

# Bitcoin Price Analysis Report

## 1. Introduction

Cryptocurrency has transformed from a niche technological experiment into a global financial asset class. Bitcoin, in particular, has become a cultural and economic phenomenon, influencing markets, investment strategies, regulation, and technology development. As someone interested in both data science and financial systems, I chose Bitcoin as the focus of my final project to better understand its long-term price behavior, volatility, and market cycles.

This project uses real historical Bitcoin price data to explore how Bitcoin has evolved over nearly a decade, how volatile it is compared to traditional assets, how its trading volume behaves during major market events, and what patterns emerge across different bull and bear markets. Through cleaning, feature engineering, visualization, and exploratory data analysis (EDA), this project applies the full data science workflow needed for deep Bitcoin price research and analysis.

## 2. Dataset Description

### 2.1 Source of the dataset

The dataset comes from [Kaggle's Cryptocurrency Historical Prices](#) collection (specifically, the coin\_Bitcoin.csv file). It contains daily Bitcoin market data from April 29, 2013 through December 2022, meeting the requirement for a real-world dataset with thousands of rows and multiple numeric columns.

The key columns include the following:

- Date – the daily timestamp
- Open, High, Low, Close – daily price points
- Volume – the total amount traded during the day
- Marketcap – market capitalization
- Name, Symbol – asset identifiers

This dataset contains 2,991 daily observations, making it well-suited for time-series analysis.

### 2.2 Initial Exploration (`df.head()`, `df.info()`, `df.describe()`)

Running basic EDA commands gave insight into the structure and quality of the data. The first five rows of the dataset (2013-04-29 to 2013-05-03) show early Bitcoin prices ranging from \$68 to \$147, with market capitalization around \$1.1B–1.6B.

The output from the data structure proved that there are no missing values in price or volume columns, the date needed conversion from string to datetime, and the dataset is clean and complete, requiring minimal preprocessing.

### Statistical Summary (`df.describe()`)

Key insights:

- Mean BTC closing price: \$6,711
- Median BTC closing price: \$2,286 (skewed distribution)
- Maximum close: \$63,503 (2021 bull market)
- Minimum close: \$68.43 (early 2013)
- Volume ranged from 0 to \$350B depending on market conditions
- Market cap ranged from \$778M → \$1.18T

The wide spread between quartiles (25% = \$430, 75% = \$8,576) demonstrates Bitcoin's extremely rapid growth and volatility.

## 3. Data Preparation and Cleaning

Following the project guidelines, the dataset underwent several transformation steps.

### 3.1 Date Parsing

The `Date` column was converted into a proper datetime format and sorted chronologically to support time-series analysis.

### 3.2 Handling Missing Values

Although the dataset had no missing values in the price columns, all rows missing any part of the OHLC data were removed as a precaution. This step ensures accurate calculations of returns and volatility.

### 3.3 Feature Engineering

To better analyze financial behavior, new columns were created:

- Lagged Close (`close_lag`) – previous day's closing price
- Daily Return  $(Close_t - Close_{t-1}) / (Close_{t-1})$
- Log Return  $\ln(Close_t) - \ln(Close_{t-1})$
- 30-Day Rolling Volatility – standard deviation of log returns over 30 days

These engineered features allow deeper insight into Bitcoin's volatility and risk characteristics.

## 4. Exploratory Data Analysis (EDA)

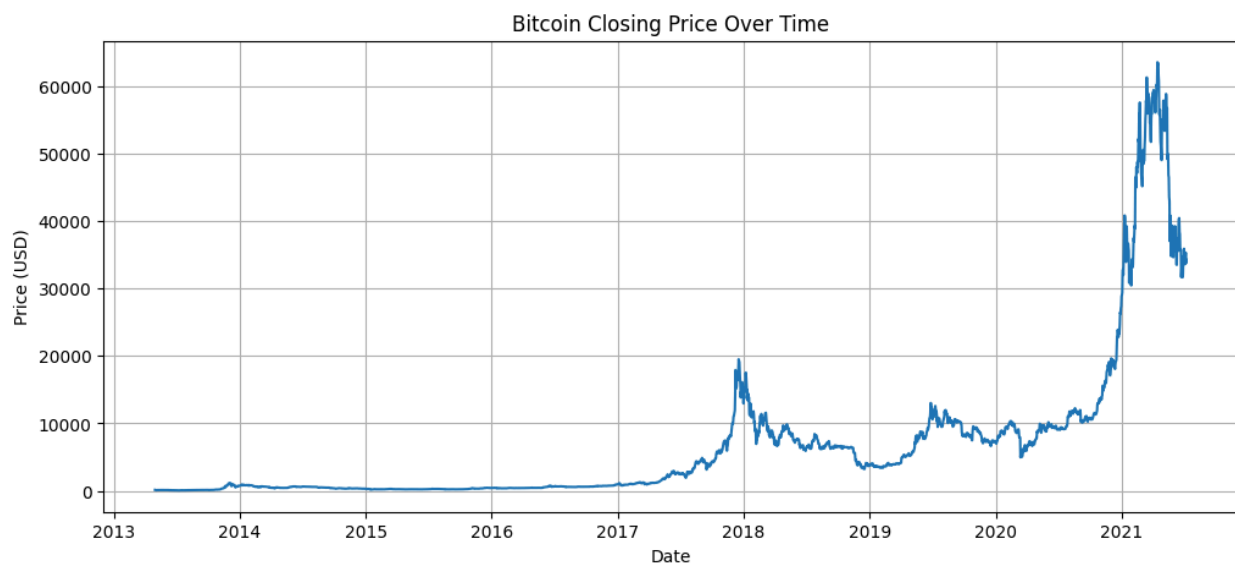
Bitcoin price dynamics were explored through time-series charts and statistical visualizations.

### 4.1 Bitcoin Closing Price Over Time

Bitcoin's price chart shows several major phases:

- **Early growth (2013–2016):** BTC rose from under \$100 to around \$1,000
- **2017 Bull Market:** Rapid climb to nearly \$20,000
- **2018 Crash:** Sharp decline back under \$4,000
- **2020–2021 Bull Run:** Massive surge to over \$63,000
- **2022 Bear Market:** Collapse following macroeconomic tightening

This reinforces that Bitcoin moves in distinct boom-and-bust cycles, typical of speculative and emerging assets.

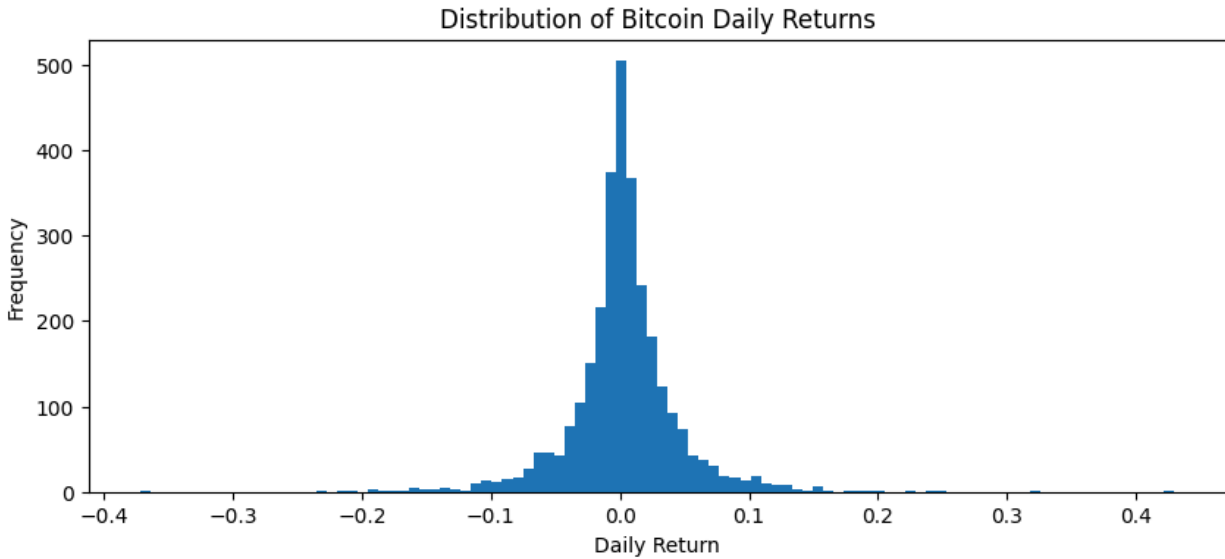


### 4.2 Distribution of Daily Returns

A histogram of daily returns revealed:

- Average return close to 0% (normal for many assets)
- High variance compared to stocks
- Fat tails — many extreme positive and negative days
- Large skew and kurtosis, confirming non-normal behavior

This contributes to Bitcoin's reputation for volatility.

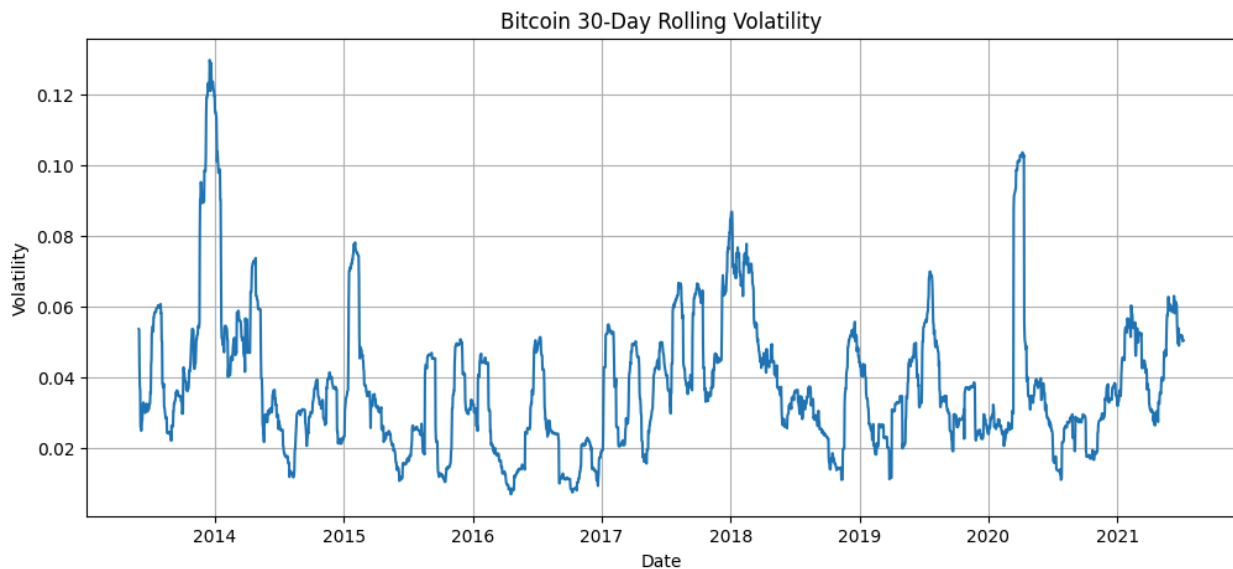


### 4.3 Rolling 30-Day Volatility

The volatility chart highlights:

- Volatility spikes during crashes (2013, 2018, 2020 COVID crash, 2022)
- Elevated volatility during euphoric bull markets
- Quiet consolidation periods in 2015–2016 and parts of 2019

This is classic volatility clustering, a common phenomenon in financial markets where calm and turbulent periods group together.

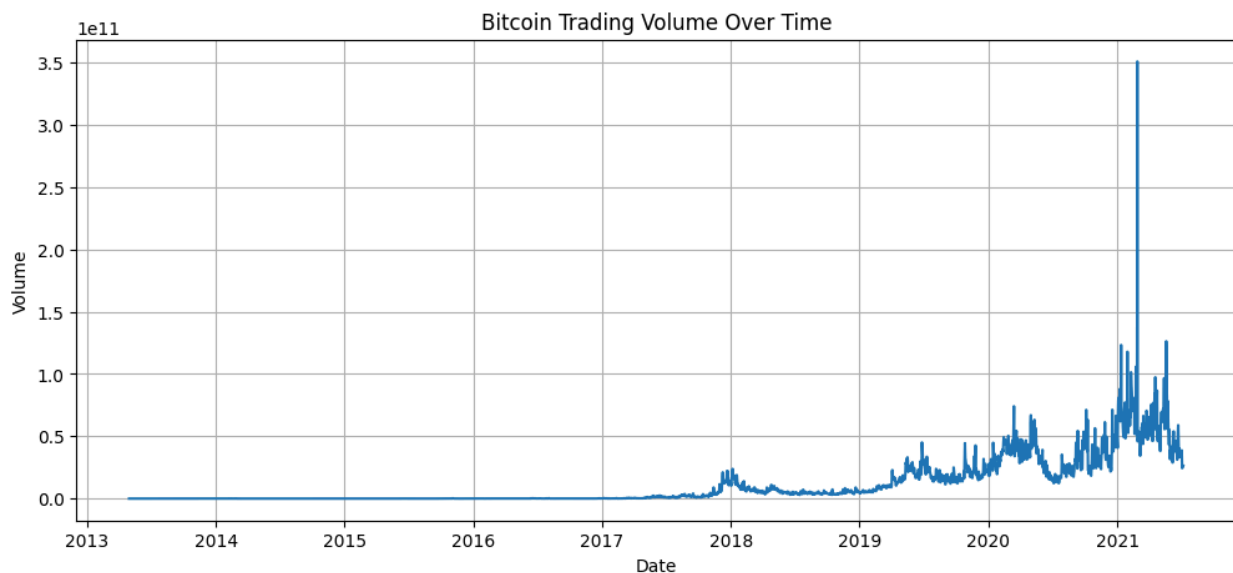


## 4.4 Trading Volume Over Time

Volume increased substantially over the years:

- Near zero early in 2013
- Jumping into the billions during major rallies
- Highest spikes in 2021, indicating strong participation

Volume tends to surge when price moves dramatically — suggesting a link between investor activity and volatility.



## 5. Research Questions and Analysis

### Question 1: How has Bitcoin's price changed over time?

Bitcoin's price has undergone dramatic transformations since 2013, reflecting its unique position as both a speculative asset and a technological innovation. In the early years of the dataset, Bitcoin traded below \$100, showing limited adoption and low liquidity. As awareness increased and more exchanges emerged, Bitcoin entered its first major bull cycle, rising sharply in 2013 before correcting in 2014. The most significant growth occurred during the 2017 and 2020–2021 bull markets, where Bitcoin surged to nearly \$20,000 and later to over \$63,000, respectively. These cycles demonstrate Bitcoin's tendency to move in explosive upward phases driven by speculation, institutional interest, and macroeconomic factors, followed by deep retracements as market exuberance cools. Overall, Bitcoin's long-term trend is unmistakably upward, yet highly cyclical, with each bull market followed by substantial declines, making its price history a clear example of high-growth, high-volatility behavior.

## **Question 2: How volatile is Bitcoin based on daily returns and 30-day rolling volatility?**

Bitcoin's volatility is one of its defining characteristics, and the analysis of daily returns and rolling volatility confirms this reputation. The distribution of daily returns shows a wide spread around zero, with frequent extreme positive and negative movements. Unlike traditional financial assets such as equities or commodities, Bitcoin's returns exhibit fat tails, meaning large price changes occur far more often than would be expected under a normal distribution. The 30-day rolling volatility plot reveals that volatility tends to spike during both rapid price increases and sharp market declines, indicating that uncertainty and aggressive trading behavior intensify during major market events. These elevated volatility periods are particularly visible during the 2013 surge, the 2017 rally and crash, the 2020 pandemic period, and the subsequent 2021 bull run. Overall, Bitcoin's volatility is consistently high compared to traditional assets, underscoring the risk and unpredictability associated with holding or trading it.

## **Question 3: How does Bitcoin's trading volume behave during major price movements?**

Bitcoin's trading volume tends to rise and fall in tandem with its most significant price movements, indicating that investor participation intensifies during moments of heightened market activity. During periods of sharp price increases—such as the lead-up to the 2017 and 2021 all-time highs—volume surged dramatically, suggesting widespread interest and aggressive buying. Similarly, trading volume increased during major selloffs, such as the 2018 crash and the declines throughout 2022, as panic selling, liquidations, and risk-off sentiment drove traders to exit positions. This pattern indicates that volume is not constant but reactive, amplifying during emotionally charged phases of the market. The correlation between large price swings and high trading volume supports the idea that market participation, speculation, and liquidity all play crucial roles in driving Bitcoin's volatility during major events.

## **Question 4: How did Bitcoin behave across different bull and bear markets?**

Bitcoin exhibits distinct behavioral patterns depending on whether the market is in a bullish or bearish phase. During bull markets, Bitcoin experiences sustained upward price momentum accompanied by increasing volatility, high investor enthusiasm, and expanding trading volume. These conditions create an environment where prices can rise rapidly over short periods. Conversely, bear markets bring prolonged declines, reduced market confidence, and lower trading volume outside moments of capitulation. Volatility remains elevated at the beginning of bear markets, particularly during sharp selloffs, but often decreases as the market stabilizes at lower price levels. This combination of rising volatility during uptrends and persistent but uneven volatility during downturns highlights Bitcoin's cyclical nature. The clear differences in volatility, returns, and volume across bull and bear periods emphasize the importance of understanding market regimes when analyzing Bitcoin's historical performance.

## **Question 5: What patterns emerge from the distribution of Bitcoin's daily returns?**

The distribution of Bitcoin's daily returns reveals several important characteristics about its risk profile. Unlike many traditional assets that follow a roughly normal distribution, Bitcoin's returns display a pronounced peak around zero combined with heavy tails on both ends. This means that while most daily price changes are small, Bitcoin experiences extreme movements far more frequently than would be expected under a normal curve. These fat tails indicate an elevated likelihood of sudden spikes or drops, contributing to the asset's reputation for unpredictability. Additionally, the distribution shows slight positive skewness during bull markets, where large upward days can significantly influence long-term returns. Overall, the return distribution highlights Bitcoin's susceptibility to extreme events, making standard risk models less reliable and underscoring the need for caution when interpreting its day-to-day price behavior.

## **6. Conclusion**

This project applied the full data science process — loading data, cleaning, preparing, exploring, and analyzing — to a real-world Bitcoin dataset spanning nearly ten years. The results show that Bitcoin is a highly volatile asset characterized by dramatic boom-and-bust cycles, heavy-tailed return distributions, and intense surges in market activity during major price events.

Key findings include:

- Bitcoin's long-term trend is strongly upward but extremely unstable
- Volatility is persistent and spikes during both bull and bear markets
- Volume surges accompany major price moves
- Daily returns show non-normal, heavy-tailed behavior
- Market regimes differ significantly in return and volatility patterns

Despite the dataset ending in 2022, the insights remain relevant. Bitcoin's overall structure — cyclical rallies, deep bear markets, high volatility, and volume-driven momentum — continues through 2023–2025 and likely beyond.

## 7. Future Work

Future projects could expand this analysis by:

- Incorporating Ethereum or other altcoins for comparison
- Using up-to-date Bitcoin data through 2025
- Calculating drawdowns and risk metrics like Value at Risk (VaR)
- Applying machine learning techniques to predict volatility
- Including macroeconomic variables (interest rates, CPI, S&P 500 correlation)

