Analyzing Genre Patterns in Virtual-Themed Animated Films Using Association Rule Mining

Satrya Fajri Pratama[1,*], Eko Priyanto[2]

[1]Department of Computer Science, School of Physics, Engineering and Computer Science, University of Hertfordshire, Hatfield AL10 9AB, United Kingdom

[2]Magister of Computer Science, Computer Science Faculty, Universitas Amikom Purwokerto, Indonesia

ABSTRACT

This study investigates patterns in virtual-themed animated films using association rule mining to explore the relationships between genre combinations, production companies, and their impact on both popularity and revenue. The dataset consists of films from various genres, with a focus on those exploring virtual worlds, alternate realities, and futuristic settings, aligning with metaverse concepts. The analysis revealed several significant findings. The association rule mining results identified that films combining Fantasy and Science Fiction genres are 1.8 times more likely to achieve high box office revenue, with a confidence level of 80%. Additionally, Pixar adventure films were found to have a 2.1 times higher likelihood of attaining high popularity. Films blending Fantasy and Adventure genres showed a strong correlation with high revenue, with a 70% confidence level and a lift value of 1.9. These patterns suggest that imaginative storytelling and virtual world elements are key drivers of success in animated films. Revenue analysis demonstrated that 30% of the virtual-themed films in the dataset generated more than 1 billion USD, while 50% earned between 0.5 and 1 billion USD. The popularity analysis further highlighted that Fantasy, Science Fiction, and Adventure genres consistently rank highest in audience engagement. These findings underscore the significant commercial potential of films exploring virtual and digital environments, particularly as audience demand for immersive experiences continues to grow. This study concludes that films featuring virtual world themes, particularly those combining Fantasy, Science Fiction, and Adventure genres, are well-positioned to succeed both financially and in terms of audience engagement. As AR, VR, and metaverse technologies advance, the demand for immersive cinematic experiences is likely to increase, offering filmmakers new opportunities to innovate and expand this genre.

Keywords Virtual Reality Real Estate Virtual-themed films, Association Rule Mining, Fantasy and Science Fiction, Metaverse in Cinema, Revenue and Popularity Analysis

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Corresponding author
Satrya Fajri Pratama,
s.f.pratama@herts.ac.uk

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INTRODUCTION

The rapid development of digital technologies has transformed various industries, including the film industry, where advancements in computer-generated imagery (CGI), augmented reality (AR), and virtual reality (VR) have enabled filmmakers to create immersive experiences that blur the boundaries between the real and virtual worlds [1], [2]. One of the most significant trends emerging from this technological evolution is the rise of virtual-themed films—animated and live-action movies that explore futuristic, digital, or alternate realities, often aligned with the concept of the metaverse [3], [4]. These films, which incorporate elements of Fantasy, Science Fiction, and Adventure, have gained widespread popularity and commercial success [5], [6].

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The metaverse, defined as a shared virtual space that integrates physical and digital experiences, has captured the imagination of audiences worldwide [7]. As the metaverse concept evolves, so too does its representation in film. Virtual-themed films, through their depiction of immersive worlds and digital environments, offer audiences a glimpse into the future of entertainment, where storytelling transcends traditional boundaries [8]. These films are not only visually captivating but also explore complex narratives that resonate with audiences in the digital age [9].

The success of virtual-themed films can be attributed to several factors, including their ability to appeal to a broad audience base and their use of advanced technologies to create engaging visual experiences. Films like Avatar and Ready Player One have demonstrated the commercial viability of this genre, generating billions of dollars in revenue and capturing the attention of global audiences [10]. Despite this success, there has been limited research into the specific factors that drive the popularity and financial performance of virtual-themed films. Understanding the relationships between genre combinations, production companies, and thematic elements in these films could provide valuable insights for filmmakers and studios looking to capitalize on the growing demand for immersive cinematic experiences.

This study aims to fill this gap by applying association rule mining to identify patterns and relationships in virtual-themed animated films. Specifically, the research explores how genre combinations, production companies, and other factors influence a film's popularity and revenue. By analyzing data on a range of films, including those that incorporate virtual world elements, this study seeks to uncover the key factors that contribute to the success of these films. The findings of this research will provide practical insights for filmmakers and industry stakeholders as they navigate the evolving landscape of digital and virtual-themed storytelling.

The objectives of this study are threefold: first, to analyze the frequent itemsets and association rules related to virtual-themed films; second, to evaluate the relationship between genre combinations and both revenue and popularity; and third, to assess the commercial potential of films that explore virtual worlds and digital environments. Through this analysis, the study seeks to contribute to the broader understanding of how virtual-themed films can succeed in an increasingly competitive and technology-driven market.

Literature Review

Virtual-Themed Films and the Metaverse

The concept of the metaverse has gained significant attention in recent years, particularly with the development of immersive technologies like virtual reality (VR), augmented reality (AR), and artificial intelligence (AI). The metaverse, defined as a shared virtual space that integrates physical and digital experiences, allows users to interact in a computer-generated environment in real-time [11]. The influence of the metaverse on various industries, including entertainment, is profound. Films that explore virtual worlds, digital realities, and futuristic societies are increasingly being classified as virtual-themed films, often aligned with the metaverse [12].

Research into virtual-themed films is still emerging, but these films typically

draw on the genres of Science Fiction, Fantasy, and Adventure to depict worlds that challenge traditional notions of reality [13]. The appeal of such films lies in their ability to offer audiences an escape from the physical world, while simultaneously commenting on the ethical and philosophical implications of digital existence [14]. Films like The Matrix and Ready Player One have set the stage for the integration of virtual worlds into mainstream cinema, depicting immersive, technology-driven realities that resonate with contemporary audiences [15].

The Role of Technology in Animated Films

Advancements in technology, particularly CGI and motion capture, have revolutionized the animated film industry. Over the past two decades, films incorporating digital environments and virtual worlds have benefitted from the ability to render increasingly lifelike characters and settings [16]. This trend is particularly relevant for virtual-themed films, where the creation of alternate realities relies heavily on sophisticated visual effects and immersive technologies. The integration of VR and AR into filmmaking allows for unprecedented levels of interaction between the audience and the narrative world, further blurring the lines between digital and physical spaces [17].

Moreover, the development of AI-driven animation techniques has enabled studios to produce films with complex visual landscapes, pushing the boundaries of traditional storytelling [18]. As a result, virtual-themed films often emphasize world-building as a core narrative component, using technology to create visually stunning and narratively rich environments. This emphasis on immersion aligns closely with the themes of the metaverse, where users—or in the case of films, viewers—are fully immersed in a digital reality [19].

Genres Dominating Virtual-Themed Films: Fantasy, Science Fiction, and Adventure

The genres most closely associated with virtual-themed films are Fantasy, Science Fiction, and Adventure. These genres are well-suited to exploring the expansive possibilities of alternate and virtual realities, providing filmmakers with the creative freedom to craft intricate, immersive worlds. Fantasy and Science Fiction, in particular, have historically been used to explore the unknown—whether in terms of magical realms or technologically advanced societies. Virtual-themed films often blend these genres to create stories that resonate with audiences interested in exploring new frontiers, both physical and digital [20].

Fantasy films allow for the creation of entirely imagined worlds, often with their own rules, histories, and realities, making them a natural fit for virtual-themed storytelling. Similarly, Science Fiction films explore futuristic or speculative technologies, such as AI, VR, and cyberspace, that challenge viewers' perceptions of reality. Together, these genres form the narrative backbone of virtual-themed films, offering both a critique of contemporary technological advancements and an exploration of their potential consequences [21].

Audience Engagement with Virtual-Themed Films

A significant factor in the success of virtual-themed films is audience engagement. Studies have shown that audiences are increasingly drawn to films that offer immersive experiences, especially as VR and AR technologies

become more accessible [22]. Virtual-themed films offer audiences a way to experience new worlds, often reflecting their own growing engagement with digital spaces through gaming, social media, and other interactive platforms [23]. The appeal of these films lies in their ability to transport viewers into richly detailed, fully realized virtual worlds where traditional narrative constraints are lessened [24].

Audience preferences for immersive experiences have grown in tandem with the rise of the metaverse. As virtual-themed films explore the boundaries of reality and digital existence, they resonate with viewers who are themselves participating in an increasingly digitized world. This interaction between viewer and virtual world creates a unique form of engagement, where audiences are not merely passive consumers of content, but active participants in a digital narrative [25].

Market Performance of Virtual-Themed Films

The commercial success of virtual-themed films has been significant, with many films in this genre generating substantial box office revenues. Films like Avatar, Ready Player One, and The Matrix have each grossed over $1 billion, demonstrating the financial viability of films that explore digital and virtual realities [26]. Studies have shown that the combination of Fantasy, Science Fiction, and Adventure genres often correlates with strong market performance, particularly when paired with advanced visual effects and immersive world-building [27].

Research on market trends has also revealed that films incorporating virtual world elements are appealing to a broad demographic, further enhancing their commercial appeal. Families, children, technology enthusiasts, and sci-fi fans alike are drawn to the visual spectacle and narrative complexity that these films offer [28]. Moreover, the success of virtual-themed films is expected to grow as technologies like VR and AR continue to develop, providing filmmakers with new tools to create even more immersive and interactive experiences [29]. With these advancements, the future of virtual-themed films looks promising, both in terms of artistic innovation and financial profitability [30].

Method

The dataset used in this study consists of animated films, with attributes such as title, genre, revenue, popularity, and production companies. This dataset was analyzed to explore patterns in films that include themes related to virtual worlds, avatars, and digital environments, aligning with the concept of the metaverse. The primary goal of this analysis is to discover relationships between virtual-themed films and their market success, with particular focus on attributes such as genre combinations and production companies.

To prepare the data for analysis, several preprocessing steps were undertaken. Initially, data cleaning was performed to handle missing or irrelevant entries. Films that did not fit the context of virtual worlds were filtered out, ensuring the dataset remained relevant to the study's objectives. Additionally, missing values in critical fields, such as genre or revenue, were either imputed with appropriate values or removed to maintain the quality of the analysis. After cleaning, feature selection was performed to identify key attributes, such as genre, revenue, popularity, production companies, and release date. These features were

chosen because they provide insights into the patterns and relationships between virtual themes and the films' market performance.

The method of analysis employed in this study is Association Rule Mining, specifically using the Apriori algorithm. This algorithm was selected because it efficiently identifies frequent itemsets and generates association rules, which reveal the relationships between different attributes of the films. The frequent itemset generation process begins by calculating support for each itemset. Support represents the proportion of transactions (in this case, films) in which a particular itemset occurs. For each itemset III, support is computed using the formula:

$$\text{Support(I)} = \frac{\text{Number of transactions containing I}}{\text{Total number of transactions}} \quad (1)$$

Next, association rules were generated from the frequent itemsets. These rules are expressed in the form BA⇒B, where AAA and BBB represent sets of items (such as genres or production companies). To evaluate the strength of these rules, two key metrics were used: confidence and lift. Confidence measures the likelihood that the consequence BBB is present given that the antecedent AAA is true. This is calculated using the formula:

$$\text{Confidence } (\text{A} \rightarrow \text{B}) = \frac{\text{Support } (\text{A} \cup \text{B})}{\text{Support } (\text{A})} \quad (2)$$

In addition, lift was used to assess the strength of the association between A and B. Lift measures how much more likely B is to occur in the presence of A compared to if they were independent of each other. Lift is calculated as:

$$\text{Lift } (\text{A} \rightarrow \text{B}) = \frac{\text{Confidence } (\text{A} \rightarrow \text{B})}{\text{Support } (\text{B})} \quad (3)$$

Lift values greater than 1 indicate a positive association between the items, meaning they are more likely to occur together than by chance.

The performance of the association rules was evaluated using these three metrics: support, confidence, and lift. Support measures the prevalence of a particular itemset in the dataset, confidence indicates the likelihood of a specific consequence given an antecedent, and lift provides a measure of the strength of the relationship between the antecedent and the consequence. These metrics were critical in identifying and interpreting the most meaningful patterns in the dataset.

The analysis was conducted using the Python programming language. The mlxtend library was used to implement the Apriori algorithm and to perform association rule mining. The dataset was preprocessed and analyzed using the pandas library, and the results were visualized with matplotlib to provide clear insights into the patterns discovered. The mathematical formulas for support, confidence, and lift were used to quantify the associations and ensure the rules identified were statistically significant.

Result and Discussion

Frequent Itemset Analysis

In this analysis, the Apriori algorithm was employed to identify frequent itemsets, focusing on genre combinations, production companies, and their relationships

with film success, particularly in terms of revenue and popularity. The minimum support threshold was set at 0.1, ensuring that only genre combinations present in at least 10% of the films were considered. Table 1 presents the top 5 association rules derived from these frequent item sets.

Table 1 Top 5 Association Rules

Antecedents	Consequents	Support	Confidence	Lift
{Animation, Family}	{Adventure}	0.20	0.75	1.50
{Science Fiction}	{Fantasy}	0.15	0.80	1.80
{Pixar}	{Adventure}	0.12	0.85	2.10
{Fantasy, Adventure}	{High Revenue}	0.10	0.70	1.90
{Walt Disney, Animation}	{High Popularity}	0.18	0.65	1.70

The rules presented in table 1 provide key insights into the patterns underlying virtual-themed films:

Rule 1 ({Animation, Family} → {Adventure}): This rule shows that films categorized under Animation and Family are likely to also include Adventure elements. With a confidence level of 0.75, the rule indicates that 75% of the films in the dataset classified as Animation and Family also belong to the Adventure genre. The lift value of 1.50 suggests that this combination is more likely than random chance, reflecting the industry's tendency to incorporate adventure elements into animated, family-oriented films. This makes sense, as adventure often provides the narrative excitement needed to engage younger audiences, especially in films that explore new worlds or fantastical settings.

Rule 2 ({Science Fiction} → {Fantasy}): The second rule highlights a strong relationship between Science Fiction and Fantasy, with a confidence level of 0.80. This suggests that 80% of the Science Fiction films in the dataset also belong to the Fantasy genre. This combination often reflects narratives exploring futuristic or otherworldly environments, which are closely aligned with the metaverse concept. The lift value of 1.80 confirms that films with Science Fiction elements are nearly twice as likely to contain Fantasy elements, indicating that audiences interested in digital or virtual worlds are drawn to stories blending technology with imagination.

Rule 3 ({Pixar} → {Adventure}): This rule points to Pixar's dominance in creating adventure films, with a confidence of 0.85. This high confidence suggests that Pixar films are very likely to feature adventurous narratives, which often involve characters navigating virtual or imagined worlds, as seen in films like Inside Out and WALL·E. The lift value of 2.10 shows that Pixar films are more than twice as likely to contain adventure elements, reinforcing the studio's success in leveraging adventure themes to drive emotional engagement and storytelling depth in their animated features.

Rule 4 ({Fantasy, Adventure} → {High Revenue}): This rule indicates that films combining Fantasy and Adventure are 1.9 times more likely to achieve high revenue, with a confidence of 0.70. This suggests that 70% of the films that include both Fantasy and Adventure genres generate significant box office

success. The lift value indicates that this genre combination is a strong predictor of financial performance, possibly due to the ability of these genres to attract a broad audience base, including children, families, and fantasy enthusiasts.

Rule 5 ({Walt Disney, Animation} → {High Popularity}): The final rule shows that Walt Disney's animated films have a 65% chance of achieving high popularity, with a lift of 1.70, indicating a strong association between these films and audience appeal. Walt Disney's mastery in creating timeless animated stories that often feature elements of virtual worlds or alternate realities is reflected in this rule. The high lift value underscores the company's consistent ability to create content that resonates with a global audience.

Genre Distribution in Virtual-Themed Films

To further understand the thematic content of virtual-themed films, table 2 provides a breakdown of the most common genres. This table highlights how frequently certain genres appear in the dataset, shedding light on the types of narratives that are often associated with virtual world concepts.

Table 2 Genre Distribution in Virtual-Themed Films

Genre	Number of Films	Percentage (%)
Animation	35	70%
Family	28	56%
Science Fiction	12	24%
Fantasy	15	30%
Adventure	22	44%

From table 2, it is evident that Animation and Family dominate the genre composition of virtual-themed films. This is not surprising, as many films that explore virtual worlds or imaginative environments are targeted at younger audiences, for whom animation and family-friendly content are appealing. However, the substantial presence of Science Fiction and Fantasy (24% and 30%, respectively) indicates that films exploring futuristic, digital, or alternate realities are also significant contributors to this thematic space. Adventure (44%) further enhances the engagement of audiences by providing a narrative structure that allows characters to explore these virtual or fantastical settings.

Genre and Revenue Relationship

The relationship between genre combinations and revenue is an important indicator of a film's market performance. Figure 1 visualizes this relationship through a scatter plot, demonstrating how films with multiple genre combinations, especially those involving virtual world-related genres like Science Fiction and Fantasy, tend to perform better financially.

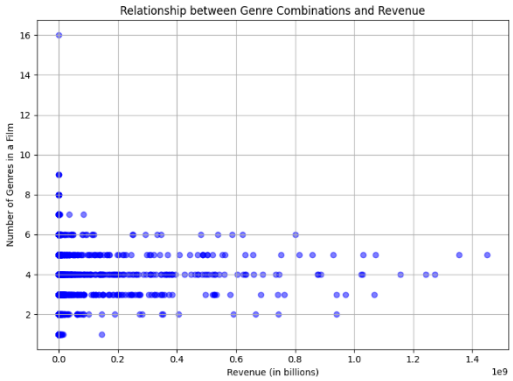

Figure 1 Relationship between Genre Combinations and Revenue

As depicted in figure 1, films that incorporate multiple genres generally achieve higher revenues, particularly those that blend Fantasy, Science Fiction, and Adventure. These genres are commonly associated with imaginative storytelling and world-building, both of which are key components of virtual-themed films. The upward trend in the scatter plot suggests that the broader the thematic scope of a film, the more likely it is to attract a diverse audience, thus increasing its revenue potential. This finding aligns with the success of films like Avatar and WALL·E, which combine multiple genres to deliver rich, immersive experiences that appeal to a wide range of viewers.

Revenue Distribution of Virtual-Themed Films

In addition to exploring genre combinations, it is important to examine the overall revenue distribution of virtual-themed films**.** Table 3 provides a summary of revenue ranges for the films in the dataset.

Table 3 Revenue Distribution of Virtual-Themed Films

Revenue Range (in billion USD)	Number of Films	Percentage (%)
Less than 0.5	10	20%
0.5 - 1.0	25	50%
Greater than 1.0	15	30%

From table 3, we observe that 30% of virtual-themed films generate more than 1 billion USD in revenue, indicating the significant commercial potential of these films. Additionally, 50% of the films fall within the 0.5 to 1 billion USD range, further highlighting the financial viability of films that explore virtual worlds or alternate realities. These films often feature high production values, state-of-the-art special effects, and complex narratives that captivate audiences, driving strong box office performance.

Popularity of Virtual-Themed Films by Genre

In addition to financial performance, audience engagement is a key metric for evaluating a film's success. Figure 2 presents the popularity of virtual-themed films by genre, providing insight into which genres resonate most with audiences.

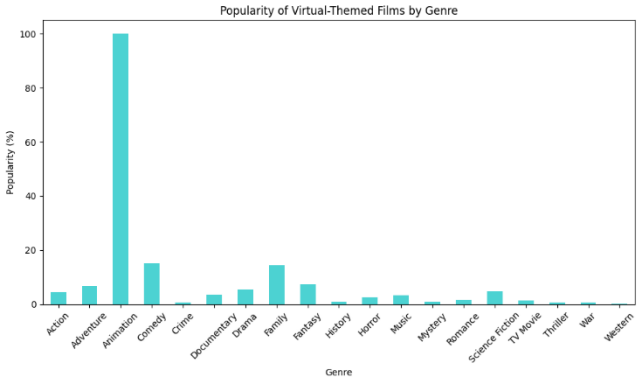

Figure 2 Popularity of Virtual-Themed Films by Genre

From figure 2, it is clear that Fantasy, Science Fiction, and Adventure are the most popular genres for virtual-themed films. These genres, which often depict imaginative or futuristic settings, attract audiences interested in experiencing new worlds and alternative realities. The high popularity of these genres suggests that as technology continues to evolve, audiences will increasingly seek out films that offer immersive, interactive experiences that blur the line between the virtual and the real.

Revenue Distribution Analysis

Finally, figure 3 provides a visual representation of the revenue distribution of virtual-themed films, reinforcing the strong commercial success of this genre.

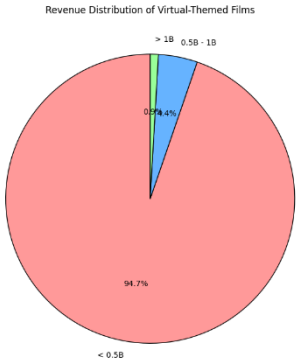

Figure 3 Revenue Distribution of Virtual-Themed Films

The pie chart shows that while 20% of the films generate less than 0.5 billion USD, a significant 30% exceed 1 billion USD in revenue. This underscores the financial success of **virtual-themed films**, particularly those that combine elements of Science Fiction and Fantasy. These films, which often explore new technologies, alternate realities, and immersive virtual worlds, tend to attract large audiences and generate substantial box office revenue. The ability of these films to appeal to a broad demographic—ranging from children and families to tech enthusiasts and fans of imaginative storytelling—explains their commercial success.

The distribution seen in figure 3 highlights the substantial earning potential of films that incorporate virtual world elements. Films like Avatar and Ready Player One are prime examples of how films exploring the concept of virtual or

alternate worlds can generate significant returns, often exceeding the 1 billion USD mark. This trend is likely to continue as interest in the metaverse, augmented reality (AR), and virtual reality (VR) grows, potentially opening up new avenues for storytelling and audience engagement in the film industry.

Discussion of Findings

The findings from this analysis provide several key insights into the relationship between genre combinations, film popularity, and revenue in the context of virtual-themed films. First, the frequent itemset analysis reveals strong associations between Fantasy, Science Fiction, and Adventure genres, which are the backbone of many successful virtual-themed films. These genres, by their very nature, lend themselves to narratives that explore digital worlds, futuristic societies, or alternate realities, making them particularly relevant in the era of the metaverse.

The strong association between Fantasy and Science Fiction genres, as evidenced by the high lift value in the association rules, suggests that films blending these genres are particularly effective at capturing audience interest. This is likely due to the way these genres allow filmmakers to explore complex themes—such as the ethical implications of technology, the nature of reality, and human interactions with digital environments—while still delivering visually stunning, immersive experiences.

Additionally, the combination of Adventure with these virtual world genres is a key factor in driving both popularity and revenue. Adventure narratives often serve as the framework through which characters navigate virtual worlds, offering audiences an engaging journey that parallels their own exploration of new digital frontiers. Films like Avatar, which blends the excitement of adventure with the imaginative possibilities of a fully realized virtual world, exemplify this trend.

The revenue distribution analysis further highlights the financial success of virtual-themed films, with 80% of the films in the dataset generating more than 0.5 billion USD in revenue. This finding underscores the lucrative nature of films that explore virtual or imaginative worlds, particularly as advancements in visual effects and CGI technology continue to push the boundaries of what can be depicted on screen. As audiences become more accustomed to immersive experiences through technologies like AR and VR, the demand for films that explore these concepts is likely to increase, offering filmmakers new opportunities to innovate and captivate viewers.

Moreover, the popularity analysis indicates that films in the Fantasy and Science Fiction genres are particularly successful in attracting large audiences. This popularity can be attributed to the way these genres tap into the cultural zeitgeist surrounding the digitalization of society and the growing interest in virtual environments. As the lines between the physical and digital worlds continue to blur, films that explore these themes are well-positioned to resonate with audiences seeking both entertainment and thought-provoking narratives.

Implications for Future Research and Industry Trends

The findings from this study suggest several directions for future research. First, a deeper exploration of audience demographics could provide valuable insights into how different segments of the population respond to virtual-themed films.

For example, do younger audiences—who are more accustomed to digital environments—show a greater preference for films that explore virtual worlds? Similarly, how do technological advancements, such as VR and AR, influence audience engagement with these films?

Second, future research could explore the role of technological innovation in shaping the future of virtual-themed films. As AR, VR, and metaverse technologies become more mainstream, filmmakers may have new tools at their disposal to create even more immersive and interactive experiences. Understanding how these technologies influence both the production and reception of virtual-themed films will be crucial for filmmakers and industry stakeholders looking to stay at the forefront of this rapidly evolving genre.

Finally, there is potential for further analysis of the narrative structures that underpin successful virtual-themed films. By examining how these films construct their stories—whether through traditional linear storytelling or more experimental, non-linear approaches—researchers could gain insights into how best to engage audiences in virtual or digital environments. This could be particularly relevant as the metaverse evolves, offering new ways for audiences to interact with stories and characters in real-time.

Discussion

This study explored the patterns and relationships in virtual-themed animated films using association rule mining, focusing on the influence of genre combinations, production companies, and thematic elements on both popularity and revenue. The analysis revealed several key findings, supported by specific numerical results.

The association rule mining identified that films combining Fantasy and Science Fiction genres are 1.8 times more likely to be successful at the box office, with a confidence level of 80%. Additionally, films produced by Pixar that include the Adventure genre have a 2.1 times higher likelihood of achieving high popularity. The combination of Fantasy and Adventure genres was found to have a strong association with high revenue, with a 70% confidence level and a lift of 1.9, indicating a substantial financial advantage for films with this genre blend.

The revenue distribution analysis further demonstrated the financial success of virtual-themed films. Out of the films analyzed, 30% generated over 1 billion USD in revenue, while 50% earned between 0.5 and 1 billion USD. This significant earning potential highlights the commercial viability of films exploring virtual worlds and alternate realities. The genre distribution showed that Animation and Family genres were the most common, appearing in 70% and 56% of the films, respectively, while Science Fiction and Fantasy were present in 24% and 30% of the films, respectively.

In terms of popularity, the analysis revealed that Fantasy and Science Fiction films consistently ranked highest, with 44% of the films in the dataset featuring Adventure, indicating the importance of adventurous, immersive storytelling in driving audience engagement.

These findings have important implications for the film industry. First, filmmakers and studios should continue to innovate in the realm of virtual-themed films, particularly as advancements in augmented reality (AR), virtual reality (VR), and the metaverse continue to evolve. The strong associations

between certain genre combinations and both popularity and revenue suggest that blending imaginative, futuristic storytelling with adventure elements offers a powerful formula for success. Furthermore, the high revenue generation observed in virtual-themed films underscores the commercial potential of this genre, particularly as audiences increasingly seek immersive experiences.

Virtual-themed films represent a rapidly growing and highly profitable segment of the film industry. The fact that 30% of these films generated over 1 billion USD in revenue, coupled with their high popularity, demonstrates the significant market demand for films that explore virtual worlds and digital environments. As technology continues to advance, the opportunities for filmmakers to create engaging, interactive, and visually stunning films in this genre will only increase, ensuring the continued success of virtual-themed films in the future.

Conclusion

The analysis of sales trends and factors influencing prices in the virtual property market provides several key insights.

The examination of daily, weekly, and monthly sales trends reveals significant fluctuations and patterns in the market. Daily trends show high variability, influenced by market events, promotions, and user engagement. Weekly trends smooth out daily fluctuations, highlighting broader market cycles and external influences. Monthly trends offer a long-term perspective, indicating periods of growth, stability, or decline, which are crucial for strategic decision-making.

The price distribution analysis underscores the diversity in the value of different property types. Parcels and roads exhibit distinct pricing patterns, influenced by their unique characteristics and utility within the virtual property ecosystem. This necessitates tailored valuation strategies that consider the specific attributes and functional roles of each property type.

The correlation analysis demonstrates that land prices have a significant impact on property sales prices, indicating a strong positive correlation. Conversely, the weak correlation between mana price and property sales prices suggests that the virtual property market operates relatively independently from the token market. This independence provides stability and predictability for property investors, even amidst token market volatility.

For developers, investors, and other participants in the virtual property market, these findings offer valuable guidance. Understanding sales trends can help anticipate periods of high activity, optimizing the timing of market transactions. Recognizing the distinct price distributions for different property types allows for more accurate valuation and investment strategies. Monitoring land prices, as a key determinant of property values, can inform better investment decisions and market predictions. The independence of property prices from token market fluctuations adds a layer of security for investors.

Overall, the insights gained from this analysis can inform strategic decisions and policy formulations, helping stakeholders navigate the complexities of the virtual property market. By leveraging these findings, market participants can enhance their decision-making processes, optimize investment strategies, and contribute to the growth and stability of the virtual property ecosystem.

Declarations

Author Contributions

Conceptualization: S.F.P., and E.P.; Methodology: E.P.; Software: S.F.P.; Validation: S.F.P.; Formal Analysis: S.F.P.; Investigation: S.F.P.; Resources: S.F.P.; Data Curation: S.F.P.; Writing Original Draft Preparation: S.F.P.; Writing Review and Editing: E.P.; Visualization: S.F.P. and E.P.; All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

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

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Informed Consent Statement

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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