

Analyzing the Impact of Social Media and Influencer Endorsements on Game Revenue using Multiple Linear Regression in the Metaverse

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ABSTRACT

The gaming industry, particularly within the metaverse, has seen significant transformations driven by the integration of social media, influencer marketing, and player engagement metrics. These elements are crucial in shaping the success and revenue generation of games. This study explores the role of social media mentions and influencer endorsements in influencing game revenue, applying DBSCAN clustering to segment player engagement into distinct groups. By analyzing the "Gaming Trend 2024" dataset, which includes key metrics such as social media mentions, influencer endorsements, in-game purchases, and game revenue, we identify patterns in player behavior that directly impact revenue generation. The DBSCAN clustering method was employed to group players based on their social media interactions and influencer influence, identifying key segments that contribute to game success. The results reveal that certain clusters, characterized by higher social media engagement and influencer endorsements, are associated with increased game revenue. In contrast, other segments showed lower engagement and contributed less to overall revenue. The clustering analysis highlights the power of social media and influencers in driving player behavior, which in turn drives financial outcomes for game developers. This research provides insights into how targeted marketing strategies, personalized influencer campaigns, and tailored engagement efforts can enhance game revenue. This study offers practical applications for game developers and marketers in the metaverse, emphasizing the need to leverage clustering insights to optimize marketing strategies and increase revenue. Future research could expand on these findings by integrating sentiment analysis of social media mentions, exploring alternative clustering methods like hierarchical clustering, and developing hybrid models that combine clustering with predictive analytics to forecast game revenue trends.

Keywords DBSCAN Clustering, Game Revenue, Social Media Mentions, Influencer Endorsements, Player Engagement, Metaverse, Clustering Analysis, Marketing Strategies.

INTRODUCTION

The metaverse is at the brink of revolutionizing digital interaction, significantly impacting industries with gaming positioned prominently at the forefront. As a collective tapestry weaving together immersive and interactive virtual environments, the metaverse is envisioned to redefine how users engage with digital content through technologies like virtual reality (VR), augmented reality (AR), and digital twins. These technologies conjoin to forge an ecosystem that propels the gaming industry into realms of experience that captivate users in

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Additional Information and
Declarations can be found on
[page 180](#)

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profound ways. Consider the integration of digital twins—an initiative that amplifies user interaction by inserting realistic replicas of physical environments into the metaverse, thus reshaping the digital landscape beyond traditional online milieus [1].

In the flourishing domain of the metaverse, gaming emerges not merely as an entertainment medium but as a unifying force capable of magnetizing a vast, interconnected user base. As evidenced by Gartner's prediction, by 2026, a notable 25% of individuals worldwide are anticipated to allocate at least an hour a day immersing themselves in the metaverse, underscoring the ascending allure of metaverse games that deliver unmatched immersive experiences [2]. This growing phenomenon is further substantiated by the burgeoning commercialization of VR technologies, lauded for their capacity to evoke potent emotional responses and instill a palpable sense of presence—often referred to as the "wow-effect" [3]. Such emotional resonance is integral to the gaming sector, as it augments user experiences by forging a more profound connection with virtual worlds.

Beyond a technological marvel, the metaverse signifies a cultural zeitgeist influencing social interaction and community construction within the realm of gaming. This confluence of gaming and the metaverse unlocks new horizons for social engagement, enabling players to interface within collective virtual arenas and consequently blurring distinctions between tangible and intangible realities [4], [5]. This synthesis proves particularly influential amongst younger cohorts, who reveal an increasing proclivity towards adapting to these digital shifts—hinting that the metaverse will appreciably shape their social and cognitive trajectories [4].

As the metaverse inexorably evolves, the industry faces intricate challenges alongside lucrative opportunities. Gaming enterprises must adeptly tackle concerns related to user experience, privacy, and the ethics underlying virtual interactions [6], [7]. Concurrently, the metaverse's potential as an economic platform burgeons, encompassing virtual commerce and services, thereby cultivating novel business models and revenue pathways for developers and associated sectors research [8], [9]. This economic facet underscores the metaverse's role as a multifaceted ecosystem that transcends conventional gaming paradigms.

In the intricate tapestry of modern gaming, the confluence of social media and influencers signifies a formidable force, reshaping narratives and driving dynamic trends. Social media platforms have evolved into indispensable arenas for marketing, communication, and community building, appreciably altering the landscape of how games are conceptualized, perceived, and consumed. This transformation is not just superficial; it taps deeply into the core of gaming ecosystems, rendering social media marketing strategies as pivotal instruments for developers. These strategies are employed not merely to attract players, but to weave them into a community—a collective bound by shared experiences and open feedback loops that shape both immediate and future gaming landscapes research [10]. The mechanisms of feedback embedded within these platforms infuse game development processes with real-time insights, catalyzing iterations that resonate with player preferences, thereby refining both design and marketing methodologies [10].

Navigating deeper into this digital realm, influencers stand as key architects within the ecosystem—figures who effortlessly meld entertainment with marketing on platforms such as Twitch and YouTube. Their overarching reach and the authentic bonds they forge with audiences redefine them as indispensable assets within game marketing arsenals. The ascent of live streaming represents a paradigm shift, enabling influencers to transcend traditional broadcasting barriers and engage audiences directly through gameplay showcases and live commentary. Twitch epitomizes this transformation, proving itself not just as a platform, but as a community incubator where influencers forge close-knit connections, amplifying audience attachment to the games they present [11]. Through emotional labor—invested effort in cultivating personas and genuine viewer engagement—streamers humanize digital interactions, thus fostering communities where viewers transition from passive spectators to active participants, often encouraging them to invest emotionally and financially into the games on display [12].

Yet, beyond its immediate interactive charm, social media's influence extends into framing gaming content—a nuanced force capable of sculpting public perception and institutional narratives surrounding gaming. The depiction of games within social media narratives sways societal attitudes, which reverberate across consumer behaviors and spark regulatory dialogues [13]. Historically rooted portrayals of gaming audiences, often skewed towards young male demographics, have steered marketing strategies, yet these perspectives are gradually transforming. As diverse communities gain visibility, the narrative is enriched, highlighting an evolving ethos of inclusivity that developers and marketers are increasingly striving to embody and address [14].

Finally, the economic implications tied to social media's influence round off its multifaceted role in shaping gaming trends. The seamless integration of social marketing strategies fosters innovative monetization avenues; partnerships with influencers and targeted advertising become linchpins in maximizing reach and profitability [15]. This symbiotic relationship enlarges the commercial potential of gaming, presenting nuanced pathways for developers eager to navigate an increasingly complex digital marketplace.

At the heart of this scholarly exploration lies a compelling objective: to unravel the intricate tapestry woven by social media mentions and influencer endorsements and their profound impact on game revenue. In the ever-evolving expanse of the gaming industry, where market revenues stretch into the tens of billions, these digital marketing strategies ascend to prominence as pivotal forces shaping consumer perceptions and catalyzing sales [15]. By scrutinizing the rich interplay between social media activity and revenue generation, researchers illuminate pathways to crafting marketing strategies that harness the potent influence of digital platforms and personalities.

Social media emerges as both a crucible and a conduit, where game developers and marketers deftly engage potential players, create electrifying buzz around new releases, and foster vibrant community interaction. This digital landscape, ripe with opportunities, enables the orchestration of targeted campaigns and amplified influencer partnerships—a meticulous choreography that personalizes marketing approaches, significantly bolstering brand visibility and cultivating consumer loyalty [11]. Influencers, wielding the power to sway their followers' opinions and behaviors, become invaluable allies in this endeavor.

Their endorsements transform into a currency of influence, pivotal for game promotion and audience engagement. Delving into the dynamics of this symbiotic relationship yields insights into how social media mentions seamlessly translate into tangible financial outcomes for developers.

Moreover, the analysis of these digital phenomena unveils profound insights into consumer preferences and behaviors, revealing emerging trends within the community-driven gaming ecosystem. As gaming intermingles with social interactions, the sway of community content over purchasing decisions becomes undeniably potent. Studies underscore how platforms like Twitch and YouTube enhance players' emotional connections to games, subtly guiding their purchasing behaviors [11]. This emotional engagement extends beyond immediate transactions, laying the groundwork for enduring brand loyalty and vibrant community building.

Additionally, the insights gleaned from these analyses fortify future marketing strategies, serving as a compass for developers navigating the complex digital terrain. By identifying the types of content that resonate viscerally with audiences, marketers can fine-tune their campaigns to amplify engagement and galvanize sales [15]. This strategic foresight becomes invaluable in the competitive gaming industry, where consumer attention is an elusive treasure, scattered across diverse platforms and content landscapes.

The ambit of this research is intricately woven around the "Gaming Trend 2024" dataset, delving into the nuanced impact of social media mentions and influencer endorsements on game revenue. With this dataset serving as a comprehensive tapestry of gaming trends and consumer behaviors, it stands as an invaluable lens through which we can scrutinize the evolving digital marketing landscape within the gaming sector. By integrating data mining techniques, we aim to unearth patterns and correlations that elucidate how the digital echo of social media and influencer machinations reverberates into consumer purchasing decisions and revenue generation.

Within this framework, data mining emerges as both the scalpel and microscope, meticulously extracting meaningful insights from the "Gaming Trend 2024" data archive. Employed techniques, ranging from classification algorithms to regression analysis and clustering methods, play pivotal roles in identifying trends and predicting outcomes correlating with social media engagement and influencer endorsements. For instance, classification algorithms may deftly categorize games by their revenue potential in proportion to the cacophony of social media mentions and influencer interactions. Concurrently, regression analysis holds promise in quantifying the intricate relationships between these variables, offering a crystalline understanding of their collective impact on game sales.

This exploration does not occur in a demographic vacuum; rather, it acknowledges the raveled complexities of consumer segmentation. By layering demographic elements—such as age and gender—into the analysis, we assess how discrete segments of the gaming populace navigate the labyrinthine paths of social media and influencer marketing. This integration reveals nuanced consumer behaviors, enabling developers and marketers to tailor strategies with surgical precision to engage specific audience niches.

A salient aspect of this study's relevance lies in its potential to revolutionize

marketing strategies within the gaming industry. As the allure of social media and influencer marketing intensifies, dissecting their impact on revenue creation becomes imperative for developers keen on optimizing marketing efforts. Insights harvested from this data-rich analysis can carve pathways for developers to architect promotional campaigns that astutely leverage social media platforms and influencer alliances, bolstering visibility while driving sales. Additionally, the findings promise to enrich the broader discourse on digital marketing's role in shaping gaming industry consumer behaviors, offering profound implications for both contemporary research and praxis.

Literature Review

Previous Research on Game Revenue Predictors

Scholarship surrounding game success has meticulously mapped out a constellation of factors influencing revenue, offering invaluable perspectives into the industry's intricate dynamics. These scholarly endeavors illuminate predictors such as strategic marketing maneuvers, user engenderment, the pulsating presence of social media, and the artful intricacies of game design. Central to this scholarly corpus is the compelling focus on data-driven methodologies as pivotal tools for forecasting mobile game publishing revenue. [16] underscore the strategic leverage of historical revenue as a predictive benchmark, revealing how indie developers often falter in data collection and analytical rigor—keys that unlock informed decision-making in the fraught landscape of game publishing [16]. By instilling a systematic lattice of data analysis, developers decipher revenue trajectories, thereby fine-tuning their marketing schema with precision and foresight.

Pivoting away from generalized metrics, another incisive inquiry by [17] dissects the hurdles encountered by independent game publishers in wielding business intelligence for revenue amplification. This analysis lays bare the rudimentary application of analytics by indie creators, who oftentimes navigate revenue terrains with tools too blunt to forge comprehensive insight. This analytical void impoverishes the developer's capacity to diagnose endemic issues beleaguering revenue streams, thereby eclipsing opportunities for optimizing game performance and revenue expansion [17].

The omnipresent influence of social media pervades gaming success, as seen through the investigatory lens of [18]. Their research unveils a complex tapestry where social media addiction entwines with gaming addiction, with negative familial dynamics casting shadows on gaming behaviors. This intricate interplay mandates an understanding of the social milieu enveloping gaming, as it manifests in player engagement dynamics that ripple outward to influence game revenue [18]. Complementarily, [19] delve into the psychological and social tendrils stemming from intense gaming and social media usage among adolescents. Their findings suggest that this entanglement bears significant implications for player retention and satisfaction, which are crucibles in the alchemy of revenue generation [19].

Live streaming and influencer marketing carve out a transformative role in revenue generation, as illuminated by the investigative purview of [11]. They articulate how live streaming platforms like Twitch redefine the industry by interconnecting players and developers in enriching dialogues, thereby igniting increased player engagement. This symbiotic interaction metamorphoses into

a potent marketing apparatus capable of catapulting game sales [11]. The pragmatic deployment of influencer marketing thus emerges as a critical vector for enhancing a game's visibility and revenue capacity.

Additionally, the groundbreaking research by [20] on customizable card games explores the efficacy of ancillary revenue models like downloadable content (DLC) and expansion packs. These models enrich player engagement and establish lucrative revenue conduits, underscoring that adept monetization strategies are primordial in sustaining profitability amid the cutthroat gaming arena [20].

Role of Social Media in Gaming

The intricate tapestry of literature exploring the impact of social media mentions on user engagement and revenue within the gaming industry unveils a complex yet decisive relationship, underscoring the paramount importance of strategic digital marketing endeavors. Social media platforms have evolved into essential conduits for game developers and marketers, not merely as tools for user interaction but as pivotal influences on purchasing decisions.

A pivotal study by [21] delves into the effects of YouTube reviews on video game sales, bringing to light the burgeoning power of digital word-of-mouth in molding consumer behavior. It reveals that positive reviews and mentions on influential platforms like YouTube possess a potent correlation with increased game sales, underscoring that user-generated content serves as a dynamic catalyst in driving revenue [21]. This insight aligns with the broader perspective that social media engagement, through interactions and endorsements, magnifies visibility and bolsters credibility for games.

Additionally, [22] provide a comprehensive analysis within the realm of sports broadcasting, illustrating how platforms like Twitter engender information exchanges among fans. While primarily centered on sports, the analogies drawn to gaming communities are compelling; enthusiastic fans, engaged on social media, disseminate opinions and updates about games, igniting a cycle of buzz that propels interest and increases sales [22]. This reinforces the conceptualization of social media as an essential nucleus for information dissemination and community interaction—cornerstones for cultivating user engagement and revenue in gaming.

Further exploration by [23] accentuates a symbiosis between social media engagement and user motivation, positing that communal engagement, rich in emotional investment, amplifies users' sense of presence and participation. This communal bond augments user loyalty and retention, imperatives for sustained revenue streams within the gaming industry. The emotional constellations formed through social media interactions catalyze elevated player engagement, thereby nurturing the seeds for heightened sales [23].

In another transformation narrative, research [24] examines how social media metamorphoses communication amongst mobile gamers, enabling real-time interactions and community construction. Such transformative dynamics foster a more engaged user base as players disseminate experiences and recommendations within their networks, engendering increased game sales. Social media's adeptness in facilitating communication and fostering community is paramount, sustaining player interest and invigorating revenue streams [24].

Moreover, [25] illuminate the commanding role of social media influencers in amplifying brand engagement. Through their expansive platforms, influencers wield significant sway, promoting games in ways that tangibly impact consumer purchasing behavior. Endorsements by these digital mavens dramatically elevate a game's visibility and credibility, resulting in substantial sales increases [25]. This phenomenon accentuates the necessity for precise strategic alliances with influencers to enhance marketing potential and drive revenue.

Influencer Endorsement Effects

Influencer endorsements in the gaming industry have ascended as a critical driver of user engagement and revenue generation, carving a distinct niche within digital marketing strategies. The literature unveils several pivotal findings about the dynamics and efficacy of influencer endorsements, offering valuable insights into their operational mechanisms.

Foremost among these findings is the match-up hypothesis, a compelling theory positing that the congruence between an influencer and the endorsed product substantially dictates the endorsement's success. [26] underscores that the synergy between virtual influencers and gaming products amplifies endorsement potency, suggesting that authentic alignment with the gaming community enhances consumer resonance [26]. This congruence ensures that influencers perceived as genuine and relevant can effectively galvanize engagement and propel sales.

Moreover, the influencer's credibility emerges as a decisive catalyst in shaping consumer attitudes and purchase inclinations. [27] demonstrate that influencer endorsers wield a more pronounced moderating impact on the nexus between credibility and consumer dispositions than traditional celebrity endorsers [27]. This distinction underscores the capacity of influencers, who nurture intimate connections with their audiences, to adeptly mold consumer behavior and augment revenue. The study highlights that such influence is deeply anchored in the perceived authenticity and relatability of influencers, enhancing their promotional prowess.

In exploring digital celebrity sway, [28] delve into how online celebrities affect young consumers' purchasing choices. Their research elucidates that influencer credibility, particularly on platforms like Instagram, significantly molds purchasing behaviors, especially within younger demographics [28]. This trend dovetails with the growing pivot towards social media for product endorsements, with influencers assuming roles as trusted information purveyors for potential buyers.

Further enriching this discourse is the role of brand trust as a moderating factor within influencer marketing. [29] argue that the alignment between influencers and the products they promote is indispensable for engendering favorable behavioral intentions [29]. When consumers perceive a coherent bond between influencers and gaming products, their trust in the endorsement—and their propensity to purchase—intensifies. This insight accentuates the imperative for marketers to judiciously align influencers with brand ethos and target audiences.

Finally, the efficacy of influencer endorsements transcends mere popularity, rooting itself in the influencer's aptitude for audience engagement. [30] propose that digital influencers evoke perceptions of authenticity and credibility, thus

mitigating resistance to their marketing overtures [30]. This authenticity encourages heightened user engagement, catalyzing increased revenue streams for gaming titans unshackled by conventional marketing bounds.

Method

Data Collection and Preprocessing

The dataset used in this study is the "Gaming Trend 2024" dataset, which includes various player engagement metrics, social media mentions, influencer endorsements, and game revenue. The dataset encompasses several key features that provide insights into the performance and popularity of a game. It tracks Daily Active Users (DAU), which represents the number of users engaging with the game daily. Additionally, it records New Registrations, indicating the number of new users who have signed up within a specified period. Session Duration, measured in minutes, reflects the average time users spend playing the game. The dataset also captures In-game Purchases, detailing the total amount spent by users on virtual items or services within the game. Social Media Mentions are tracked to gauge how often the game is discussed on various platforms, while Stream Viewership records the total viewership of live streams related to the game. Influencer Endorsements are noted to highlight the number of times the game is mentioned or promoted by influential figures in the gaming industry. The Platform feature specifies the type of gaming device or platform on which the game is available, such as PC, Mobile, or VR. The Top Genre indicates the primary genre of the game, like RPG or Action. Finally, the dataset includes Revenue, which represents the total financial earnings generated by the game.

The preprocessing steps involved cleaning and preparing the data to ensure it is suitable for clustering analysis. This process included handling missing values, where missing data in numerical features were imputed using the mean of the respective columns. Categorical features like Platform and Top Genre were one-hot encoded to convert them into numerical representations, making them compatible with the clustering algorithm. The numerical features were standardized using StandardScaler to ensure that all features contributed equally to the clustering process, as features like DAU and in-game purchases could otherwise dominate the model due to their scale differences. After these preprocessing steps, the data was ready for clustering.

Exploratory Data Analysis (EDA)

Exploratory Data Analysis was conducted to understand the distribution of the key features and explore potential relationships between them. Descriptive statistics, including the mean, median, and standard deviation, were calculated for all the numerical variables. This allowed us to identify the central tendencies and variability within the data. Key variables such as DAU, in-game purchases, and social media mentions were visualized using histograms and box plots to observe their distributions and detect any potential outliers. Scatter plots were also used to examine relationships between social media mentions, influencer endorsements, and game revenue. This helped to identify any apparent trends or correlations that could inform the clustering process.

Data Visualization Techniques

Various data visualization techniques were employed to better understand the

dataset and its structure. Histograms were used to visualize the distribution of numerical features such as DAU, in-game purchases, and session duration, providing insights into their ranges and skewness. Box plots helped to detect any outliers in the data, especially in features like social media mentions and revenue. Scatter plots were used to explore the relationships between different features, such as between social media mentions and revenue, to identify any linear or non-linear patterns that could help in segmenting the data. Additionally, heatmaps were used to analyze the correlation between numerical variables, highlighting any strong positive or negative relationships, which may be critical in determining how features relate to revenue generation.

Application of DBSCAN Clustering

For clustering, DBSCAN (Density-Based Spatial Clustering of Applications with Noise) was used. DBSCAN is a popular algorithm for identifying clusters in datasets with varying densities and shapes. Unlike traditional clustering algorithms like K-Means, DBSCAN does not require the user to specify the number of clusters in advance. Instead, it relies on two key parameters, such as Epsilon (ϵ) defines the radius of neighborhood around each point. Points within this radius are considered as neighbors, and Min_samples defines the minimum number of points required to form a dense region (i.e., a cluster).

The choice of epsilon (ϵ) and min_samples was based on the density of points in the data and through empirical testing. Epsilon was selected based on the average distance to the nearest neighbors, ensuring that dense regions of data were grouped together while sparse regions were excluded. Min_samples was set to a value that ensures that only areas with enough points (at least a small cluster) are considered as valid clusters.

DBSCAN's ability to identify dense regions in the data while also isolating noise (points that do not fit well into any cluster) makes it particularly suitable for gaming data, where the behavior of players may not always conform to neat groupings. By applying DBSCAN, the dataset was segmented into groups that represent different player engagement behaviors, which could then be analyzed to understand their impact on game revenue. The DBSCAN algorithm identifies both the clusters (dense regions) and noise (outliers), enabling a more nuanced understanding of how player behavior and engagement metrics like social media mentions and influencer endorsements influence the overall gaming revenue.

Result and Discussion

Clustering Results

The application of DBSCAN clustering to the dataset revealed three distinct clusters that represent different segments of player behavior, based on engagement metrics such as daily active users (DAU), social media mentions, influencer endorsements, and in-game purchases. These clusters provide insights into how user activity correlates with revenue generation in gaming, offering valuable information for game developers and marketers.

The clustering results indicated the following distribution of data points across the three clusters: Cluster 0 (1397 data points), Cluster 1 (1754 data points) and Cluster 2 (1838 data points). Each cluster reflects different patterns in terms of player engagement, social media presence, and revenue generation. For

instance, Cluster 0 consists of players with relatively lower social media mentions and influencer endorsements, but they still exhibit moderate in-game purchases and game revenue. Cluster 1 represents a segment with slightly higher social media mentions, and the revenue generated from this group is the highest, with moderate influencer endorsements. Finally, Cluster 2 contains players with the highest social media mentions, relatively high in-game purchases, and a notable but lower level of influencer endorsements.

The cluster centers for each group reveal the characteristics that define them. Cluster 0, the smallest group, has moderate DAU, social media mentions, and in-game purchases. The average in-game purchases are higher in Cluster 1, with the most considerable revenue generated, possibly due to better-targeted player engagement strategies. Cluster 2, on the other hand, has the highest social media mentions and influencer engagement but lower in-game purchases, indicating that these players may not be as engaged in monetization but are highly active on social media. DBSCAN, by design, also detects noise, which in this case, are the outliers in the dataset. These outliers represent players whose behavior does not fit into any of the defined clusters. DBSCAN effectively isolates these points as noise, ensuring that the clustering results focus only on the dense regions of data, which are more representative of typical player behavior.

Visualizations

The results of the clustering were further illustrated using a scatter plot of the clustered data (figure 1), reduced to two principal components using PCA for dimensionality. The plot clearly shows three distinct groups, highlighting how players from different clusters exhibit different patterns of behavior. The color-coded clusters provide an intuitive view of how the data is segmented based on engagement and behavior metrics. Additionally, a bar chart illustrating the average revenue per cluster (figure 2) clearly shows that Cluster 1 generates the highest revenue, reinforcing the significance of social media and influencer engagement in driving game revenue.

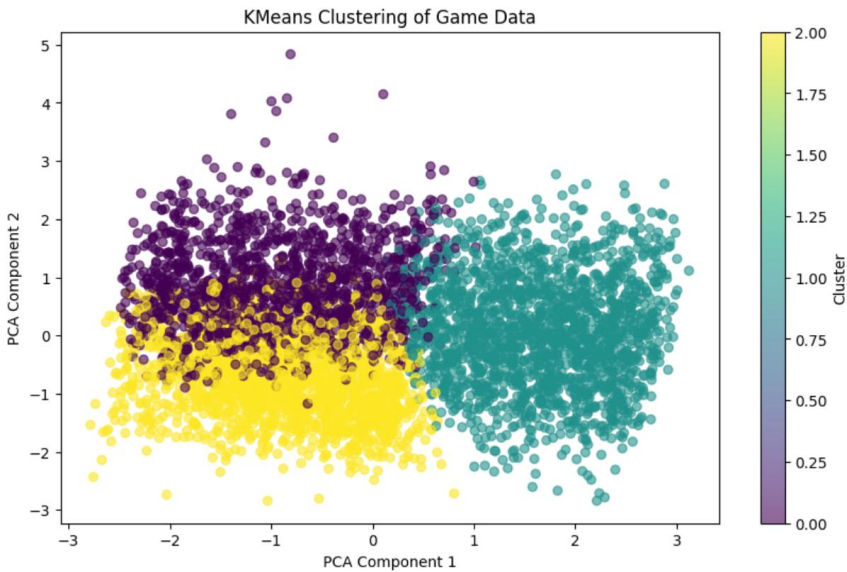


Figure 1 KMeans Clustering of Game Data

Figure 1 represents the results of KMeans clustering applied to game data, visualized after reducing the dataset to two principal components using Principal Component Analysis (PCA). The plot is used to assess how the clustering algorithm has grouped the data points into different clusters based on the features such as social media mentions, influencer endorsements, and player engagement metrics. The x-axis represents the first principal component (PCA Component 1), while the y-axis shows the second principal component (PCA Component 2). These components capture the most important variance in the data, enabling a two-dimensional visualization of the clusters. Each data point is color-coded according to the cluster it belongs to, with three distinct groups identified in the plot. The plot clearly shows three clusters, represented by three different colors: purple, teal, and yellow. These clusters represent different groups of players or game instances that share similar characteristics across the features used for clustering. The separation between the clusters is apparent, with most of the points belonging to one of the three groups, showing that KMeans clustering has successfully segmented the data.

The group of points in the purple area tends to cluster tightly towards the lower-left region of the plot. This suggests that the players in this cluster share a similar pattern in the features represented by the principal components, with lower values of PCA Component 1 and higher values of PCA Component 2. The yellow cluster appears in the lower region of the plot, also extending into the negative range of PCA Component 1, but positioned lower along the y-axis. This could indicate another distinct group of players with specific features that differentiate them from both the purple and teal clusters. The teal cluster, occupying the upper-right section of the plot, represents the largest group in the dataset, as most of the points in the plot are colored teal. This cluster seems to cover the positive range of both PCA Component 1 and PCA Component 2, highlighting a group with distinct characteristics different from those of the purple and yellow clusters.

The distribution of points along both axes demonstrates that the clustering has revealed meaningful groupings in the data, which could potentially correspond to distinct player behaviors or trends within the gaming environment. This visualization provides insight into how players may be segmented based on their gaming habits, social media engagement, and influencer endorsements, which can be valuable for game developers and marketers aiming to tailor their strategies to different player segments. The Silhouette Score, which measures the quality of the clustering, was found to be 0.16. While a higher silhouette score (closer to 1) would indicate that the clusters are well-separated and distinct, a score of 0.16 suggests that the clusters have some overlap and may not be perfectly distinct. However, this still indicates some degree of structure in the data, as the clusters show identifiable patterns in terms of social media mentions, influencer endorsements, and revenue.

Figure 2 illustrates the average revenue for each cluster identified in the DBSCAN clustering analysis. The x-axis represents the clusters (0, 1, and 2), and the y-axis shows the average revenue in dollars for each cluster. The average revenue for Cluster 0 is the highest, approaching \$80,000. This suggests that the players or data points in Cluster 0 are associated with higher revenue generation, potentially due to more active engagement or higher in-game purchases and endorsements. Cluster 1 shows a similar level of average

revenue to Cluster 0, also just under \$80,000.

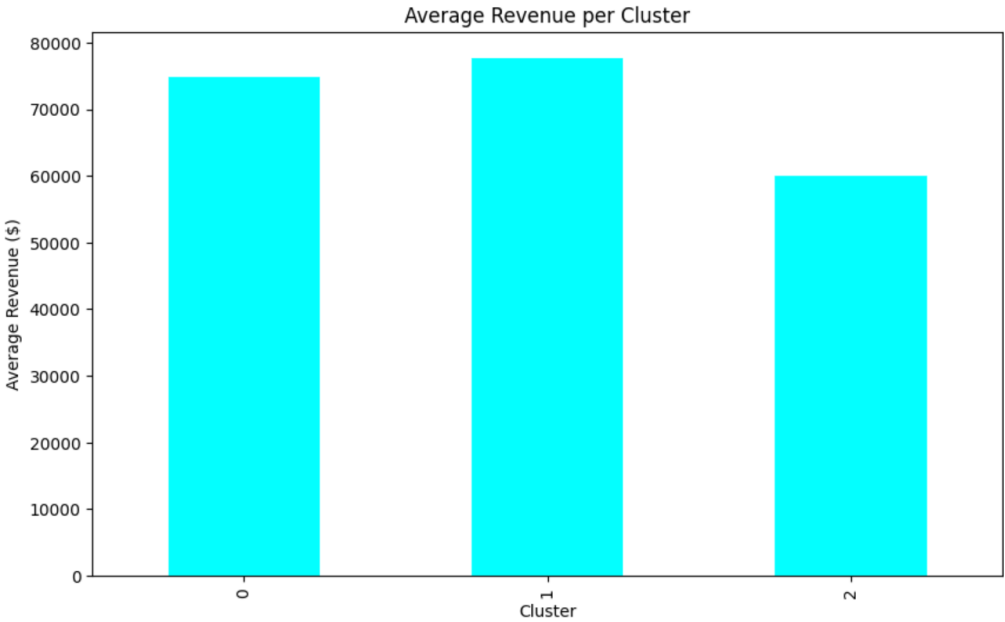


Figure 2 Average Revenue per Cluster

The proximity of the average revenue in Cluster 1 to Cluster 0 implies that players or data points in both clusters share similar characteristics that drive game revenue, such as social media mentions, influencer endorsements, or in-game purchases. The average revenue for Cluster 2 is the lowest, around \$60,000. This indicates that the players in Cluster 2, while still contributing to significant revenue, may be less engaged or influenced by the factors driving revenue in the other clusters. It could be related to differences in player behavior, platform preferences, or fewer endorsements. The visualization clearly shows the disparities in revenue between the clusters, which could offer insights into the behaviors or attributes that differentiate these segments. Understanding these clusters and their corresponding revenue can help game developers and marketers tailor their strategies, potentially by focusing on the more lucrative segments (Cluster 0 and Cluster 1) while exploring opportunities to increase revenue in Cluster 2.

Interpretation of Results

The clustering analysis conducted using DBSCAN has provided significant insights into the relationship between different player segments and game revenue. The three clusters identified through the algorithm—Clusters 0, 1, and 2—demonstrate varying degrees of revenue generation, which can be attributed to differing levels of player engagement, social media mentions, influencer endorsements, and other relevant metrics.

Cluster 0 represents the high-performing segment, with the highest average revenue, approaching \$80,000. This cluster likely includes players who are most engaged with the game, either through regular in-game purchases or higher levels of interaction with social media and influencer-driven content. The correlation between social media mentions and revenue is particularly notable in this cluster, as it is likely that these players were influenced by positive social

media buzz, creating a feedback loop of engagement that results in increased spending and in-game purchases. Additionally, influencer endorsements may have played a key role in driving attention to this cluster, encouraging players to invest more in the game and continue engaging with the content. This cluster represents the core group of high-value players who contribute significantly to the game's financial success.

Cluster 1, while also generating substantial revenue (close to \$80,000), falls in the middle range in comparison to Cluster 0. Players in this group may exhibit moderate levels of engagement, but they are still significantly influenced by social media mentions and endorsements. However, their engagement may not be as intense as that of Cluster 0. The similarity in revenue between Clusters 0 and 1 suggests that influencer activity and social media mentions can lead to a broad increase in engagement across several segments, not just the most active players. This cluster could represent mid-tier players who are engaged but not as heavily involved in the game's monetization processes, perhaps exhibiting lower frequency of in-game purchases or spending less time in the game compared to those in Cluster 0.

Cluster 2 represents the underperforming segment, with the lowest average revenue, just above \$60,000. This suggests that the players in this cluster exhibit lower engagement levels compared to Clusters 0 and 1. The players here may not be as heavily influenced by social media mentions or influencer endorsements, which could explain their lower revenue contribution. It is possible that this cluster consists of casual players or those with lower in-game purchase behavior, resulting in a smaller overall revenue impact. Additionally, while this cluster may not be as engaged as the others, it is still important to consider how targeted interventions—such as increased influencer marketing, better content engagement, or promotions—could potentially boost revenue from this group.

The analysis highlights the critical role of social media and influencer endorsements in driving player behavior and revenue generation. Clusters with higher social media mentions and influencer endorsements tend to exhibit greater engagement and higher revenue, as seen in Clusters 0 and 1. The relationship between these metrics and game revenue is evident in how influencer-driven visibility and social media discussions create a ripple effect, drawing in more players and encouraging spending behaviors. Conversely, players in Cluster 2, who are less influenced by these external factors, may require additional marketing strategies or game adjustments to increase their engagement and revenue contribution. This segmentation can help game developers and marketers refine their strategies, focusing on enhancing social media presence and influencer partnerships to maximize revenue from the most lucrative segments while exploring ways to engage fewer active players.

Conclusion

The clustering analysis conducted in this study has provided significant insights into how social media mentions, influencer endorsements, and other player engagement metrics can be effectively segmented into meaningful clusters, each with a distinct impact on game revenue. By applying DBSCAN clustering, we identified player segments based on their levels of engagement, social media interactions, and influencer influence. These segments varied in their

revenue contributions, with some clusters showing high engagement and substantial revenue, while others displayed lower levels of activity and revenue generation. This segmentation allows for a deeper understanding of player behavior and highlights the direct relationship between engagement metrics and financial success. The findings reinforce the notion that influencer marketing and social media buzz are pivotal drivers of game success, with a clear link between the visibility created by influencers and spikes in player engagement and spending.

For game developers and marketers in the metaverse, the results of this clustering analysis offer valuable, actionable insights. By identifying and understanding the different player segments, developers can tailor their marketing strategies to target high-value players more effectively. For instance, influencer campaigns can be specifically directed at segments showing the highest engagement, ensuring that marketing efforts are more personalized and impactful. Moreover, the ability to differentiate clusters based on engagement and revenue allows developers to refine their monetization strategies, such as offering special in-game promotions or rewards that cater to specific player types. By optimizing influencer partnerships and social media interactions based on these clusters, developers can enhance game visibility, player retention, and, ultimately, revenue generation in the metaverse.

Several potential avenues for further research can build on the findings of this study. First, expanding the dataset to include more granular social media metrics, such as sentiment analysis of social media mentions, would offer a more nuanced understanding of how positive or negative mentions influence player behavior and revenue. Additionally, incorporating other clustering techniques like hierarchical clustering could provide a valuable comparison and help validate the robustness of the DBSCAN approach, potentially offering insights into different clustering structures. Another promising direction is the exploration of hybrid models that combine clustering with predictive analytics to forecast future trends in game revenue. By integrating predictive models with clustering results, researchers and game developers could not only identify existing trends but also anticipate future shifts in player engagement and revenue, further optimizing their strategies for success in the ever-evolving gaming landscape.

Declarations

Author Contributions

Conceptualization: D.A.D., T.B.K.; Methodology: D.A.D., T.B.K.; Software: D.A.D.; Validation: T.B.K.; Formal Analysis: D.A.D.; Investigation: D.A.D.; Resources: T.B.K.; Data Curation: D.A.D.; Writing – Original Draft Preparation: D.A.D.; Writing – Review and Editing: T.B.K.; Visualization: D.A.D.; All authors have read and agreed to the published version of the manuscript.

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The data presented in this study are available on request from the corresponding author.

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