Final Project Report

Introduction to Bloomberg & Thomson-Reuters

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Assumption

The goal of this project is to evaluate the relationship between changes in Federal Reserve interest rates and the monthly returns of the S&P 500 index over the past 10 years. Specifically, the assumption is that changes in interest rates have a measurable impact on S&P 500 returns, with the hypothesis that increases in interest rates negatively affect stock market returns.

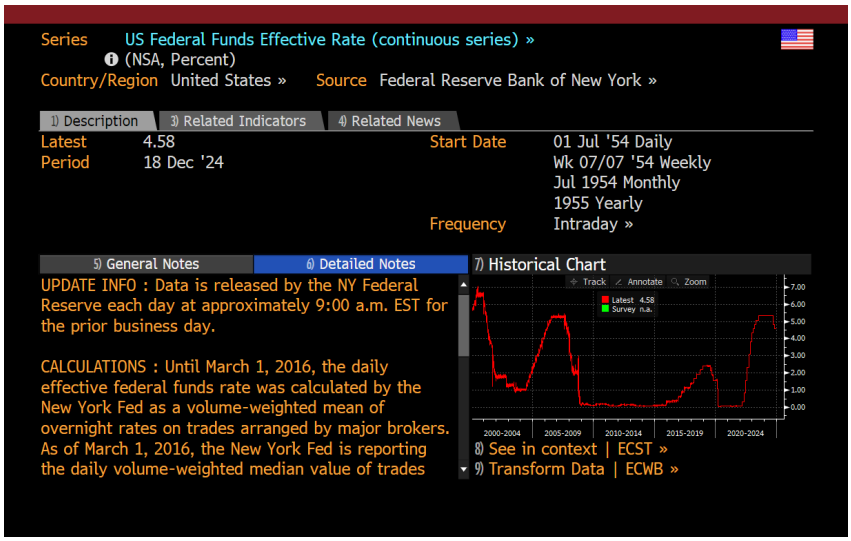
Data Sources and Gathering Process

Data Selection

To evaluate the assumption, the following datasets were required:

1. **S&P 500 Historical Prices:** monthly closing prices of the S&P 500 index for the past 10 years.

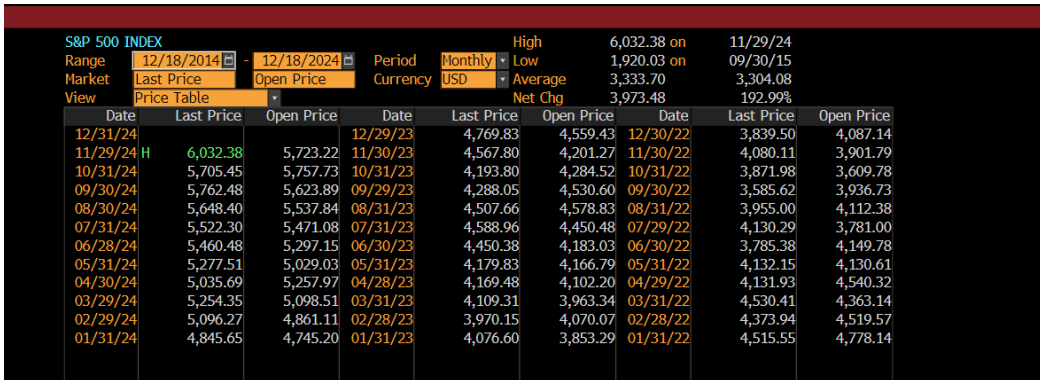
2. **Federal Reserve Interest Rate Changes:** Historical data on interest rate changes by the Federal Reserve over the same 10-year period.



Data Sources

1. S&P 500 Data:

- Data was obtained from the Bloomberg Terminal. Using the ticker symbol for the S&P 500 index ("SPX"), monthly historical closing prices and percentage changes were exported. [SPX INDEX HP]
- Relevant fields included:
  - PX_LAST: The closing price of the S&P 500.
  - PX_OPEN



S&P 500 INDEX — High 6,032.38 on 11/29/24 — Low 1,920.03 on 09/30/15 — Average 3,333.70 — 3,304.08 — Net Chg 3,973.48 — 192.99%

Range 12/18/2014 - 12/18/2024 — Period Monthly — Market Last Price — Open Price — Currency USD — View Price Table

Date	Last Price	Open Price	Date	Last Price	Open Price	Date	Last Price	Open Price
12/31/24			12/29/23	4,769.83	4,559.43	12/30/22	3,839.50	4,087.14
11/29/24 H	6,032.38	5,723.22	11/30/23	4,567.80	4,201.27	11/30/22	4,080.11	3,901.79
10/31/24	5,705.45	5,757.73	10/31/23	4,193.80	4,284.52	10/31/22	3,871.98	3,609.78
09/30/24	5,762.48	5,623.89	09/29/23	4,288.05	4,530.60	09/30/22	3,585.62	3,936.73
08/30/24	5,648.40	5,537.84	08/31/23	4,507.66	4,578.83	08/31/22	3,955.00	4,112.38
07/31/24	5,522.30	5,471.08	07/31/23	4,588.96	4,450.48	07/29/22	4,130.29	3,781.00
06/28/24	5,460.48	5,297.15	06/30/23	4,450.38	4,183.03	06/30/22	3,785.38	4,149.78
05/31/24	5,277.51	5,029.03	05/31/23	4,179.83	4,166.79	05/31/22	4,132.15	4,130.61
04/30/24	5,035.69	5,257.97	04/28/23	4,169.48	4,102.20	04/29/22	4,131.93	4,540.32
03/29/24	5,254.35	5,098.51	03/31/23	4,109.31	3,963.34	03/31/22	4,530.41	4,363.14
02/29/24	5,096.27	4,861.11	02/28/23	3,970.15	4,070.07	02/28/22	4,373.94	4,519.57
01/31/24	4,845.65	4,745.20	01/31/23	4,076.60	3,853.29	01/31/22	4,515.55	4,778.14

2. Interest Rate Data:

- Data on Federal Reserve interest rate changes was also sourced from the Bloomberg Terminal. Using appropriate Bloomberg queries, historical rate changes and their respective dates were exported. [FDL01 INDEX HP]
- The exported data included:
  - PX_LAST: The latest Federal interest rate on a given day.
  - CHG_PCT_1D: monthly percentage change in the index.

US Federal Funds Effective Rate (continuous series) — High 5.33 on 08/31/23 — Low 0.05 on 04/30/20 — Average 1.75 — 6.90 — Net Chg 4.52 — 3766.67%

Range 12/18/2014 - 12/18/2024 — Period Monthly — Market Last Price — Price Change 1 — Currency USD — View Price Table

Date	Last Price	Price Cha...	Date	Last Price	Price Cha...	Date	Last Price	Price Cha...
12/31/24			12/31/23	5.33	0.00	12/31/22	4.10	8.47
11/30/24	4.64	-3.93	11/30/23	5.33	0.00	11/30/22	3.78	22.73
10/31/24	4.83	-5.85	10/31/23	5.33	0.00	10/31/22	3.08	20.31
09/30/24	5.13	-3.75	09/30/23	5.33	0.00	09/30/22	2.56	9.87
08/31/24	5.33	0.00	08/31/23 H	5.33	4.10	08/31/22	2.33	38.69
07/31/24	5.33	0.00	07/31/23	5.12	0.79	07/31/22	1.68	38.84
06/30/24	5.33	0.00	06/30/23	5.08	0.40	06/30/22	1.21	57.14
05/31/24	5.33	0.00	05/31/23	5.06	4.76	05/31/22	0.77	133.33
04/30/24	5.33	0.00	04/30/23	4.83	3.87	04/30/22	0.33	65.00
03/31/24	5.33	0.00	03/31/23	4.65	1.75	03/31/22	0.20	150.00
02/29/24	5.33	0.00	02/28/23	4.57	5.54	02/28/22	0.08	0.00
01/31/24	5.33	0.00	01/31/23	4.33	5.61	01/31/22	0.08	0.00

Data Preparation

1. Data from both sources was exported as separate CSV files.
2. In Python, the datasets were loaded into Pandas DataFrames.
3. Dates were converted to a uniform datetime format to ensure proper merging of the datasets.
4. The datasets were merged based on the Date column, aligning the monthly S&P 500 returns with corresponding interest rate changes.
5. Derived variables included:
   - SP500_Return: The monthly percentage change in the S&P 500 index.
   - Rate_Change_Pct: The percentage change in Federal interest rates.

Load Libraries in Your Notebook

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
```

Step 2: Load Your Data ¶

Export the S&P 500 and Federal Interest Rates data from Bloomberg Terminal to CSV files.

[2]:
```
# Load datasets
sp500 = pd.read_csv('S&P_Month.csv')  # Replace with your file name
interest_rates = pd.read_csv('FED_Month.csv')  # Replace with your file name

# Display first few rows to verify
print(sp500.head())
print(interest_rates.head())
```

```
       Date  PX_LAST  PX_OPEN
0  30/11/24  6032.38  5723.22
1  31/10/24  5705.45  5757.73
2  30/09/24  5762.48  5623.89
3  30/08/24  5648.40  5537.84
4  31/07/24  5522.30  5471.08
       Date  PX_LAST  CHG_PCT_1D
0  30/11/24     4.64       -3.93
1  31/10/24     4.83       -5.85
2  30/09/24     5.13       -3.75
3  30/08/24     5.33        0.00
4  31/07/24     5.33        0.00
```

```
sp500.dropna(subset=['Date'], inplace=True)
interest_rates.dropna(subset=['Date'], inplace=True)
```

```
print(sp500.head())
print(interest_rates.head())
```

```
        Date  PX_LAST  PX_OPEN
0 2024-11-30  6032.38  5723.22
1 2024-10-31  5705.45  5757.73
2 2024-09-30  5762.48  5623.89
3 2024-08-30  5648.40  5537.84
4 2024-07-31  5522.30  5471.08
        Date  PX_LAST  CHG_PCT_1D
0 2024-11-30     4.64       -3.93
1 2024-10-31     4.83       -5.85
2 2024-09-30     5.13       -3.75
3 2024-08-30     5.33        0.00
4 2024-07-31     5.33        0.00
```

```
sp500['Date'] = pd.to_datetime(sp500['Date'])
interest_rates['Date'] = pd.to_datetime(interest_rates['Date'])
```

Merge the Datasets: Align both datasets by date

```
# Merge on the Date column
data = pd.merge(sp500, interest_rates, on='Date', how='inner')

# Rename columns for clarity
data.rename(columns={'SP500_Close': 'S&P_500', 'Interest_Rate': 'InterestRate'}, inplace=True)
```

```
print(data.isnull().sum())
data.dropna(inplace=True)  # Drop rows with missing values
```

```
Date          0
PX_LAST_x     0
PX_OPEN       0
PX_LAST_y     0
CHG_PCT_1D    0
dtype: int64
```

```
print(data.head()) # merged data
```

```
        Date  PX_LAST_x  PX_OPEN  PX_LAST_y  CHG_PCT_1D
0 2024-11-30    6032.38  5723.22       4.64       -3.93
1 2024-10-31    5705.45  5757.73       4.83       -5.85
2 2024-09-30    5762.48  5623.89       5.13       -3.75
3 2024-08-30    5648.40  5537.84       5.33        0.00
4 2024-07-31    5522.30  5471.08       5.33        0.00
```

replacing to avoid confusion

Calculate Returns: Compute monthly returns for S&P 500 and rate changes:

```
data.rename(columns={
    'PX_LAST_x': 'SP500_Close',
    'PX_OPEN': 'SP500_Open',
    'PX_LAST_y': 'InterestRate',
    'CHG_PCT_1D': 'Rate_Change_Pct'
}, inplace=True)
```

```
print(data.head())
```

```
        Date  SP500_Close  SP500_Open  InterestRate  Rate_Change_Pct
0 2024-11-30      6032.38     5723.22          4.64            -3.93
1 2024-10-31      5705.45     5757.73          4.83            -5.85
2 2024-09-30      5762.48     5623.89          5.13            -3.75
3 2024-08-30      5648.40     5537.84          5.33             0.00
4 2024-07-31      5522.30     5471.08          5.33             0.00
```

```
data['SP500_Return'] = (data['SP500_Close'] - data['SP500_Open']) / data['SP500_Open']
```

Analysis

Methodology

A simple linear regression was performed using the following variables:

- **Dependent Variable (Y):** monthly percentage change in S&P 500 returns (SP500_Return).
- **Independent Variable (X):** Percentage change in Federal interest rates (Rate_Change_Pct).

Exploratory Data Analysis (EDA)

```
print(data.describe()) #stats
```

```
                      Date  SP500_Close   SP500_Open  InterestRate  \
count                  120   120.000000   120.000000    120.000000
mean   2019-12-15 00:36:00  3333.699167  3304.079833      1.746250
min    2014-12-31 00:00:00  1920.030000  1919.650000      0.050000
25%    2017-06-22 12:00:00  2420.507500  2408.862500      0.120000
50%    2019-12-15 00:00:00  2978.560000  2977.300000      1.150000
75%    2022-06-07 12:00:00  4180.165000  4170.850000      2.400000
max    2024-11-30 00:00:00  6032.380000  5757.730000      5.330000
std                    NaN  1075.861823  1054.882210      1.862809

       Rate_Change_Pct  SP500_Return
count       120.000000    120.000000
mean          6.895333      0.009075
min         -92.310000     -0.131020
25%           0.000000     -0.016068
50%           0.415000      0.013670
75%           8.362500      0.033979
max         150.000000      0.165867
std          26.214960      0.045348
```

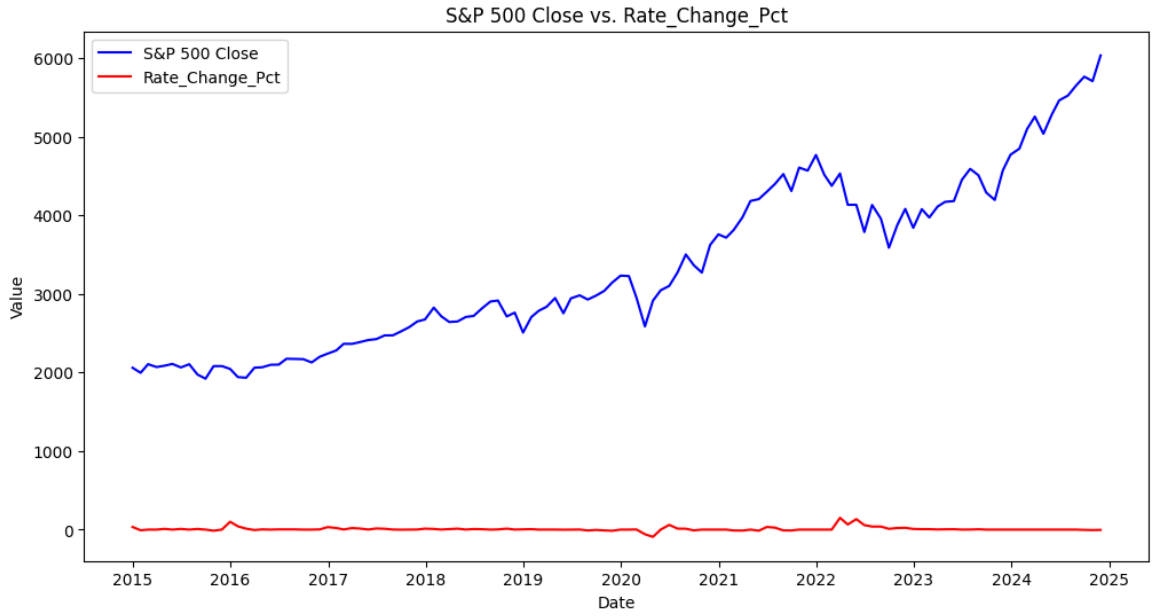
Correlation Analysis: Check if there is any correlation between S&P 500 returns and interest rate changes:

```
print(data[['SP500_Return', 'Rate_Change_Pct']].corr())
```

```
                 SP500_Return  Rate_Change_Pct
SP500_Return         1.000000        -0.129744
Rate_Change_Pct     -0.129744         1.000000
```

Visualizations: Line Plot of S&P 500 Close and Interest Rate Over Time:

```
plt.figure(figsize=(12, 6))
plt.plot(data['Date'], data['SP500_Close'], label='S&P 500 Close', color='blue')
plt.plot(data['Date'], data['Rate_Change_Pct'], label='Rate_Change_Pct', color='red')
plt.xlabel('Date')
plt.ylabel('Value')
plt.title('S&P 500 Close vs. Rate_Change_Pct')
plt.legend()
plt.show()
```

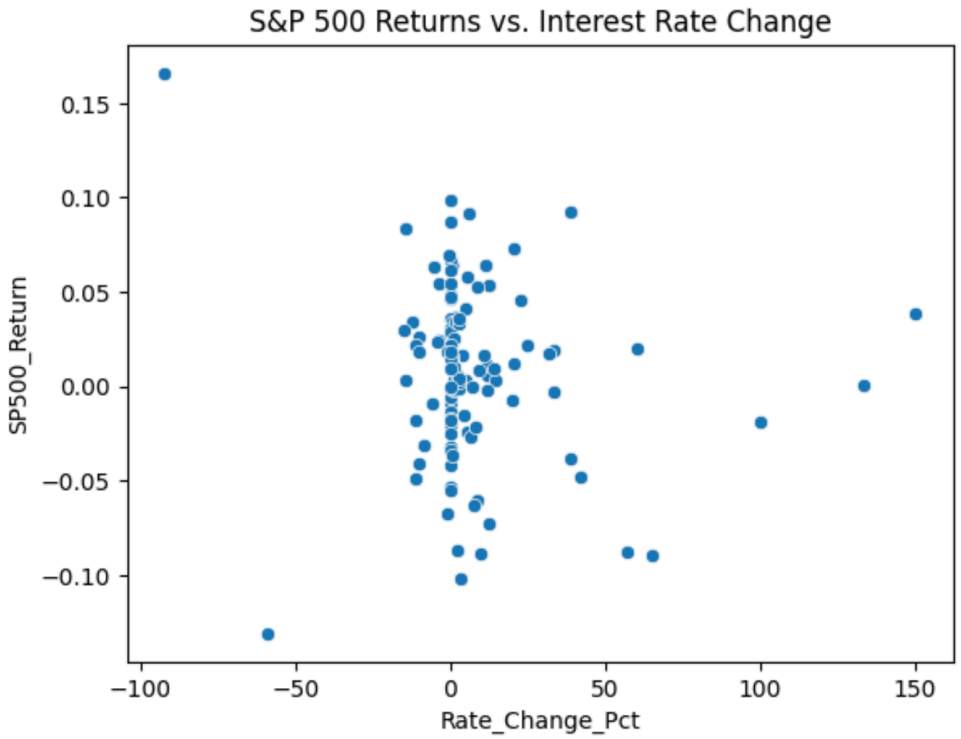


Time Series Plot

- A combined line chart of S&P 500 closing prices and Federal interest rate changes highlighted distinct trends:
    - S&P 500 exhibited a clear upward trend over the 10-year period.
    - Interest rate changes remained flat with occasional adjustments, showing no direct correlation with major S&P 500 movements

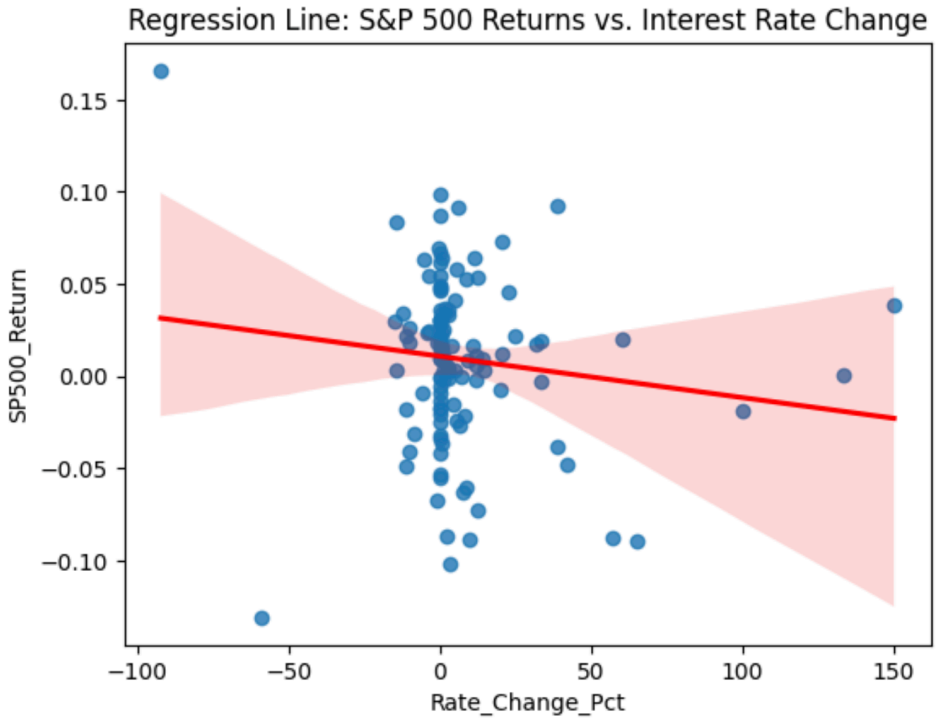
Scatter Plot Between S&P 500 Returns and Rate Change:

```
sns.scatterplot(data=data, x='Rate_Change_Pct', y='SP500_Return')
plt.title('S&P 500 Returns vs. Interest Rate Change')
plt.show()
```



Regression Line

```
sns.regplot(data=data, x='Rate_Change_Pct', y='SP500_Return', line_kws={'color': 'red'})
plt.title('Regression Line: S&P 500 Returns vs. Interest Rate Change')
plt.show()
```



Scatterplot with Regression Line

- A scatterplot showed the relationship between S&P 500 returns and interest rate changes, with a regression line overlaid.
- The near-horizontal slope of the line and the wide scatter of points confirmed the weak relationship between the variables.

Tools Used

1. **Programming Environment:** Python (Jupyter Notebook).
2. **Libraries:**
   - Pandas and NumPy for data manipulation.
   - Statsmodels for regression analysis.
   - Matplotlib and Seaborn for data visualization.

Results

Statistical Summary

Regression Analysis

Prepare Data for Regression:

Independent Variable: Rate_Change_Pct

Dependent Variable: SP500_Return

```
import statsmodels.api as sm

X = data[['Rate_Change_Pct']]  # Independent variable
y = data['SP500_Return']  # Dependent variable
X = sm.add_constant(X)  # Add a constant term for the intercept
```

```
model = sm.OLS(y, X).fit()
print(model.summary())
```

Regression Output:

- **R-squared:** 0.017 (1.7% of the variance in S&P 500 returns is explained by interest rate changes).
- **Adjusted R-squared:** 0.009.
- **Coefficient for Rate_Change_Pct:** -0.0002 (indicating a very small inverse relationship).
- **P-value for Rate_Change_Pct:** 0.158 (not statistically significant).

```
                            OLS Regression Results
==============================================================================
Dep. Variable:           SP500_Return   R-squared:                       0.017
Model:                            OLS   Adj. R-squared:                  0.009
Method:                 Least Squares   F-statistic:                     2.020
Date:                Thu, 19 Dec 2024   Prob (F-statistic):              0.158
Time:                        21:12:28   Log-Likelihood:                 202.45
No. Observations:                 120   AIC:                            -400.9
Df Residuals:                     118   BIC:                            -395.3
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0106      0.004      2.491      0.014       0.002       0.019
Rate_Change_Pct   -0.0002      0.000     -1.421      0.158      -0.001    8.82e-05
==============================================================================
Omnibus:                        7.309   Durbin-Watson:                   2.395
Prob(Omnibus):                  0.026   Jarque-Bera (JB):                8.163
Skew:                          -0.395   Prob(JB):                       0.0169
Kurtosis:                       4.005   Cond. No.                         27.9
==============================================================================

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

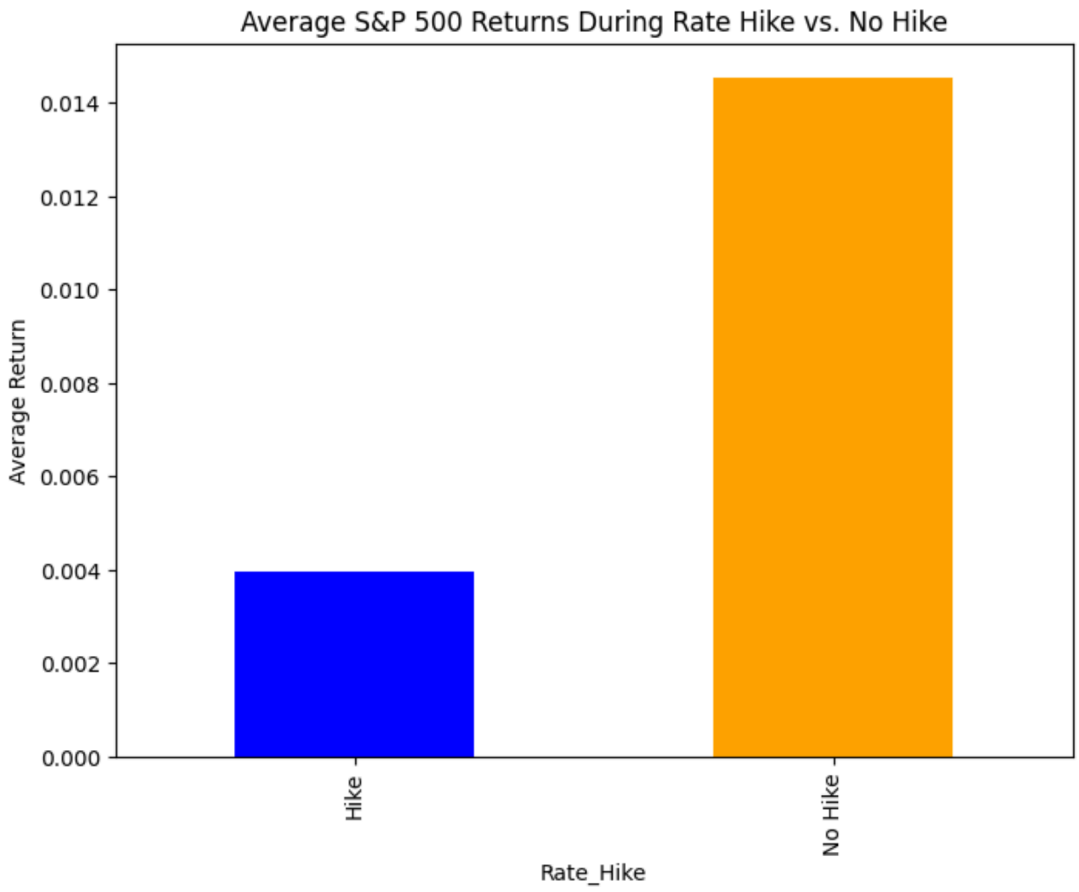
Group Analysis: Group the data by periods of rate hikes (Rate_Change_Pct > 0) vs. no hikes:

```
data['Rate_Hike'] = data['Rate_Change_Pct'].apply(lambda x: 'Hike' if x > 0 else 'No Hike')
avg_returns = data.groupby('Rate_Hike')['SP500_Return'].mean()
print(avg_returns)
```

```
Rate_Hike
Hike       0.003958
No Hike    0.014544
Name: SP500_Return, dtype: float64
```

Visualize Average Returns:

```
avg_returns.plot(kind='bar', color=['blue', 'orange'], figsize=(8, 6))
plt.title('Average S&P 500 Returns During Rate Hike vs. No Hike')
plt.ylabel('Average Return')
plt.show()
```



Conclusion

Key Findings

1. The analysis revealed a very weak and statistically insignificant relationship between changes in Federal interest rates and S&P 500 daily returns.

2. The R-squared value of 0.017 indicates that interest rate changes explain only a small fraction of the variance in stock market returns.

3. The P-value for the Rate_Change_Pct variable (0.158) further suggests that the relationship is not significant.

4. Visualizations supported the regression analysis, showing no observable pattern linking interest rate changes to S&P 500 movements.

Implications

- The results suggest that while interest rates may impact the broader economy, their immediate influence on daily S&P 500 returns is minimal.

- Other factors, such as corporate earnings, global events, and investor sentiment, may play a more significant role in driving market returns.

Future Improvements

1. For further research, a more complex model (e.g., multivariate regression) could be used to account for additional variables influencing stock returns.

2. Consider the lagged effects of interest rate changes or applying time-series models to explore longer-term impacts.

3. Incorporate macroeconomic indicators such as GDP growth, inflation rates, and unemployment data to build a comprehensive model.