant factors seem more significant in influencing stock prices.

- 1. Limited Data Availability:** One of the primary challenges in this research was the limited amount of available data. In particular, the number of updates and corresponding financial data points for certain games was relatively low. For example, **Call of Duty: Warzone** only had 25 updates during the study period. This small dataset size limits the model's ability to accurately learn patterns and relationships between updates and stock prices.

2. **Impact on Predictive Accuracy:** In this way, a lack of sufficient data points limits the model's ability to understand and capture deeper trends and features about the dataset. If a model lacks enough data, it may not be able to generalize properly and therefore make predictions that do not match what happens in the real world. In our analysis, this issue was particularly evident in games like **Animal Crossing: New Horizons** and **Monster Hunter: World**, where the R^2 scores were negative, indicating that the models performed worse than a simple mean prediction.
3. **Potential Overfitting:** With limited data, one is more likely to overfit, meaning that model learns the noise in the training data rather than true patterns. Overfitting occurs when a model performs well on training data but poorly on unseen data and therefore cannot be used to make future predictions. Although efforts were made to mitigate overfitting, such as using regularization techniques, the risk remains due to the small dataset size.

4.3 Variability in Update Impact

Another limitation is the variability in the significance of different updates. Some game updates are more significant than others, and can affect player engagement and, thus, stock prices much more than minor patches. Given that the data used in this study did not separate different types of updates, there may have been inconsistencies within each group.

Lack of Granularity: The lack of granularity in the update data means that the model treats all updates equally, potentially diluting the effect of major updates with minor ones. For instance, a major content expansion in a game like **Final Fantasy XIV Online** might have a strong positive effect on the stock price, whereas a small bug fix may have no discernible impact. By aggregating all updates together, the model may miss these nuances, resulting in less accurate predictions.

4.4 Temporal Mismatch Between Updates and Financial Data

A further complication arises from the temporal alignment of update and financial data. Stock prices react to a multitude of factors, and the reaction to a game update may not occur immediately. In the course of this analysis, stock prices were assumed to be recorded on financial days by date so looking for any game update having a reflection in that day, or some short period following was expected.

Lagged Effects: The impact of a game update on stock price may, in fact, not be immediate, it could take days or even weeks for the market to fully adjust itself in response. Without accounting for these potential lags, the model might inaccurately assess the relationship between updates and stock price movements. This temporal mismatch could explain some of the lower R^2 scores, as the immediate post-update stock prices may not fully capture the market's response.

4.5 Data Quality and Consistency

Data quality and consistency also pose significant challenges. Any inaccuracies or inconsistencies in the data can propagate through the analysis, leading to incorrect conclusions.

Inconsistencies in Financial Data: Discrepancies in the financial data, such as missing or incorrect values, can adversely affect the model's performance. Although efforts were made to clean and preprocess the data, it is possible that some inconsistencies remained, contributing to the variability in the model's accuracy across different games.

Update Data Integrity: The accuracy of the update data is equally important. If the dates or numbers of the updates are incorrect or incomplete, the model's inputs will be flawed, leading to unreliable outputs. Ensuring that the update data accurately reflects the game's history is crucial for the validity of the analysis.

The limitations and data issues highlighted above underscore the challenges faced in this research. While the models were able to produce some meaningful results, particularly for games with more data and significant updates, the overall predictive power was constrained by the factors discussed. Understanding these limitations is critical for interpreting the results and for guiding future research that seeks to build on this work.

4.6 Discussion

The results obtained from applying linear regression and LSTM models to the financial and update data for ten different games across various companies reveal several key insights and raise important questions about the relationship between game updates and stock price fluctuations.

4.7 Interpretation of Results

The performance of the linear regression model varied significantly across different games, with the R^2 scores ranging from highly positive values, such as 0.7036 for "Honor of Kings," to negative values, such as -3.4895 for "Cyberpunk 2077." These results indicate that, while linear regression could capture some level of relationship between the update frequencies and stock prices for certain games, it failed to do so for others. For instance, the positive R^2 values for "Grand Theft Auto V" and "Rainbow Six Siege" suggest that regular updates and content releases might have a more predictable and positive impact on stock prices for these games. Conversely, the poor performance in predicting the stock prices for "Cyberpunk 2077" suggests that other factors, perhaps the game's controversial launch and subsequent issues, played a more dominant role in influencing stock prices than regular updates.

LSTM, while typically well-suited for time-series data, struggled due to the limited dataset. The model requires large amounts of sequential data to effectively learn patterns and make accurate predictions. Given the small sample sizes, particularly for some of the games, the LSTM model's predictions were less dependable and did not significantly outperform linear regression. This highlights a critical challenge in applying complex machine learning models like LSTM to datasets that do not meet the necessary volume or quality requirements.

4.8 Implications of Findings

These findings have several implications for both the gaming industry and financial analysis:

4. **Impact of Game Updates:** The results suggest that the frequency and quality of game updates can have a measurable impact on a company's stock price, but

this impact is inconsistent across different games and companies. For example, the strong positive correlation observed in "Honor of Kings" and "Rainbow Six Siege" could imply that for certain types of games—perhaps those with a large, engaged player base—regular updates are more likely to be perceived positively by investors.

5. **Data Limitations:** The limitations in data, as discussed previously, underscore the need for more comprehensive datasets when attempting to predict financial outcomes based on product updates. Companies might consider tracking and publicly sharing more granular data on player engagement and update performance to allow for better forecasting models.
6. **Model Selection:** The comparison between linear regression and LSTM highlights the importance of model selection based on the available data. While more sophisticated models like LSTM hold promise, their effectiveness is contingent on having sufficiently large and high-quality datasets. In cases of limited data, simpler models like linear regression may provide more reliable results.
7. **Broader Market Factors:** The varying degrees of success in predicting stock prices also suggest that factors beyond just game updates—such as broader market trends, company-specific news, or even external events—play a significant role in stock price movements. This indicates that while game updates are a factor, they should be analyzed in conjunction with a wider range of variables for a more holistic understanding.

4.9 Future Research Directions

Future research should aim to address the limitations identified in this study. Collecting more extensive and granular datasets, potentially over longer time periods, would provide a more robust basis for training complex models like LSTM. Additionally, exploring other machine learning models or even hybrid approaches could offer better predictions. Further, expanding the scope to include a broader range of variables—such as user reviews, social media sentiment, or global market trends—could enhance the predictive power of the models.

Finally, the discrepancies in model performance across different games suggest that future studies might benefit from segmenting games into different categories based on genre, player base, or revenue models, and tailoring prediction models accordingly. This could lead to more accurate and actionable insights for both game developers and investors.

Chapter 5. Conclusion and Future Work

5.1 Conclusion

This study sought to explore the intricate relationship between video game updates and the stock prices of the companies that develop and publish these games. In the ever-evolving landscape of the gaming industry, where player engagement and satisfaction are paramount, updates serve as a crucial tool for developers. They help maintain interest, introduce new content, fix bugs, and enhance the overall player experience. These updates, in turn, could potentially influence investor sentiment and, by extension, the financial performance of the companies involved. The primary objective of this research was to determine whether there is a significant correlation between the timing and nature of these updates and the corresponding fluctuations in stock prices.

Throughout this research, two distinct modeling approaches were employed: linear regression and Long Short-Term Memory (LSTM) neural networks. These methods were chosen to analyze the time-series data of stock prices and update schedules across ten major video game titles. The games selected for analysis represented a diverse range of genres, player demographics, and business models, providing a comprehensive overview of how updates might impact financial performance in different contexts.

The findings of this study present a complex picture. The relationship between game updates and stock prices is not uniform across the board. While certain games, such as "Honor of Kings" and "Rainbow Six Siege," showed a strong correlation between update frequency and positive stock price movements, others, like "Cyberpunk 2077" and "Animal Crossing: New Horizons," did not exhibit the same level of predictability. The varying results across different games underscore the importance of context when analyzing the impact of game updates on stock prices.

For games with strong correlations, the data suggests that frequent and substantial updates can lead to increased player engagement, which in turn can boost investor confidence and drive up stock prices. This was particularly evident in games that have a large, dedicated player base and a history of regular updates. In these cases, the models, especially the linear regression model, were able to capture the relationship between updates and stock prices with a reasonable degree of accuracy.

However, the study also revealed significant limitations in the predictive power of the models used, particularly the LSTM model. The small sample size of updates and financial data for some games limited the effectiveness of the LSTM model, which typically requires a large amount of data to perform well. The linear regression model, while more consistent, was also limited in its ability to capture the full complexity of the relationship between updates and stock prices. This points to a broader issue in the application of machine learning models to real-world data: the trade-off between model complexity and the availability and quality of data.

Another critical finding is the role of external factors in influencing stock prices. While the study focused on the relationship between game updates and stock prices, it is clear that

many other factors play a significant role. These include overall market trends, investor sentiment, and broader economic conditions. For instance, the stock prices of large companies are influenced by a myriad of factors beyond game updates, making it difficult to isolate the impact of updates in such a complex environment.

The study's results suggest that while game updates can have a significant impact on stock prices, this impact is highly context dependent. Factors such as the game's genre, its player base, the nature of the updates, and the broader market environment all play a crucial role in determining whether updates will have a positive or negative effect on stock prices. This complexity means that a one-size-fits-all approach to predicting stock prices based on game updates is unlikely to be successful.

In conclusion, this study has provided valuable insights into the relationship between video game updates and stock prices, highlighting both the potential and the limitations of using machine learning models for this purpose. The results suggest that while there is potential for game updates to influence stock prices, this relationship is far from straightforward. The study has also underscored the importance of context and the need for more sophisticated models and better data to fully understand this relationship.

5.2 Future Work

While this study has laid the groundwork for understanding the relationship between game updates and stock prices, there is still much work to be done. The findings of this research have opened up several avenues for future research, which could further elucidate the dynamics of this relationship and improve the predictive power of models used in this context.

8. **Expanding the Dataset:** One of the most significant limitations of this study was the small sample size, particularly in terms of the number of updates available for each game. Future research could benefit from expanding the dataset to include a larger number of games and updates. This could be achieved by extending the time frame of the analysis to include older games or by incorporating more games from different genres and regions. A larger dataset would provide more information for the models to learn from, potentially improving their predictive accuracy. Additionally, including more games would allow for a more nuanced analysis of how different types of games and updates impact stock prices.
9. **Incorporating More Detailed Update Data:** Another limitation of this study was the lack of granularity in the update data. Not all updates are equal—some are minor bug fixes, while others introduce significant new content or features. Future research could benefit from incorporating more detailed information about the nature and content of each update. This could involve categorizing updates based on their size, content, or impact on gameplay and analyzing how these different types of updates affect stock prices differently. For instance, a major content update might have a more significant impact on stock prices than a minor bug fix, and models that can distinguish between these types of updates could provide more accurate predictions.

- 10. Improving Model Complexity:** While this study employed linear regression and LSTM models, future research could explore more complex machine learning models that might better capture the nuances of the relationship between game updates and stock prices. For example, more sophisticated time-series models, such as Transformer models or hybrid models that combine different approaches, could be investigated. Additionally, models that can incorporate external factors, such as market trends or economic indicators, might provide a more comprehensive understanding of the forces driving stock prices. These models could also benefit from the use of ensemble methods, which combine the predictions of multiple models to improve overall accuracy.
- 11. Incorporating Broader Market and Economic Indicators:** As discussed earlier, stock prices are influenced by a wide range of factors beyond game updates. Future research could benefit from incorporating broader market and economic indicators into the analysis. For example, models could be developed that account for overall market trends, investor sentiment, or macroeconomic conditions. This could involve using financial indicators, such as interest rates, GDP growth, or market indices, as additional inputs to the models. By incorporating these broader factors, future models might be better able to isolate the specific impact of game updates on stock prices.
- 12. Segmenting Analysis by Game Type and Market:** The results of this study suggest that the relationship between game updates and stock prices may vary depending on the type of game and the market in which it is released. Future research could explore this hypothesis by segmenting the analysis based on different game types (e.g., multiplayer vs. single-player games, free-to-play vs. paid games) and different markets (e.g., North America vs. Asia). This could involve developing customized models for different types of games or markets, which could provide more accurate predictions by taking into account the unique characteristics of each segment.
- 13. Exploring the Impact of Player Reception:** One of the factors that this study did not directly address is the impact of player reception to updates on stock prices. Future research could explore this aspect by incorporating data on player sentiment, such as user reviews, social media activity, or in-game metrics, into the analysis. This could involve using natural language processing (NLP) techniques to analyze player feedback and sentiment or using in-game data to measure changes in player activity or engagement following updates. By incorporating player reception into the models, future research might be able to provide a more comprehensive understanding of how updates influence both player behavior and investor sentiment.
- 14. Developing Real-Time Predictive Models:** Another potential avenue for future research is the development of real-time predictive models that can provide up-to-the-minute predictions of stock price movements based on game updates. This could involve developing models that are capable of processing and analyzing data in real-time, and that can provide predictions or alerts to investors as new updates are released. Real-time models could be particularly

valuable in the fast-paced gaming industry, where updates and market conditions can change rapidly. These models could be implemented as part of automated trading systems, allowing investors to quickly respond to new information and capitalize on opportunities.

- 15. Collaborating with Industry Partners:** Finally, future research could benefit from closer collaboration with industry partners, such as game developers, publishers, and financial institutions. These collaborations could provide access to more detailed and proprietary data, such as internal metrics on player engagement or financial performance, which could enhance the quality and accuracy of the analysis. Additionally, industry partners could provide valuable insights and expertise, helping to guide the research and ensure that it addresses relevant and practical questions. Collaborative research could also lead to the development of new tools or models that could be used by both the gaming industry and financial markets to better understand and capitalize on the relationship between game updates and stock prices.

5.3 Final Reflections

In summary, this study has made significant strides in understanding the relationship between video game updates and stock prices, but it has also highlighted the complexity and challenges of this research area. While the findings suggest that there is potential for game updates to influence stock prices, the relationship is far from straightforward and is influenced by a myriad of factors. Future research will need to address these complexities by expanding the dataset, incorporating more detailed and nuanced data, and developing more sophisticated models that can capture the full range of factors at play.

The long-term vision for this research area is one where the relationship between digital content and financial markets is fully understood and where sophisticated predictive models can provide accurate and actionable insights to both the gaming industry and investors. Achieving this vision will require continued research, innovation, and collaboration between academia, industry, and financial institutions. With the rapid advancements in data analytics, machine learning, and artificial intelligence, the tools, and techniques available to researchers are constantly improving, opening up new possibilities for exploration and discovery.

Ultimately, the goal is to develop a comprehensive understanding of how digital content, such as video game updates, impacts financial markets, and to use this knowledge to drive better decision-making and outcomes for all stakeholders involved. As the gaming industry continues to grow and evolve, the importance of this research will only increase, making it a critical area of focus for both researchers and practitioners alike.

References

1. **Bai, J., Tang, X., & Zheng, Y. (2023).** Serving the truth: Do directors with media background improve financial reporting quality? *International Review of Financial Analysis*, 85, 102452.
2. **Chen, A., & Gong, J. J. (2019).** Accounting comparability, financial reporting quality, and the pricing of accruals. *Advances in Accounting*, 45, 100415.
3. **Cockcroft, S., & Russell, M. (2016).** Big data opportunities for accounting and finance practice and research. *Australian Accounting Review*, 26(2), 173-190.
4. **D. E'leimat, M. M. Al Ebbini, L. A. Aryan, & S. I. S. Al-Hawary. (2023).** The effect of big data on financial reporting quality. *International Journal of Data and Network Science*, 7(4), 1775–1780.
5. **Dong, X. (2020).** Evolutionary game model of stock price synchronicity from investor sentiment. *Discrete Dynamics in Nature and Society*, 2020(1), 1-10.
6. **Ghasemaghaei, M., & Calic, G. (2020).** Assessing the impact of big data on firm innovation performance: Big data is not always better data. *Journal of Business Research*, 108, 147-162.
7. **Hasan, M. M., Popp, J., & Oláh, J. (2020).** Current landscape and influence of big data on finance. *Journal of Big Data*, 7(1), 1-17.
8. **Hodent, C. (2020).** The gamer's brain: How neuroscience and UX can impact video game design. *CRC Press*.
9. **Hsu, Y. L., & Yang, Y. C. (2022).** Corporate governance and financial reporting quality during the COVID-19 pandemic. *Finance Research Letters*, 47, 102778.
10. **Jaffal, Y., & Wloka, D. (2015).** Employing game analytics techniques in the psychometric measurement of game-based assessments with dynamic content. *Journal of e-Learning and Knowledge Society*, 11(3), 101-115.
11. **Marczak, D., Paradowski, M., & Persada, S. (2019).** Big data in game analytics: Implications for player satisfaction and expenditure. *International Journal of Information Management*, 48, 173-186.
12. **Medler, B., & Magerko, B. (2010).** Analytics through measures of meaningful connection. *Journal of Information Mapping*, 3(3), 1-8.
13. **Medler, B., & Magerko, B. (2019).** Measuring player engagement in the modern gaming landscape. *Entertainment Computing*, 32, 1-12.
14. **Mislevy, R. J., Almond, R. G., & Lukas, J. F. (2003).** A brief introduction to evidence-centered design. *ETS Research Report Series*, 2003(1), 1-29.
15. **Mukherjee, S. P. (2019).** A guide to research methodology: An overview of research problems, tasks, and methods. *CRC Press*.
16. **Payan, H. (2017).** The utilization of data analytics in the entertainment sector (Doctoral dissertation, University of Southern California). ProQuest Dissertations Publishing.
17. **Persada, S., Miraja, B. A., & Nadlifatin, R. (2019).** Understanding the impact of determinants in game learning acceptance: An empirical study. *International Journal of Educational Technology in Higher Education*, 16(1), 1-21.
18. **Roohi, S., Kim, Y., & Lee, J. (2019).** Predictive modeling of player behavior using ensemble methods. *Computational Intelligence and Neuroscience*, 2019, 1-15.

19. **Sihombing, R. P., Narsa, I. M., & Harymawan, I. (2023).** Big data analytics and auditor judgment: An experimental study. *Accounting Research Journal*, 36(2/3), 201-216.
20. **Sivarajah, U., Kamal, M. M., Irani, Z., & Weerakkody, V. (2017).** Critical analysis of big data challenges and analytical methods. *Journal of Business Research*, 70, 263-286.
21. **Ulrich, K., Burghof, H. P., & Holz, T. (2020).** Financial analytics and its impact on investment decision making. *International Journal of Financial Studies*, 8(2), 25.
22. **Wamba, S. F., Akter, S., & Edwards, A. (2015).** Big data analytics in e-commerce: A systematic review and research agenda. *Electronic Markets*, 26(3), 1-20.
23. **Wang, S., & Zhang, Y. (2019).** Data mining in the real world: Methods and case studies. *Journal of Big Data*, 6, 19.
24. **Xie, H. (2022).** Role of big data in the accounting profession. *International Journal of Management and Education*.
25. Steam. (n.d.). *Updates and news for Call of Duty: Warzone*. Retrieved August 16, 2024, from <https://store.steampowered.com/news/app/1962663?updates=true>
26. Steam. (n.d.). *Updates and news for Grand Theft Auto V*. Retrieved August 16, 2024, from <https://store.steampowered.com/news/app/271590?updates=true>
27. Steam. (n.d.). *Updates and news for Tom Clancy's Rainbow Six Siege*. Retrieved August 16, 2024, from <https://store.steampowered.com/news/app/359550?updates=true>
28. Steam. (n.d.). *Updates and news for Cyberpunk 2077*. Retrieved August 16, 2024, from <https://store.steampowered.com/news/app/1091500?updates=true>
29. Steam. (n.d.). *Updates and news for Final Fantasy XIV Online*. Retrieved August 16, 2024, from <https://store.steampowered.com/news/app/39210?updates=true>
30. Steam. (n.d.). *Updates and news for Monster Hunter: World*. Retrieved August 16, 2024, from <https://store.steampowered.com/news/app/582010?updates=true>
31. Steam. (n.d.). *Updates and news for Borderlands 3*. Retrieved August 16, 2024, from <https://store.steampowered.com/news/app/397540?updates=true>
32. Yahoo Finance. (n.d.). *Financial data for Electronic Arts (EA)*. Retrieved August 16, 2024, from <https://finance.yahoo.com/quote/EA/>
33. Yahoo Finance. (n.d.). *Financial data for Take-Two Interactive Software, Inc. (TTWO)*. Retrieved August 16, 2024, from <https://finance.yahoo.com/quote/TTWO/>
34. Yahoo Finance. (n.d.). *Financial data for Ubisoft Entertainment (UBSFY)*. Retrieved August 16, 2024, from <https://finance.yahoo.com/quote/UBSFY/>
35. Yahoo Finance. (n.d.). *Financial data for Nintendo Co., Ltd. (NTDOY)*. Retrieved August 16, 2024, from <https://finance.yahoo.com/quote/NTDOY/>
36. Yahoo Finance. (n.d.). *Financial data for Tencent Holdings Ltd. (TCEHY)*. Retrieved August 16, 2024, from <https://finance.yahoo.com/quote/TCEHY/>
37. Yahoo Finance. (n.d.). *Financial data for Square Enix Holdings Co., Ltd. (SQNXF)*. Retrieved August 16, 2024, from <https://finance.yahoo.com/quote/SQNXF/>
38. Yahoo Finance. (n.d.). *Financial data for Capcom Co., Ltd. (CCOEY)*. Retrieved August 16, 2024, from <https://finance.yahoo.com/quote/CCOEY/>
39. Yahoo Finance. (n.d.). *Financial data for Konami Holdings Corporation (THQQF)*. Retrieved August 16, 2024, from <https://finance.yahoo.com/quote/THQQF/>