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University of Milan Bicocca

**School of Science**

**Department of Computer Science, Systems and Communication**

**Bachelor's Degree in Computer Science**

# Business Intelligence Project for the financial services

**Analysis of:**

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**Summary of data used** ..... **4**
Titles Used ..... 4
Technology Sector ..... 4
NVIDIA ..... 4
Apple ..... 4
Automotive Sector ..... 5
Tesla ..... 5
Ford Motor Co ..... 5
Banking Sector ..... 6
JPMorgan ..... 6
Bank Of America ..... 6
Data Presentation ..... 7
**Descriptive Statistics** ..... **9**
Performance Analysis ..... 9
Compound annual return ..... 14
Analysis ..... 15
Distribution of returns through histogram and dispersion analysis ..... 16
Standard deviation of stocks ..... 17
Performance analysis using 3-section diagnostic charts (histogram and kernel density, boxplot, qq-plot) ..... 19
Comments ..... 25
Univariate Descriptive Statistics (Annualized) ..... 25
Comments ..... 26
Covariance matrices and correlation of returns ..... 27
Comments ..... 28
Time correlations and scatterplots ..... 29
NVDA - AAPL Correlation Comments ..... 30
TSLA - F correlation comments ..... 32
JPM - BAC Correlation Comments ..... 34
**Forecast Analysis** ..... **35**
Model results ..... 35
NVIDIA ..... 35
APPLE ..... 37
FORD ..... 38
TESLA ..... 39
FORD ..... 40
JP MORGAN ..... 41
BANK OF AMERICA ..... 42
Conclusions ..... 43
**Trading Strategies and Backtesting – Technical Analysis** ..... **43**
SMA Crossover Strategy - NVIDIA ..... 43
How it works ..... 43
Trading Signals ..... 44
Strategy Building ..... 44

Strategy Graphical View....45
Comparing returns with a BUY & HOLD strategy.... 46
Conclusion....46
**CAPM....47**
Asset Beta.... 47
Expected annual returns on securities....48
Exposure of securities to Fama-French risk factors.... 49
Fama-French Function.... 49
Stock Exposure Analysis.... 50
NVIDIA....50
APPLE....51
TESLA....52
FORD.... 53
BAC....54
JPM....55
**Trading strategies and backtesting – CPPI and TIPP dynamic strategies....56**
How it works....56
CPPI algorithm in 5 steps.... 57
CPPI Results.... 58
Conclusions....61

# Summary of data used

## Titles Used

The following titles have been chosen based on the sector:

### Technology Sector

# NVIDIA

Between 2015 and 2025, Nvidia experienced extraordinary growth, transforming from a leader in gaming GPUs to a cornerstone of artificial intelligence and advanced computing. In 2016, the Pascal architecture consolidated its dominance in gaming and data centers, while the cryptocurrency boom (2017-2018) boosted sales, before a crypto-related crash. Since 2019, the acquisition of Mellanox and Ampere GPUs (2020) have strengthened its presence in data centers, also capitalizing on pandemic demand for gaming and the cloud. 2021-2022 saw Nvidia at the center of the AI revolution, with GPUs essential for models like ChatGPT, despite chip tensions and the correction in tech markets. In 2023-2024, the explosion of generative AI has driven record revenues, with H100 and Blackwell GPUs becoming indispensable for global data centers. In the short term, tariff uncertainty due to US-China tensions in the semiconductor and AI sectors could cause volatility in Nvidia stock in 2025, and an escalation of restrictions could dampen earnings, especially if AI demand shows signs of slowing.

# Apple

Apple's stock has experienced ups and downs linked to innovation, crises, and strategic shifts. Between 2015 and 2017, growth was driven by record iPhone sales and the launch of products like the Apple Watch and AirPods, while in 2018-2019, a profit warning due to declining sales in China sent the stock plummeting, before a recovery thanks to buybacks and the expansion of services. In 2020, despite the initial COVID-19 crash, Apple benefited from the tech boom, surpassing a $2 trillion market cap thanks to demand for Macs and iPads and the shift to M1 chips. Between 2021 and 2022, the stock reached new highs before correcting due to supply chain issues and rising interest rates. From 2023 onwards, attention has shifted to AI, the launch of Vision Pro, and plans for the Apple Car, with the market now weighing whether Apple can maintain its innovation leadership or face geopolitical and antitrust risks. in 2025, trade tariffs, especially between the US and China, remain a critical factor,

impacting costs, supply chain and margins as well as potentially impacting the stock price.

**Automotive Sector**

# Tesla

Tesla has had a turbulent but enormously growing journey: in 2015-2016, it launched the Model 3, attracting record pre-orders, but faced liquidity crises and doubts about its future. Between 2017 and 2019, it overcame the Model 3's "production hell," avoiding bankruptcy and achieving initial profitability. 2020 was the turning point, with its entry into the S&P 500, booming sales in China, and a historic stock rally (+700%), fueled by euphoria over electric vehicles. In 2021-2022, the stock reached record highs ($1,200) before collapsing due to rate hikes, Musk's forced sales for Twitter, and growing competition. In 2023-2024, Tesla cut prices to compete (compromising margins), launched the Cybertruck with delays, and faced the rise of BYD. The 2025 tariffs are protecting Tesla from direct Chinese competition, but they are forcing it to undertake a costly reconfiguration of its supply chain. The challenge is balancing competitive prices and sustainable margins.

# Ford Motor Co.

Between 2015 and 2017, the company, under Mark Fields, faced market saturation and declining sales in China, with shares stable between $12 and $16. In 2018-2020, with the arrival of Jim Farley, Ford accelerated its electric vehicle (EV) program, but the pandemic caused the stock to plummet to $4-$5 in 2020 before recovering. 2021-2022 saw a rally (over $25) thanks to electric vehicle euphoria, followed by a decline due to the chip crisis and inflation. In 2023, the split into Ford Blue (thermal) and Ford Model E (electric) attempted to attract investors, but high interest rates held the stock back below $12-$13. The outlook for 2025 depends on Ford's ability to scale production while competing with Tesla and new rivals. Furthermore, tariffs on Chinese vehicles and components, introduced under Trump, could lead to higher costs, slowing the growth of already less profitable EVs if batteries become more expensive.

**Banking Sector**

# JPMorgan

From 2015 to 2025, JPMorgan Chase (JPM) stock was impacted by major macroeconomic and financial events: in 2015-2016, the post-crisis recovery and the Fed's rate hike supported banking margins. Between 2017 and 2019, Trump's tax reform and the market boom pushed the stock to new highs. In 2020, the pandemic caused an initial collapse, followed by a rapid recovery thanks to monetary stimulus and the boom in trading and investment banking. Between 2021 and 2022, inflation and Fed rate hikes supported profits, while in 2023, the acquisition of First Republic Bank after the regional banking crisis strengthened its position. Looking ahead to 2025, the outlook depends on interest rate management, investments in AI and digital banking, and the risks of a recession or tighter regulations; Trade tensions would increase uncertainty in financial markets. JPMorgan, as a global bank with exposure to international trade, could see increased demand for risk management and trading services.

# Bank of America

Bank of America (BAC) experienced ups and downs between 2015 and 2025, primarily influenced by monetary policies, economic crises, and changes in the banking sector. Since 2015, the post-crisis recovery and the Fed's rate hikes (2015-2018) have supported the stock, taking it from $15 to $30, also supported by Trump's tax reform (2017). The 2020 pandemic caused an initial collapse (zero rates and increased reserves for non-performing loans), followed by a rapid recovery thanks to government stimulus. Between 2021 and 2022, inflation and repeated rate hikes pushed BAC towards $50, the high of the period, while in 2023, the regional banking crisis and concerns about commercial lending have slowed growth. The outlook for 2025 depends on economic stability; New tariffs on China, the EU, or other partners could trigger retaliation and trade wars, reducing global trade and hurting American businesses.

# Data presentation

I report the first 10 rows of the generated dataframe (fig. 1.1) and the closing price graph (fig. 1.2).

| Ticker<br>Date | NVDA | AAPL | TSLA | F | JPM | BAC |
|---|---|---|---|---|---|---|
| **2014-06-02** | 0.450631 | 19.792877 | 13.646667 | 9.343301 | 40.953011 | 12.230069 |
| **2014-06-03** | 0.448728 | 20.072775 | 13.662667 | 9.405814 | 41.137974 | 12.190002 |
| **2014-06-04** | 0.449204 | 20.301983 | 13.599333 | 9.542216 | 41.197163 | 12.190002 |
| **2014-06-05** | 0.451107 | 20.381638 | 13.793333 | 9.479700 | 41.900066 | 12.366322 |
| **2014-06-06** | 0.452773 | 20.325594 | 13.878000 | 9.707030 | 42.151634 | 12.494551 |
| **2014-06-09** | 0.453249 | 20.650831 | 13.687333 | 9.661568 | 42.484577 | 12.694910 |
| **2014-06-10** | 0.455628 | 20.772053 | 13.486667 | 9.667249 | 42.839718 | 12.759030 |
| **2014-06-11** | 0.461576 | 20.686094 | 13.631333 | 9.604733 | 42.373592 | 12.494551 |
| **2014-06-12** | 0.464431 | 20.340075 | 13.568000 | 9.388767 | 42.203411 | 12.358303 |
| **2014-06-13** | 0.464907 | 20.117481 | 13.761333 | 9.411498 | 42.203411 | 12.374331 |

*Fig. 1.1 First 10 rows of the generated dataframe*

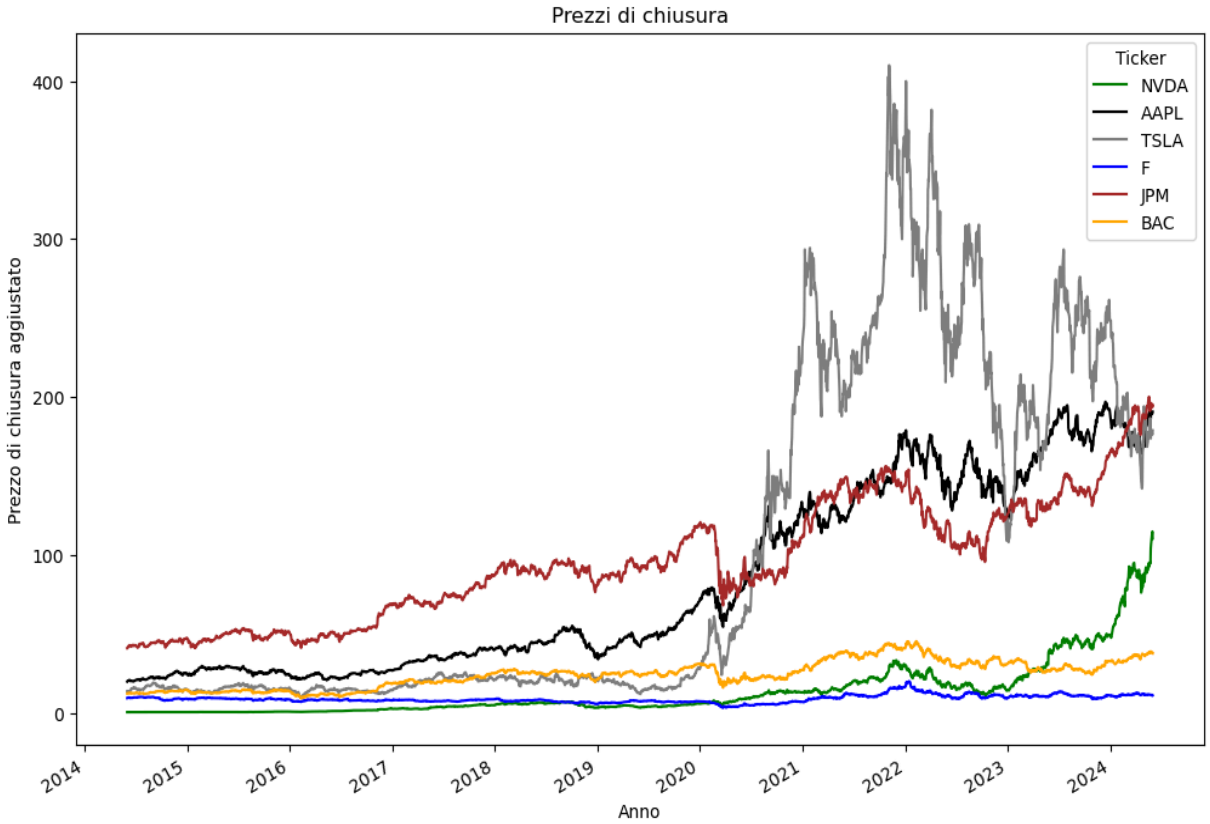
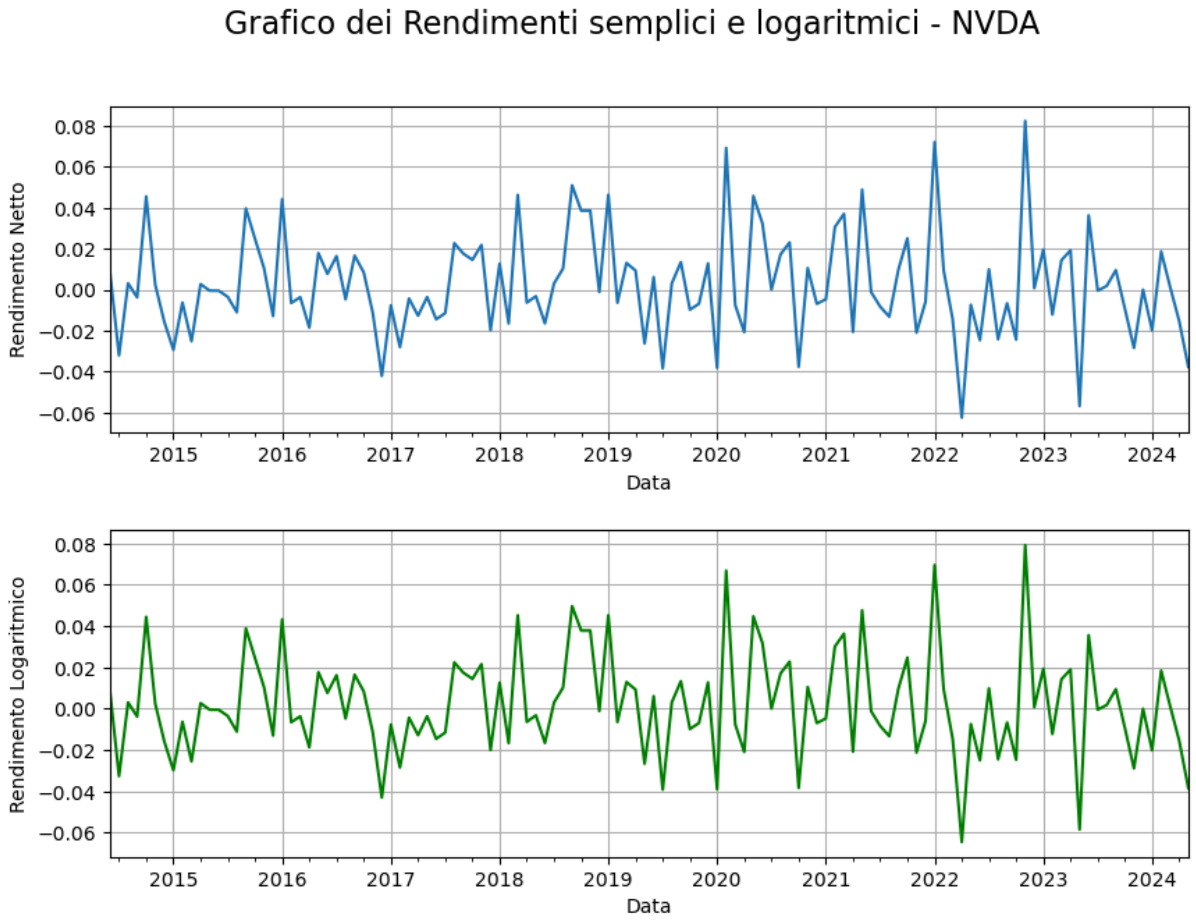



*Figure 1.2 Chart of closing prices of stocks*

# Descriptive Statistics

## Performance Analysis



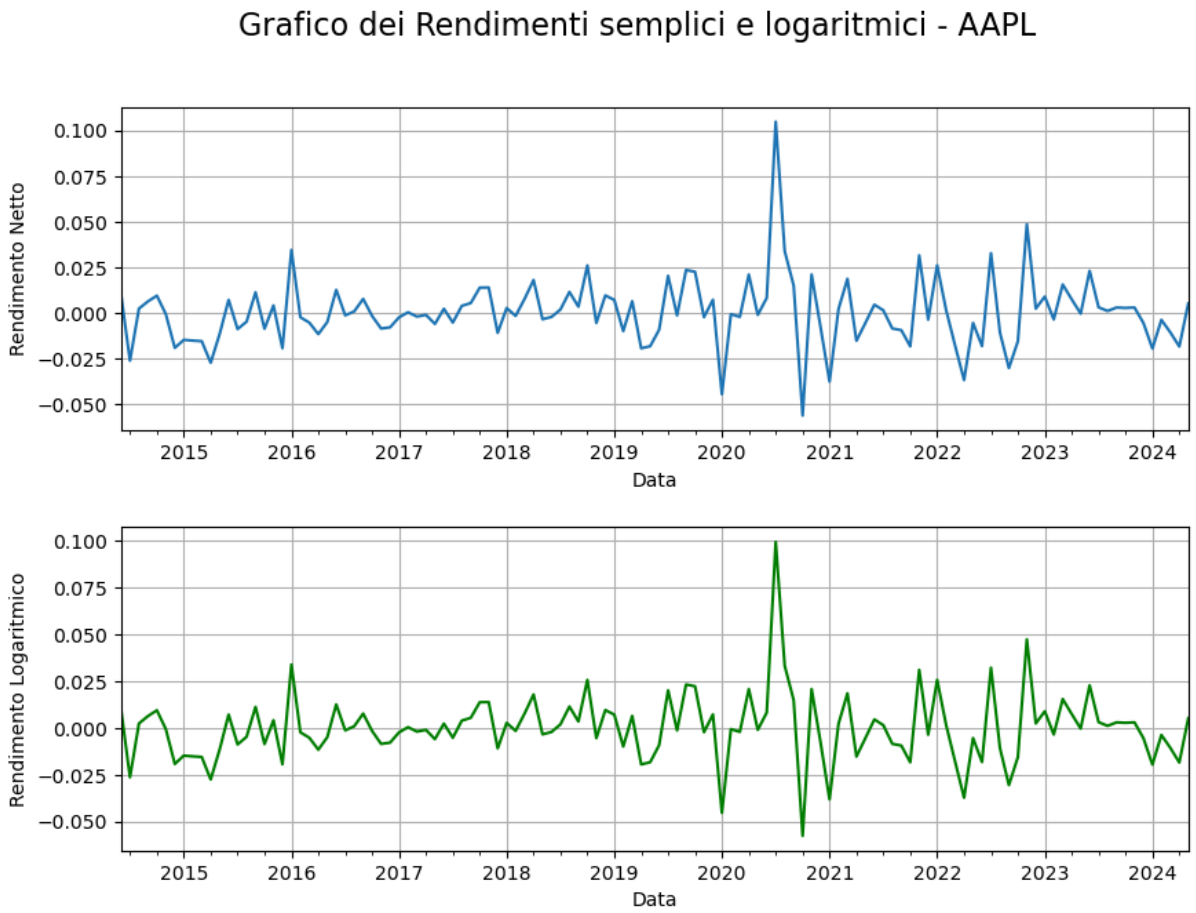


Grafico dei Rendimenti semplici e logaritmici - AAPL
Rendimento Netto
0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Data
Rendimento Logaritmico
0.100
0.075
0.050
0.025
0.000
−0.025
−0.050
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Data

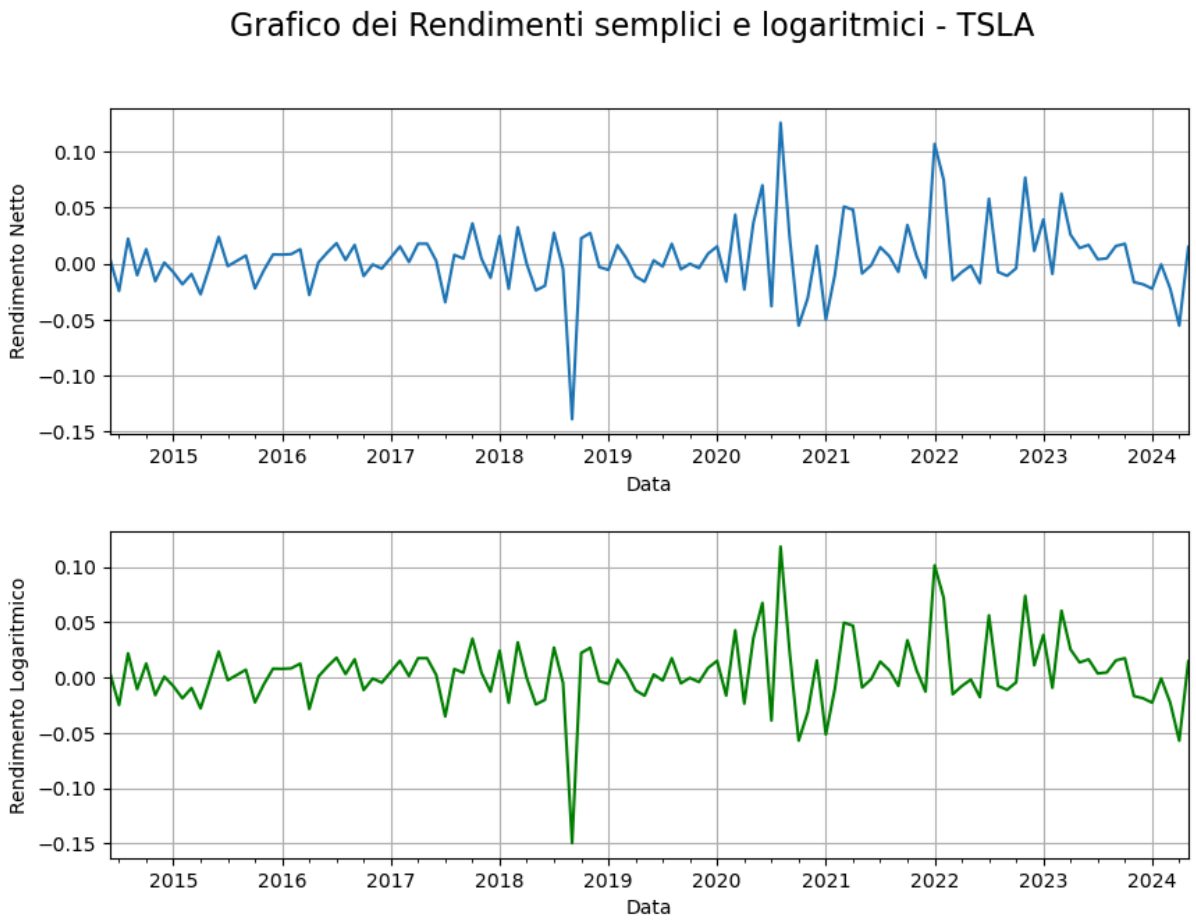
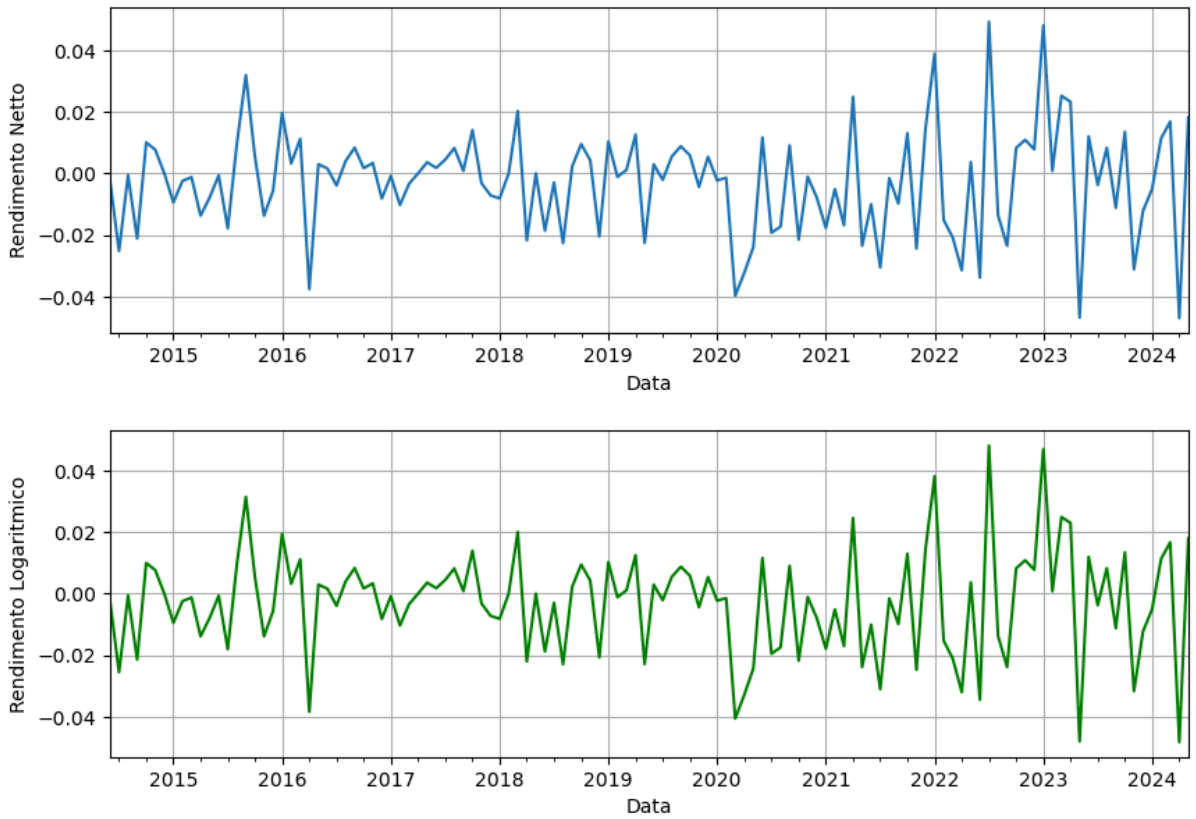


Grafico dei Rendimenti semplici e logaritmici - TSLA
Rendimento Netto
0.10
0.05
0.00
−0.05
−0.10
−0.15
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Data
Rendimento Logaritmico
0.10
0.05
0.00
−0.05
−0.10
−0.15
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Data

Grafico dei Rendimenti semplici e logaritmici - F



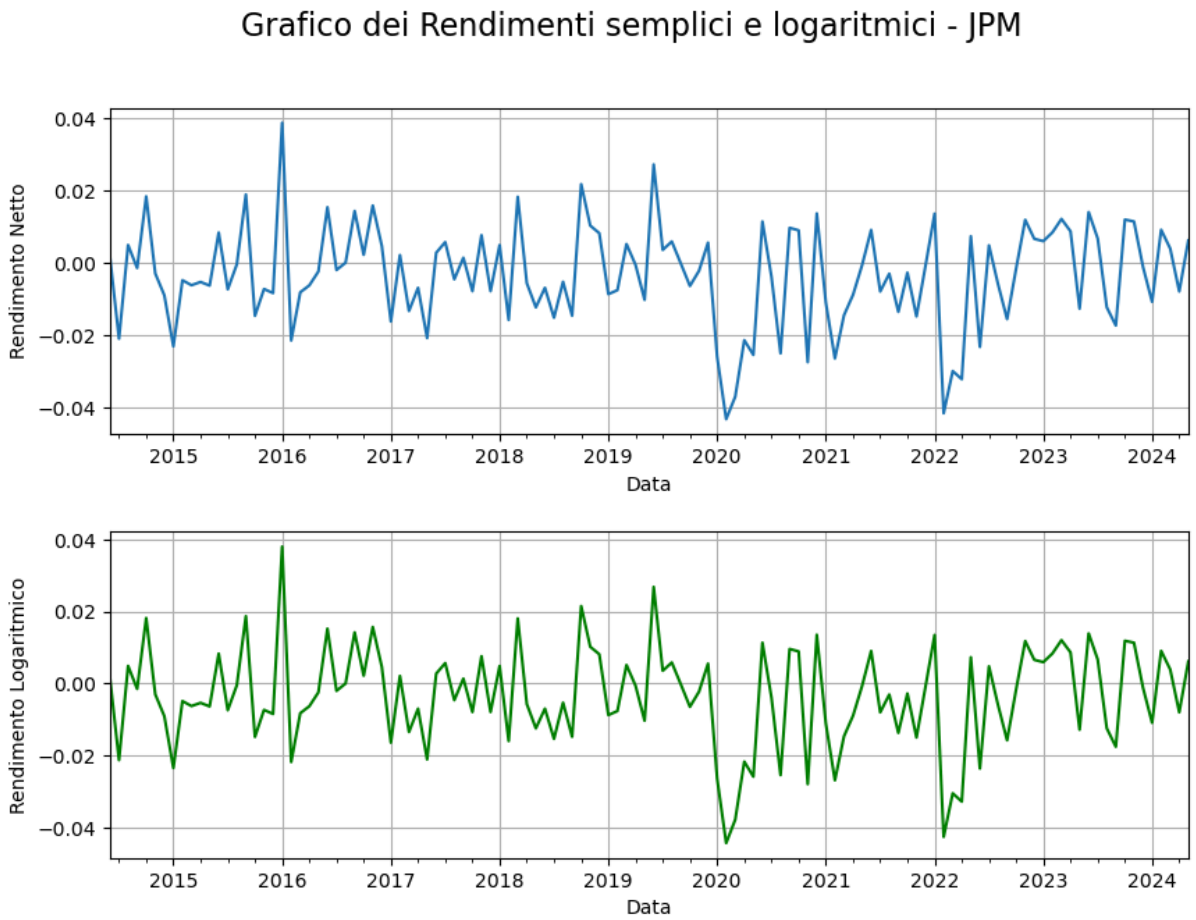
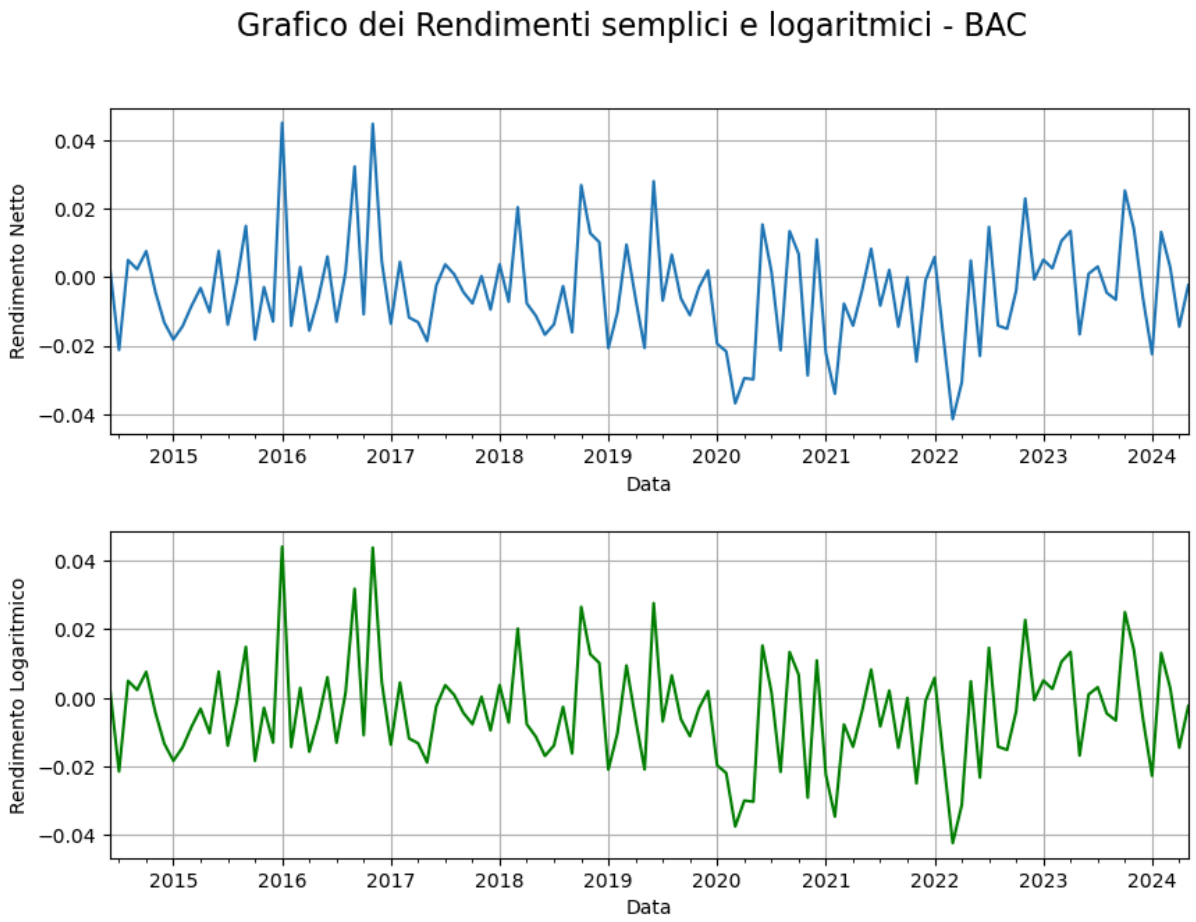


Grafico dei Rendimenti semplici e logaritmici - JPM
Rendimento Netto
0.04
0.02
0.00
−0.02
−0.04
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Data
Rendimento Logaritmico
0.04
0.02
0.00
−0.02
−0.04
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Data




## Compound annual return

- NVDA_R_COMP (Nvidia) 0.734167
- AAPL_R_COMP (Apple) 0.252418
- TSLA_R_COMP (Tesla) 0.293199
- F_R_COMP (Ford) 0.016443
- JPM_R_COMP (JPMorgan) 0.168229
- BAC_R_COMP (Bank Of America) 0.119504

## Analyses

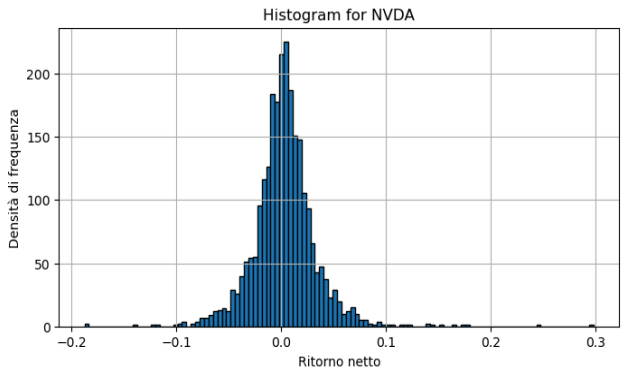
1. The analyzed time series exhibit common fluctuations, with periods of high volatility and lows, but overall they reveal an upward trend. In early 2016, markets suffered some of the worst losses in history, driven by concerns about global growth, particularly related to the China crisis and the collapse of the oil price. In 2020, all time series recorded a sharp decline due to the pandemic, but were followed by a rapid recovery. 2022, however, was marked by a renewed market collapse, driven by record inflation, rate hikes, and the risk of recession. The war in Ukraine and post-COVID uncertainties worsened the situation, fueling volatility.

2. There is certainly a correlation between APPLE and NVIDIA. There is a certain similarity in their return patterns, especially in positive peaks, for example in 2020-2021. This suggests a possible positive correlation linked to the technology boom during the pandemic, with the increase in remote working, increased gaming activity, and the adoption of artificial intelligence. However, I don't see any significant correlations for either the automotive or banking sectors.

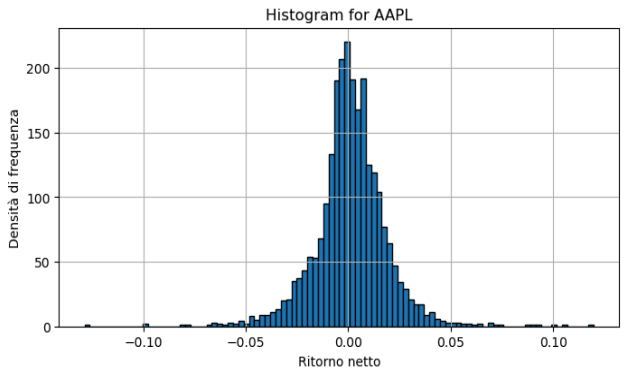
3. Between 2020 and 2021, TESLA recorded exceptionally high returns, driven by three key factors: its inclusion in the S&P 500, which attracted large inflows of financial investment; the booming electric vehicle (EV) market, with rapidly growing demand; and better-than-expected financial results, including the first consecutive year of positive net earnings. In the same sector, Ford also experienced above-average performance from 2022 to 2023, also driven by growing sales of electric vehicles.

   Aside from the pandemic, NVIDIA saw significant growth in 2023, driven by continued explosive demand for GPUs for AI development.

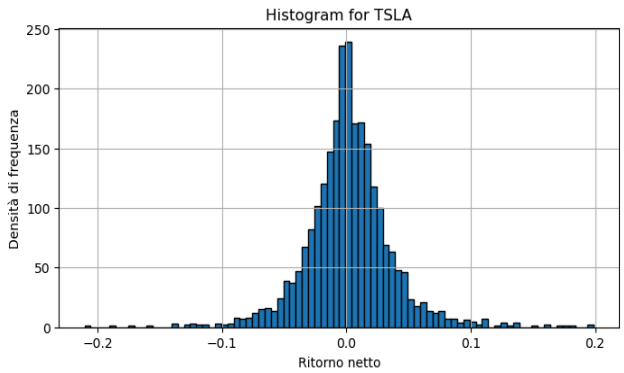
## Distribution of returns through histogram and dispersion analysis



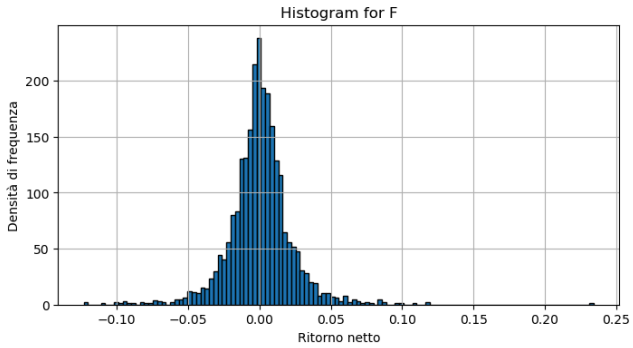

**Nvidia**It shows a broad distribution that extends from -0.2 to 0.3. Its return dispersion is high, indicating that the stock is quite volatile.



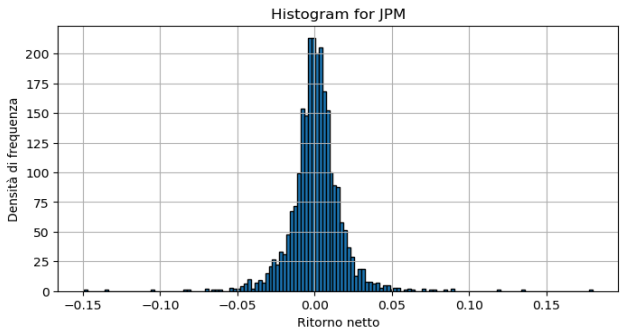

**Apple**has a narrower distribution in the range of ±0.05 with only a few returns extending beyond ±0.10, its dispersion is lower than **Nvidia**, indicating lower volatility.



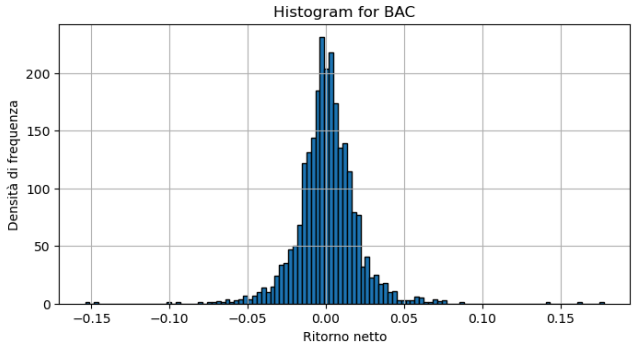

For**Tesla**The distribution of returns is mainly in the range of ±0.1 but there are multiple returns that extend up to ±0.2. Its volatility is similar to that of **Nvidia,**slightly higher.




**Ford Company Co.**It presents concentrated returns in the range ±0.05 but peaks around 0.25. Its volatility is significantly reduced compared to**Nvidia** And **Tesla**.




**JP Morgan**It is the least volatile stock, with few returns exceeding ±0.1.




**Bank of America**follows the same characteristics as**JPM**, being in a similar context, with a distribution of returns mainly between -0.1 and 0.1. Also **BAC**It has low dispersion, indicating lower volatility.

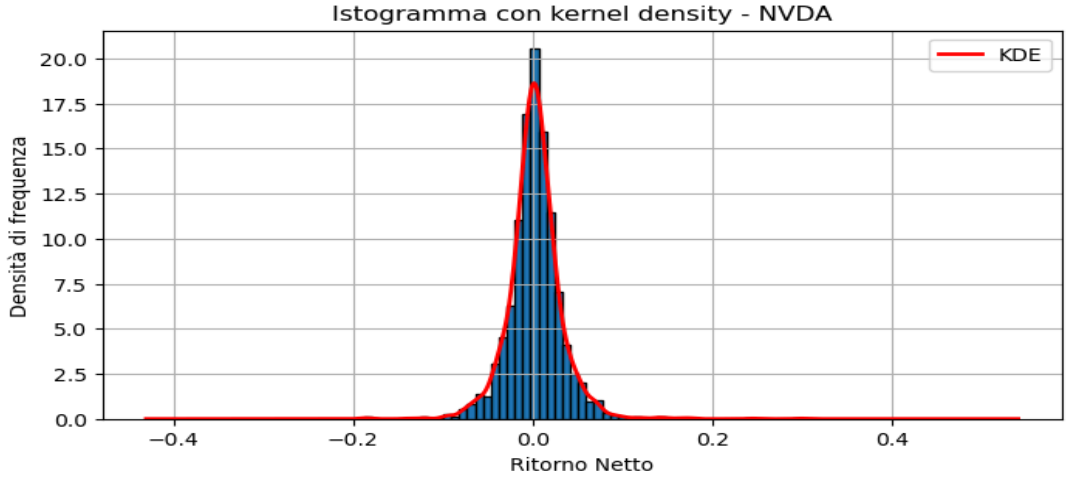
## Standard deviation of stocks

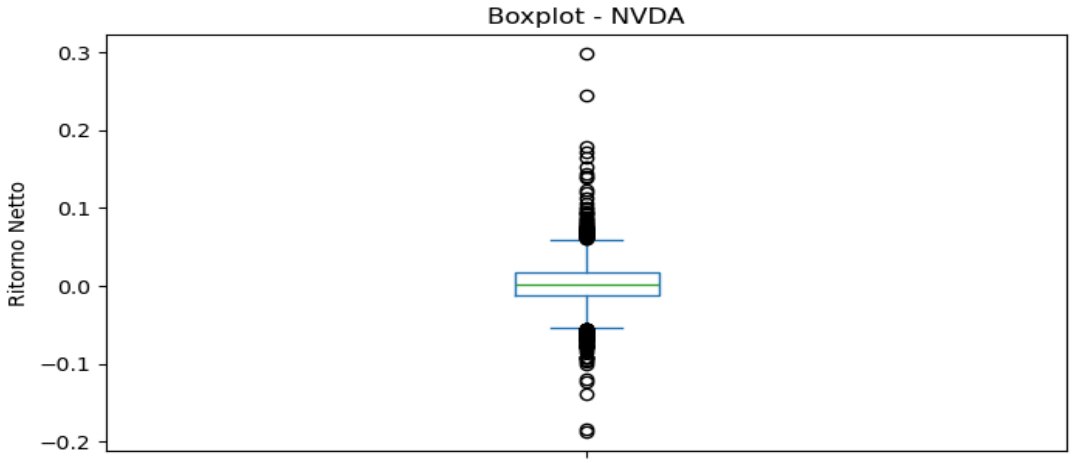
- NVDA (Nvidia) – 0.029824
- AAPL (Apple) – 0.017841
- TSLA (Tesla) – 0.034993

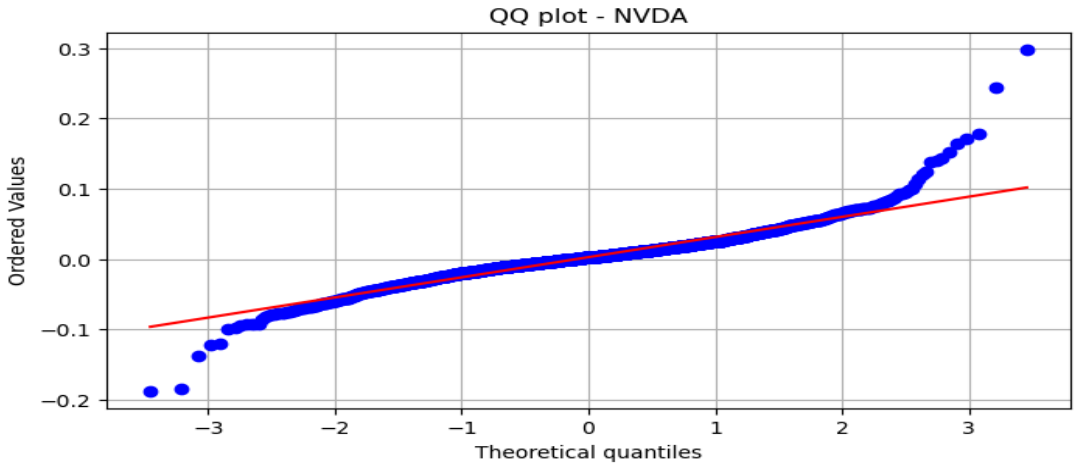
- F (Ford) – 0.022087
- JPM (JPMorgan) – 0.016972
- BAC (Bank Of America) – 0.019474

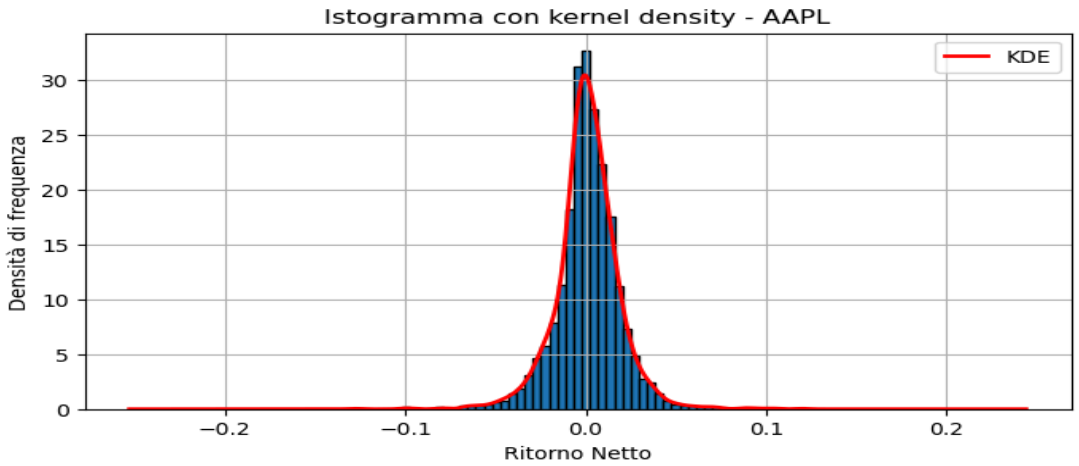
Looking at the standard deviation values, we have confirmation of the analysis carried out previously: **NVDA**And**TSLA**they present the greatest volatility among all securities**.**The volatility of**F** it is more moderate while the titles**JPM**And**BAC**they are more stable, with**JPM**the less volatile of the two.

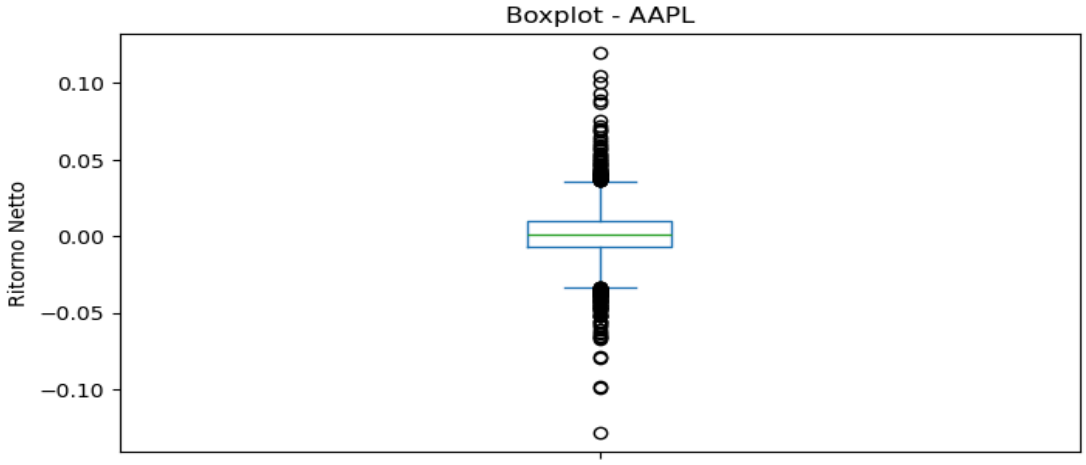
**Performance analysis using 3-section diagnostic charts (histogram and kernel density, boxplot, qq-plot).**

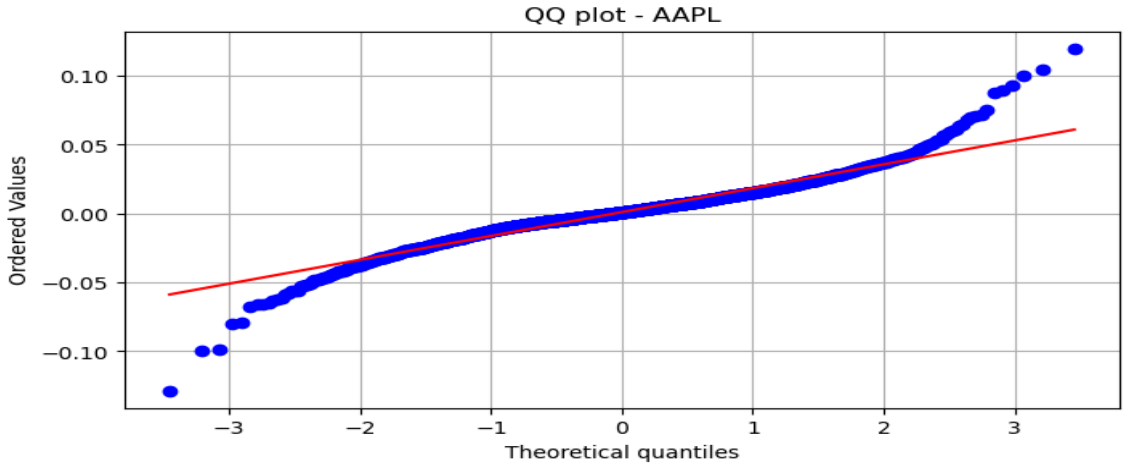


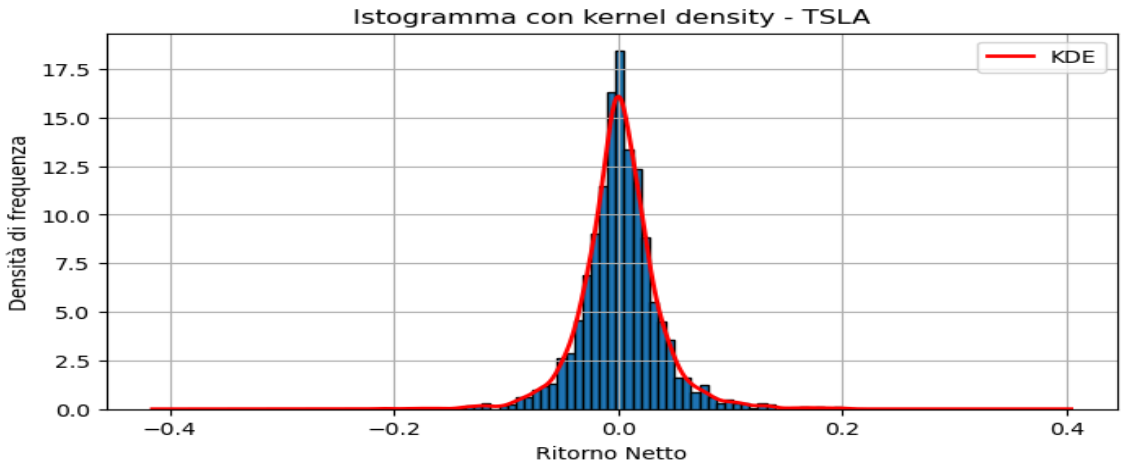



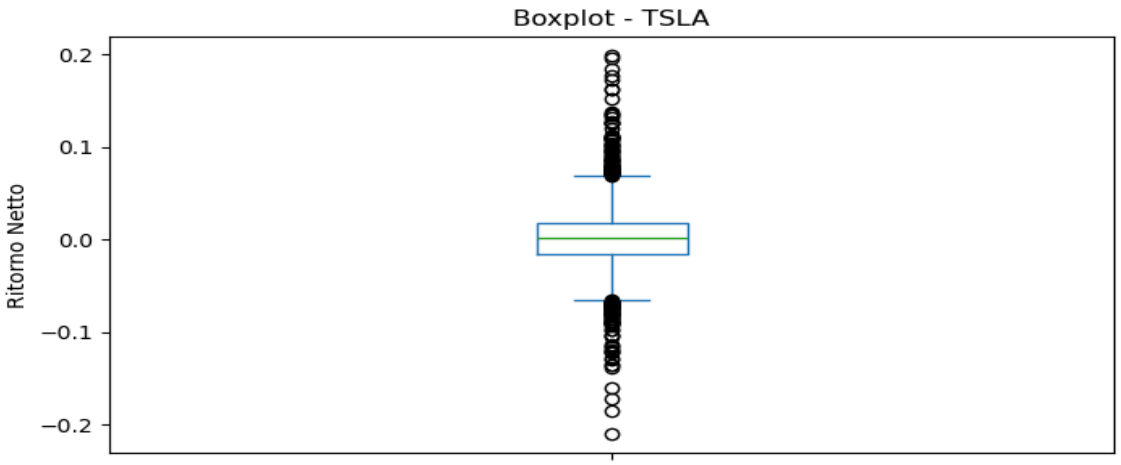



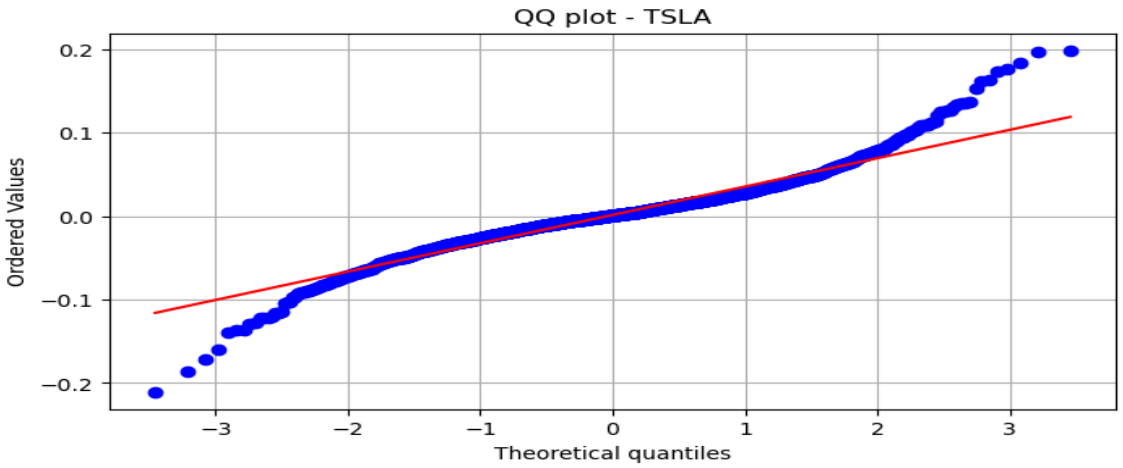

Istogramma con kernel density - AAPL
KDE
Densità di frequenza
Ritorno Netto
30
25
20
15
10
5
0
−0.2
−0.1
0.0
0.1
0.2

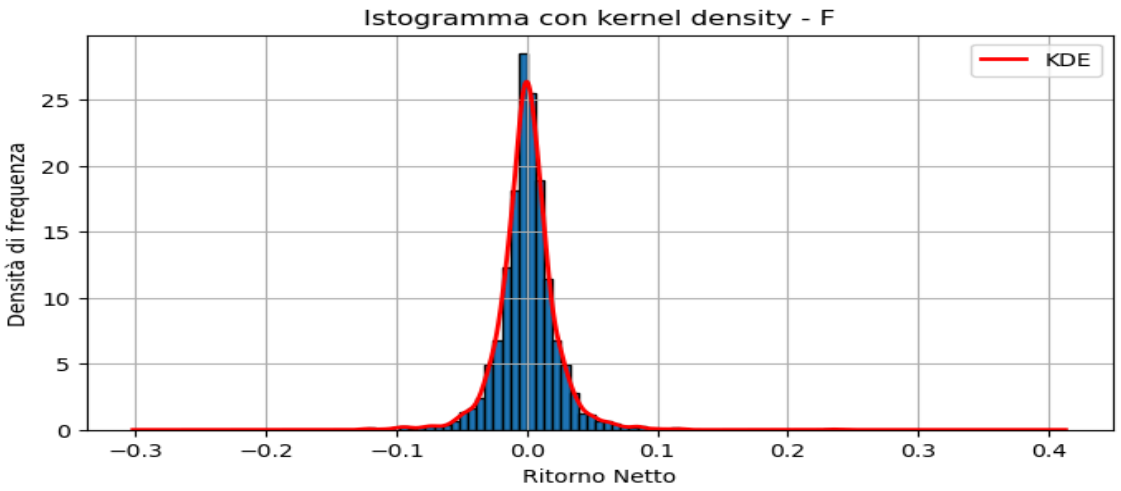

Boxplot - AAPL
Ritorno Netto
0.10
0.05
0.00
−0.05
−0.10

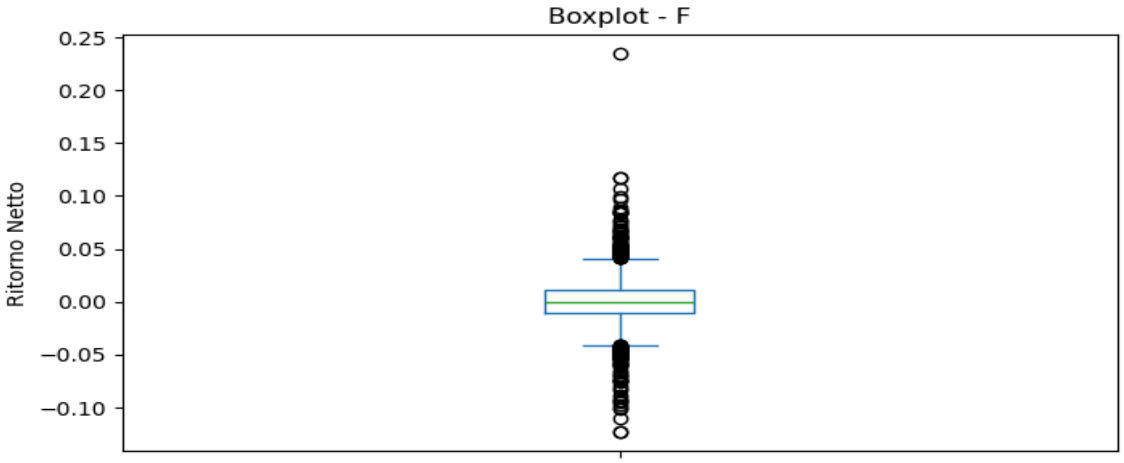

QQ plot - AAPL
Ordered Values
Theoretical quantiles
0.10
0.05
0.00
−0.05
−0.10
−3
−2
−1
0
1
2
3

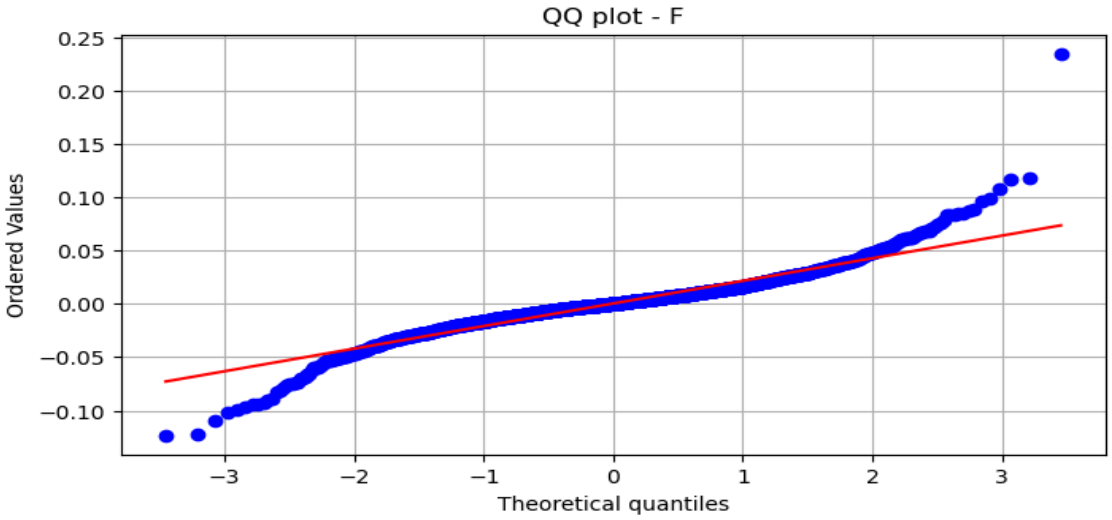

Istogramma con kernel density - TSLA
KDE
Densità di frequenza
Ritorno Netto
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
−0.4
−0.2
0.0
0.2
0.4

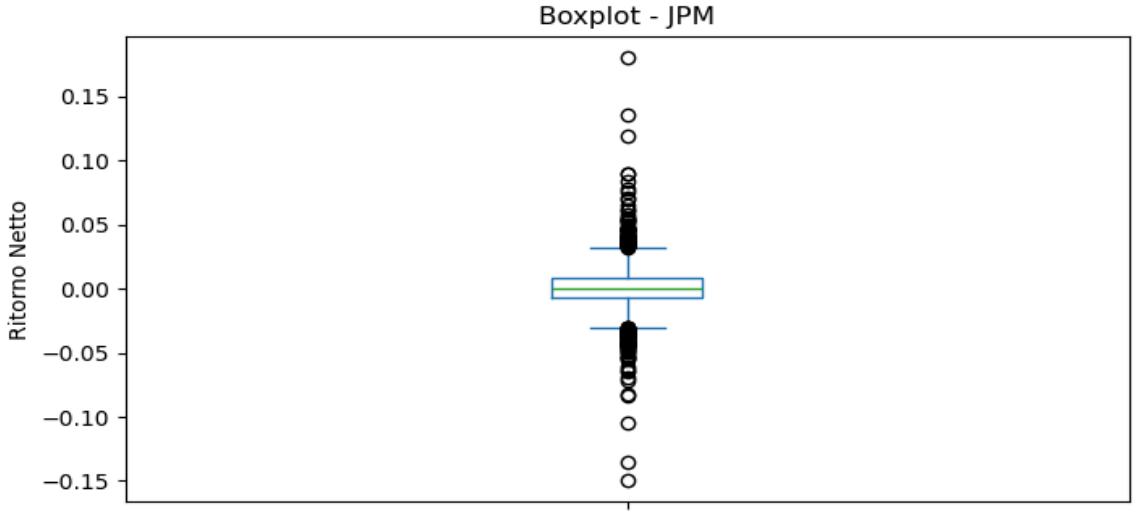

Boxplot - TSLA
Ritorno Netto
0.2
0.1
0.0
−0.1
−0.2

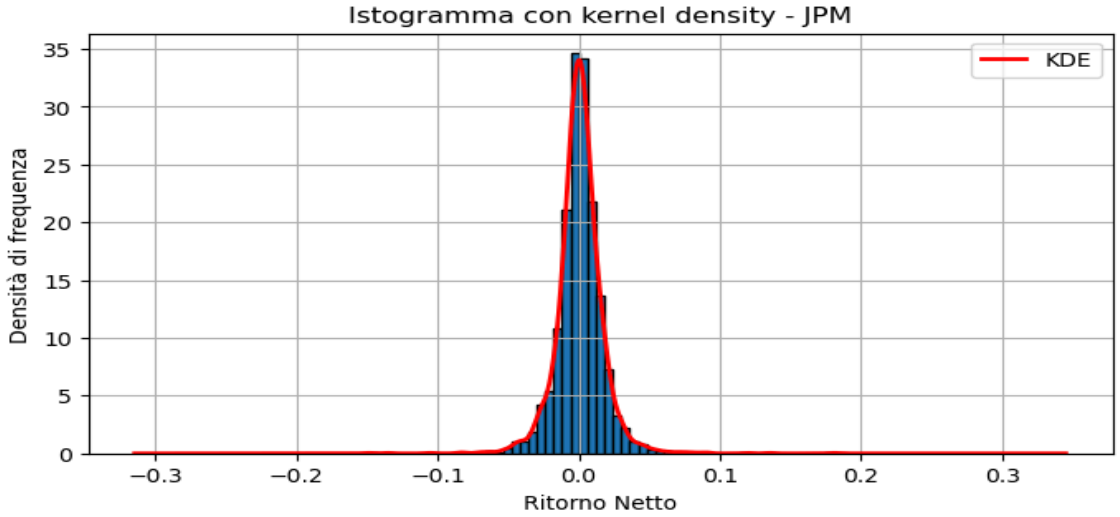

QQ plot - TSLA
Ordered Values
Theoretical quantiles
0.2
0.1
0.0
−0.1
−0.2
−3
−2
−1
0
1
2
3

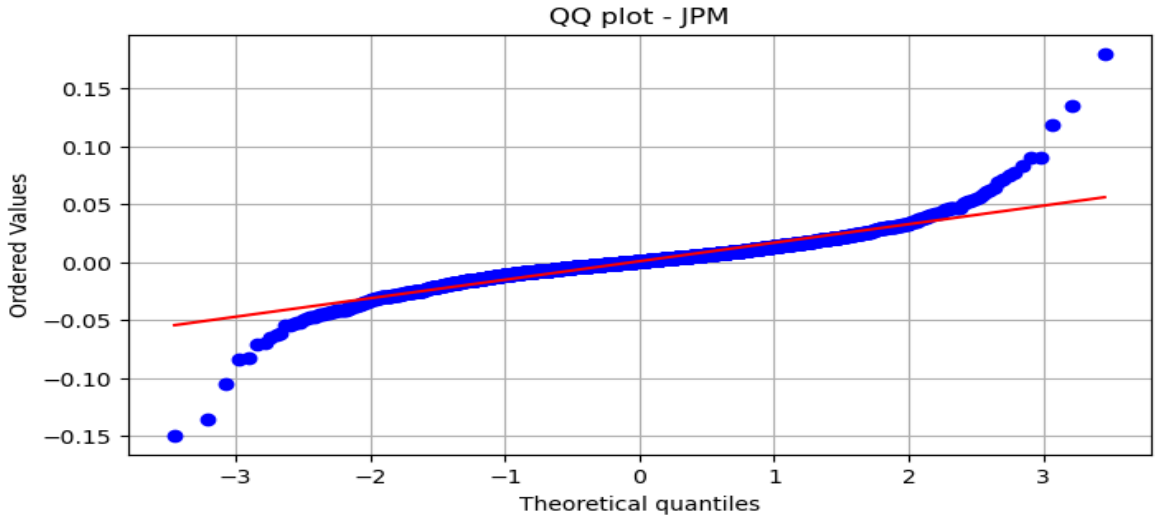

Istogramma con kernel density - F
KDE
Densità di frequenza
Ritorno Netto
0
5
10
15
20
25
−0.3
−0.2
−0.1
0.0
0.1
0.2
0.3
0.4

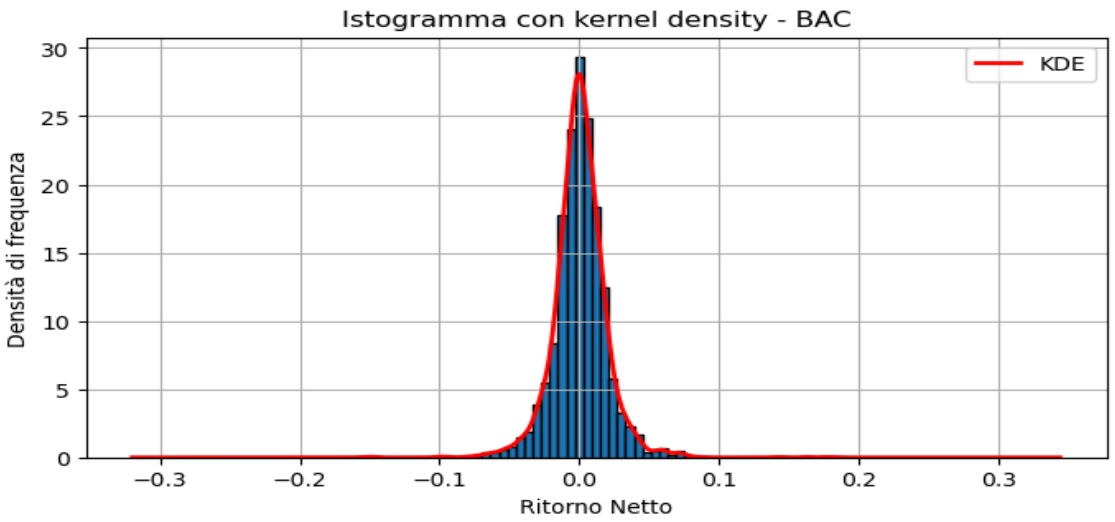

Boxplot - F
Ritorno Netto
0.25
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10

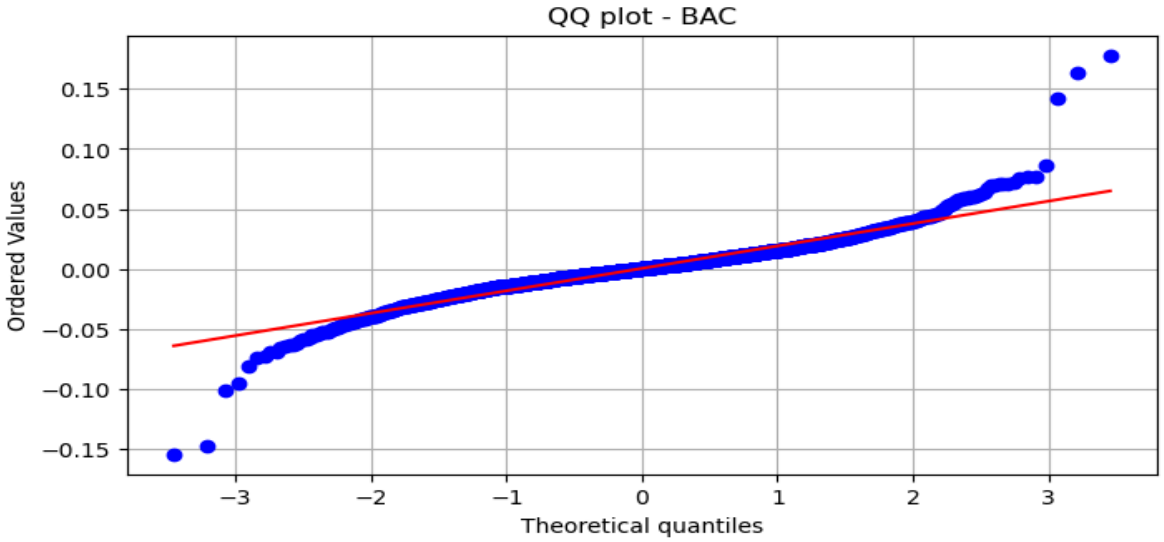

QQ plot - F
Ordered Values
Theoretical quantiles
0.25
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10
−3
−2
−1
0
1
2
3

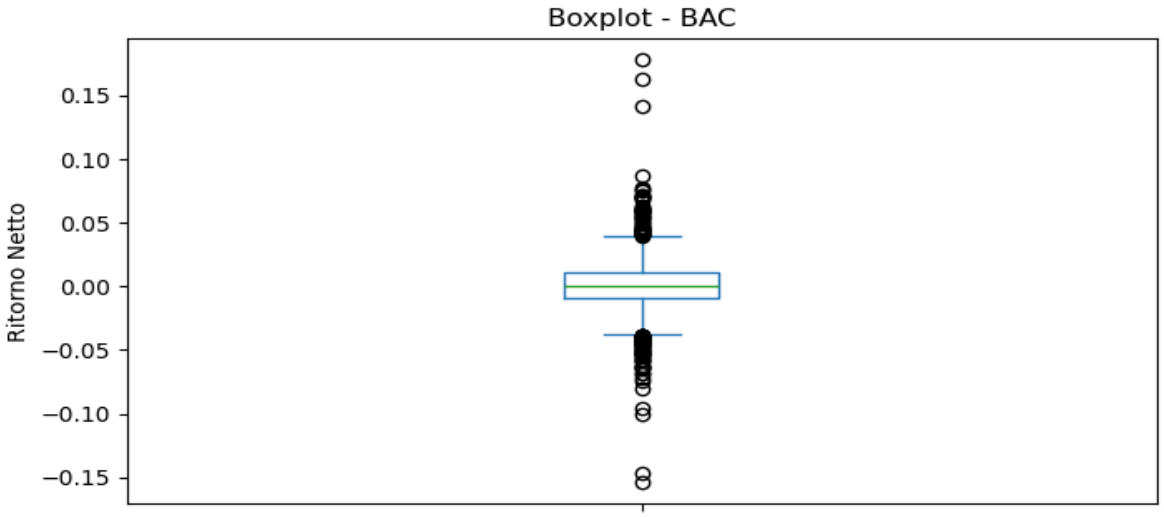

Boxplot - JPM
Ritorno Netto
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15


Istogramma con kernel density - JPM
KDE
Densità di frequenza
35
30
25
20
15
10
5
0
−0.3
−0.2
−0.1
0.0
0.1
0.2
0.3
Ritorno Netto


QQ plot - JPM
Ordered Values
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−3
−2
−1
0
1
2
3
Theoretical quantiles


Istogramma con kernel density - BAC
KDE
Densità di frequenza
Ritorno Netto
30
25
20
15
10
5
0
−0.3
−0.2
−0.1
0.0
0.1
0.2
0.3


QQ plot - BAC
Ordered Values
Theoretical quantiles
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−3
−2
−1
0
1
2
3


Boxplot - BAC
Ritorno Netto
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15

### Comments

Looking at the quantile plots, we can see that all the stocks have points that cluster along the diagonal except at the extremes, which suggests that extreme returns (both positive and negative) are more frequent than a normal distribution would predict.

At the boxplot level, we can observe that there are outliers significantly deviating from the central distribution, indicating that there have been highly volatile events that have led to sharp price drops or sudden spikes.

## Univariate descriptive statistics (Annualized)

| Ticker | Media | Varianza | Dev. Standard | Asimmetria | Curtosi |
|---|---|---|---|---|---|
| NVDA | 0.002629 | 0.000889 | 0.029824 | 0.690360 | 9.271241 |
| AAPL | 0.001060 | 0.000318 | 0.017841 | -0.018297 | 5.360839 |
| TSLA | 0.001634 | 0.001225 | 0.034993 | 0.209974 | 4.411360 |
| F | 0.000310 | 0.000488 | 0.022087 | 0.388257 | 8.930719 |
| JPM | 0.000764 | 0.000288 | 0.016972 | 0.297652 | 14.113159 |
| BAC | 0.000637 | 0.000379 | 0.019474 | 0.282792 | 10.097509 |

## Comments

THE. Looking at the values produced by the univariate statistics, in particular the average of the returns, the lowest one appears to belong to the title**F**(Ford Company) while the highest returns appear to be found in the stock**NVDA**(Nvidia).

II. The stock with the highest standard deviation is**TSLA**(Tesla), surpassing**Nvidia**by a small margin, but we can conclude that both are the most volatile in the sectors. The less volatile stocks, which therefore have a lower standard deviation, are **AAPL**(Apple) and**JPM**(JPMorgan).

III. Using the charts we created for simple and logarithmic returns, we observe that the technology and automotive sectors have been the most volatile, with**Nvidia** which presents very large peaks with clearly positive returns, especially during periods of crisis, followed by**TESLA**, this stock has also proven to be very volatile, during the same period of volatility as**Nvidia**The banking sector, on the other hand, experienced more limited volatility, but obviously with lower returns than the others.

IV. Looking at the kurtosis values we notice that the stock with the closest return distribution to normal is**TSLA**, while the furthest one is**JPM.**

## Covariance matrices and correlation of returns

| Ticker<br>Ticker | NVDA | AAPL | TSLA | F | JPM | BAC |
|---|---|---|---|---|---|---|
| **NVDA** | 0.000889 | 0.000289 | 0.000419 | 0.000224 | 0.000175 | 0.000197 |
| **AAPL** | 0.000289 | 0.000318 | 0.000265 | 0.000140 | 0.000131 | 0.000146 |
| **TSLA** | 0.000419 | 0.000265 | 0.001225 | 0.000245 | 0.000156 | 0.000183 |
| **F** | 0.000224 | 0.000140 | 0.000245 | 0.000488 | 0.000208 | 0.000238 |
| **JPM** | 0.000175 | 0.000131 | 0.000156 | 0.000208 | 0.000288 | 0.000296 |
| **BAC** | 0.000197 | 0.000146 | 0.000183 | 0.000238 | 0.000296 | 0.000379 |

| Ticker<br>Ticker | NVDA | AAPL | TSLA | F | JPM | BAC |
|---|---|---|---|---|---|---|
| **NVDA** | 1.000000 | 0.543972 | 0.401633 | 0.340553 | 0.345753 | 0.339758 |
| **AAPL** | 0.543972 | 1.000000 | 0.425149 | 0.354446 | 0.433365 | 0.418809 |
| **TSLA** | 0.401633 | 0.425149 | 1.000000 | 0.316592 | 0.262752 | 0.268914 |
| **F** | 0.340553 | 0.354446 | 0.316592 | 1.000000 | 0.555403 | 0.553346 |
| **JPM** | 0.345753 | 0.433365 | 0.262752 | 0.555403 | 1.000000 | 0.895274 |
| **BAC** | 0.339758 | 0.418809 | 0.268914 | 0.553346 | 0.895274 | 1.000000 |

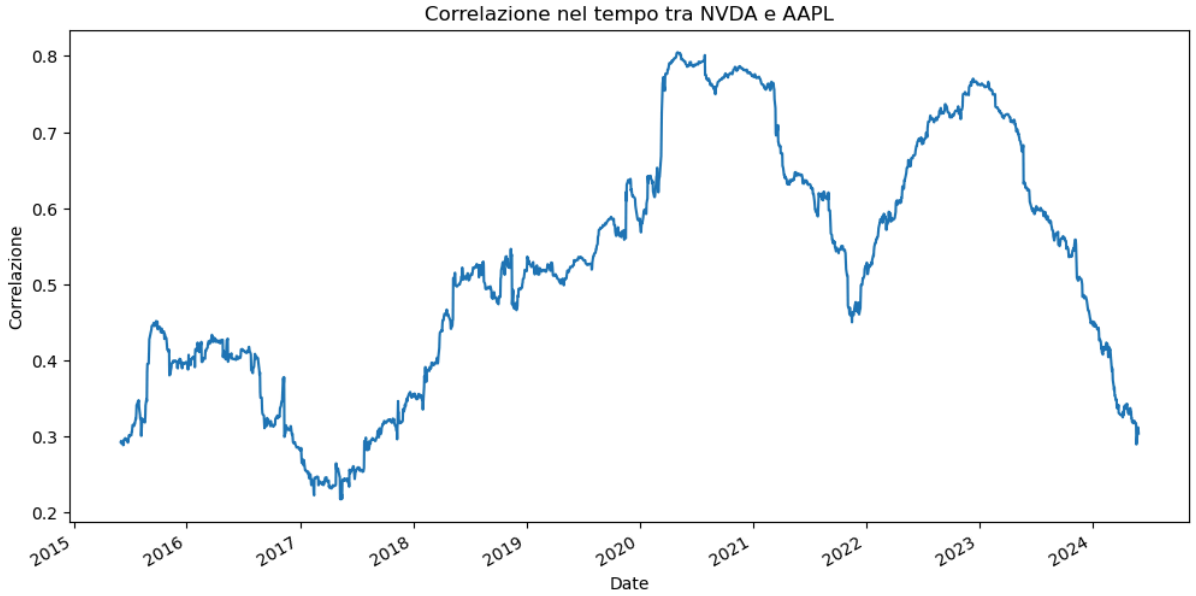
## Comments

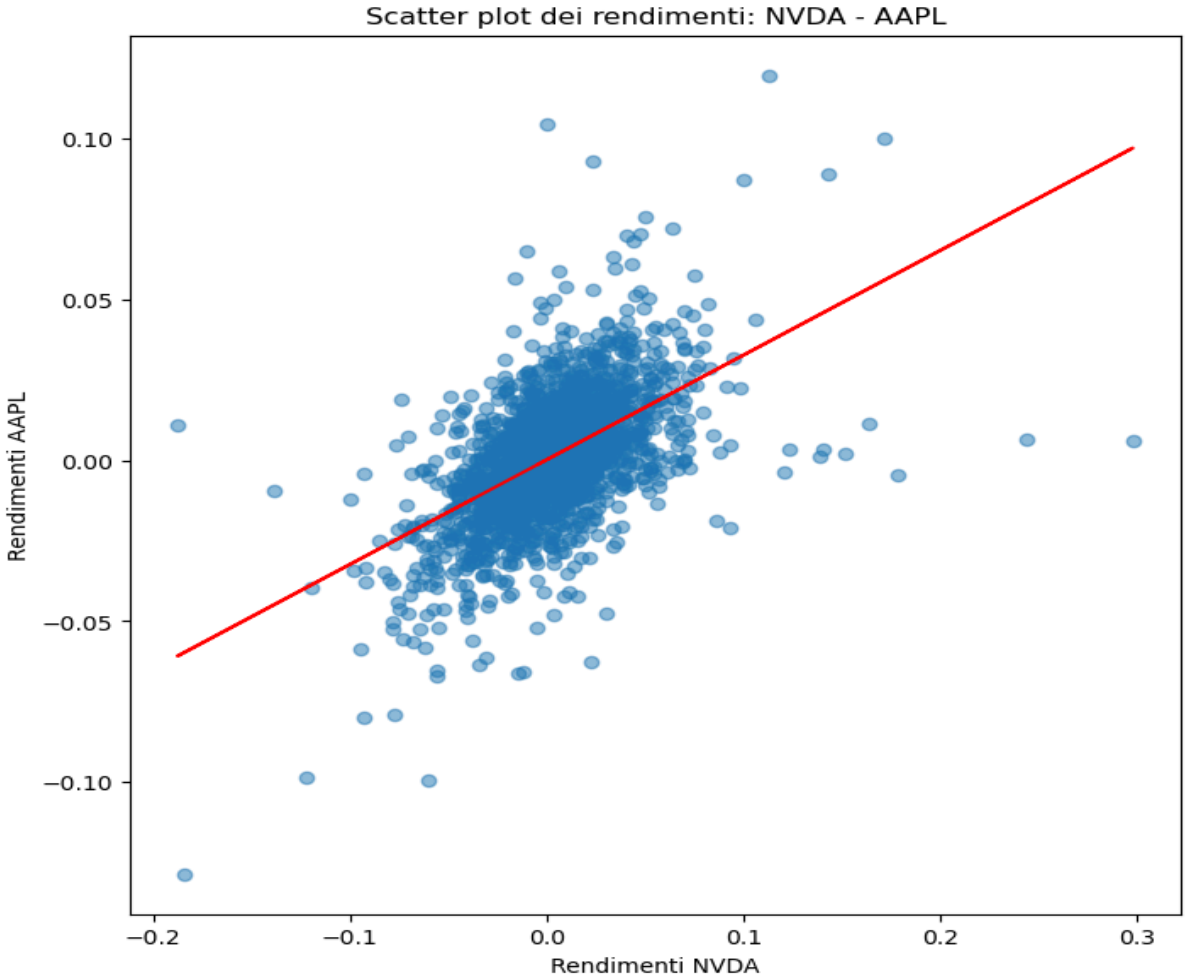
The titles with**highest correlation**they result**JPM**And**BAC**This is because both companies operate in the same industry and therefore most events have affected their shares to the same extent.

The lowest correlation is found with**TSLA**compared to bank stocks,**JPM**And **BAC,**This may be due to the fact that Tesla is highly growth-oriented, sensitive to innovation, and attracts more speculative investors.

Other correlations to note are between**BAC/JPM**And**FORD**, with a correlation of 0.55, the action**F** being more “traditional” it is more affected by economic changes.
Another important correlation is that between**Apple**And**Nvidia**, this is predictable as they operate in the same sector.

# Time correlations and scatterplots



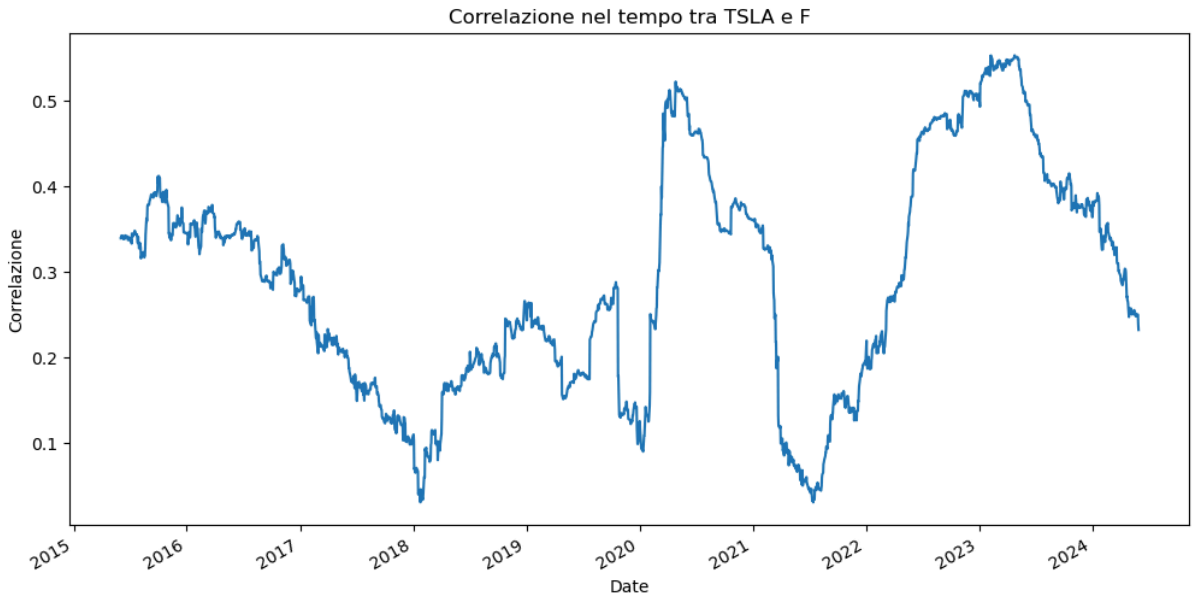



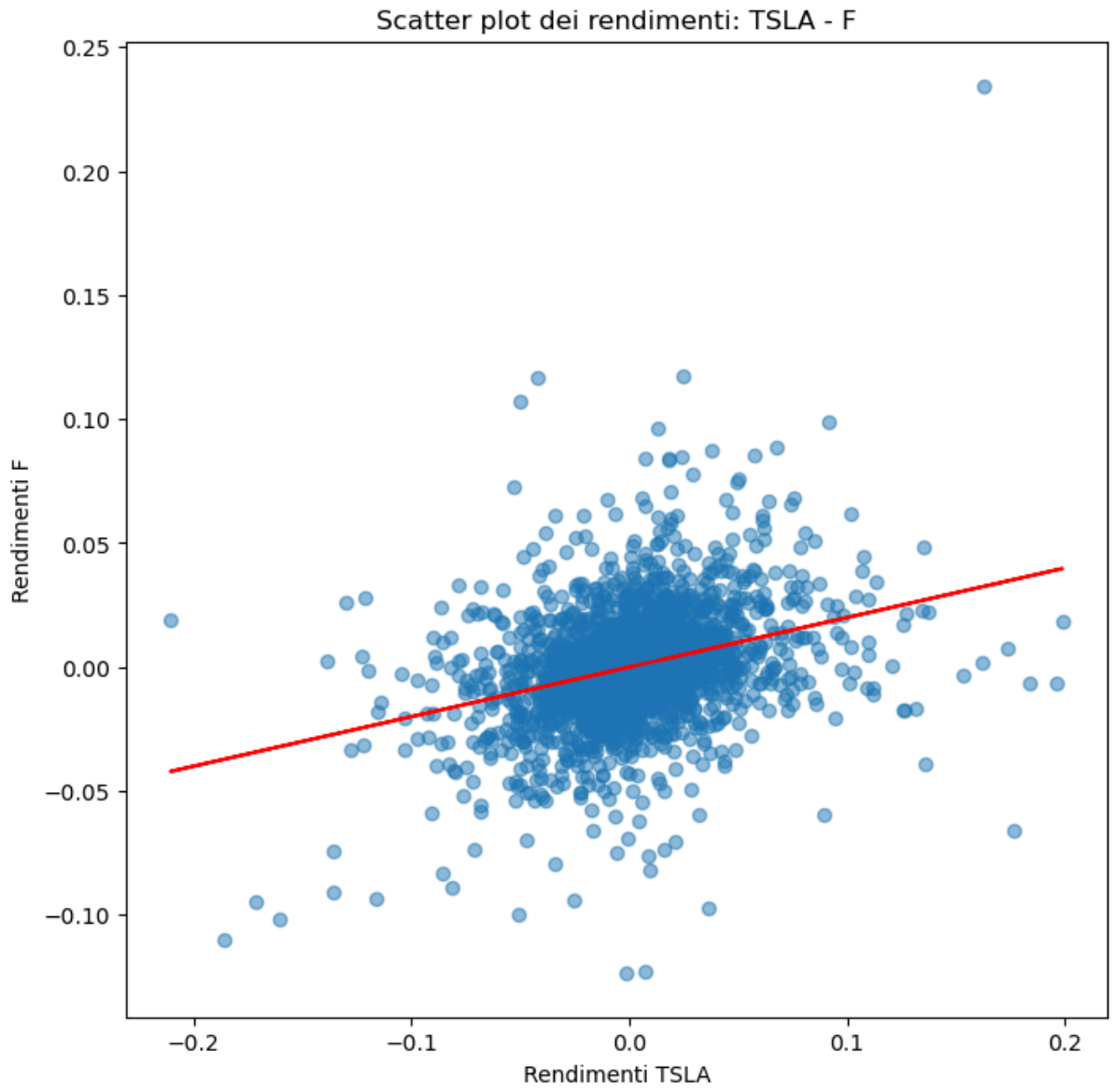
# NVDA - AAPL Correlation Comments

For the first three years, the correlation between the two stocks was relatively low. From 2018 onwards, it exceeded 0.5, peaking at 0.8. Towards the end of 2022, the correlation returned to around 0.5, before rising again, approaching 0.8. Subsequently, after the second peak, the correlation returned to its lowest point. Therefore, we note that the correlation between the returns of **NVDA**and**AAPL**It is highly variable and subject to events that occur over time.

Looking at the scatter plot of returns, most of the points seem to be concentrated in the center indicating that the most controlled returns are common for both stocks, however, there are some extreme points that indicate greater volatility.

The dispersion of the points, even when observed diagonally, confirms a positive linear relationship, meaning positive returns for one security lead to the same result for the other, and vice versa for negative returns. The line is imperfect, as there are points far from it, indicating that in some periods the returns between the two securities are uncorrelated.

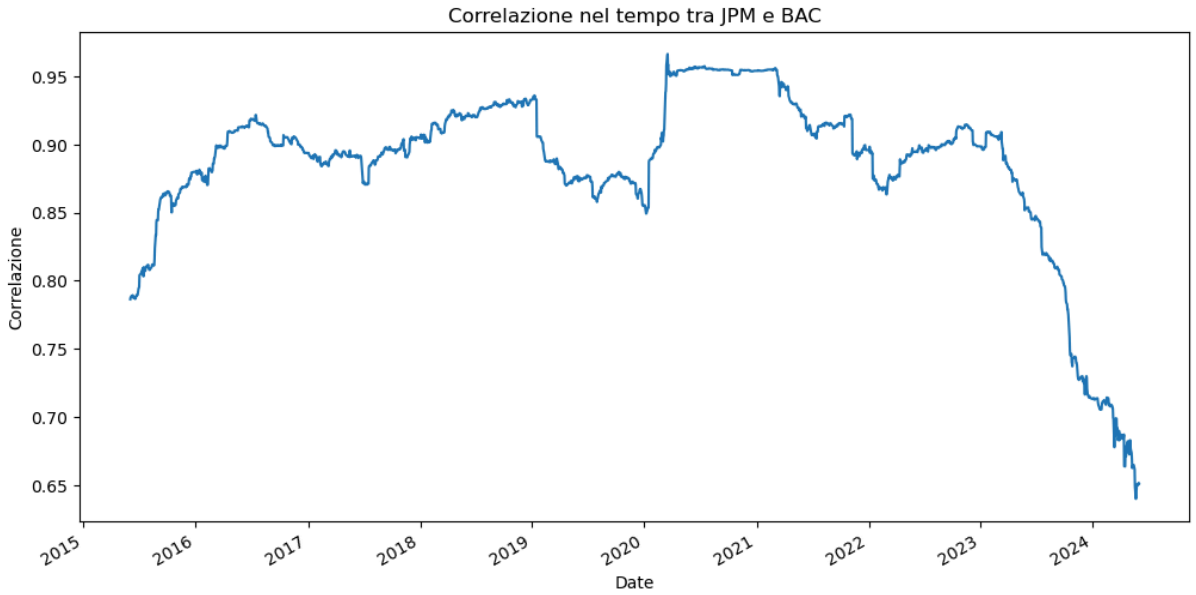

Correlazione nel tempo tra TSLA e F
Correlazione
0.5
0.4
0.3
0.2
0.1
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Date

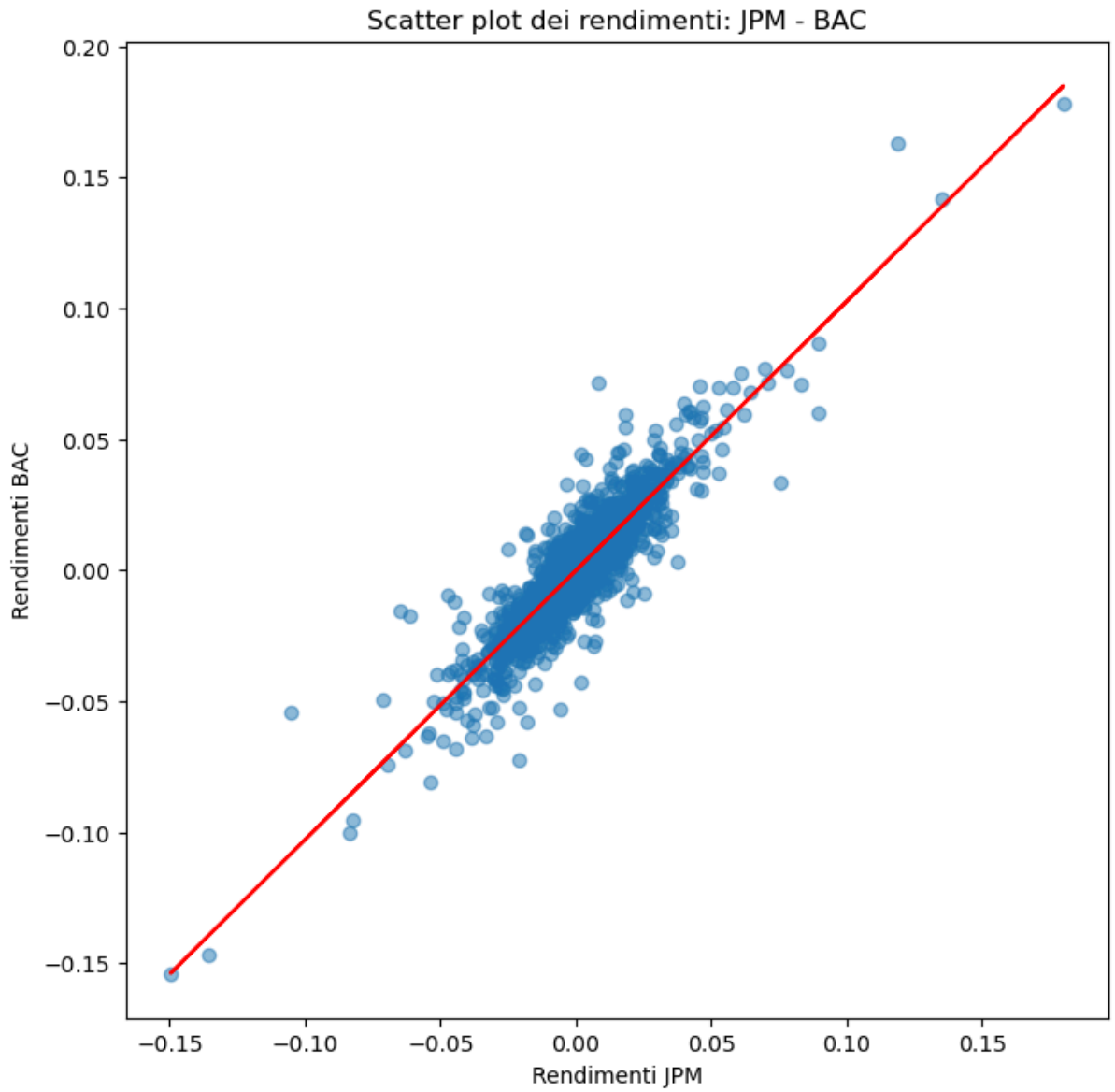

Scatter plot dei rendimenti: TSLA - F
Rendimenti F
0.25
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.2
−0.1
0.0
0.1
0.2
Rendimenti TSLA

## TSLA - F correlation comments

The correlation between TSLA and F has generally been lower; for the first few years, the stocks had a correlation of around 0.4, then dropped below 0.1. There were only two peaks in 2020 and 2023, which peaked at around 0.5. Between these two years, however, there was another drop towards the 2018 lows. We can see that the returns between these two companies, despite belonging to the same sector, were not strongly correlated, which suggests that many of the stocks' returns are subject to events independent of each other.

From the scatter plot, we can notice that the points are not arranged centrally but many are scattered away from the diagonal line, which is still positive but much weaker than that seen on the correlation between NVDA and AAPL.


Correlazione nel tempo tra JPM e BAC
Correlazione
0.95
0.90
0.85
0.80
0.75
0.70
0.65
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Date


Scatter plot dei rendimenti: JPM - BAC
Rendimenti BAC
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.15
−0.10
−0.05
0.00
0.05
0.10
0.15
Rendimenti JPM

# JPM - BAC Correlation Comments

The graph shows that the correlation between JPM and BAC is very strong over time. Until the end of 2016, there was continuous growth, exceeding 0.90. In the following years, the correlation held above 0.85 until 2023. The correlation has generally remained very high, reaching 0.95.

From the scatter plot we can have confirmation, as we have a clear positive linear diagonal with most of the surrounding points close to it, there are very few points that are distant, this leads us to conclude that we have a linear relationship between the two returns, therefore, an increase in one leads to an increase in the other and vice versa.

# Forecast analysis

The Arima (AutoRegressive Integrated Moving Average) model was used to forecast the stock price.

1. First, the data was prepared, taking prices at monthly frequency (last value of each month). Furthermore, to obtain a better forecast, the data was logarithmically transformed.

2. The data was then divided as follows:
   - 80 months for the**training set**
   - 30 months for the**test set**
   - the remaining 10 months for comparison with forecasts

3.To identify the best parameters for the model**ARIMA**the function was used **auto_arima**Imported from the pmdarima library, this allows you to test different parameters and determine the most stable ones for prediction.

4.For training and fitting the model, the function**auto_arima**already provides an automated one with the best parameters and based on the data of the**training set**.

5.Using the specific function I collect the forecasts made on the**test set**, over the entire period.

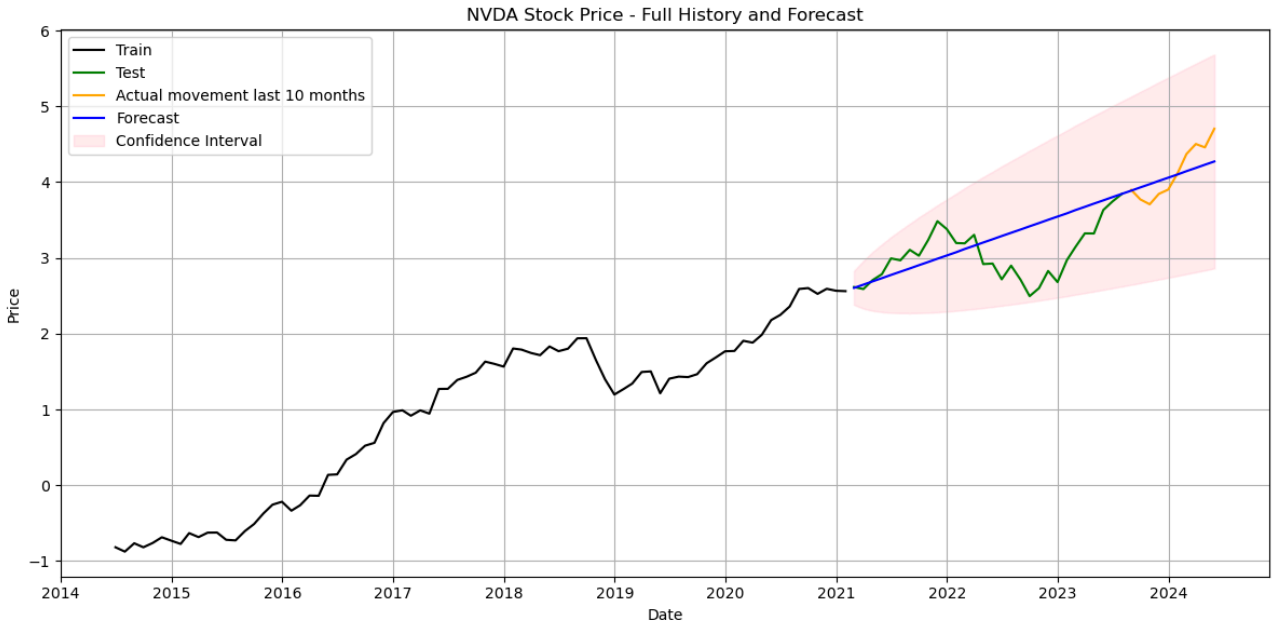
6. I evaluate the results of the forecast taking into account the last 10 months.

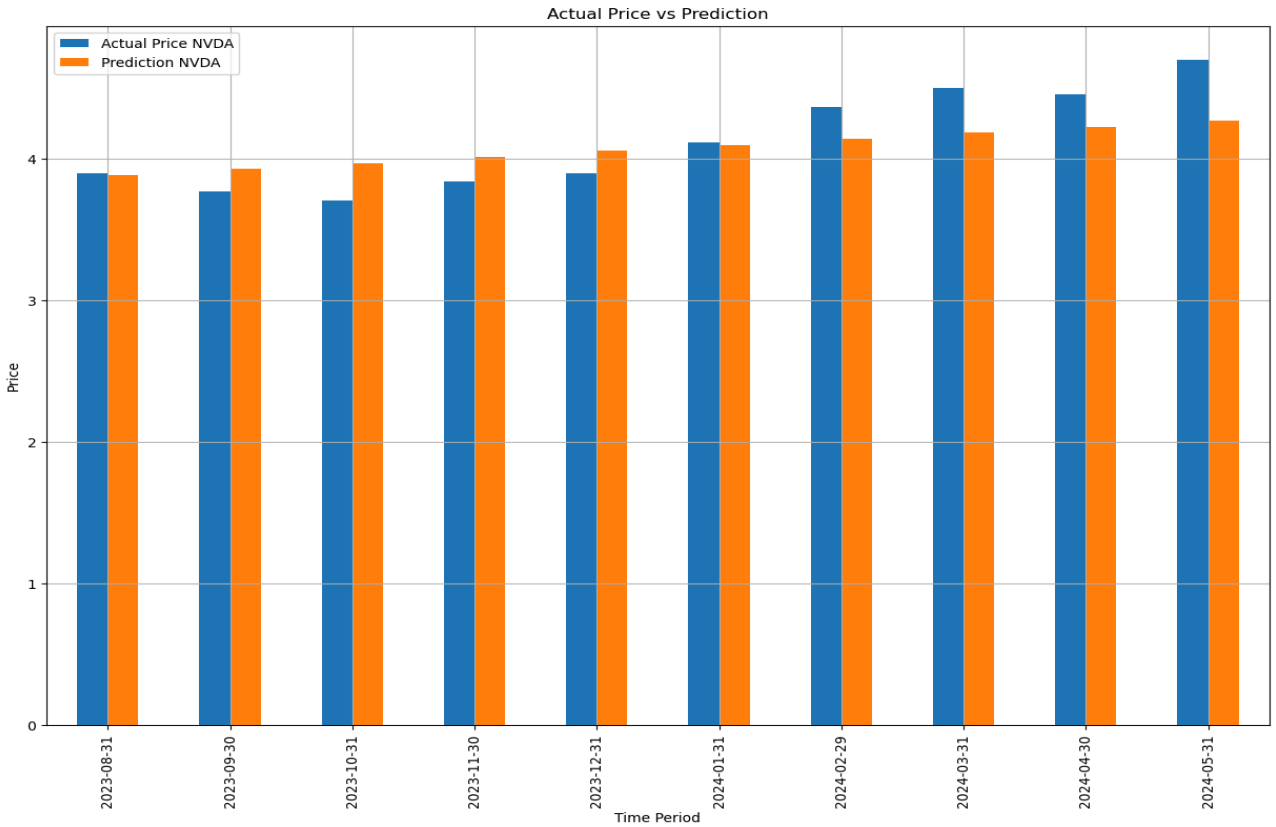
## Model results

### NVIDIA

Best set of parameters found for the model: (0, 1, 0)

- MAE: 0.19827346925679964
- MSE: 0.053972168073191454
- RMSE: 0.23231910828253335

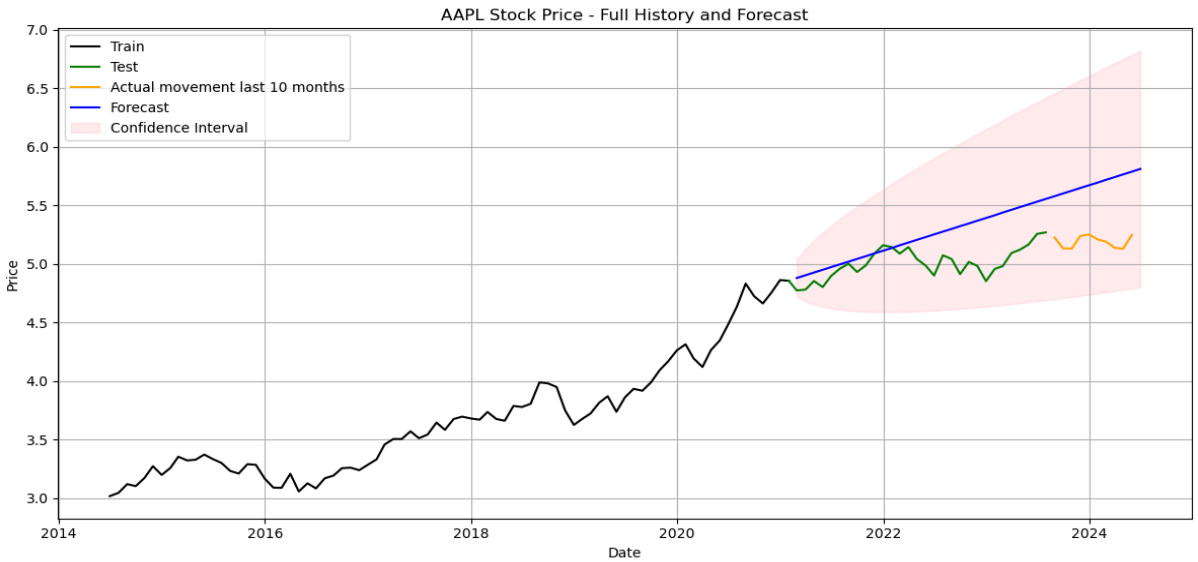

NVDA Stock Price - Full History and Forecast
Train
Test
Actual movement last 10 months
Forecast
Confidence Interval
Price
Date
6
5
4
3
2
1
0
−1
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

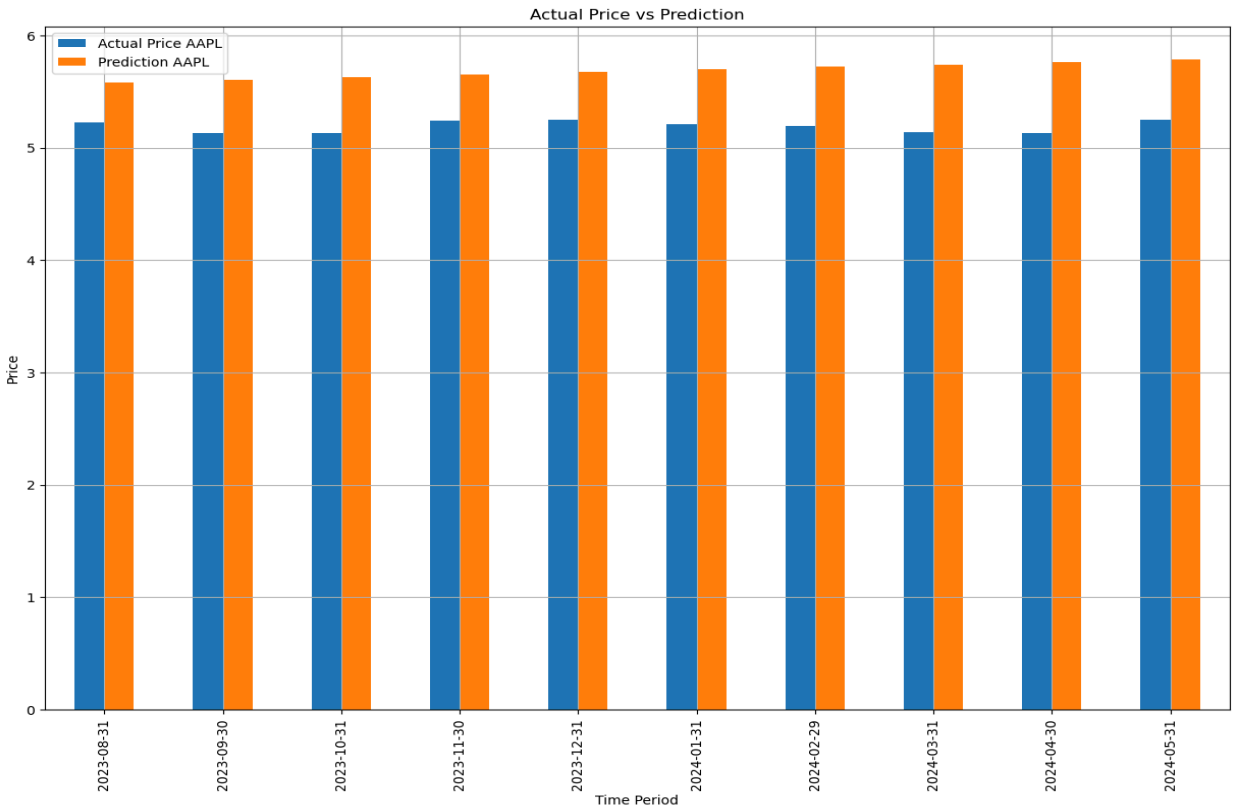

Actual Price vs Prediction
Actual Price NVDA
Prediction NVDA
Price
Time Period
4
3
2
1
0
2023-08-31
2023-09-30
2023-10-31
2023-11-30
2023-12-31
2024-01-31
2024-02-29
2024-03-31
2024-04-30
2024-05-31

## APPLE

Best set of parameters found for the model: (0, 1, 0)

- MAE: 0.4937318649295787
- MSE: 0.25060834322281833
- RMSE: 0.500607973590931

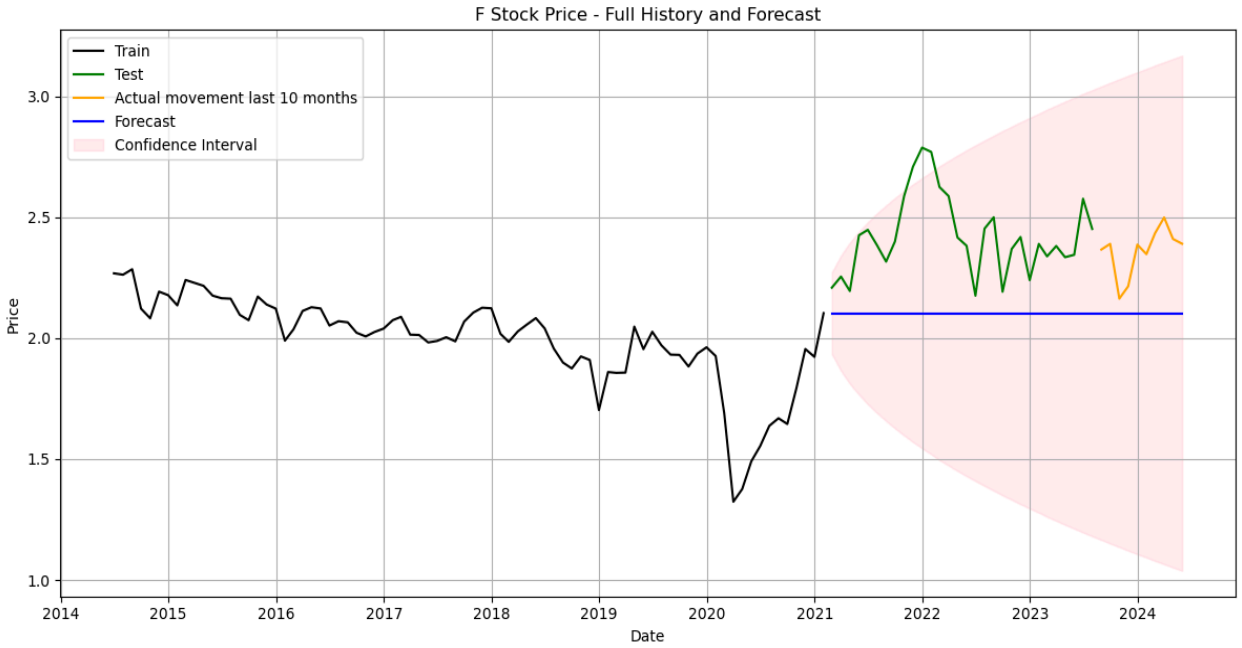


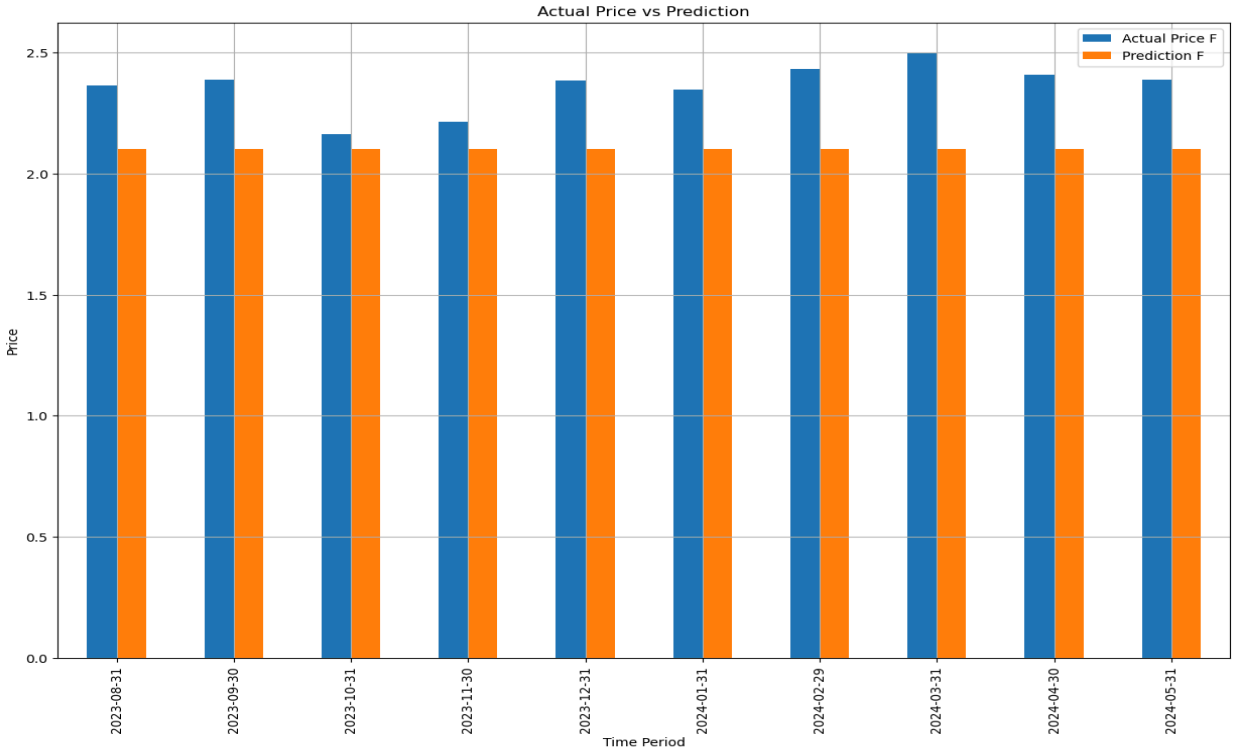



## FORD

Best set of parameters found for the model: (0, 1, 0)

- MAE: 0.2567330042660706
- MSE: 0.07489708815556481
- RMSE: 0.2736733237923726

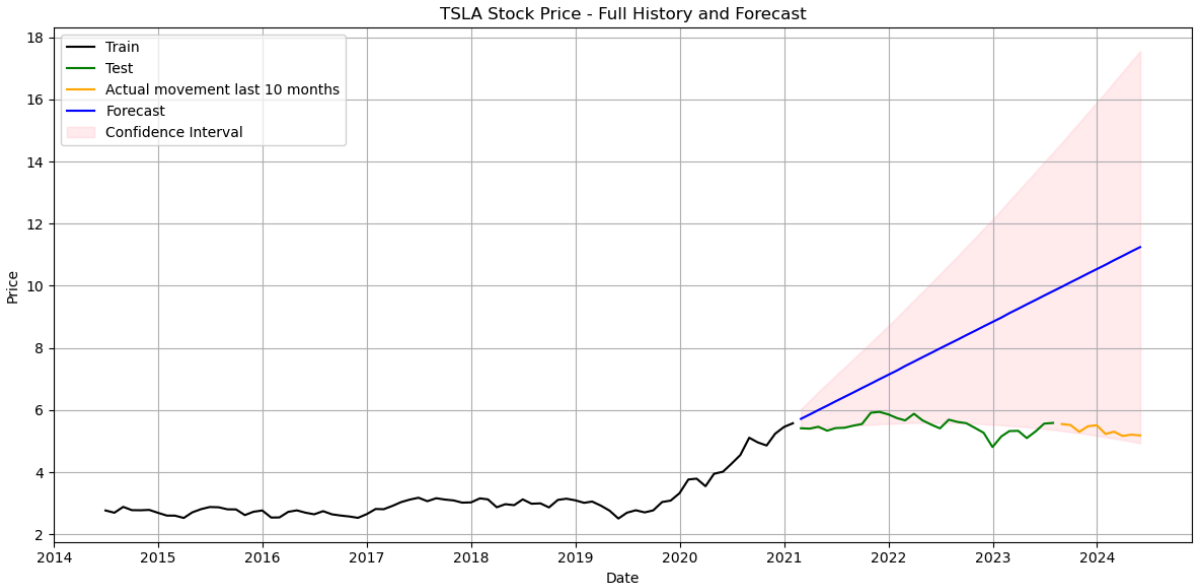


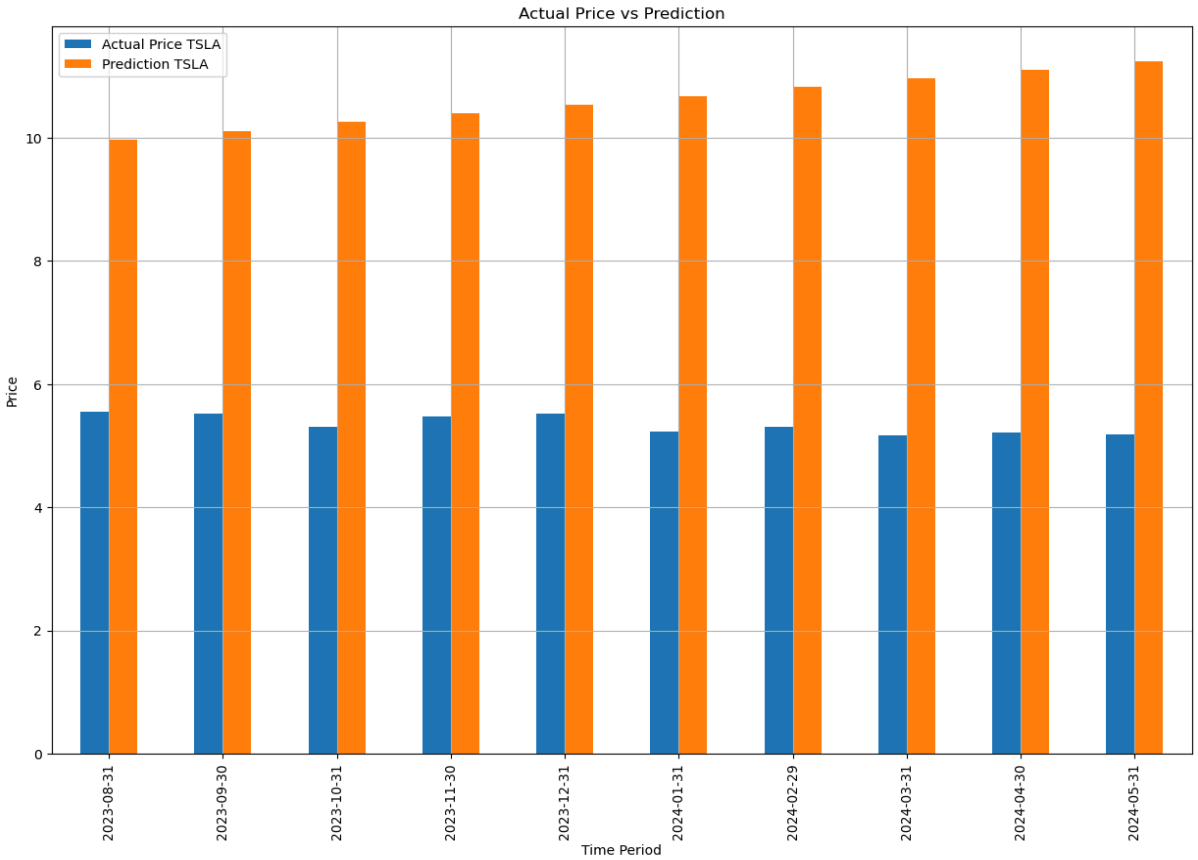



## TESLA

Best set of parameters found for the model: (0, 2, 1)

- MAE: 5.259785426666354
- MSE: 27.950679286546034
- RMSE: 5.286840198695818

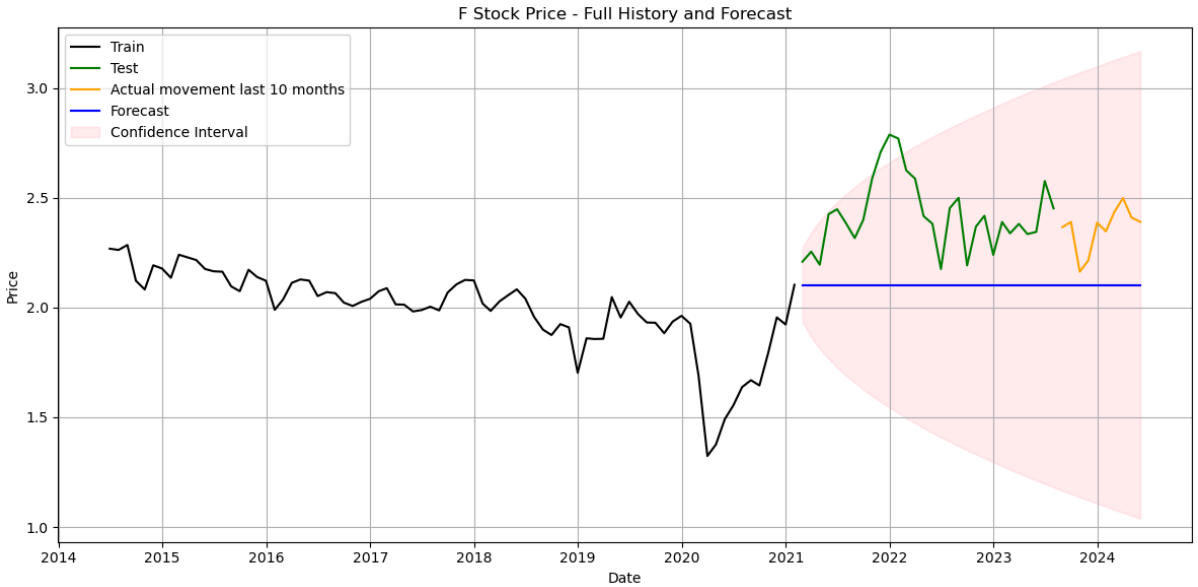


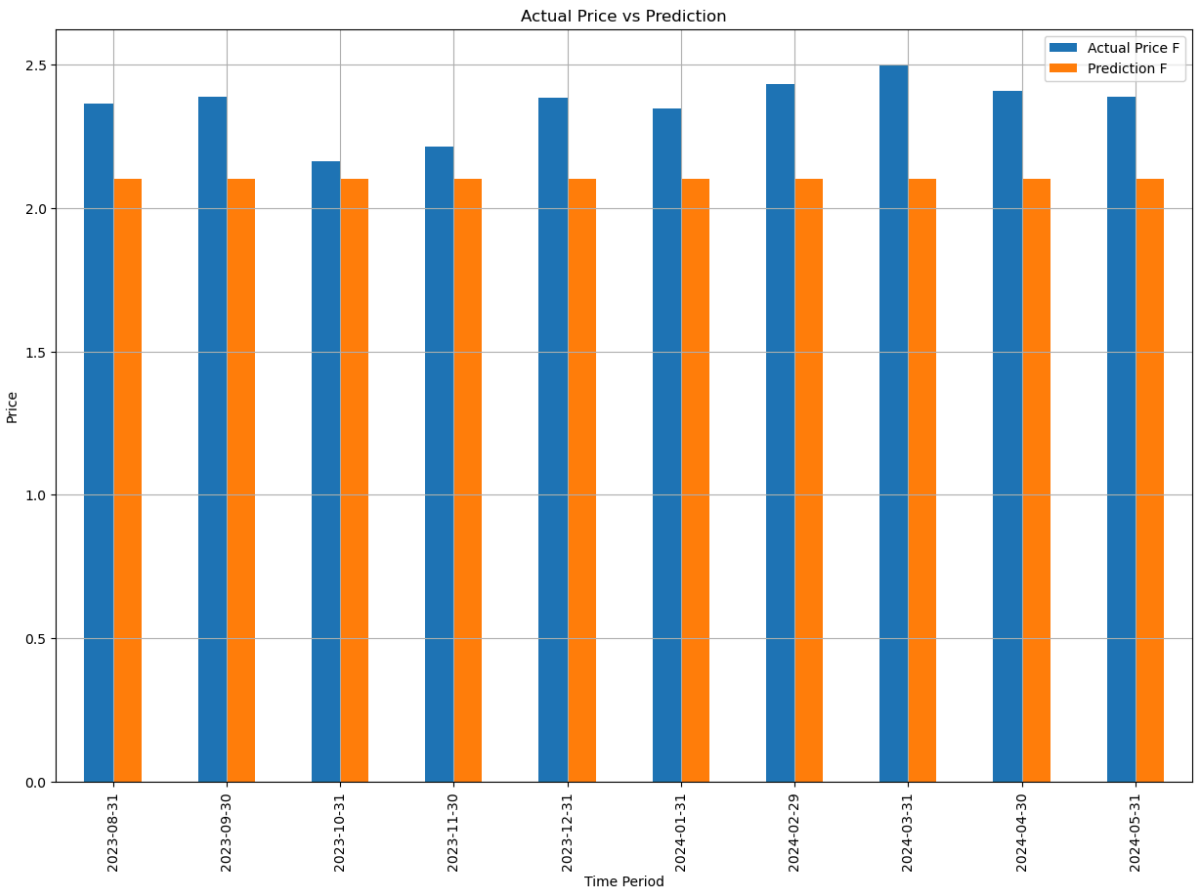



## FORD

Best set of parameters found for the model: (0, 1, 0)

- MAE: 0.2567330042660706
- MSE: 0.07489708815556481
- RMSE: 0.2736733237923726

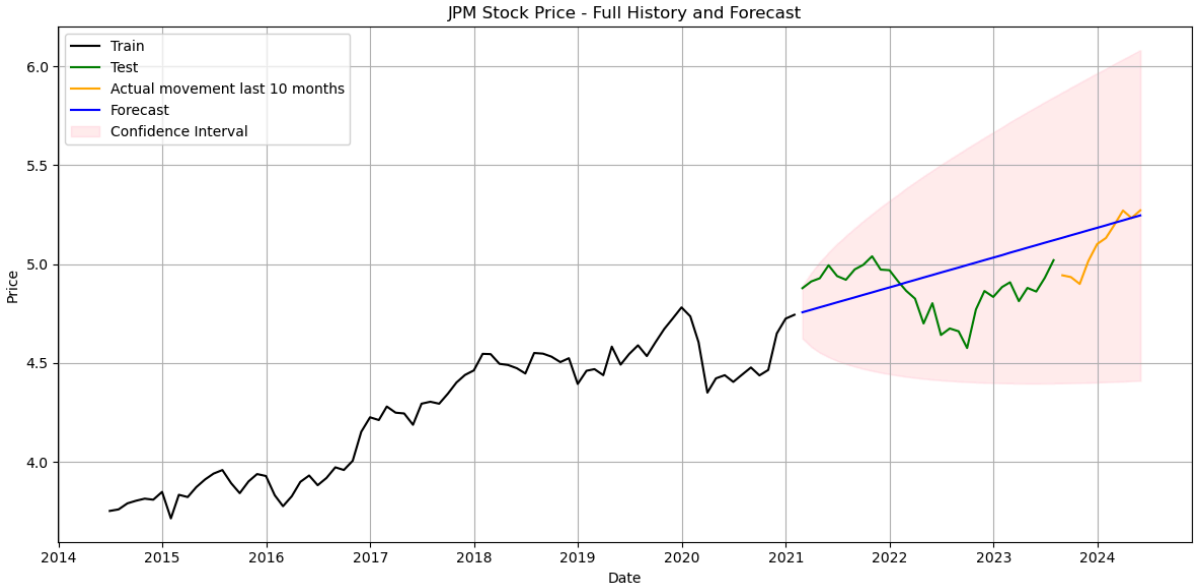


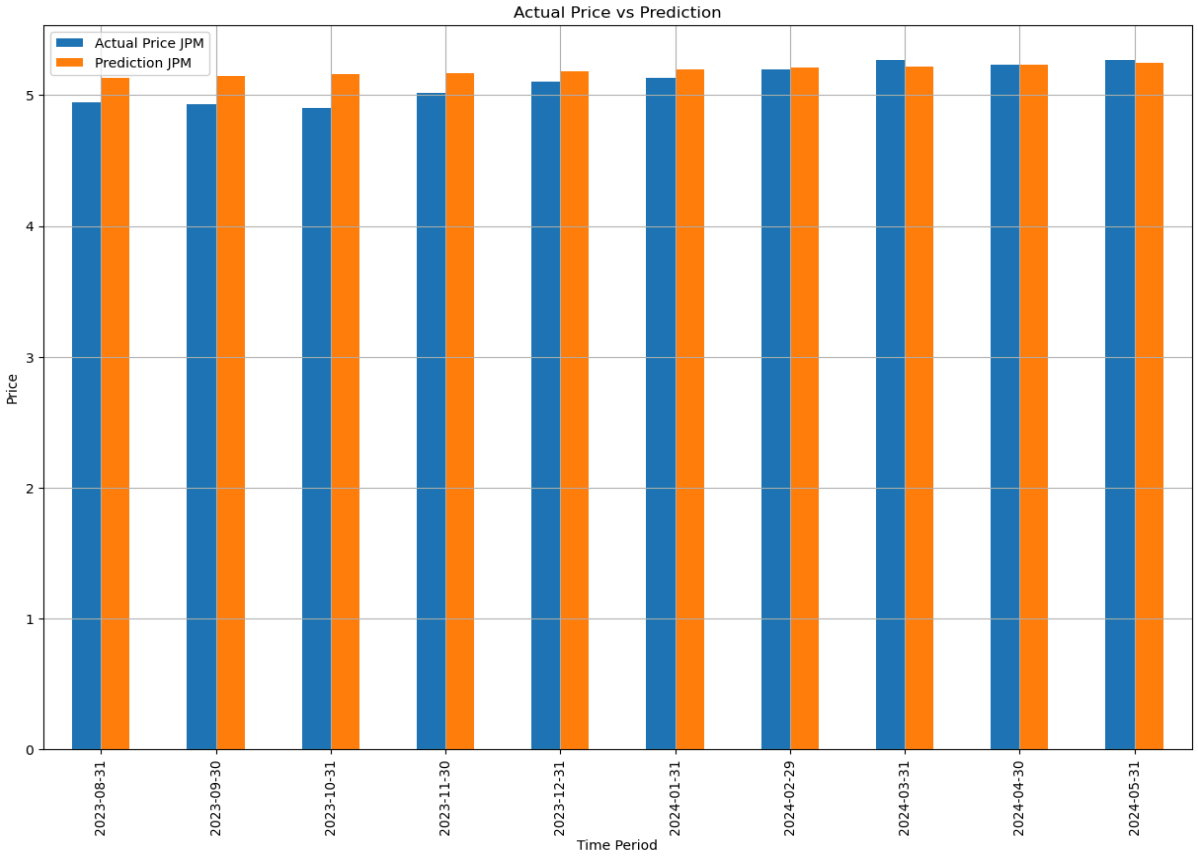



# JP MORGAN

Best set of parameters found for the model: (0, 1, 0)

- MAE: 0.10486659312570365
- MSE: 0.018581532996956678
- RMSE: 0.13631409683872273

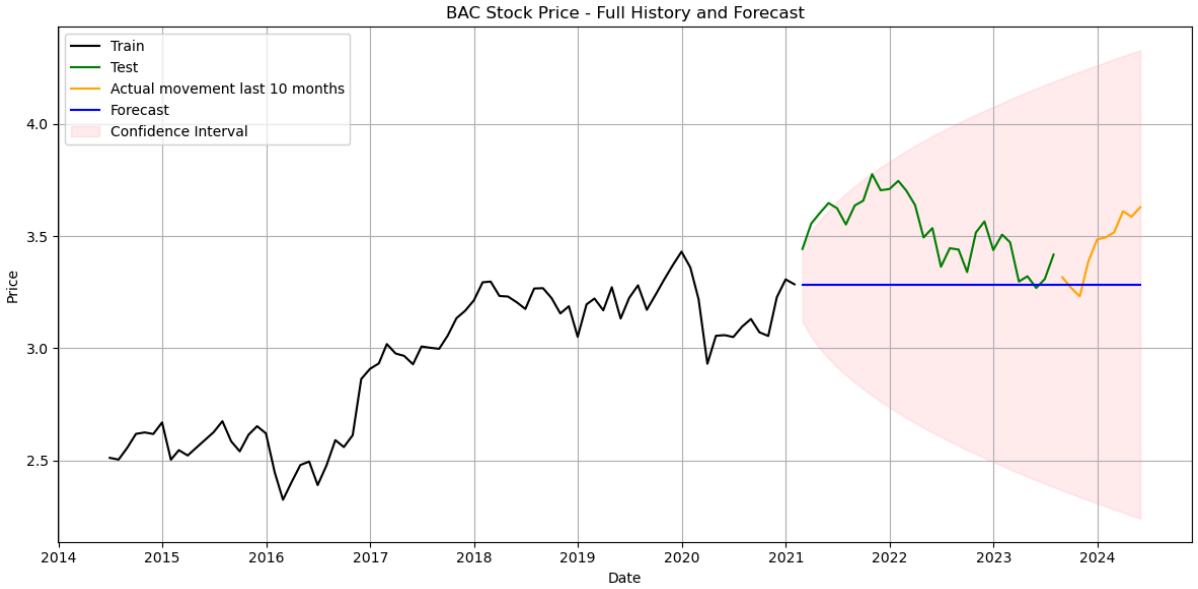


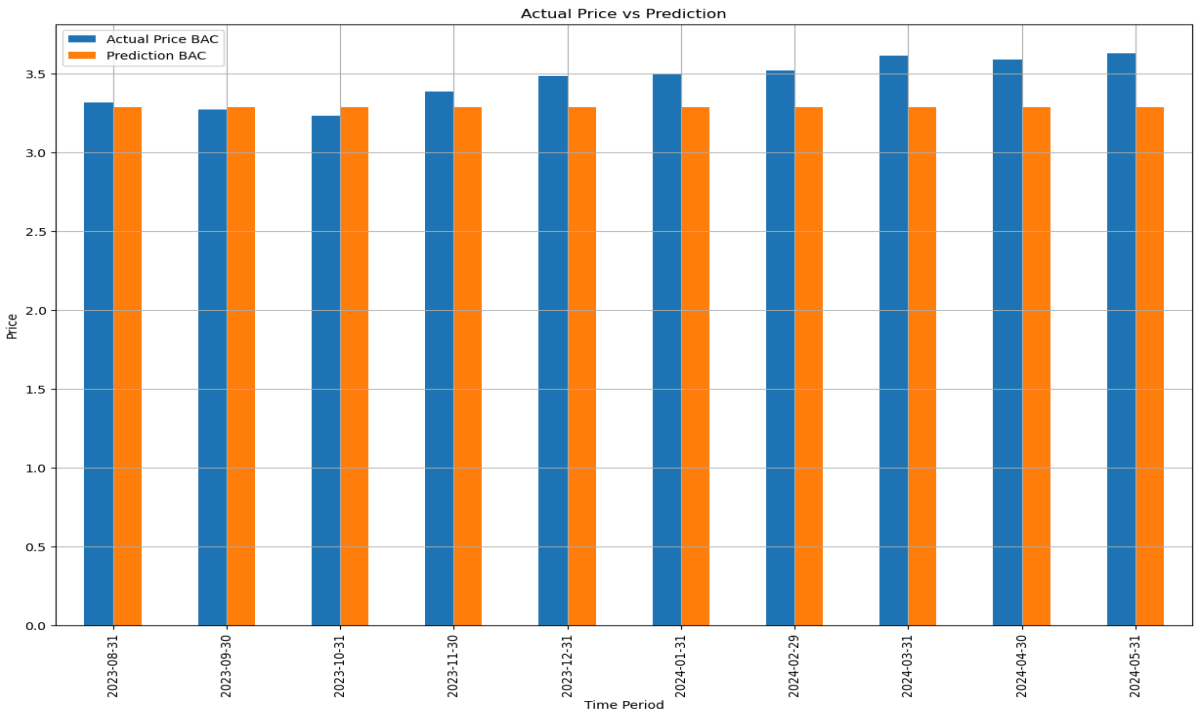



## BANK OF AMERICA

Best set of parameters found for the model: (0, 1, 0)

- MAE: 0.18135829212831847
- MSE: 0.04675818825136885
- RMSE: 0.21623641749568653



### Conclusions

Almost all models do not show high errors, as we can also see from the comparison graph of the forecasts provided by the model with current prices. The only stock that shows a high error is**TSLA,** In fact, you can also notice from the graph that the forecast price is significantly different from the current price of the last 10 months. This may be due to the fact that the stock is the most volatile, with movements that often do not follow the trend of the rest of the market.

# Trading Strategies and Backtesting – Technical Analysis

## SMA Crossover Strategy - NVIDIA

The SMA Crossover Strategy is one of the most widely used techniques in technical analysis for identifying trends and trading signals. It uses two moving averages with different periods to generate buy and sell signals.

I decided to test the strategy on**NVIDIA**as it has had greater upward volatility.

## How it works

Simple moving averages (SMAs) help smooth out price fluctuations, eliminating market noise and revealing trend direction. The strategy involves the use of:

- A short (more reactive) moving average → E.g. 50 days
- A long (slower) moving average → E.g. 200 days

## Trading Signals

1. Buy signal (Golden Cross)

   When the short-term average (e.g. 50-day) crosses above the long-term average (e.g. 200-day), it indicates a potential start of an uptrend.

   - *Example*: If the SMA 50 crosses above the SMA 200 from below, it is a signal to enter long.

2. Sell Signal (Death Cross)

   When the short-term average (e.g. 50-day) crosses downwards the long-term average (e.g. 200-day), it suggests a possible downtrend.

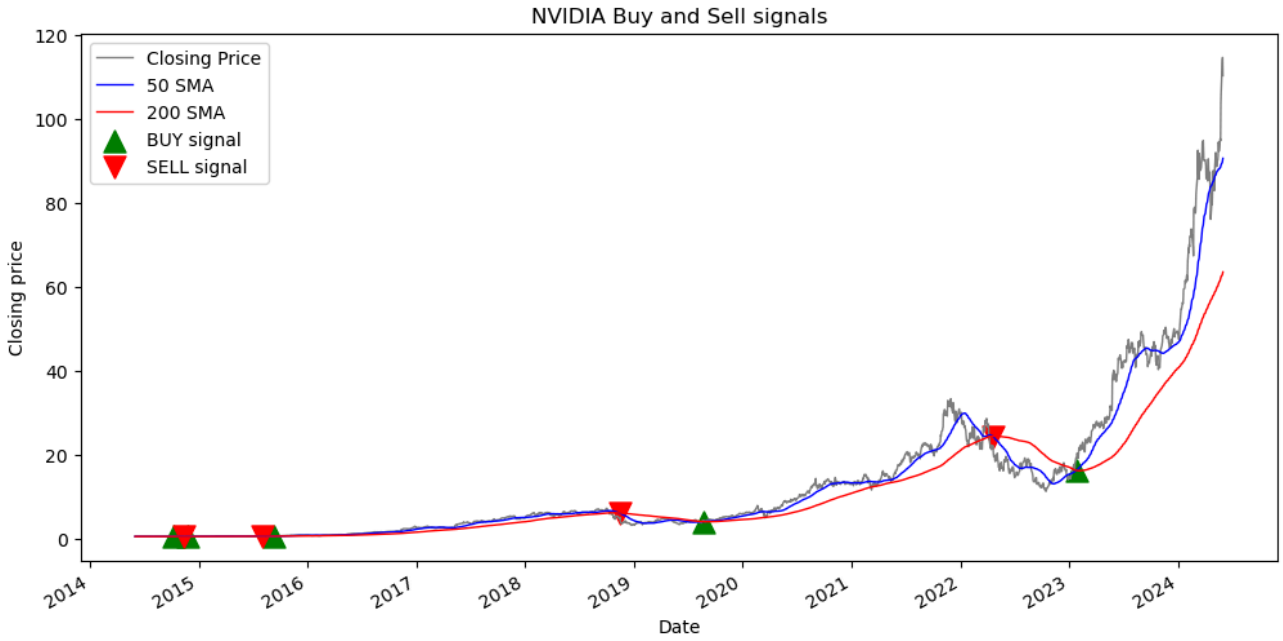
   - *Example*: If the SMA 50 drops below the SMA 200 from above, it is a signal to sell or short.

## Strategy building

To build the strategy, in addition to the short and long average, additional information for the title was provided:

- **Signal:**The value 1 is set if the 50-day SMA is greater than the 200-day SMA, the value 0 is set when the 200-day SMA is greater than the 50-day SMA.
- **Position**: is the day-to-day difference in the 'Signal' column.
- **Trade:**It is generated like the Signal, with the exception of setting the value -1 instead of 0 when the 200-day SMA is higher than the 50-day SMA.
- **Return:**It is generated using the logarithmic return, where first the logarithm of the price is calculated and then the difference between consecutive logarithmic values.
- **Total Returns:**It is the total return, calculated by multiplying the 'Return' and 'Trade' columns.

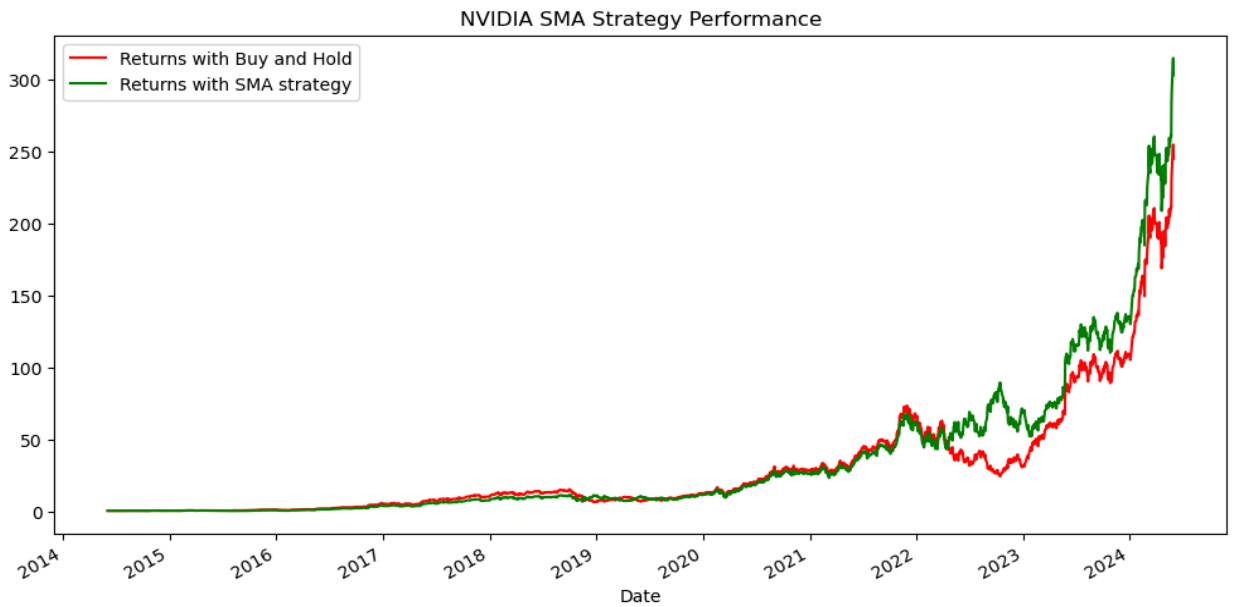
## Strategy graphical display




In the graph in the figure it is possible to observe that when**50 SMA**crosses**200 SMA**upwards, a position is opened**long**with Buy Signal (green triangle pointing upwards) while when the opposite happens, a position is opened**short**with Sell Signal.

### Comparing returns with a BUY & HOLD strategy

NVIDIA Trading System total return: 30283.33%
NVIDIA Hold strategy return: 24513.09%




## Conclusion

From the results obtained we can see that the SMA strategy offers a higher overall return (30283.33%) than the normal Buy & Hold strategy (24513.09%).

Furthermore, we have that the risk measure using this strategy is approximately 0.030. This is considering the NVIDIA stock, but in general, the higher the return, the greater the risk.

However, the strategy depends on the selected stock and it may happen that the BUY & HOLD technique proves more efficient than the constructed trading strategy.

Obviously, relying only on one strategy may not be enough and it is therefore essential to integrate it with other tools (Volume, MACD, RSI, etc.)

# CAPM

The Capital Asset Pricing Model (CAPM) describes the relationship between the expected return on assets and the systematic risk of the market.

The CAPM indicates that the expected return on an asset is equal to the risk-free return plus a risk premium. The CAPM assumes that investors are rational and want to maximize returns and minimize risk. The objective of the CAPM is therefore to calculate the return an investor can expect to earn for a given risk premium relative to the risk-free rate.

We can define the formula for the CAPM as follows:

$$E(R_{the}) = R_f + \beta_{the}( E(R_m) - R_f)$$

Where:

$E(R_{the})$ is the expected return of stock i.

$R_f$it is the risk-free rate

$\beta_{the}$indicates the beta of asset i relative to the market

$E(R_m)$ is the expected return in the market (in this case S&P 500)

## Asset Beta

To calculate the beta, the covariance of the returns R is used.$_{the}$and $R_m$divided by the variance of returns $R_m$

By applying the formula we obtain the following results:

- NVDA beta index: 1.8057870772043347

- Beta Index for AAPL: 1.2379347731675534
- Beta Index for TSLA: 1.8275492832883087
- Beta index for F: 1.47718368903094
- Beta index for JPM: 1.1380748955818132
- Beta index for BAC: 1.404854050167389

Interpretation of the index:

| Value of beta | Effect on correlation and volatility ratio | Interpretation |
|---|---|---|
| $\beta < 0$ | $\rho < 0$, $\frac{\sigma_i}{\sigma_M} > 0$ | Asset moves in the opposite direction of the movement of the market |
| $\beta = 0$ | $\rho = 0$ | Movements of the asset and the market are uncorrelated |
| $0 < \beta \leq 1$ | $\rho > 0$, $0 < \frac{\sigma_i}{\sigma_M} \leq 1/\rho$ | Asset moves in the same direction as the market, volatility of asset can be $<$ or $>$ volatility of market |
| $\beta > 1$ | $\rho > 0$, $\frac{\sigma_i}{\sigma_M} > 1/\rho > 1$ | Asset moves in the same direction as the market but with greater volatility |

## Expected annual returns on securities

To complete the returns formula I recovered the risk-free rate**$R_f$**based on the **Treasury Bill Rate**in the year 2023.

The interest rate**risk-free**searched is equal to 0.0484.

Subsequently, after having also calculated the average market return**S&P 500** annualized (0.12299429408195972), we get the following expected data for the stock:

- Expected returns for NVDA: 0.18310141228638266
- Expected Returns for AAPL: 0.14074287052394457
- Expected Returns for TSLA: 0.18472474868688282
- Expected returns for F: 0.15858947451264807
- Expected returns for JPM: 0.13329389344832537
- Expected returns for BAC: 0.1531940961604184

# Exposure of securities to Fama-French risk factors

The Fama-French model is a method for determining which factors influence returns. In our case, this tool is applied to the returns of a single stock.

We analyze how much of its excess return (compared to the risk-free rate) can be explained by these three factors. This allows us to:

- Understand what factors contribute to stock performance.
- Support more informed stock selection and portfolio construction.

The Fama-French three-factor model predicts:

1. Excess Market Return (Mkt-RF)
    - Calculated as the return of the S&P 500 Index minus the risk-free rate.
    - This factor captures the overall movement of the market.
2. Size factor (SMB, Small Minus Big)
    - Difference between the return on small-cap stocks and that of large-cap stocks.
    - Measures the outperformance of small-caps versus large-caps.
3. Value Factor (HML, High Minus Low)
    - Difference between the return of value stocks (with a low price-to-book ratio) and that of growth stocks (with a high price-to-book ratio).
    - Captures the outperformance of value stocks versus growth stocks.

# Fama-French function

To apply the Fama-French three-factor model on the securities, the library was used **statsmodels**.

- The function**OLS**allows you to specify the function formula
- The model formula is defined as:
    - Dependent variable (Y): Excess returns of the security (over the risk-free rate).
    - Independent variables (X): The three Fama-French factors (Mkt-RF, SMB, HML).

## Stock exposure analysis

### NVIDIA

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Excess_Return   R-squared:                       0.419
Model:                            OLS   Adj. R-squared:                  0.404
Method:                 Least Squares   F-statistic:                     27.70
Date:                Fri, 16 May 2025   Prob (F-statistic):           1.49e-13
Time:                        01:09:33   Log-Likelihood:                 101.79
No. Observations:                 119   AIC:                            -195.6
Df Residuals:                     115   BIC:                            -184.5
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0364      0.010      3.685      0.000       0.017       0.056
Mkt-RF         1.7884      0.220      8.130      0.000       1.353       2.224
SMB           -0.0938      0.367     -0.256      0.799      -0.821       0.634
HML           -0.9300      0.257     -3.612      0.000      -1.440      -0.420
==============================================================================
Omnibus:                        6.764   Durbin-Watson:                   1.839
Prob(Omnibus):                  0.034   Jarque-Bera (JB):                6.395
Skew:                           0.473   Prob(JB):                       0.0409
Kurtosis:                       3.628   Cond. No.                         39.3
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

NVIDIA is a high-risk, high-reward stock (high beta + positive alpha). Its performance is driven primarily by the market (Market-Return) and its growth nature (negative HML), not by size. The significant alpha suggests that NVIDIA may have a competitive advantage or exceed expected growth.

## APPLE

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Excess_Return   R-squared:                       0.535
Model:                            OLS   Adj. R-squared:                  0.523
Method:                 Least Squares   F-statistic:                     44.16
Date:                Fri, 16 May 2025   Prob (F-statistic):           4.62e-19
Time:                        01:09:52   Log-Likelihood:                 176.83
No. Observations:                 119   AIC:                            -345.7
Df Residuals:                     115   BIC:                            -334.6
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0078      0.005      1.479      0.142      -0.003       0.018
Mkt-RF         1.2404      0.117     10.594      0.000       1.008       1.472
SMB           -0.2197      0.195     -1.124      0.263      -0.607       0.167
HML           -0.5663      0.137     -4.132      0.000      -0.838      -0.295
==============================================================================
Omnibus:                        9.597   Durbin-Watson:                   2.128
Prob(Omnibus):                  0.008   Jarque-Bera (JB):               11.886
Skew:                          -0.466   Prob(JB):                      0.00262
Kurtosis:                       4.237   Cond. No.                         39.3
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

Apple is a less risky and more predictable stock than NVIDIA but still market-sensitive.
It does not offer "free" outperformance, but it is well explained by systematic risk factors.

Suitable for portfolios seeking stability with moderate growth exposure.

## TESLA

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Excess_Return   R-squared:                       0.291
Model:                            OLS   Adj. R-squared:                  0.273
Method:                 Least Squares   F-statistic:                     15.74
Date:                Fri, 16 May 2025   Prob (F-statistic):           1.21e-08
Time:                        01:09:53   Log-Likelihood:                 57.701
No. Observations:                 119   AIC:                            -107.4
Df Residuals:                     115   BIC:                            -96.29
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0158      0.014      1.104      0.272      -0.013       0.044
Mkt-RF         1.7598      0.319      5.523      0.000       1.129       2.391
SMB            0.7001      0.532      1.316      0.191      -0.353       1.754
HML           -1.0736      0.373     -2.879      0.005      -1.812      -0.335
==============================================================================
Omnibus:                       21.127   Durbin-Watson:                   1.843
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               30.860
Skew:                           0.876   Prob(JB):                     1.99e-07
Kurtosis:                       4.777   Cond. No.                         39.3
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

Tesla is a bet on extreme growth and the EV sector, with high volatility. Less suited to conservative portfolios, better suited to tactical or speculative strategies.

It also requires further monitoring of non-systematic factors.

## FORD

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Excess_Return   R-squared:                       0.480
Model:                            OLS   Adj. R-squared:                  0.466
Method:                 Least Squares   F-statistic:                     35.36
Date:                Fri, 16 May 2025   Prob (F-statistic):           2.87e-16
Time:                        01:09:53   Log-Likelihood:                 140.78
No. Observations:                 119   AIC:                            -273.6
Df Residuals:                     115   BIC:                            -262.4
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.0056      0.007     -0.785      0.434      -0.020       0.009
Mkt-RF         1.3430      0.159      8.472      0.000       1.029       1.657
SMB            0.5054      0.265      1.910      0.059      -0.019       1.030
HML            0.5762      0.186      3.106      0.002       0.209       0.944
==============================================================================
Omnibus:                        6.873   Durbin-Watson:                   2.062
Prob(Omnibus):                  0.032   Jarque-Bera (JB):                6.604
Skew:                           0.465   Prob(JB):                       0.0368
Kurtosis:                       3.684   Cond. No.                         39.3
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

Ford is a value option (suitable for those looking for "undervalued" stocks with dividend yields).

Less volatile than Tesla/Nvidia, but riskier than Apple. Ideal in growth-to-value rotation scenarios or economic recovery.

## BAC

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Excess_Return   R-squared:                       0.762
Model:                            OLS   Adj. R-squared:                  0.756
Method:                 Least Squares   F-statistic:                     123.0
Date:                Fri, 16 May 2025   Prob (F-statistic):           9.80e-36
Time:                        01:09:53   Log-Likelihood:                 210.05
No. Observations:                 119   AIC:                            -412.1
Df Residuals:                     115   BIC:                            -401.0
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0014      0.004      0.355      0.723      -0.006       0.009
Mkt-RF         1.3397      0.089     15.127      0.000       1.164       1.515
SMB            0.1107      0.148      0.749      0.455      -0.182       0.404
HML            1.0285      0.104      9.922      0.000       0.823       1.234
==============================================================================
Omnibus:                        1.983   Durbin-Watson:                   1.890
Prob(Omnibus):                  0.371   Jarque-Bera (JB):                1.589
Skew:                          -0.078   Prob(JB):                        0.452
Kurtosis:                       3.544   Cond. No.                         39.3
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

Bank of America is ideal for value/dividend portfolios, offering exposure to the financial sector with lower volatility than technology. It benefits from value-growth rotations when value stocks are favored (e.g., during interest rate hikes). The model's high efficiency makes it suitable for quantitative strategies, with predictable returns well explained by market factors.

## JPM

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          Excess_Return   R-squared:                       0.749
Model:                            OLS   Adj. R-squared:                  0.742
Method:                 Least Squares   F-statistic:                     114.4
Date:                Fri, 16 May 2025   Prob (F-statistic):           2.26e-34
Time:                        01:09:53   Log-Likelihood:                 230.68
No. Observations:                 119   AIC:                            -453.4
Df Residuals:                     115   BIC:                            -442.3
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0056      0.003      1.674      0.097      -0.001       0.012
Mkt-RF         1.0850      0.074     14.571      0.000       0.938       1.233
SMB            0.0598      0.124      0.481      0.632      -0.186       0.306
HML            0.8497      0.087      9.748      0.000       0.677       1.022
==============================================================================
Omnibus:                        0.378   Durbin-Watson:                   1.833
Prob(Omnibus):                  0.828   Jarque-Bera (JB):                0.371
Skew:                          -0.130   Prob(JB):                        0.831
Kurtosis:                       2.915   Cond. No.                         39.3
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

Unlike BAC, JPM is a more stable bank with a less extreme value profile, suitable for those seeking a compromise between returns and risk.

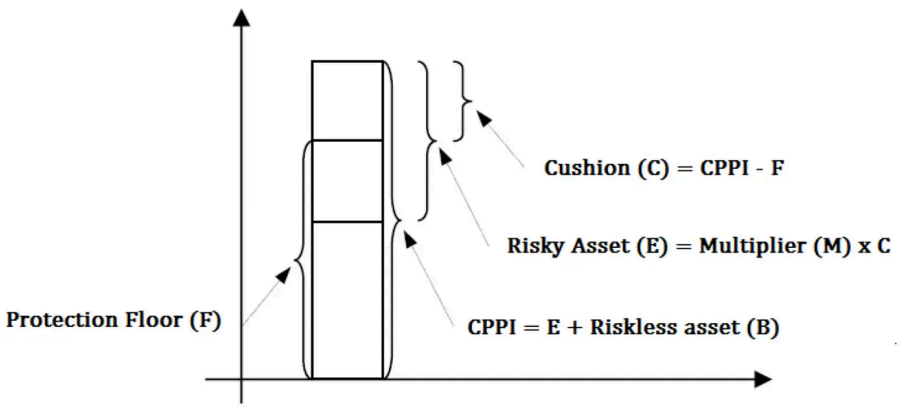
# Trading strategies and backtesting – Dynamic CPPI and TIPP strategies

The**Constant Proportion Portfolio Insurance**(CPPI) and the**Time-Invariant Portfolio Protection**(TIPPs are two of the most popular portfolio insurance strategies that play an important role in investment management and risk mitigation. These strategies are designed to address the fundamental challenge of balancing the pursuit of financial growth with the primary goal of protecting capital from market downturns.

The difference between the two is that while in the CPPI the floor grows at a rate**constant**, in the TIPP is a function of the portfolio value and therefore has a nature**path-dependent**.

## How it works

A portion of your portfolio is allocated to risky assets, in a multiple (M) of the difference between the value of the assets (AV) and a pre-established floor (F), while the remainder is allocated to risk-free assets.



The**floor**It is necessary to keep the value of the investment at a certain minimum and prevent possible downward volatility.
Parameters:

**- m:**allows you to set the level of aggressiveness of the strategy.

**- F:**This parameter defines the percentage of the floor that the CPPI strategy must maintain.

**- cppi budget:**the budget to allocate to the strategy.

- **safe_asset_rate:**The rate of return earned on the portion of the portfolio invested in risk-free assets (e.g. T-Bill).

## CPPI Algorithm in 5 Steps

1. Calculate the cushion value: C = CPPI - F

2. Calculate the allocation to the risky asset: E = C × m

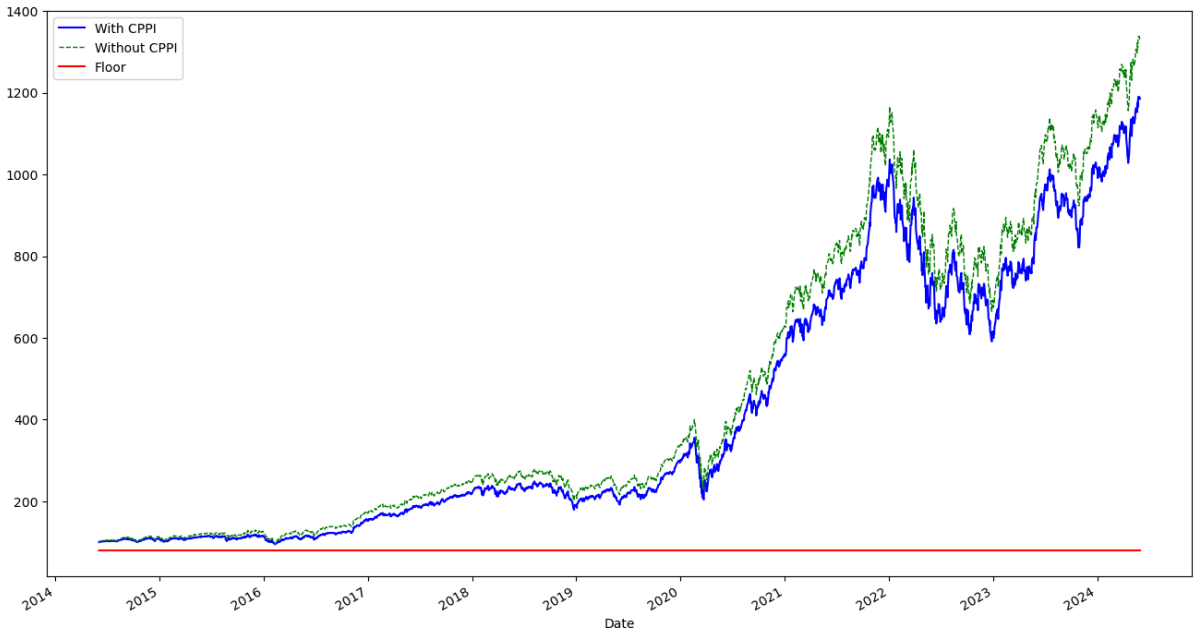
3. Calculate the allocation to the safe asset, which is the remainder: B = CPPI - E

4. Calculate the growth of your risky and safe allocations:

$$CPPI = E \times (1 + \text{risky asset price change}) + B \times (1 + \text{safe asset return})$$

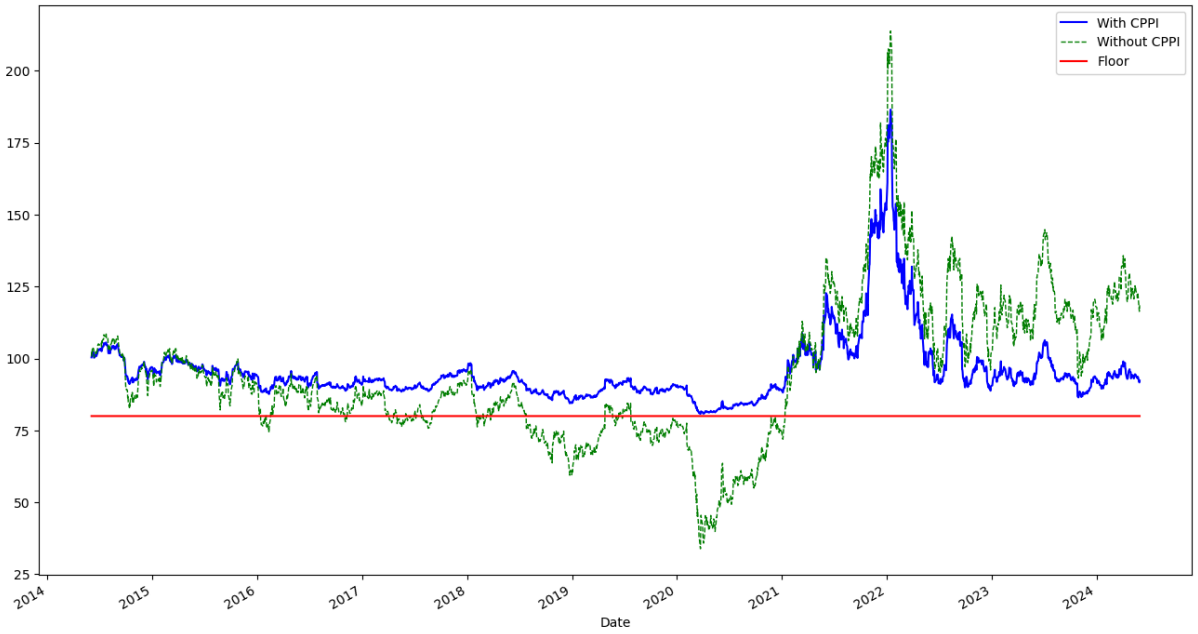
# CPPI Results

CPPI on portfolio:




We can observe that by exploiting the CPPI strategy it is possible to protect the portfolio from any downside, to have a more detailed view, a specific asset of the portfolio that has had the greatest downward volatility is selected,**FORD.**

CPPI on single asset (FORD):




From this chart we can see the effect that the use of the CPPI guarantees: the floor (RED LINE) is never broken downwards, which allows for the mitigation of losses from sudden changes in trend in the market.

One disadvantage is that once the portfolio's value reaches new highs, the likelihood of a decline sufficient to breach the initially set floor is dramatically reduced—in the short term, this is almost impossible. As a result, one would find oneself entirely invested in risky assets.

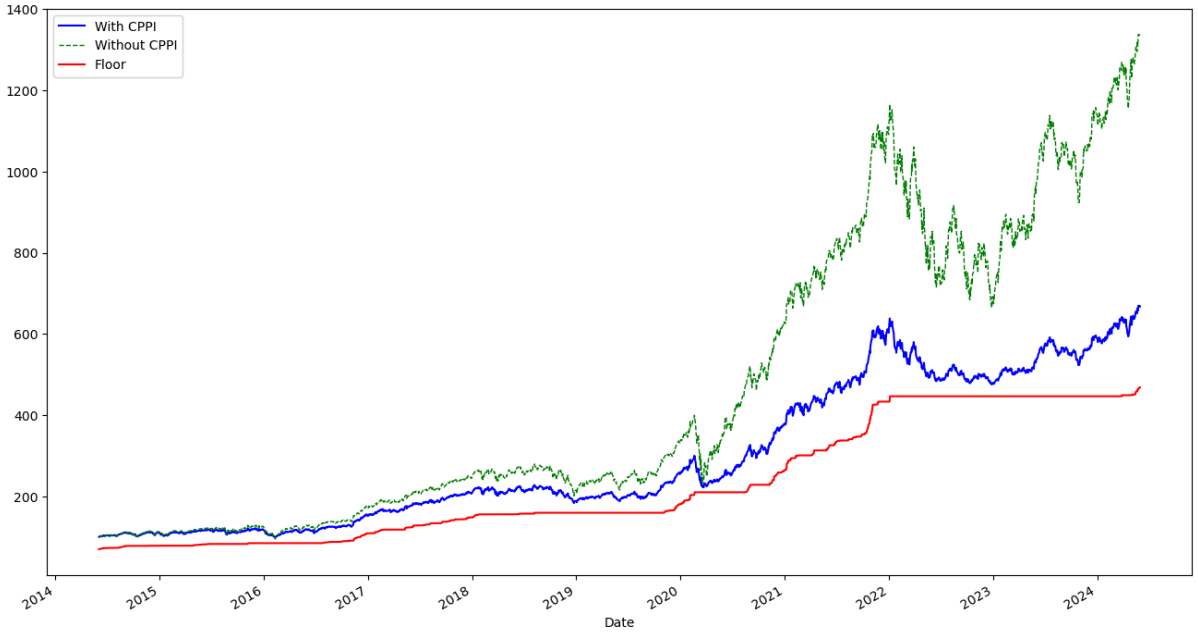
It would be more logical to adjust the floor based on the portfolio's performance.

# TIPP variant

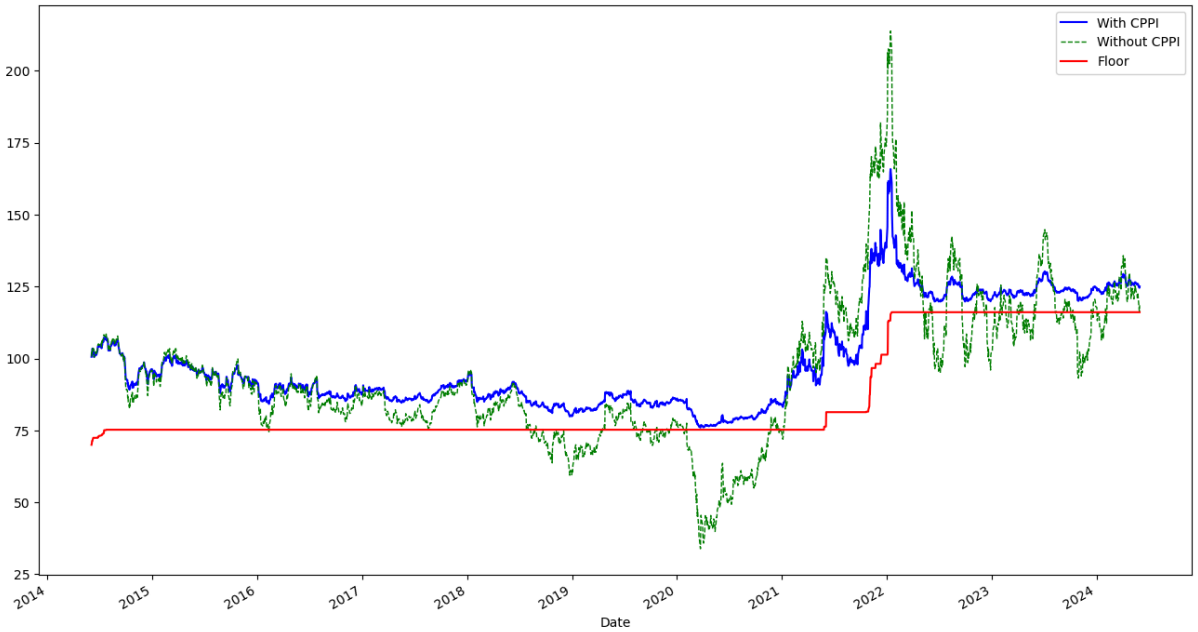
The strategy**TIPP**It is useful for remedying the disadvantage of the CPPI and therefore allows the floor to be made "dynamic", the latter being increased based on the previous maximum portfolio value and not the first.

# TIPP Results

TIPP on wallet:




TIPP on single asset:



## Conclusions

We observe that by using a dynamic floor, the portfolio investments are further “strengthened”, preventing possible downsides from bringing profits back towards the initial floor.

You can vary the parameters of the function, and observe how the**floor**and the **multiplier** can significantly influence the strategy's reaction.