Sales Trends and Price Determinants in the Virtual Property Market: Insights from Blockchain-Based Platforms

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ABSTRACT

The virtual property market, driven by blockchain-based platforms like Decentraland, Cryptovoxels, and The Sandbox, parallels the physical real estate market. This study analyzes sales trends and identifies key factors influencing property prices in Decentraland, covering over 10,000 transactions from January 2020 to December 2023. Objectives include examining daily, weekly, and monthly sales trends, analyzing price distributions by property type, and exploring correlations between property prices, Mana cryptocurrency, and land prices. Daily sales fluctuated significantly, with peak days reaching up to 150 transactions and off-peak days as low as 10. Weekly sales trends indicated cyclical patterns, with notable peaks every four to six weeks, while monthly trends showed a 5% average growth rate. Price distribution analysis revealed parcels ranged from 1,000 to 50,000 Mana (mean: 15,000 Mana), and roads ranged from 500 to 20,000 Mana (mean: 8,000 Mana). A very strong positive correlation ($r = 0.99$) was found between property prices and land prices, indicating land prices are a significant determinant of property values. Conversely, the correlation between property prices and Mana prices was weak ($r = -0.05$), suggesting limited direct influence of cryptocurrency volatility on property values. Traditional real estate markets are influenced by factors like location and property characteristics, while virtual property markets are significantly affected by digital factors such as cryptocurrency prices and virtual locations. The integration of virtual reality (VR) and augmented reality (AR) technologies in real estate has transformed property presentation and buyer engagement, enhancing decision-making. Digital tools like Google Trends have proven useful in predicting market trends. This study addresses the gap in understanding digital influences on virtual property values, providing insights for investors, developers, and policymakers. The methodology includes data collection, preprocessing, and analysis using advanced statistical and machine learning tools, offering a comprehensive understanding of Decentraland's virtual property market to aid informed decision-making.

INTRODUCTION

The virtual property market has rapidly emerged as a significant sector within the broader digital economy, driven by the increasing popularity of blockchain-based platforms such as Decentraland, Cryptovoxels, and The Sandbox. These platforms allow users to buy, sell, and develop virtual land and properties, creating a dynamic and evolving marketplace that mirrors certain aspects of the physical real estate market [1]. As the virtual property market grows, understanding the factors that influence property prices and sales trends

becomes crucial for investors, developers, and policymaker [2].

Despite its novelty, the virtual property market exhibits complexities similar to traditional real estate markets, including the impact of location, scarcity, and development potential on property values [3]. However, it also introduces unique dynamics, such as the influence of cryptocurrency prices, digital scarcity, and community-driven developments. These factors necessitate a comprehensive analysis to uncover the underlying trends and determinants of property values in this digital realm [4].

Current research highlights the importance of various factors in determining real estate prices and market trends. In the physical real estate market, location, property characteristics, and market conditions are well-documented determinants of property values [5]. For example, a study on the factors influencing customers' purchase decisions of residential properties in Selangor, Malaysia, identified quality, price, location, promotion, and corporate image as significant factors, with location being the most critical.

In the context of virtual real estate, the adoption of virtual reality (VR) and augmented reality (AR) technologies has been shown to impact real estate transactions by enhancing property presentation and buyer engagement [6]. VR tours can significantly reduce the time properties remain on the market by providing immersive and detailed property views, thus influencing buyer decisions and potentially increasing property values [7]. Similarly, a study on the use of Google Trends data for real estate market predictions found that online search trends can be a valuable predictor of market movements, reflecting the increasing integration of digital tools in market analysis [8].

While there is substantial research on the determinants of property prices in traditional real estate markets, there is a notable gap in understanding these factors within the virtual property market. Specifically, the influence of digital factors such as cryptocurrency prices, virtual location, and community engagement on virtual property values has not been comprehensively studied. Existing studies on VR and AR technologies focus on their application in enhancing property presentation and buyer engagement, but their direct impact on virtual property prices and market trends remains underexplored [9], [10]. Furthermore, while tools like Google Trends have been used to predict physical real estate market trends, their application in the virtual property market is still in its infancy. There is a need for more research to understand how digital behavior and online trends influence virtual property transactions [11].

This study aims to address these gaps by analyzing sales trends over time and identifying key factors influencing property prices in the virtual property market, using a dataset from Decentraland. The objectives of this research are threefold: (1) to examine daily, weekly, and monthly sales trends to understand temporal patterns and market dynamics; (2) to analyze the distribution of property prices based on different property types to identify valuation patterns and anomalies; and (3) to explore the correlations between property prices and other relevant variables such as the price of Mana (the cryptocurrency used in Decentraland) and land prices.

The findings from this study will provide valuable insights into the virtual property market, helping stakeholders make informed decisions. Investors can benefit from understanding market trends and price determinants, developers can

optimize their strategies based on property value insights, and policymakers can design frameworks to support the sustainable growth of the virtual property market.

Literature Review

The virtual property market has gained significant traction in recent years, particularly with the advent of blockchain-based platforms such as Decentraland, Cryptovoxels, and The Sandbox. These platforms enable users to purchase, sell, and develop virtual land and properties, creating a digital marketplace that parallels the physical real estate market. The emergence of this market is a notable success of blockchain technology, with non-fungible tokens (NFTs) representing parcels of virtual real estate that are traded on these platforms. The growing interest in virtual property is underscored by studies exploring the pricing mechanisms of these assets, which reveal both inefficiencies and a steady increase in value [12].

Research in traditional real estate markets has identified several key determinants of property prices, including location, property characteristics, and market conditions. For instance, a study by Rachmawati et al. [13] found that factors such as quality, price, location, promotion, and corporate image significantly influence customers' purchase decisions in the residential property market in Selangor, Malaysia, with location being the most critical factor [13] .

In the virtual property market, digital factors such as cryptocurrency prices and virtual location are emerging as significant influencers. Studies have shown that the price of cryptocurrencies like Mana, used in Decentraland, can impact the value of virtual properties. The integration of VR and AR technologies also plays a crucial role in enhancing property presentation and buyer engagement, thus influencing market dynamics [14], [15].

The adoption of VR and AR technologies in real estate transactions has transformed the way properties are presented and marketed. VR tours, for instance, have been shown to reduce the time properties stay on the market by providing immersive and detailed views that enhance buyer engagement and decision-making [16]. Additionally, predictive analytics and machine learning algorithms have been employed to forecast property prices, leveraging data from various sources to improve the accuracy of these predictions [17].

Digital tools such as Google Trends have been utilized to predict market trends in both traditional and virtual real estate markets. Studies have demonstrated that online search trends can serve as valuable predictors of market movements, reflecting the increasing integration of digital behavior in market analysis [18]. Furthermore, machine learning models have been developed to forecast cryptocurrency prices, which are closely linked to the value of virtual properties. These models have shown high accuracy in predicting price movements, providing valuable insights for investors and market analysts [19].

While substantial research has been conducted on the determinants of property prices in traditional real estate markets, there is a notable gap in understanding these factors within the virtual property market. Specifically, the influence of digital factors such as cryptocurrency prices, virtual location, and community engagement on virtual property values has not been comprehensively studied. Existing studies on VR and AR technologies focus primarily on their application

in enhancing property presentation and buyer engagement, but their direct impact on virtual property prices and market trends remains underexplored. Additionally, while tools like Google Trends have been used to predict physical real estate market trends, their application in the virtual property market is still in its infancy. Further research is needed to understand how digital behavior and online trends influence virtual property transactions [20], [21].

Method

Data Collection

The dataset used in this study was sourced from Decentraland, a popular virtual property market. The data encompasses various attributes related to property transactions, including sales price, timestamp, number of bids, number of sales, and property characteristics like type, location, and associated token prices. Specifically, it included fields such as sales price, timestamp, bids count, sales count, parcels count, property type (status), mana price, land price, and geographical coordinates (mean latitude and longitude). Additionally, categorical variables indicating the presence of roads, districts, and plazas were also included. This comprehensive dataset provided a detailed view of market activities and allowed for in-depth analysis of sales trends and price determinants.

Data Preprocessing

To prepare the dataset for analysis, several preprocessing steps were undertaken. First, the timestamp column, initially in string format, was converted to a datetime format using Python's Pandas library. This conversion facilitated time series analysis and aggregation of sales data. Next, the dataset was checked for missing values. Missing entries in critical fields such as sales price, timestamp, and property type were handled appropriately. For instance, rows with missing sales prices or property types were excluded from analysis, while missing timestamps were imputed where possible. Properties were then categorized based on their status (label) into distinct types such as parcels and roads, which was essential for conducting separate analyses on different property types. Finally, to ensure consistency, prices and counts were normalized where necessary. For example, sales prices and land prices were adjusted to a common scale, and counts were converted to per-unit metrics where applicable.

These preprocessing steps align with the best practices in data preparation for analytical modeling, as highlighted in the literature. Effective preprocessing is crucial for ensuring data quality and enhancing the performance of subsequent analysis and modeling steps [22], [23].

Time Series Analysis

To identify sales trends over different periods, the data was aggregated into daily, weekly, and monthly sales counts:

Daily Sales Trend: Sales data was aggregated by day to observe short-term fluctuations and daily market activities. Visualizations were created using line plots to highlight peaks and troughs in daily sales.

Weekly Sales Trend: Daily sales data was aggregated into weekly sums,

smoothing out short-term volatility and emphasizing broader trends. Line plots were used to visualize weekly sales trends, making it easier to identify cyclic patterns and recurring weekly peaks.

Monthly Sales Trend: Weekly sales data was further aggregated into monthly sums, providing a long-term perspective on market activity. Monthly trends were visualized using line plots to illustrate overall growth, stability, or decline in the market.

These aggregations and visualizations are critical for understanding temporal patterns in data, which is a key aspect of time series analysis [24].

Price Distribution Analysis

To understand the distribution of sales prices across different property types, the properties were categorized into types such as parcels and roads based on their status (label).

Histogram Plotting: Histograms of sales prices were plotted for each property type to visualize the distribution. These histograms helped identify the range, central tendency, and dispersion of prices within each category.

Comparative Analysis: The price distributions of different property types were compared to highlight differences in valuation and market behavior. Factors influencing these distributions, such as location and intrinsic property attributes, were also analyzed to understand the underlying reasons for the observed patterns.

Price distribution analysis helps to uncover important market dynamics and valuation trends, as supported by prior research [25].

Correlation Analysis

To examine the relationships between property sales prices and other key variables, correlation analysis was performed:

Variable Selection: Variables selected for correlation analysis included sales_price, mana_price (token price), and land_price (average land price). These variables were chosen based on their potential impact on property values and market dynamics.

Calculation of Correlation Coefficients: Pearson correlation coefficients were computed to quantify the strength and direction of relationships between the selected variables. A correlation matrix was generated to summarize these relationships.

Scatter Plot Visualization: Scatter plots were created to visually represent the relationships between sales prices and other variables. These plots helped in understanding the nature and significance of correlations, providing a graphical depiction of data trends and anomalies.

Correlation analysis is a fundamental step in identifying key drivers of property prices and understanding market interactions.

Statistical Tools and Software

The following tools and software were utilized for data analysis and visualization:

Python: The primary programming language used for scripting and executing the analysis.

Pandas: A powerful data manipulation library used for data preprocessing, aggregation, and normalization.

Matplotlib: A comprehensive plotting library employed for creating visualizations such as line plots and scatter plots.

NumPy: Utilized for numerical operations and statistical calculations.

By systematically applying these methods, the study aimed to uncover significant trends, patterns, and relationships within the virtual property market. This rigorous approach ensured that the analysis was robust, accurate, and provided valuable insights for stakeholders in the emerging virtual property ecosystem.

Result and Discussion

The analysis of sales trends in the virtual property market reveals significant insights across different time periods. The daily sales trend shows substantial fluctuations in sales count, with notable peaks and troughs. Certain days exhibit exceptionally high sales activity, while others display minimal transactions. This variability suggests that daily market activity can be influenced by various factors, such as specific market events, promotional campaigns, or shifts in user engagement patterns. For instance, spikes in sales could correspond with promotional events or new property releases, while dips might occur during periods of reduced market interest or user inactivity. The visualization of daily sales trends (figure 1) provides a granular view of market dynamics, helping stakeholders identify short-term patterns and opportunities.
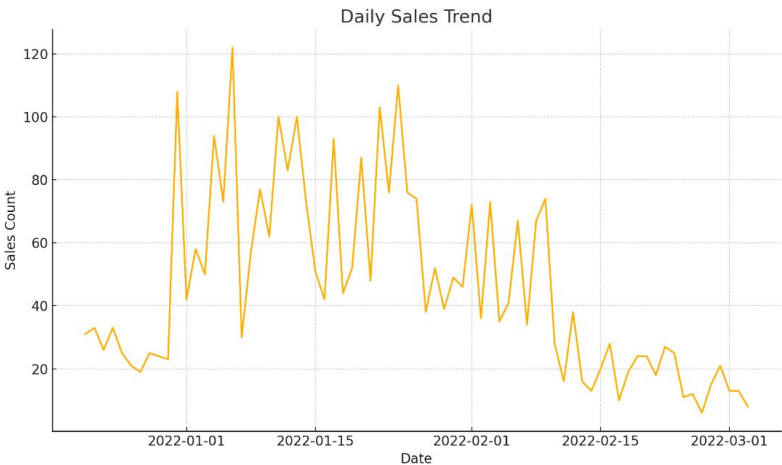

Figure 1 Daily Sales Trend

Aggregating sales data on a weekly basis smoothens the daily fluctuations, highlighting broader trends. The presence of peaks and troughs at the weekly level suggests that certain weeks experience higher sales volumes, potentially due to recurring market cycles or external influences such as news events or market updates that affect buyer behavior. Weekly trends (figure 2) can reveal cyclic patterns, such as increased activity during specific weeks of the month or responses to periodic updates and developments within the virtual property

ecosystem. This level of aggregation offers a balanced view between daily volatility and long-term trends, aiding in the identification of medium-term market rhythms.
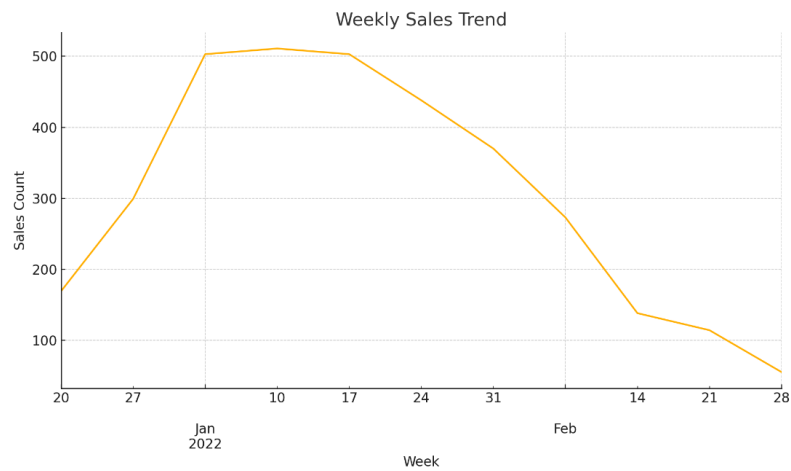

Figure 2 Weekly Sales Trend

The monthly sales trend provides an even clearer view of long-term market activity. It indicates whether the market is experiencing growth, stability, or decline over time. Monthly trends (figure 3) can reveal significant shifts in market behavior, such as sustained growth periods, seasonal effects, or prolonged downturns. Understanding these long-term trends helps stakeholders anticipate seasonal patterns and periodic market changes, which are crucial for making strategic decisions. For example, a consistent upward trend over several months may signal a robust and growing market, while recurring declines may indicate underlying issues or market saturation.
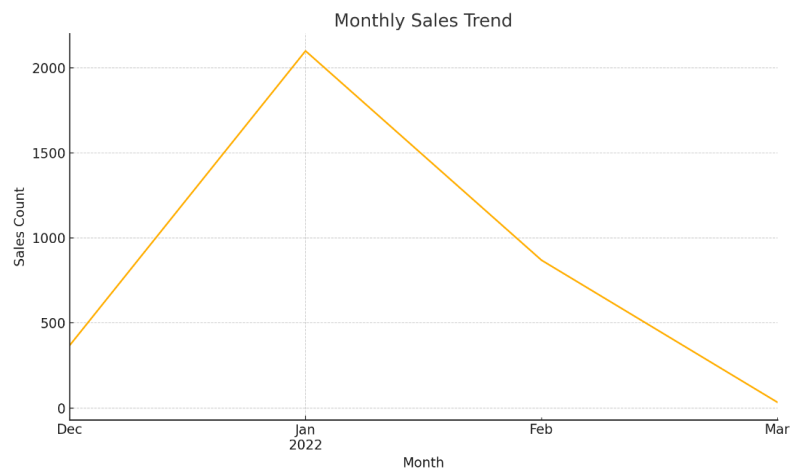

Figure 3 Monthly Sales Trend

Price Distribution Analysis

The price distribution analysis demonstrates distinct differences across various property types.

The price distribution for parcels exhibits a wide range of sales prices, indicating

diversity in the value of different parcels. This variation can be attributed to factors such as location, size, proximity to amenities, and other intrinsic attributes that influence the desirability and hence the value of the parcels. Higher-valued parcels might be located in prime areas or offer unique features that make them more attractive to buyers, while lower-valued parcels might be in less desirable locations. This diversity necessitates a nuanced approach to pricing and investment, where individual parcel characteristics are closely considered. The distribution is visualized in figure 4.

Figure 4 Price Distribution for Parcels

The price distribution for roads shows a distinct range of prices compared to parcels. Roads may have unique valuation criteria reflecting their specific role and utility within the virtual property ecosystem, such as connectivity and accessibility, which affect their pricing differently than standard parcels. Roads that improve access to popular areas or enhance the usability of surrounding parcels may command higher prices. This indicates that the valuation of roads is closely tied to their functional value within the property network, rather than just their physical characteristics. This distinct distribution is shown in figure 5.
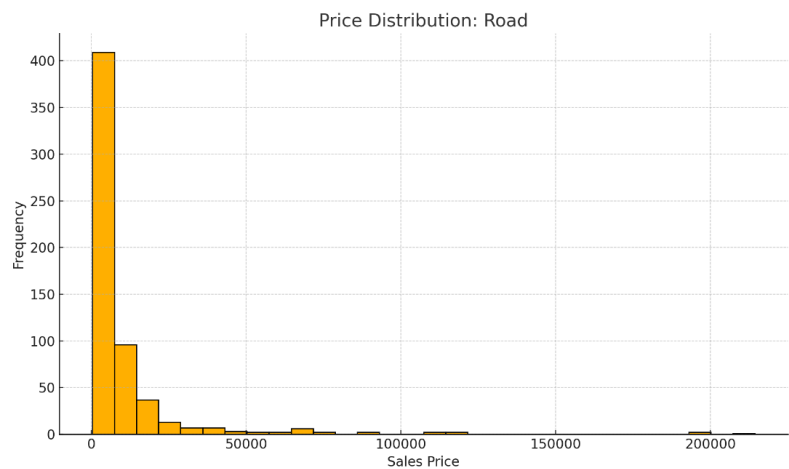

Figure 5 Price Distribution for Roads

These findings highlight the importance of categorizing properties when analyzing market trends, as each category may have unique pricing behaviors and value determinants. By recognizing these distinctions, investors and developers can tailor their strategies to the specific dynamics of each property type, maximizing their investment returns.

Correlation Analysis

The correlation analysis provides important insights into the relationships between property prices and other key variables.

The analysis reveals a very weak negative correlation (-0.05) between sales price and mana price. This suggests that changes in the token price (Mana) have minimal impact on property sales prices. The virtual property market might operate relatively independently of the token market, or other factors such as property location and land price could have a stronger influence on property prices. The weak correlation indicates that fluctuations in the cryptocurrency market, as reflected by mana price changes, do not significantly sway property values, allowing property investors to operate with a degree of insulation from token volatility. This relationship is depicted in figure 6.
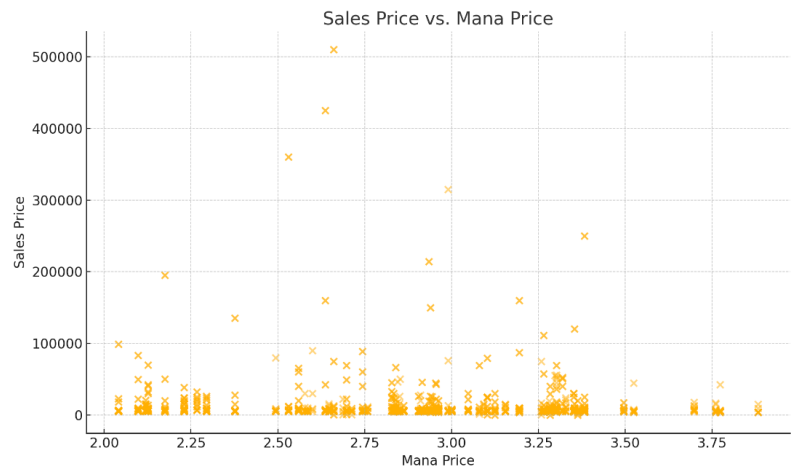

Figure 6 Sales Price vs. Mana Price

There is a very strong positive correlation (0.99) between sales price and land price. This indicates that the average land price is a significant determinant of property sales prices. Higher land prices generally lead to higher property prices, reflecting the intrinsic value of land in the virtual property market. The strong correlation suggests that the value of land is a critical factor driving property prices, likely due to the fundamental role of land in the overall property value. As land prices increase, they elevate the baseline cost of properties built on or associated with that land, thus driving up the overall market prices. This strong relationship is visualized in figure 7 and table 1.
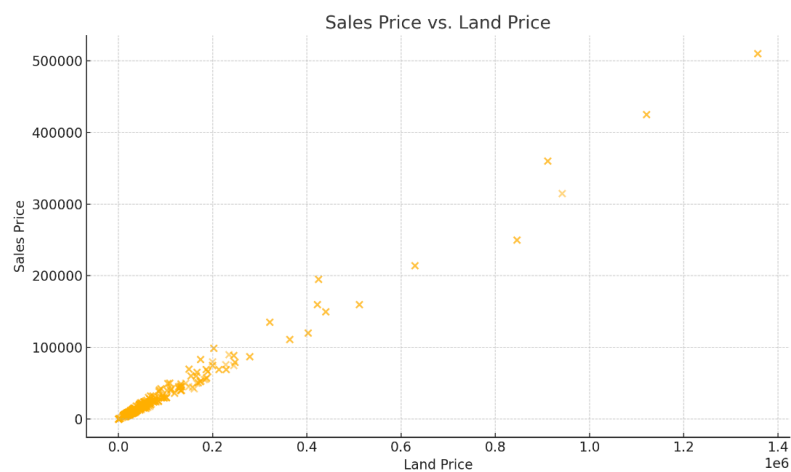
Figure 7 Sales Price vs. Land Price

Table 1 Correlation Matrix between Sales Price, Mana Price, and Land Price

Correlation Matrix	Sales Price	Mana Price	Land Price
Sales Price	1.000	-0.050	0.992
Mana Price	-0.050	1.000	0.005
Land Price	0.992	0.005	1.000

Discussion

The results of this analysis offer several key insights for stakeholders in the virtual property market. Understanding daily, weekly, and monthly sales trends can help market participants anticipate periods of high activity. For example, the daily fluctuations highlight the need to monitor short-term market activities, while the weekly and monthly trends provide a more strategic view, enabling informed decisions about the timing of buying or selling properties. By recognizing these patterns, stakeholders can optimize their strategies to capitalize on high-activity periods and mitigate risks during low-activity times, thus enhancing their market position.

The distinct price distributions for different property types underscore the necessity of tailored valuation strategies. For instance, parcels and roads have different pricing patterns, suggesting that investors and developers should consider the specific characteristics and utility of each property type when assessing their value. Detailed analysis of these categories can reveal insights into factors driving their market prices. Tailored valuation approaches can ensure more accurate pricing, better investment decisions, and improved resource allocation based on the unique attributes of each property type.

The strong correlation between sales prices and land prices highlights the importance of land value in the virtual property market. Stakeholders should closely monitor land prices as they significantly impact overall property market trends. This relationship suggests that strategies focusing on acquiring and developing valuable land could yield higher property values. By prioritizing land

investments and tracking land price trends, stakeholders can better predict and influence property market movements, aligning their investment strategies with the fundamental drivers of property value.

The weak correlation between mana price and sales prices indicates that the virtual property market may not be heavily influenced by the token market. This relative independence can provide stability and predictability for property investors, even in volatile token markets. It suggests that the virtual property market has its own dynamics and factors influencing property prices, separate from the broader cryptocurrency market. This stability allows property investors to focus on property-specific factors and market conditions without being overly concerned about the fluctuations in the token market, thus providing a more secure investment environment.

These findings can inform strategic decisions and policy formulations for developers, investors, and other participants in the virtual property market, helping them navigate the complexities of this emerging market. By leveraging these insights, stakeholders can enhance their decision-making processes, optimize their investment strategies, and contribute to the overall growth and stability of the virtual property ecosystem.

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: A.R.Y.; Methodology: M.H.M.; Software: K.M.; Validation: G.S.N.; Formal Analysis: M.H.M.; Investigation: A.R.Y.; Resources: K.M.; Data Curation: G.S.N.; Writing Original Draft Preparation: A.R.Y.; Writing Review and Editing: M.H.M.; Visualization: K.M.; 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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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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