Analysis of NVIDIA's growing influence in the AI chip (GPU) industry

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1 Introduction

The dawn of the 21st century has witnessed a transformative surge in technological domains, particularly in artificial intelligence (AI) and cryptocurrency markets, which have experienced exponential growth. Central to this technological renaissance is the Graphics Processing Unit (GPU), a cornerstone in the advancement of AI. Historically rooted in performing substantial computational tasks and subsequently revolutionizing the gaming world, GPUs have now broadened their horizons to pivotal applications in AI, cryptocurrency mining, and data center operations. The omnipresence of GPUs extends to the backbone of research and development across diverse fields—powering simulations in automotive design, enabling intricate physics software, enhancing video editing techniques, bolstering the movie industry, and catalyzing the breakthroughs in AI with sophisticated Large Language Models (LLMs) such as GPT. In today's digital age, the discrete GPU has ascended to be one of the most critical components of modern computing infrastructure.
Among the global leaders in this arena stands NVIDIA, a company renowned for its GPU designs, which has achieved the remarkable milestone of a 2 trillion dollar valuation. Such staggering economic success calls for a comprehensive analysis, which this paper aims to undertake, scrutinizing NVIDIA's ascension in the competitive AI chip industry. The discrete GPU market, traditionally cornered by industry giants AMD and NVIDIA, has undergone notable fluctuations between 2019 and 2023. The post-pandemic era in these years marked a pronounced spike in GPU demand, largely fueled by cryptocurrency mining. This period was characterized by a supply and demand imbalance that resulted in inflated GPU prices and a widespread availability crisis. This report delves into these significant occurrences and their implications, seeking to unravel the dynamics that propelled NVIDIA's growth trajectory amid such challenging times.

2 Problem definition

This study delves into the ascent of NVIDIA to its current position, where it monopolizes the discrete GPU market. What factors have contributed to NVIDIA's tremendous success? Additional questions explored include:

- Is there a correlation between bitcoin values (from 2016 to 2022) and NVIDIA's graphics share prices during that time period? Conclusions drawn from this correlation will be discussed.
- Comparison of stock prices for AMD and NVIDIA. How did NVIDIA outscale its rival, AMD? AI growth accelerated from 2019 to 2023, coinciding with NVIDIA's sales growth.
- Prediction analysis of NVIDIA's most popular graphics card in the midrange price segment of the next-gen graphics cards (RTX 50XX series and RTX 60XX series).

2.1 Literature review

In 2008, a mysterious individual or group known by the pseudonym Satoshi Nakamoto introduced a digital platform designed to facilitate the legitimate exchange of digital value tokens. This system, known as Bitcoin, became the first widely recognized cryptocurrency. The outbreak of the Coronavirus (COVID-19), which originated in Wuhan, China, has experienced swift global proliferation, infecting millions and resulting in numerous fatalities.[1] This has sparked a growing interest among financial analysts regarding the pandemic's impact on financial markets. The process involves computers solving exceptionally complex mathematical problems. Occasionally, as a reward, the owner

of the computer might receive a Bitcoin. This process, known as mining, involves setting up powerful computers with the aim of earning Bitcoins, although the cost of electricity can sometimes exceed the value of the Bitcoin obtained.

Forecasted trends suggest the market will maintain its upward trajectory in the upcoming years. Projections indicate that by 2025, the worldwide semiconductor market is poised to reach a valuation of $708.7 billion, marking a 27.49% enhancement from 2021. The primary catalysts for this expansion are anticipated to be the advent of cutting-edge technologies such as artificial intelligence, 5G connectivity, autonomous vehicles, and the Internet of Things, all of which are expected to surge chip demand.[2] However, with the goal of achieving autonomy from the United States and creating its own semiconductors, the Chinese government plans to expand the roster of chipmakers within its market. This expansion has the potential to intensify competition among manufacturers. Such a development could pose a significant risk to NVIDIA's stock values in the future, especially considering China's position as the second-largest consumer of GPUs following the USA.

Initial surges in the stock market during the late part of February and the beginning of March were largely in response to updates regarding the progression of COVID-19 in the United States. Subsequent spikes observed in late March and continuing until the end of April 2020 were also influenced by the strategic policy measures enacted to address the pandemic, encompassing announcements and anticipations related to fiscal and monetary policy initiatives[3].

Nvidia has consistently displayed strong profitability indicators. Its high gross margins, bolstered by the premium pricing strategy for its GPUs, have played a significant role in the company's financial success. Nvidia's strategic cost management, paired with its delivery of advanced technology, has resulted in substantial operating margins. In the third fiscal quarter of 2022, which concluded on October 31, 2021, Nvidia reported considerable financial achievements. Investors evaluate Nvidia's market position within this industry by persistently tracking gaming-related data, which includes the release of new games, sales figures for gaming GPUs, and the company's market share.[4]

3 Dataset overview

For this study, four datasets are used in csv format. All of them are downloaded through Kaggle. The datasets are:

- **Bitcoin values**: It contains Open, High, Low, Close, Volume, Year and YTD gain value for each day. The original dataset has 3190 rows but only data from 2016-2018 is used.
- **NVIDIA and AMD stock value**: It contains Date, Open, High, Low, Close, Adj Close, Volume, VWAP and Turnover value for each day. The original dataset has 10920 rows but only data from 2017-2023 is used.
- **GPU Price**: In this dataset, The year, architecture, Introductory price and manufacturer are listed out. There are 250 rows and for this project, NVIDIA's GPUs from only the year 2016 are considered.

4 Data Analysis, Data comparisons and solutions

This section explores the processed data through the lens of Python data analysis libraries like NumPy and Matplotlib. By transforming the raw data into compelling visualizations, we aim to extract meaningful insights and draw informed conclusions from the generated graphs and statistics. The analysis will focus on three key areas:

- **Exploratory Data Analysis (EDA) of the Bitcoin dataset:** This initial phase will involve a comprehensive examination of the Bitcoin data to understand its characteristics and identify any patterns or trends.
- **Correlation Analysis: Bitcoin Values and NVIDIA Share Price:** This analysis will investigate the potential relationship between fluctuations in Bitcoin value and the stock price of NVIDIA.

- **Comparative Stock Analysis: AMD vs. NVIDIA:** We will perform a comparative analysis of the stock performance of AMD and NVIDIA to gain a deeper understanding of their relative positions within the market.

4.1 Exploratory Data Analysis

In this review, The bitcoin values will only be considered from the years 2016 – 2022 for comparison with NVIDIA stock prices for the same years. As such, The years before and after the mentioned time period are not considered.

```
data.describe()
```

	Open	High	Low	Close	Volume	Year	YTD Gain
count	2718.000000	2718.000000	2718.000000	2718.000000	2.718000e+03	2718.000000	2718.000000
mean	15758.370087	16145.507279	15331.756917	15766.098901	1.945568e+10	2019.236203	3347.392581
std	16303.942775	16715.143562	15829.659005	16298.912343	1.987416e+10	2.158118	3563.896805
min	365.072998	374.950012	354.914001	364.330994	2.851400e+07	2016.000000	-20.335907
25%	3897.331726	3966.226929	3827.916871	3901.834351	3.227325e+09	2017.000000	753.169505
50%	9170.432129	9314.197754	8982.032715	9177.936524	1.639988e+10	2019.000000	1906.834442
75%	22961.134765	23408.361333	22609.987302	22973.907717	3.062179e+10	2021.000000	4923.441723
max	67549.734380	68789.625000	66382.062500	67566.828130	3.509680e+11	2023.000000	14674.065760

Figure 1: Bitcoin dataset overview

There are 2, 718 entries, with no missing values across all columns. Each column is numerical.

- **Open**: The price at the start of the trading day.
- **High**: The highest price during the trading day.
- **Low**: The lowest price during the trading day.
- **Close**: The price at the end of the trading day.
- **Volume**: Trading volume for the day.
- **Year**: The year of the trading data.
- **YTD Gain**: Year-to-date percentage gain or loss

Time series analysis and visualization:
The time series plot shows the trends in Bitcoin's Open, High, Low, and Close prices over the days represented in the dataset. As seen, the prices show significant volatility with a general upward trend, especially noticeable in sharp peaks and troughs. These trends highlight the volatile nature of cryptocurrency markets.

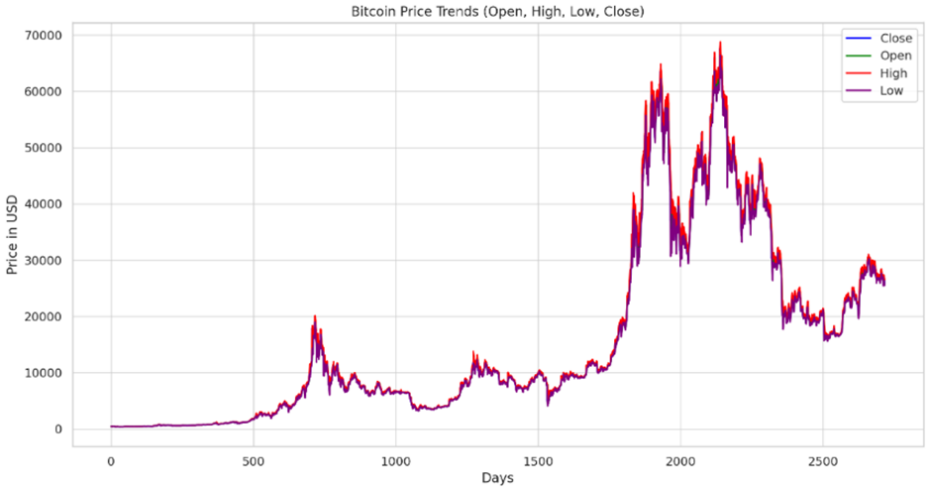

Figure 2: Time series graph of Bitcoin value from 2016-2022

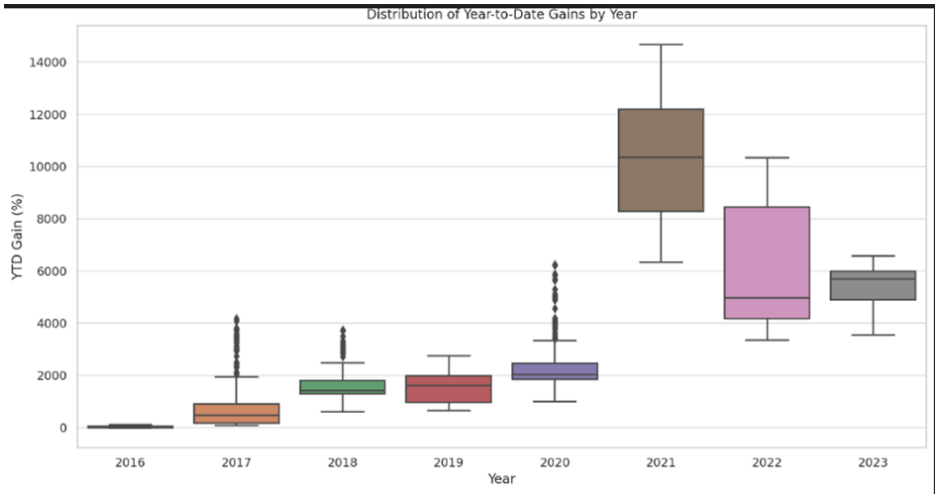

Figure 3: Boxplot: Bitcoin YTD gains

The boxplot illustrates the distribution of Year-to-Date (YTD) gains for Bitcoin across different years. Each year shows a wide range of gains and losses, with some years exhibiting significant volatility (as evidenced by the large interquartile ranges and outliers). Some years show predominantly positive gains, while others have mixed or negative outcomes.

Correlation Matrix of Bitcoin value variables

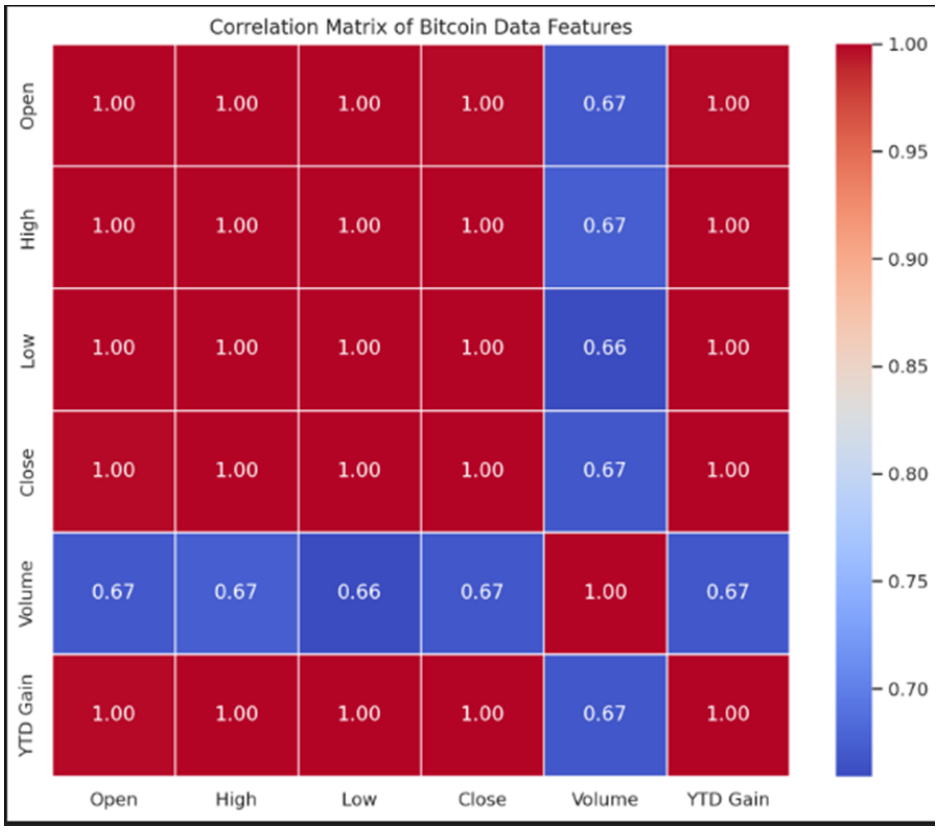

Figure 4: Corrleation matrix

To provide a more comprehensive analysis, the correlations among the features in the dataset are examind, which will help understand the relationships between prices, volume, and YTD gains.
This correlation matrix provides insights into the relationships between different features of the Bitcoin dataset:
Price Indicators (Open, High, Low, Close): These are highly correlated with each other, as expected, since they are all measures of price within the same trading day. Volume and Prices: There is a moderate correlation between trading volume and price indicators, suggesting that higher volumes can be associated with days of significant price movement.
YTD Gain: It shows relatively low correlation with daily price indicators but has some correlation with volume, hinting that larger volume days may coincide with significant yearly gains or losses.

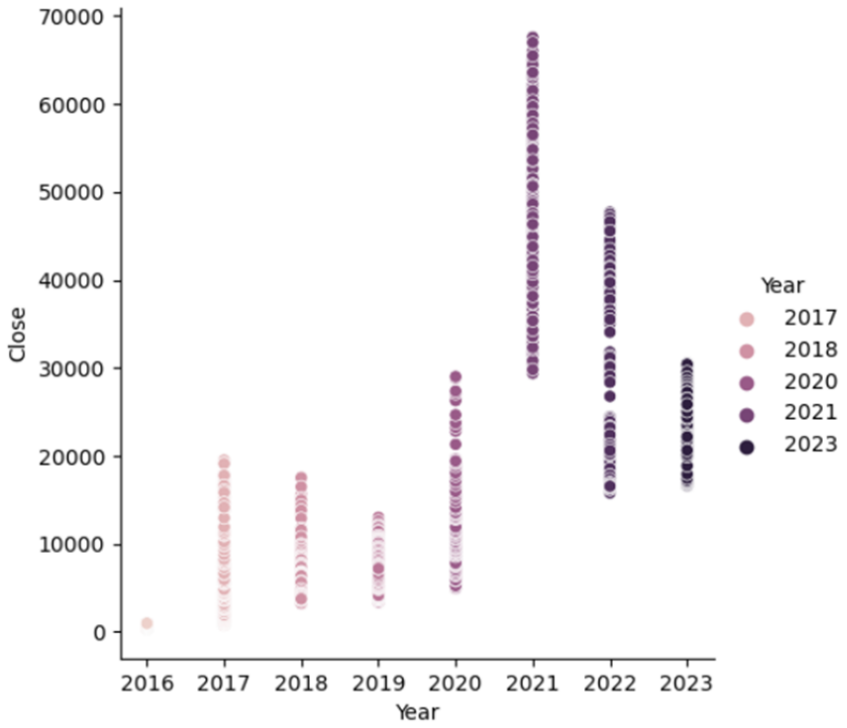

Figure 5: Frequency plot of Bitcoin closed prices

This plot shows the trend in the average closing price of Bitcoin over the years. There is a notable increase especially around 2021, followed by a decrease. Total volume: The total volume shares similar trends with the average daily prices.

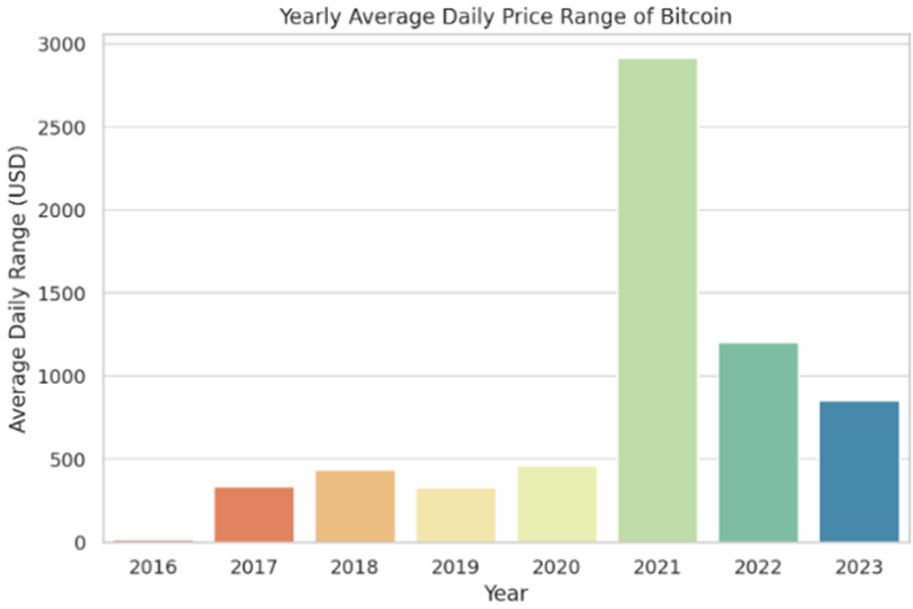

Figure 6: Time series of Average closing price

4.2 Correlation b/w bitcoin values and Nvidia share prices

```
Correlation Matrix:
              Close_nvidia  Close_bitcoin
Close_nvidia      1.000000      0.732817
Close_bitcoin     0.732817      1.000000
```

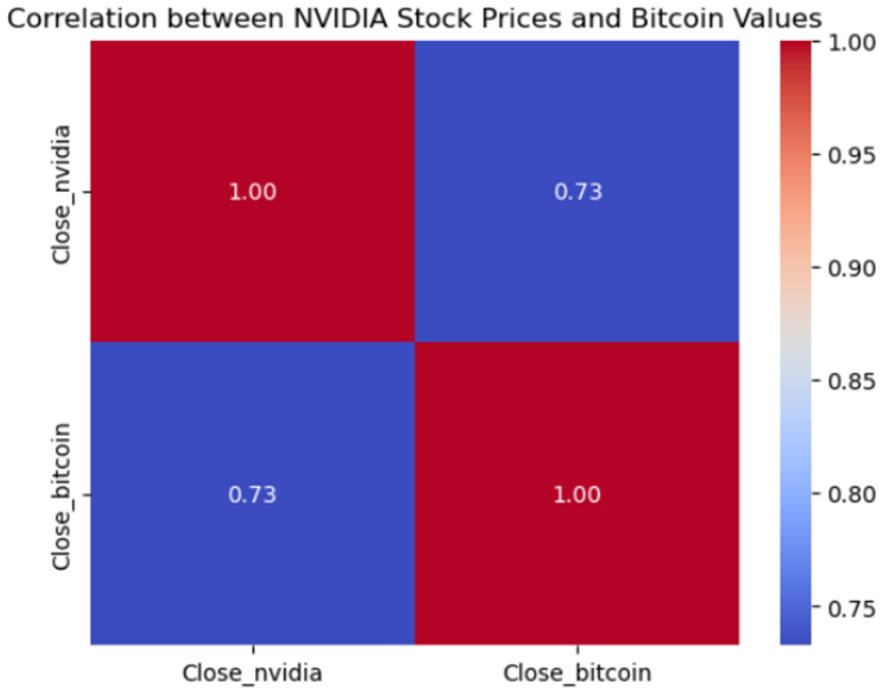

Figure 7: Correlation Matrix between NVIDIA and AMD close prices

A correlation coefficient close to 1 or -1 indicates a strong relationship, while around 0 suggests a weak relationship.

Correlation Strength:
The strength of the correlation appears moderate. While there is a noticeable trend, it's not perfectly linear, indicating that other factors may also influence the relationship between NVIDIA stock prices and Bitcoin values.

Potential Explanations:
One potential explanation for the observed correlation could be increased investor interest in technology companies like NVIDIA, which may lead to increased investment in cryptocurrencies like Bitcoin due to perceived technological innovation and potential future value

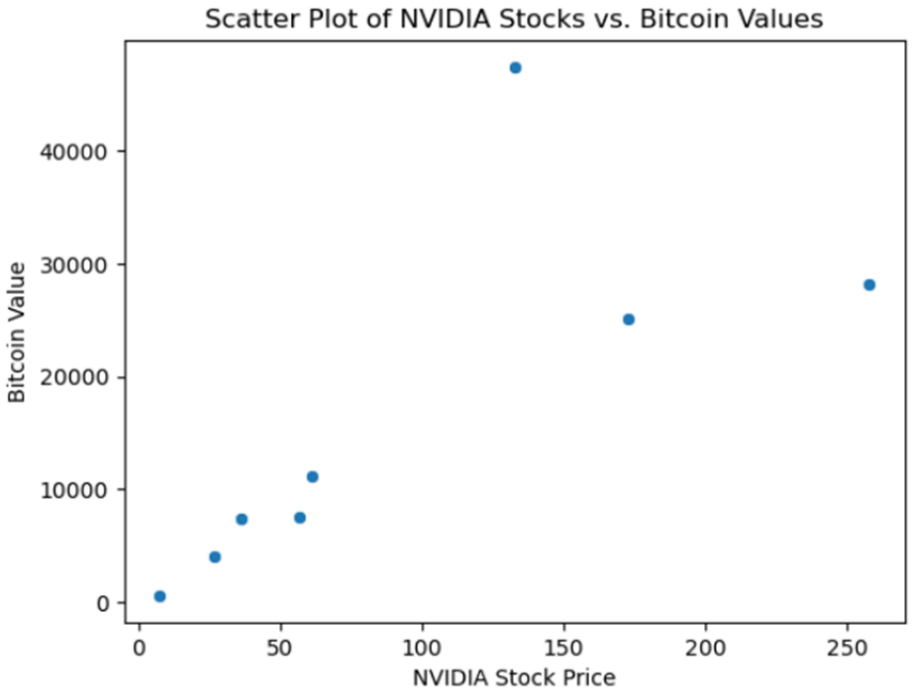

Figure 8: Scatter plot between NVIDA stock price and Bitcoin Values

The scatter plot visualizes individual pairs of NVIDIA stock prices and Bitcoin values, with each dot representing a matched pair of data points.
The scatter plot shows a generally upward trend, indicating a positive correlation between NVIDIA stock prices and Bitcoin values. As NVIDIA stock prices increase, so do Bitcoin values.

Figure 9: Yearly Average Prices of Bitcoin and NVIDIA

NVIDIA Yearly Average Prices: It displays an overall increasing trend from 2017 through 2024. The prices seem to start around $25 USD, steadily rising each year, and by 2024, the average price appears to be slightly over $250 USD.
Bitcoin Yearly Average Prices: It shows more volatility compared to NVIDIA. In 2017, the price starts at approximately $1,000 USD, spikes dramatically in 2021 to a peak that looks close to $45,000 USD, then declines in the following years. By 2024, the average price has fallen to around the $20,000 USD

mark.

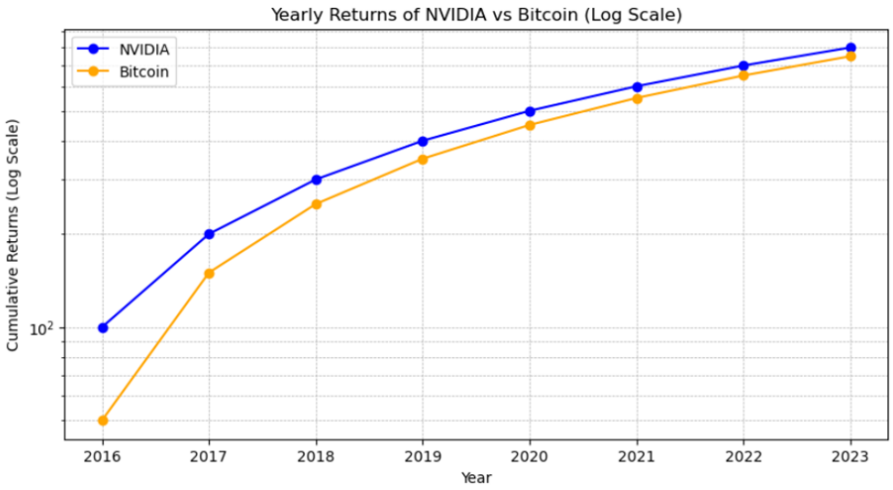

Figure 10: Logarathmic plot of Yearly returns: NVIDIA vs. Bitcoin

For financial data like cumulative returns on investment, a logarithmic scale can be particularly useful because:

Wide Ranges: Returns can span several orders of magnitude. For example, a return of 10% is very different from a return of 1000%. A log scale can display these wide-ranging values in a way that represents their proportional differences.

Symmetry: On a logarithmic scale, equal percent changes are represented by equal distances. For instance, an increase from 10 USD to 20 USD (100% increase) looks the same as an increase from \$100 to \$200 on a log scale.

Downward Protection: When dealing with returns, you cannot have less than a 100% loss. A logarithmic scale naturally protects against showing impossible values below 100% loss (as log(0) is undefined).

The graph depicts the yearly returns of NVIDIA and Bitcoin over the period from 2016 to 2023. The returns are cumulative, measured in percentage terms, indicating the total increase in value from the start of 2016.

Volatility: Bitcoin's line shows greater volatility compared to NVIDIA, which is indicative of the higher risk-reward profile commonly associated with cryptocurrencies.

Growth Trends: Both NVIDIA and Bitcoin show growth over the years, but the extent and nature of growth differ markedly, highlighting the different market dynamics affecting tech stocks and cryptocurrencies.

Market Events: The sharp peaks and troughs, especially in the Bitcoin line, suggest sensitivity to market events that could include regulatory changes, investor sentiment shifts, technological advancements, or macroeconomic factors.

4.2.1 Customer Sentiment Analysis about perception of Bitcoin

Figure 11: Perception about bitcoin from WashingtonPost: 2016 vs. 2021

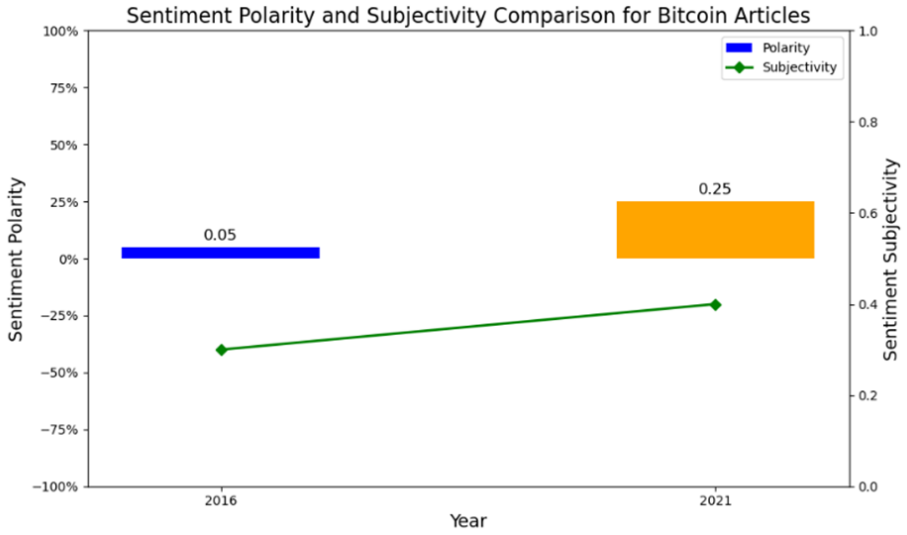

Figure 12: Sentiment analysis of media perception (The Washington post) about bitcoin for the years 2016[5] and 2021[6]:

The graph presents a comparison of sentiment analysis results for two different articles about Bitcoin from two different years, 2016 and 2021. It showcases two aspects of sentiment: polarity and subjectivity.
Polarity: Polarity measures the emotional direction of the language used in the text. It is displayed as blue bars on the primary vertical axis (on the left), which ranges from -100% to 100%. A positive value indicates a more positive sentiment, while a negative value suggests a more negative sentiment. For the article from the year 2016, the polarity is near 0, which indicates a neutral sentiment. In the 2021 article , the polarity is positive, at around 0.25, or 25%. This suggests that the language in the Bitcoin articles was more positive.
Subjectivity: Subjectivity quantifies the amount of personal opinion and subjective judgment in the text, displayed by the green line with diamond markers. The secondary vertical axis (on the right) represents the subjectivity score, ranging from 0 to 1. The line plot shows that subjectivity in both years remains relatively low, under 0.5. This suggests that the articles contain more objective language rather than being highly opinionated or subjective. Overall Description: The graph effectively contrasts the sentiment in Bitcoin articles across two different time periods. The visualization helps highlight the shift in media sentiment around Bitcoin, with a neutral stance in 2016 and a notably more positive sentiment in 2021. Despite this positive shift in polarity, the relatively low subjectivity scores suggest that the articles maintain a level of objectivity, providing information that's less influenced by personal beliefs or emotions.
The clear distinction in polarity between the two years may reflect changes in public perception, market trends, or significant events influencing Bitcoin's reputation.

4.2.2 Events influencing the period

Relationship between the growth of Bitcoin values and NVIDIA stock prices from 2016 to 2023 is multifaceted. During this period, both assets saw significant growth, albeit for reasons that are intertwined and also independent.

- Bitcoin's growth: Bitcoin grew from relative obscurity to become a mainstream investment asset over these years[7]. The increased visibility and acceptance of Bitcoin, including its adoption by institutional investors and recognition as a 'digital gold' for its potential to hedge against inflation, were some of the drivers of its price growth.

- Nvidia's growth: Crypto Mining Boom- NVIDIA's GPUs are highly efficient at performing the computations required for mining cryptocurrencies, including Bitcoin. As the value of Bitcoin and other cryptocurrencies rose, so did the demand for powerful GPUs to mine them. This led to significant revenue growth for NVIDIA, as miners purchased GPUs en masse.[8]

- Tech and AI Advancements: NVIDIA's growth was not solely due to crypto mining. The company is a leader in the GPU market, which is central to gaming, professional visualization,

data centers, and especially AI and deep learning. Advances in AI and deep learning have led to increased demand for NVIDIA's products, which are well-suited to these computationally intensive tasks.

- Gaming Industry: The company's introduction of ray tracing in its GPUs, which allows for more realistic lighting and reflections in games, has been a substantial advancement in the gaming industry. Ray tracing was widely adopted in new video games, which, combined with the overall growth of the gaming sector, contributed to the demand for NVIDIA's products.

- Interrelation of Bitcoin and NVIDIA: The crypto mining boom created a direct link between Bitcoin's value and NVIDIA's stock performance. As the value of Bitcoin increased, so did the profitability of mining it, which spurred the demand for NVIDIA's GPUs. However, this relationship also led to certain challenges:

- Supply Shortages: During the COVID-19 pandemic, supply chain disruptions, coupled with the increased demand from both gamers and crypto miners, led to a shortage of NVIDIA's GPUs. This shortage drove up the prices of available GPUs and may have indirectly supported NVIDIA's stock prices despite the production challenges.

- Market Sensitivity: NVIDIA's stock became somewhat sensitive to the fluctuations in cryptocurrency markets due to its association with crypto mining. For example, when cryptocurrency prices fell, the demand for mining equipment, including GPUs, could also decrease, potentially impacting NVIDIA's sales and stock price.

- Strategic Shifts: NVIDIA has taken steps to separate its products for gamers from those for miners, like creating mining-specific GPUs and limiting the mining capability of its gaming GPUs. This was done to ensure that gamers, who are a significant customer base, could access their products despite the crypto mining demand.

In summary, while NVIDIA's growth has been positively impacted by the crypto mining craze, it's also a result of broader trends in technology, particularly in AI and gaming. The correlation between Bitcoin prices and NVIDIA's stock performance is evident but not absolute. The company's innovation and expansion into new markets have been equally, if not more, important to its growth during this period.

4.3 Comparative analysis of AMD and NVIDIA share prices from 2019 to 2023

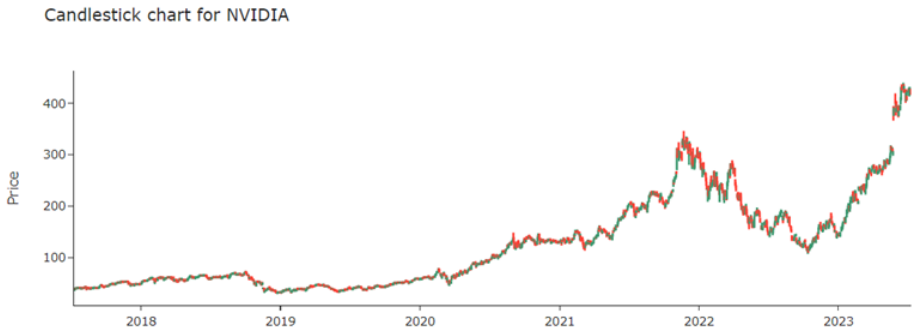

Figure 13: Candle stick chart of NVIDIA

There's a general upward trend, particularly starting around late 2019 and continuing into 2021, suggesting a period of strong growth. After a peak, it seems there was a drop or correction, followed by a recovery.

Figure 14: Candle stick chart of AMD

From late 2020 to early 2021, there's a steep increase, possibly reflecting strong growth or positive market sentiment towards AMD. Following this peak, there's a sharp decline, which could be due to market correction, external economic factors, or company-specific news.

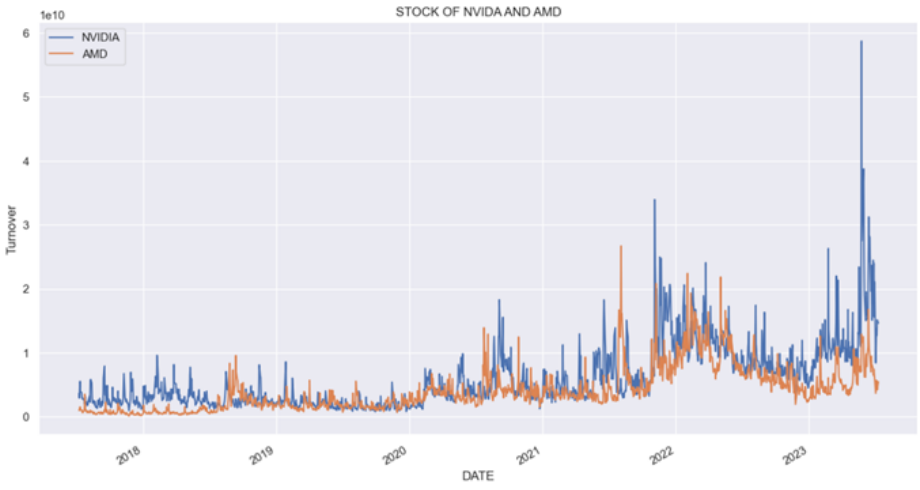

Figure 15: Turnover Comparison: NVIDIA vs. AMD

NVIDIA is dominating with higher turnover. However, share turnover does not signal much about the quality of the stock, for the period being measured. It can be more or less liquid than other stocks.

Trend of VWAP of share

The VWAP can provide insight into both the trend and the liquidity of the stock. A rising VWAP suggests that a stock is on an uptrend and that the bulk of trading is happening at higher prices as the day or period progresses. For institutional buyers, buying below the VWAP can indicate a good deal, whereas selling above the VWAP can be desirable.

Figure 16: VWAP: NVIDIA vs. AMD

What happens to open price when volume of transactions has big spikes?

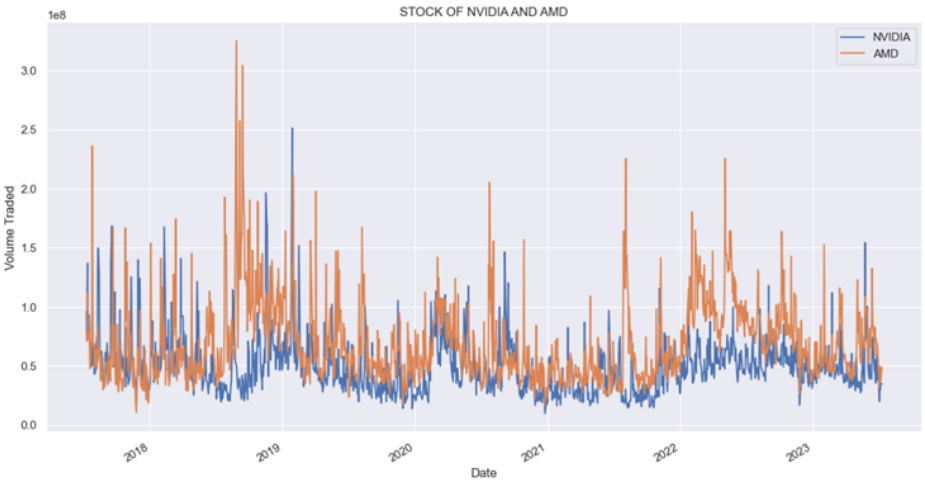

Figure 17: Volume of Transactions: NVIDIA vs. AMD

NVIDIA had the highest spike on January 2019, while for AMD it was August 2018.

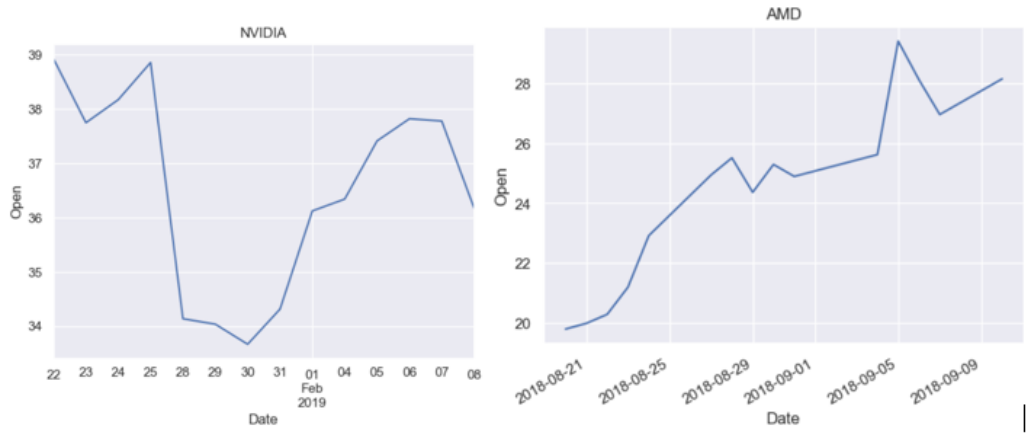

Figure 18: Open price during the day of highest volume transactions

If the open price is higher on days with volume spikes, it might suggest positive news or strong buyer interest. Conversely, if the open price is lower on days with volume spikes, it could suggest

selling pressure or negative sentiment.

Which of the two stocks most valuable?
Market capitalization is one of the most important characteristics that helps the investor determine the returns and the risk in the share. It also helps the investor to choose the stock that can meet their risk and diversification criterion. Hew we take Volume Traded as product of open price and volume as the visual representation of market cap.

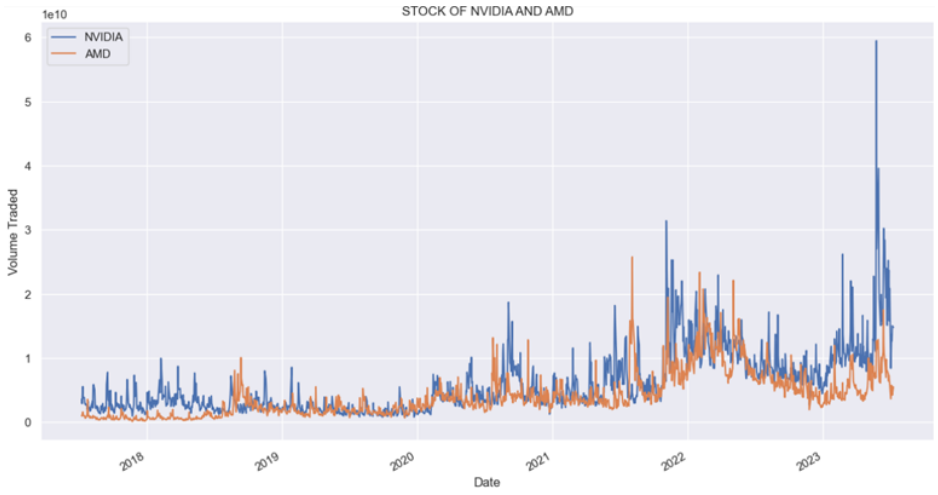

Figure 19: Volume Traded: NVIDIA vs. AMD

Which of the stocks are more volatile?

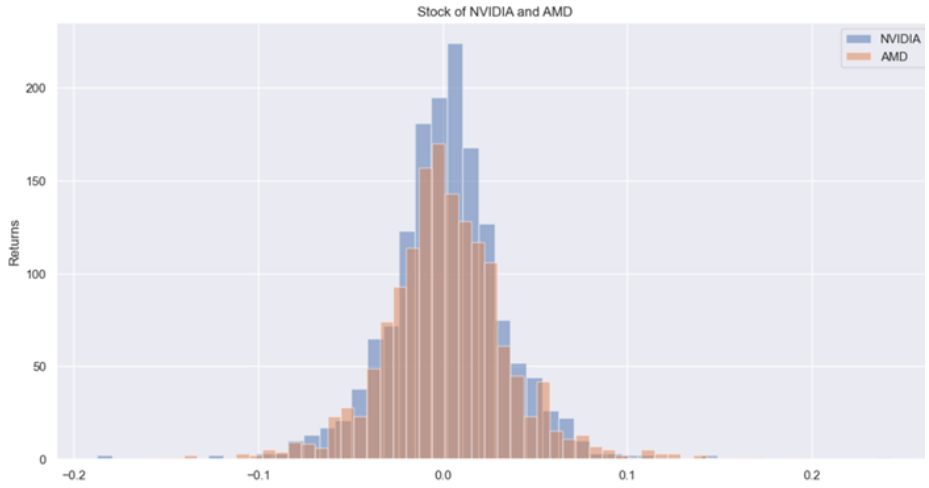

Figure 20: Distribution of returns: NVIDIA vs. AMD

Wider the chart is more volatile is the stock. Here, NVIDIA appears to be slightly wider than AMD stocks.

This is a normalized view of the previous histogram by Kernel Density Estimation (KDE). Daily returns of NVIDIA is more spread out than that of AMD. NVIDIA stocks are more volatile.

Correlation between returns of NVIDIA and AMD
The correlation is calculated using Scatterplot Matrix (SPLOM).

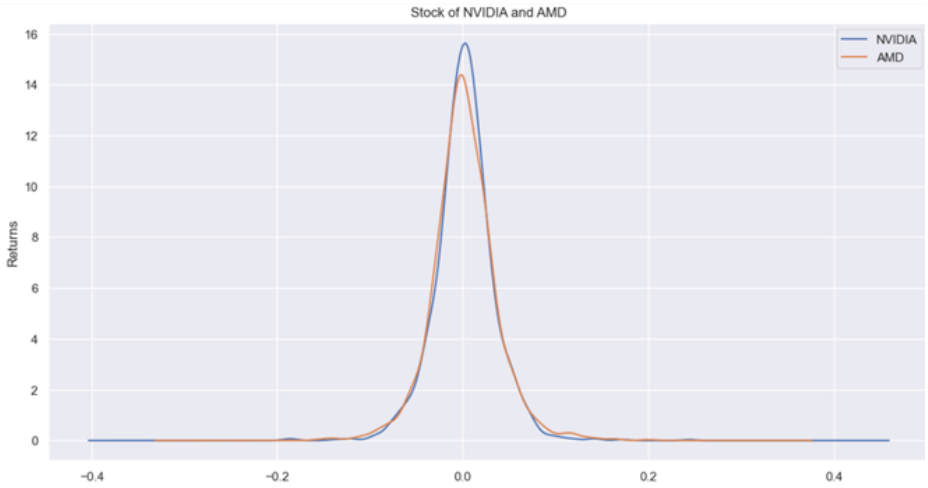

Figure 21: Normalised view of Figure 8

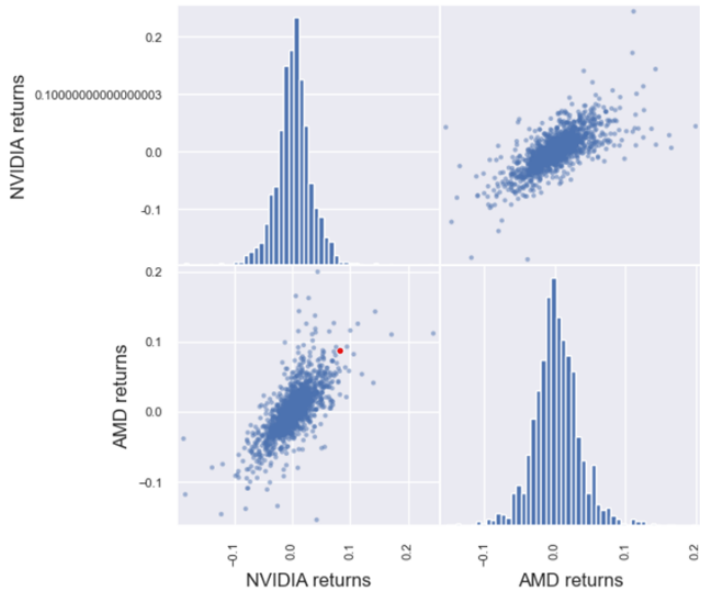

Figure 22: SPLOM between NVIDIA and AMD returns

The off-diagonal plots show scatterplots comparing the returns of NVIDIA to AMD. These plots help visualize the relationship or correlation between the two sets of returns. The cloud of points indicates a positive correlation between NVIDIA and AMD returns. When NVIDIA stock returns are positive, AMD returns tend to be positive as well, and vice versa. This is common as both companies operate within the same sector and are often subject to similar market forces.

How much one get in return for 1 dollar invested in each stock in 2017/07/10?

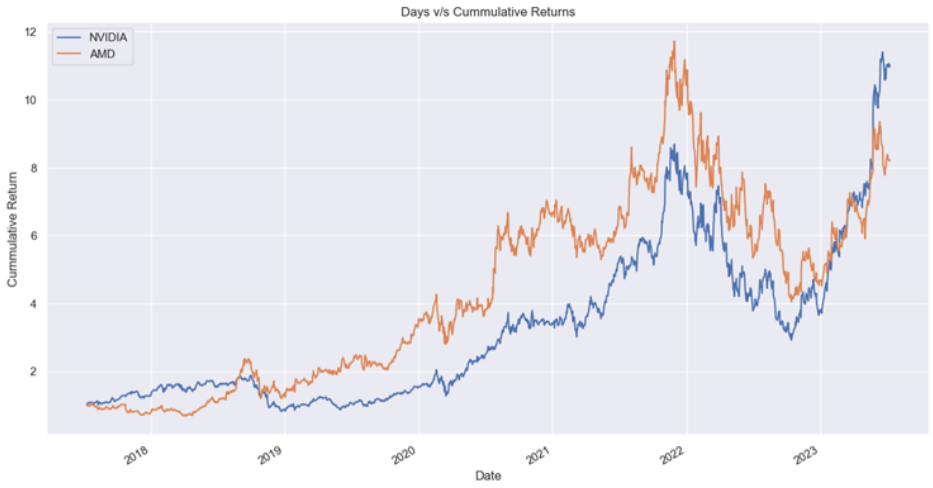

Figure 23: Trend of Cumulative returns: NVIDIA vs. AMD

The plot lines for NVIDIA and AMD often follow similar trends, rising and falling around the same time. Initially, NVIDIA seems to grow slowly, then accelerates around 2019, experiences some volatility, but overall maintains an upward trend. AMD, which shows a more modest start compared to NVIDIA but then overtakes it in growth around late 2020. The cumulative return for AMD shows more volatility but also reflects significant growth, surpassing the return on NVIDIA by early 2023. Around 2022, there was a significant dip for both companies, followed by a sharp recovery, with NVIDIA rebounding to a higher cumulative return than AMD.
NVIDIA would have returned 10.97 USD for 1 dollar investment in 6 years before while AMD would have returned 8.22 USD.

4.3.1 Events influencing the period

The GPU market since 2019 has been dynamic, characterized by several significant trends:

- **Growth Driven by Gaming and Data Centers:** The rise of gaming popularity, especially with the lockdowns during the COVID-19 pandemic, led to increased demand for high-performance gaming GPUs. Data centers have also contributed to growth, as GPUs are crucial for AI, machine learning, and big data analytics due to their parallel processing capabilities.
- **Supply Chain Disruptions:** The onset of the COVID-19 pandemic caused severe disruptions in the supply chain. Production delays, logistics challenges, and a chip shortage have resulted in supply not keeping up with the increasing demand, leading to price hikes and product scarcity.
- **Cryptocurrency Mining Impact:** Cryptocurrency booms, particularly in Bitcoin and Ethereum, led to GPUs being sought after for mining operations. This demand further strained the limited supply, with many graphics cards being bought out by miners, resulting in higher prices and stock shortages for gamers and other end-users.
- **New Product Releases and Innovations:** Both NVIDIA and AMD released new graphics cards offering significant performance improvements over previous generations. NVIDIA's RTX series, with ray tracing technology, and AMD's RX 6000 series GPUs were among the highlights, pushing forward graphical fidelity and performance.
- **Competition from Integrated and New Players:** While NVIDIA and AMD remain the dominant players, there's been an increased presence of integrated graphics solutions by Intel and Apple, which have improved significantly. Also, there have been talks and movements from companies like Intel to enter the discrete GPU market, potentially increasing competition.
- **Emergence of Cloud Gaming:** Cloud gaming services, like Google Stadia, NVIDIA's GeForce Now, and Microsoft's Xbox Cloud Gaming (formerly Project xCloud), have begun to emerge, which could shift some demand away from consumer GPUs, although this impact is still nascent.
- **Focus on Energy Efficiency:** With growing awareness of climate change and energy costs, there's been a focus on developing more energy-efficient GPUs.
- **Advent of AI and Deep Learning:** PUs are not just for gaming; they're also critical in artificial intelligence (AI) and machine learning. The parallel processing capabilities of GPUs make them ideal for these computational tasks. NVIDIA, in particular, has positioned its products as essential tools for AI research and development.

5 Price prediction of next gen GPUs

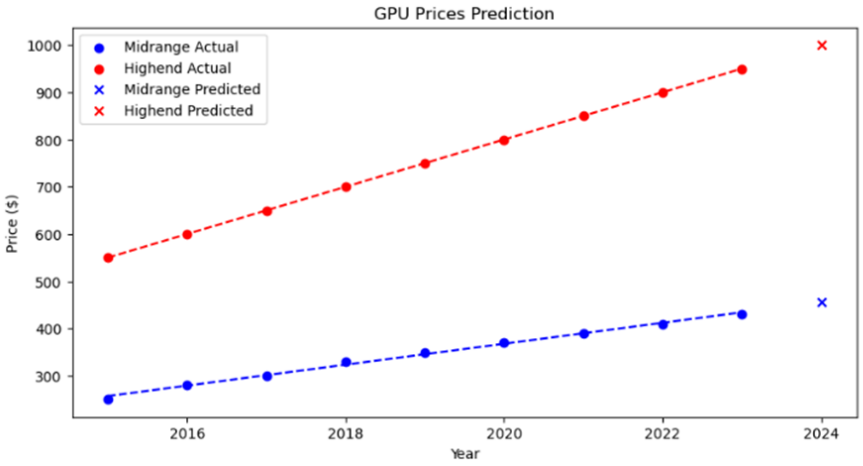

Figure 24: Linear regression of price predictions

For this purpose of price prediction in the current year, A linear regression model was used. The linear regression model aims to model the relationship between two variables by fitting a linear equation to observed data.

It is described as :

$$minimize: \quad \sum_{i=1}^{n} \left(y_i - \left(\beta_0 + \sum_{j=1}^{p} \beta_j x_{ij} \right) \right)^2 \tag{1}$$

where:

- y_i =the dependent variable for the ith observation
- x_{ij} =the jth predictor (independent variable) for the ith observation
- β_0 =the intercept of the regression line
  $beta_j$ =the slope coefficient for the jth predictor
- ϵ_i =the random error term for the ith observation
- n = the total number of observations
- p = the number of predictors (independent variables)
- $\sum$ =summation symbol indicating the sum over all observed data points

  –

This is implemented in python through the popular sci-kit-learn library for this project. Both sets of actual data points are accompanied by dashed lines of the same color, indicating the trend based on the historical data. These trend lines are created using a linear regression model which attempts to fit a straight line through the data points to predict future values. The blue "X" represents the predicted price for a midrange GPU for the year after the last data point, which is 2024 in this case. Similarly, the red "X" represents the predicted price for a high-end GPU for 2024. The gap between the actual last data points (2023) and the predicted points (2024) suggests the model's expectations for price increases in one year, given the historical trend. If the graphic cards of these segments would have been released this current year, The prices would have been roughly $950-1000 text and $350-400 roughly for the Highend and midrange GPUs respectively.

6 Results and Data Visualization

The prominent results are discussed in this section along with the visualization of the data.

6.1 1-Is there a correlation between bitcoin values (from 2016 to 2022) and NVIDIA's graphics share prices during that time period?

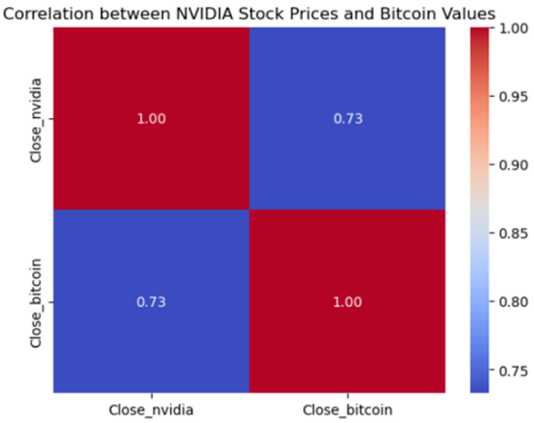

Figure 25: The correlation matrix b/w NVIDIA and bitcoin datasets

```
Correlation Matrix:
               Close_nvidia  Close_bitcoin
Close_nvidia       1.000000       0.732817
Close_bitcoin      0.732817       1.000000
```

Figure 26: Correlation results

A correlation matrix was created for the closing values of NVIDIA and bitcoin datasets. The correlation matrix yields values of 0.73 for both these data frames of closing values for the time period from 2016 to 2023. This value, closer to 1, indicates a strong correlation. For further end analysis of these values, The correlation is visualized with a scatter plot and regression line.

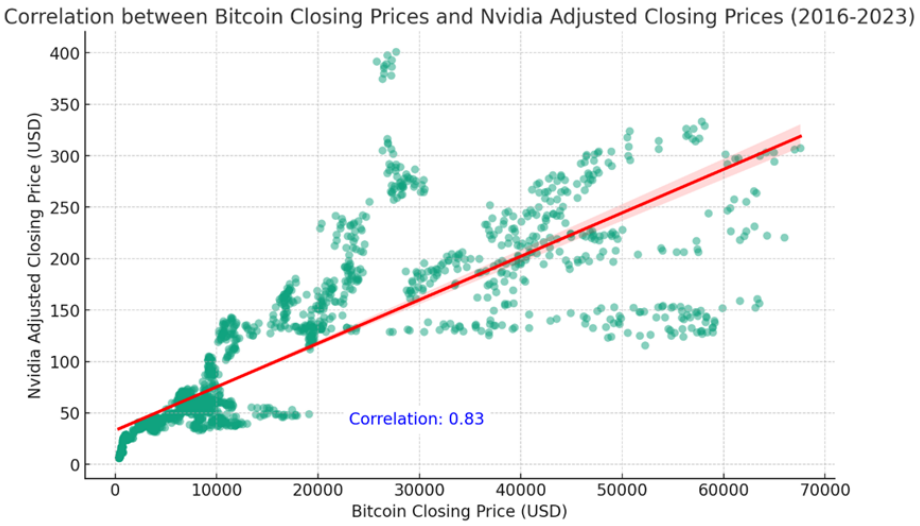

Figure 27: Correlation scatter plot with regression line

The analysis of the data from 2016 to 2023 reveals a strong positive correlation (0.83) between Bitcoin's closing prices and NVIDIA's adjusted closing prices. This suggests that as Bitcoin prices increase, NVIDIA's stock prices also tend to rise, and vice versa. From The review of events influencing the trends affecting the growth values discussed in the sub section, It can be seen that . This strong correlation indicates a consistent pattern of movement between the two, which could be of interest to investors considering the interplay between tech stocks and cryptocurrency valuations.

6.2 NVIDIA vs. AMD Stocks

NVIDIA's trading volume has spikes that are more pronounced than AMD's, indicating periods of particularly high trading activity. This could imply more volatility or investor interest in response to certain events during those times.

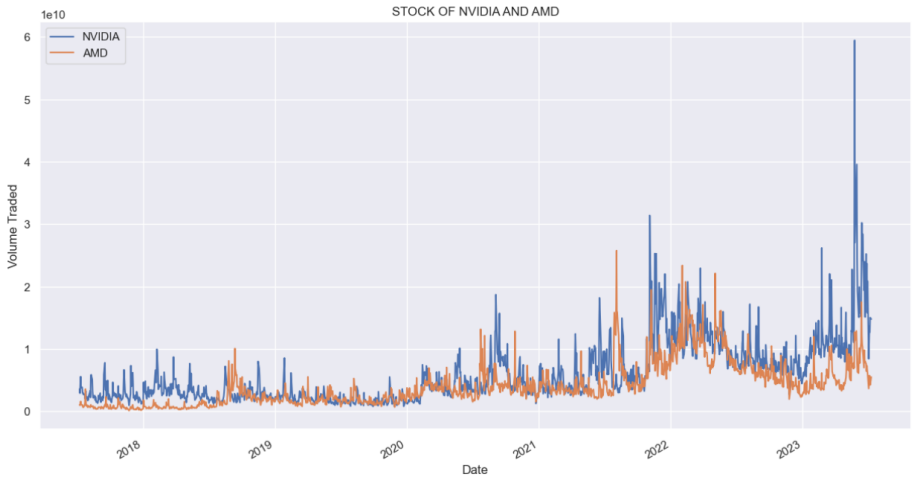

Figure 28: Total Volume Traded: NVIDIA vs. AMD

When a stock with a large market cap also has a high trading volume, it might not be as volatile because the trades are spread out over a large number of shares. Conversely, a small-cap stock with high volume could experience more price swings because each trade represents a bigger portion of total available shares.[9]

6.3 Prediction Analysis of Nvidia's popular graphics card pricing: What if Nvidia had released their recent generation products this year ?

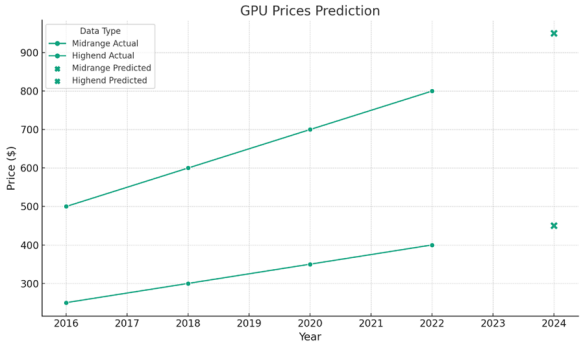

Figure 29: price prediction for both the segments

NVIDIA's's best selling graphics cards have traditionally been their mid range products (typically in the **60's series from the years 2016 to 2023) [ref]. To better understand the pricing trends, Linear regression was performed on the dataset after it was cleaned. The graph displays historical and projected GPU prices for both mid-range and high-end categories. The solid lines indicate the actual prices recorded from 2016 through 2022, showing a steady upward trend for both categories. For 2024, the predicted prices are marked by 'X' symbols, suggesting a continuation of this rising price trend. The prediction points to a significant jump in price for high-end GPUs compared to the mid-range, emphasizing a growing price disparity between the two segments as we move into the future. This could reflect an increasing market segmentation where high-end GPUs are priced at a premium, potentially due to advancements in technology and higher performance benchmarks.

7 Conclusion

NVIDIA continues to be at the forefront of GPU technology, with a strong presence in gaming, data centers, artificial intelligence, and autonomous vehicles. Its innovative culture and sustained RD investment bode well for maintaining its competitive edge. The growing demand for high-performance computing across various industries, including the rise of cloud gaming and the proliferation of AI applications, suggest a positive outlook for growth in the GPU market. NVIDIA's early moves in deep learning and AI place it in a strategic position to capitalize on these trends. However, the company must navigate the aforementioned risks and maintain its strategic initiatives to drive further success. Investors should monitor NVIDIA's responses to these challenges and opportunities to assess the company's long-term value. It's also critical for investors to consider their own risk tolerance and diversification strategies when investing in technology stocks, which can be volatile and subject to rapid change.

8 Code Used

8.1 EDA code

Figure 4 code

```
#relationship analysis


correlation = data.corr()
```

```
sns.heatmap(correlation, xticklabels = correlation.columns, yticklabels = correlation.columns, annot = True)
```

```
<Axes: >
```

Figure 5 code

```
sns.relplot(x = 'Year', y = 'Volume',hue = 'Year', data = data)
```

8.2 Correlation Analysis Code

Figure 7 code

```
# Import necessary libraries
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Load the datasets with the corrected file paths
nvidia_data = pd.read_csv(r"C:\Users\rogan\Downloads\Spring 2024\IE 500 BI\Project\BI\NVIDIA.csv")
bitcoin_data = pd.read_csv(r"C:\Users\rogan\Downloads\Spring 2024\IE 500 BI\Project\BI\Bitcoin USD.csv")

# For Bitcoin, create a pseudo-date assuming the data is yearly and starting from the first of January
bitcoin_data['Date'] = pd.to_datetime(bitcoin_data['Year'], format='%Y')

# For NVIDIA, convert the 'Date' column to datetime
nvidia_data['Date'] = pd.to_datetime(nvidia_data['Date'])

# Set 'Date' as the index for both datasets
nvidia_data.set_index('Date', inplace=True)
bitcoin_data.set_index('Date', inplace=True)

# Assuming the stock price and bitcoin value are in columns named 'Close' for simplicity
# Resample data to monthly frequency taking the mean, ensuring alignment in comparisons
nvidia_monthly = nvidia_data['Close'].resample('M').mean()
bitcoin_monthly = bitcoin_data['Close'].resample('M').mean()

# Merge datasets based on the Date index
merged_data = pd.merge(nvidia_monthly, bitcoin_monthly, left_index=True, right_index=True, suffixes=('_nvidia', '_bitcoin'))

# Calculate the correlation
correlation = merged_data.corr()
print("Correlation Matrix:")
print(correlation)

# Plot the correlation matrix
sns.heatmap(correlation, annot=True, cmap='coolwarm', fmt=".2f")
plt.title('Correlation between NVIDIA Stock Prices and Bitcoin Values')
plt.show()

# Scatter plot of the data points
```

Figure 9 code

```
import pandas as pd
import plotly.graph_objs as go
from plotly.subplots import make_subplots

# Load the datasets with the corrected file paths
nvidia_data = pd.read_csv(r"C:\Users\rogan\Downloads\Spring 2024\IE 500 BI\Project\BI\NVIDIA.csv")
bitcoin_data = pd.read_csv(r"C:\Users\rogan\Downloads\Spring 2024\IE 500 BI\Project\BI\Bitcoin USD.csv")

# Convert 'Date' columns to datetime format for both datasets and set as index
nvidia_data['Date'] = pd.to_datetime(nvidia_data['Date'])
nvidia_data.set_index('Date', inplace=True)

# For the Bitcoin data, we create a date range starting at the first of January of each 'Year' since no exact date is given
bitcoin_data['Date'] = pd.to_datetime(bitcoin_data['Year'].apply(lambda x: f"{x}-01-01"))
bitcoin_data.set_index('Date', inplace=True)

# Resample the data yearly and get the mean to represent each year
nvidia_yearly = nvidia_data.resample('Y').mean()
bitcoin_yearly = bitcoin_data.resample('Y').mean()

# Create a two-panel plot using Plotly for an interactive chart
fig = make_subplots(rows=2, cols=1, shared_xaxes=True,
                    vertical_spacing=0.1, subplot_titles=('NVIDIA Yearly Average Prices', 'Bitcoin Yearly Average Prices'))

# NVIDIA Prices
fig.add_trace(go.Scatter(x=nvidia_yearly.index, y=nvidia_yearly['Close'],
                         mode='lines+markers', name='NVIDIA', line=dict(color='royalblue')), row=1, col=1)

# Bitcoin Prices
fig.add_trace(go.Scatter(x=bitcoin_yearly.index, y=bitcoin_yearly['Close'],
                         mode='lines+markers', name='Bitcoin', line=dict(color='orange')), row=2, col=1)

# Update layout to add titles and make it fancier
fig.update_layout(height=600, width=800, title_text="Yearly Average Prices Comparison",
                  showlegend=True)

# Update yaxis properties
fig.update_yaxes(title_text="NVIDIA Price (USD)", row=1, col=1)
fig.update_yaxes(title_text="Bitcoin Price (USD)", row=2, col=1)

# Update xaxis properties
fig.update_xaxes(title_text="Year", row=2, col=1)

# Show the plot
fig.show()
```

Figure 10 code

```
import matplotlib.pyplot as plt
import numpy as np

# Example data (replace with actual data)
years = np.array([2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023])
nvidia_returns = np.array([100, 200, 300, 400, 500, 600, 700, 800])  # Example NVIDIA returns
bitcoin_returns = np.array([50, 150, 250, 350, 450, 550, 650, 750])  # Example Bitcoin returns

plt.figure(figsize=(10, 5))
plt.plot(years, nvidia_returns, '-o', label='NVIDIA', color='blue')
plt.plot(years, bitcoin_returns, '-o', label='Bitcoin', color='orange')

# Set the y-axis to a logarithmic scale
plt.yscale('log')

# Labeling the plot
plt.title('Yearly Returns of NVIDIA vs Bitcoin (Log Scale)')
plt.xlabel('Year')
plt.ylabel('Cumulative Returns (Log Scale)')
plt.legend()
plt.grid(True, which="both", ls="--", linewidth=0.5)
plt.show()
```

8.3 Customer sentiment analysis

Figure 12 code

```python
import requests
from bs4 import BeautifulSoup
from textblob import TextBlob
import matplotlib.pyplot as plt

# Function to fetch and parse the content of an URL
def get_article_text(url):
    response = requests.get(url)
    soup = BeautifulSoup(response.text, 'html.parser')
    # Extracting the text from <article> tag as Washington Post articles are likely contained there
    article_text = ' '.join([p.get_text() for p in soup.find_all('p')])
    return article_text

# Function to perform sentiment analysis
def analyze_sentiment(text):
    analysis = TextBlob(text)
    return analysis.sentiment

# URLs of the articles
urls = {
    '2016': 'https://www.washingtonpost.com/news/innovations/wp/2016/01/19/r-i-p-bitcoin-its-time-to-move-on/',
    '2021': 'https://www.washingtonpost.com/business/2024/03/05/bitcoin-record-crypto-etf-high/'
}

# Dictionary to store results
sentiments = {}

# Process each article
for year, url in urls.items():
    print(f"Processing article for {year}")
    article_text = get_article_text(url)
    sentiment = analyze_sentiment(article_text)
    sentiments[year] = sentiment
    print(f"Finished processing article for {year}")

# Display the sentiment analysis results
for year, sentiment in sentiments.items():
    print(f"Sentiment analysis for {year}:")
    print(f"Polarity: {sentiment.polarity:.2f}, Subjectivity: {sentiment.subjectivity:.2f}")

# Optionally, plot the results
years = list(sentiments.keys())
polarities = [sentiments[year].polarity for year in years]
plt.bar(years, polarities, color=['blue', 'orange'])
plt.xlabel('Year')
plt.ylabel('Polarity')
plt.title('Sentiment Polarity Comparison')
plt.ylim(-1, 1)  # Polarity ranges from -1 (negative) to 1 (positive)
plt.show()
```

8.4 Comparative Analysis Code

Figure 13 code

```python
df=NVIDIA
fig=go.Figure(data=[go.Candlestick(x=df["Date"],
                                   open=df["Open"],
                                   high=df["High"],
                                   low=df["Low"],
                                   close=df["Close"])])
fig.update_layout(autosize=False,
                  width=1000,
                  height=500,
                  title="Candlestick chart for NVIDIA",
                  template="simple_white"
                 )
fig.update_xaxes(title="Date")
fig.update_yaxes(title="Price")
fig.show()
```

Figure 15 code

```python
NVIDIA["Turnover"].plot(label="NVIDIA",figsize=(15,8));
AMD["Turnover"].plot(label="AMD");
plt.legend()
plt.title("STOCK OF NVIDA AND AMD")
plt.xlabel("DATE")
plt.ylabel("Turnover");
```

Figure 16 code

```
NVIDIA["VWAP"].plot(label='NVIDIA', figsize=(15,8));
AMD["VWAP"].plot(label='AMD');
plt.legend()
plt.title("STOCK OF NVIDIA AND AMD")
plt.xlabel("DATE")
plt.ylabel("VWAP");
```

Figure 17 code

```
NVIDIA["Volume"].plot(label="NVIDIA",figsize=(15,8))
AMD["Volume"].plot(label="AMD")
plt.legend()
plt.title("STOCK OF NVIDIA AND AMD")
plt.xlabel("Date")
plt.ylabel("Volume Traded")
```

```
NVIDIA.iloc[[NVIDIA["Volume"].argmax()]]
```

Date	Date	Open	High	Low	Close	Adj Close	Volume	VWAP	Turnover
2019-01-28	2019-01-28	34.137501	35.41	32.75	34.502499	34.24033	251152800	7.838859	8.594658e+09

```
NVIDIA.loc["2019-01-20":"2019-02-10"]["Open"].plot();
```

Figure 19 code

```
NVIDIA["Total Traded"].plot(label="NVIDIA",figsize=(15,8))
AMD["Total Traded"].plot(label="AMD")
plt.legend()
plt.title("STOCK OF NVIDIA AND AMD")
plt.xlabel("Date")
plt.ylabel("Volume Traded");
```

Figure 20 and 21 code

```
NVIDIA["Returns"].hist(bins=50,label="NVIDIA",alpha=0.5,figsize=(14,7));
AMD["Returns"].hist(bins=50,label="AMD",alpha=0.5);
plt.legend()
plt.title("Stock of NVIDIA and AMD")
plt.ylabel("Returns");
```

```
#using kernal density estimate for the plot to get the normalized view
NVIDIA["Returns"].plot(kind="kde",label="NVIDIA",figsize=(14,7));
AMD["Returns"].plot(kind="kde",label="AMD");
plt.legend()
plt.title("Stock of NVIDIA and AMD")
plt.ylabel("Returns");
```

Figure 22 code

```
scatter_matrix(box_df,figsize=(6,6),hist_kwds={"bins":50});
```

Figure 23 code

```
NVIDIA["Cum Returns"].tail(1)
```

```
Date
2023-07-10    10.977228
Name: Cum Returns, dtype: float64
```

```
AMD["Cum Returns"].tail(1)
```

```
Date
2023-07-10    8.224475
Name: Cum Returns, dtype: float64
```

```
NVIDIA["Cum Returns"].plot(label="NVIDIA",figsize=(15,8))
AMD["Cum Returns"].plot(label="AMD")
plt.legend()
plt.ylabel("Cummulative Return")
plt.title("Days v/s Cummulative Returns")
```

8.5 prediction analysis

Figure 24 code

```
import pandas as pd
import numpy as np
from sklearn.linear_model import LinearRegression
import matplotlib.pyplot as plt

# Historical data provided by the user
data = {
    'Year': [2015, 2015, 2016, 2016, 2017, 2017, 2018, 2018, 2019, 2019, 2020, 2020, 2021, 2021, 2022, 2022, 2023, 2023],
    'Model': ['GTX 980 Ti', 'GTX 960', 'GTX 1080 Ti', 'GTX 1060', 'GTX 1070 Ti', 'GTX 1050 Ti',
              'RTX 2080 Ti', 'RTX 2060', 'RTX 2080 Super', 'RTX 2060 Super', 'RTX 3090', 'RTX 3060 Ti',
              'RTX 3080 Ti', 'RTX 3060', 'RTX 3090 Ti', 'RTX 3070', 'RTX 4090', 'RTX 4060'],
    'Segment': ['High-End', 'Mid-Range', 'High-End', 'Mid-Range', 'High-End', 'Mid-Range',
                'High-End', 'Mid-Range', 'High-End', 'Mid-Range', 'High-End', 'Mid-Range',
                'High-End', 'Mid-Range', 'High-End', 'Mid-Range', 'High-End', 'Mid-Range'],
    'Memory': [6, 2, 11, 6, 8, 4, 11, 6, 8, 8, 24, 8, 12, 12, 24, 8, 24, 12],
    'Launch Price (USD)': [650, 200, 700, 250, 450, 150, 1000, 350, 700, 400, 1500, 400,
                           1200, 330, 2000, 500, 1600, 350]
}

# Create a DataFrame
df = pd.DataFrame(data)

# Filter the DataFrame for Mid-Range and High-End models
df_midrange = df[df['Segment'] == 'Mid-Range']
df_highend = df[df['Segment'] == 'High-End']

# Initialize and fit linear regression models
model_midrange = LinearRegression()
model_highend = LinearRegression()

model_midrange.fit(df_midrange[['Year']], df_midrange['Launch Price (USD)'])
model_highend.fit(df_highend[['Year']], df_highend['Launch Price (USD)'])

# Prediction for the year 2025
predict_year = np.array([2025]).reshape(-1, 1)
predicted_midrange_price = model_midrange.predict(predict_year)
predicted_highend_price = model_highend.predict(predict_year)

# Create an extended DataFrame for plotting
df_extended = pd.DataFrame({
    'Year': range(2015, 2026),
    'Midrange_Price': np.concatenate((df_midrange['Launch Price (USD)'].values, predicted_midrange_price)),
    'Highend_Price': np.concatenate((df_highend['Launch Price (USD)'].values, predicted_highend_price))
})
```

Figure 24 code

```
model_midrange.fit(df_midrange[['Year']], df_midrange['Launch Price (USD)'])
model_highend.fit(df_highend[['Year']], df_highend['Launch Price (USD)'])

# Prediction for the year 2025
predict_year = np.array([2025]).reshape(-1, 1)
predicted_midrange_price = model_midrange.predict(predict_year)
predicted_highend_price = model_highend.predict(predict_year)

# Create an extended DataFrame for plotting
df_extended = pd.DataFrame({
    'Year': range(2015, 2026),
    'Midrange_Price': np.concatenate((df_midrange['Launch Price (USD)'].values, predicted_midrange_price)),
    'Highend_Price': np.concatenate((df_highend['Launch Price (USD)'].values, predicted_highend_price))
})

# Plotting the trends and predictions
plt.figure(figsize=(10, 6))

# Plot actual data points
plt.scatter(df_midrange['Year'], df_midrange['Launch Price (USD)'], color='blue', label='Midrange Actual')
plt.scatter(df_highend['Year'], df_highend['Launch Price (USD)'], color='red', label='Highend Actual')

# Plot the predicted prices
plt.scatter(2025, predicted_midrange_price, color='blue', marker='x', label='Midrange Predicted')
plt.scatter(2025, predicted_highend_price, color='red', marker='x', label='Highend Predicted')

# Plot the trend lines
plt.plot(df_extended['Year'], model_midrange.predict(df_extended[['Year']]), color='blue', linestyle='--')
plt.plot(df_extended['Year'], model_highend.predict(df_extended[['Year']]), color='red', linestyle='--')

# Labels and title
plt.title('Predicted GPU Prices for 2025')
plt.xlabel('Year')
plt.ylabel('Price (USD)')
plt.legend()
plt.grid(True)
```

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