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STUDENT NUMBER	854389
MODULE CODE and TITLE	**MN-M058**
ASSIGNMENT TITLE	Coursework 1
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DECLARATION

In submitting this assessment, I certify that this is my own work (except, where indicated as group work) and that the use of material from other sources has been appropriately acknowledged in the text. Neither this work, nor any part of it, has been submitted in the same format in connection with any other assessment.

I have read and understood the University's Academic Misconduct Policy and University Proofreading Policy, and definitions including plagiarism, collusion and commissioning therein, and I therefore understand that the consequences of committing Academic Misconduct will result in an investigation for academic misconduct and, if proven, may result in cancellation of marks for the paper, a mark of zero for the module, cancellation of marks for the level of study, or cancellation of all marks and disqualification from the programme.

In making a submission of work for assessment I hereby confirm the above declaration to be true:
Student Number: 854389

Interest Rates and Stock Prices: An Empirical Analysis of Market Dynamics

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Introduction

Brief about the Topic

The relationship between interest rates and stock prices is a fundamental aspect of financial economics. Interest rates, determined by central banks, are a critical factor in the economy, influencing borrowing costs, consumer spending, and investment decisions. Generally, higher interest rates increase the cost of borrowing, which can reduce corporate profits and, consequently, lower stock prices. Conversely, lower interest rates can stimulate economic activity by making borrowing cheaper, potentially boosting stock prices.

Several studies, including empirical research conducted on the Colombo Stock Exchange, have investigated this dynamic relationship. Amarasinghe (2015) found that interest rates significantly impact stock prices, with higher rates typically leading to lower stock prices due to increased discount rates applied to future cash flows. Similarly, an article on Investopedia explains that when interest rates rise, bonds become more attractive due to higher returns, causing a shift of investments from stocks to bonds, leading to a decrease in stock prices.

Brief about the Data

For this analysis, I have compiled two primary datasets: the historical data of the S&P 500 Index and the 10-Year Treasury Yield (DGS10).

S&P 500 Index Data:

Source: The historical data for the S&P 500 Index was sourced from Kaggle.

Content: This dataset includes daily data from 1927 to 2020, with columns for the date, opening price, highest price, lowest price, closing price, adjusted closing price, and the number of shares traded each day.

Relevance: The S&P 500 is a widely recognized benchmark for U.S. equity markets, representing the performance of 500 large companies listed on stock exchanges in the United States. The adjusted closing price is particularly important as it accounts for dividends and stock splits, providing a more accurate reflection of the stock's value over time.

10-Year Treasury Yield Data (DGS10):

Source: This data was obtained from the Federal Reserve Economic Data (FRED).

Content: The dataset includes daily observations of the 10-Year Treasury Yield from July 2002 onwards. The data is presented with columns for the date and the yield percentage (DGS10).

Relevance: The 10-Year Treasury Yield is a key indicator of long-term interest rates and is widely used as a benchmark for other interest rates. It reflects investor sentiment and expectations about future economic conditions and is a critical variable in the analysis of the relationship between interest rates and stock prices.

Literature Review

Hypothesis

Given the numerous theoretical and practical investigations, the hypothesis of the study is: There is a statistically significant inverse relationship between interest rates and stock prices. Precisely, with an increase in interest rates, stock prices will decrease, and vice versa.

Relevance of Readings and Theory

U.S. Bank Point of View on Interest Rates and the Stock Market

U.S. Bank explains the linkage between interest rates and the stock market from its angle. As already explained, in a situation where the interest rates go up, the money borrowed by consumers and businesses becomes more expensive, which discourages consumer spending and then affects corporate profitability. This is likely to decrease the stock prices of businesses. If, on the other hand, the interest rates decline, borrowing becomes less expensive; it may raise economic activity and result in elevated stock prices. It further points out that the relation is not always direct in that higher interest rates might be experienced during periods of economic strength, which would support the prices of stocks despite the higher rates. (U.S. Bank, 2022)

Investopedia on Interest Rates and Stock Market

Rising interest rates typically make bonds more attractive than stocks because bonds offer higher returns with lower risk. The preferences of the investors can shift which may sometimes cause a decrease in stock prices. Also, an increase in interest rates will increase the financing costs of companies and affect their profitability and hence stock prices. The overall effect on the stock market has to be analyzed in the context of a host of other factors that are likely to affect the stock market, such as present economic conditions and investor expectations. (Hall, 2024)

An Empirical Study on Colombo Stock Exchange

The impact of interest rates on stock prices in the Colombo Stock Exchange was studied and published in the Journal of Fisheries and Environment. It found that higher interest rates lead to lower stock prices, which dovetails with the DCF model. The study points out that the inverse relationship is due in fact to increased discount rates being applied to future cash flows with rising interest rates. (Amarasinghe, 2015)

The Relationship Between Interest Rates and Stock Prices

An academic paper on SSRN discusses the broader implications of interest rate changes on the stock market. Theoretical expectations within the Discounted Cash Flow (DCF) model, along with empirical evidence from numerous stock markets worldwide, support the hypothesis of an inverse relationship between interest rates and stock prices. There is considerable support in the literature for this hypothesis, indicating that as interest rates rise, stock prices tend to fall, and vice versa. Through an analysis of the impact of interest rates on stock prices over a 10-year period, this study contributes to the existing body of knowledge and provides insight into the dynamics of this critical relationship (Alam & Uddin, 2009).

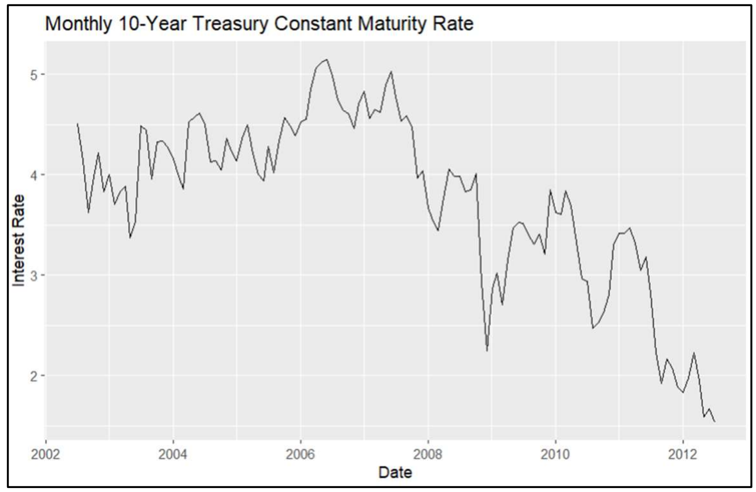
Exploratory Statistics

1. Monthly 10-Year Treasury Constant Maturity Rate

Trend: The interest rate shows a general declining trend from 2002 to 2012. (Market Yield on U.S. Treasury Securities, 2024)

Peaks and Troughs: There are noticeable peaks around 2006-2007 where the interest rates were above 5%. Following this peak, there is a sharp decline coinciding with the 2008 financial crisis, where rates fell below 3%.

Post-2008: After the crisis, the rates remain low, fluctuating around 2-3%, and further decline towards the end of the period.

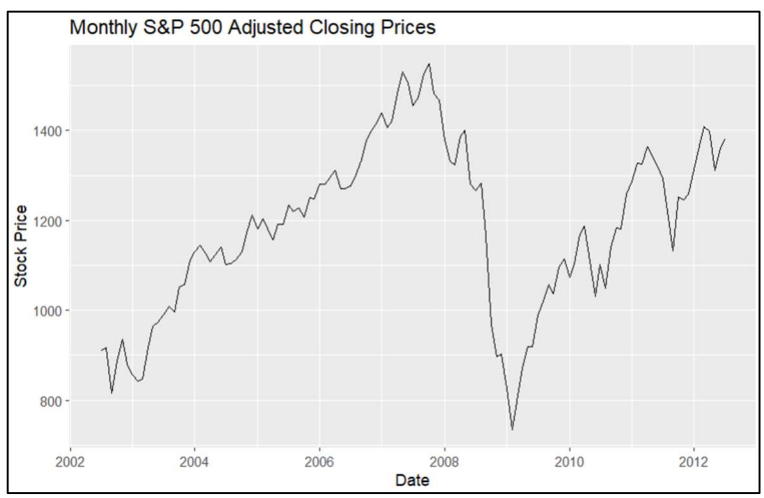


2. Monthly S&P 500 Adjusted Closing Prices

Trend: The S&P 500 adjusted closing prices show an overall upward trend from 2002 to 2012, with some significant fluctuations.

2008 Financial Crisis: There is a significant drop in stock prices during the 2008 financial crisis, reflecting the market turmoil. Prices fell from a peak of around 1,500 in 2007 to below 800 in early 2009.

Recovery: Following the crisis, there is a strong recovery in stock prices, with a steady upward trend reaching around 1,400 by 2012.

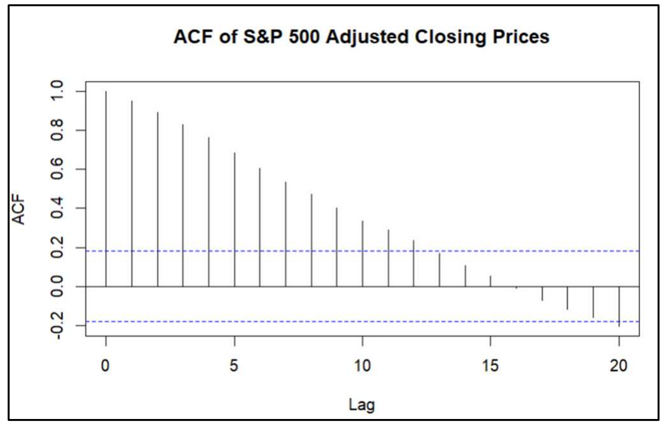


Analysis of ACF Plots

1. ACF of S&P 500 Adjusted Closing Prices

The ACF graph for the S&P 500 Adjusted Closing Prices shows how past prices influence future prices. Here's a simpler explanation:

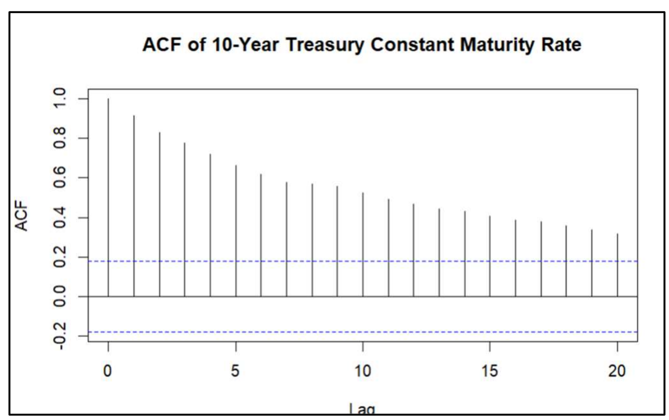
1. **First Few Months (Lags 0-6)**: The first few bars are tall, meaning that stock prices from the past six months strongly affect the current prices.
2. **Gradual Decrease**: As you move right, the bars get shorter, indicating that the influence of past prices decreases over time.
3. **Significant Influence**: Bars that go beyond the blue dashed lines show a significant impact. This is visible up to lag 6.
4. **Higher Lags**: Some bars drop below zero at higher lags, showing a slight negative influence, but these are not strong enough to be significant.



2. ACF of 10-Year Treasury Constant Maturity Rate

The ACF graph for the 10-Year Treasury Constant Maturity Rate shows how past rates influence future rates. Here's a simple explanation:

1. First Few Months (Lags 0-5): The first few bars are tall, indicating that past interest rates from the last five months strongly affect the current rates.
2. Gradual Decrease: As you move to the right, the bars get shorter, showing that the influence of past rates decreases over time.
3. Significant Influence: Bars that go beyond the blue dashed lines show a significant impact. This is visible up to lag 5.
4. Higher Lags: The influence of past rates continues to decrease but remains within the blue dashed lines, indicating these influences are not statistically significant.



Discussion of Stationarity

Interpretation of ADF Test Results

1. ADF Test for S&P 500 Adjusted Closing Prices:

- **Null Hypothesis (H0):** The time series has a unit root (is non-stationary).
- **Alternative Hypothesis (H1):** The time series is stationary.
- **Result:** The test statistic is -2.3979, and the p-value is 0.4113. Since the p-value is greater than 0.05, we fail to reject the null hypothesis, indicating that the series is non-stationary.

```
print(adf_test_stock)

     Augmented Dickey-Fuller Test

data:  monthly_data_clean$StockPrice
Dickey-Fuller = -2.3979, Lag order = 4, p-value = 0.4113
alternative hypothesis: stationary
```

2. ADF Test for 10-Year Treasury Constant Maturity Rate:

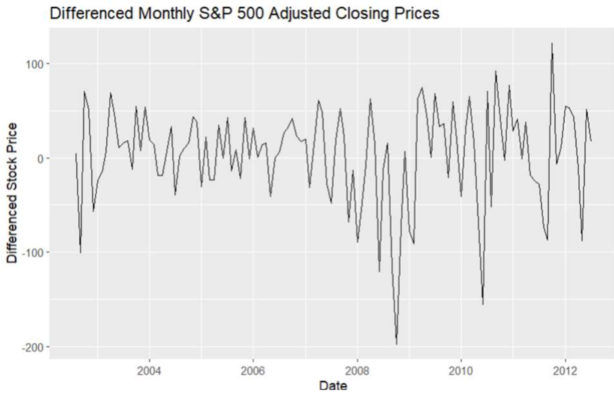
- **Null Hypothesis (H0):** The time series has a unit root (is non-stationary).
- **Alternative Hypothesis (H1):** The time series is stationary.
- **Result:** The test statistic is -2.0226, and the p-value is 0.5672. Since the p-value is greater than 0.05, we fail to reject the null hypothesis, indicating that the series is non-stationary.

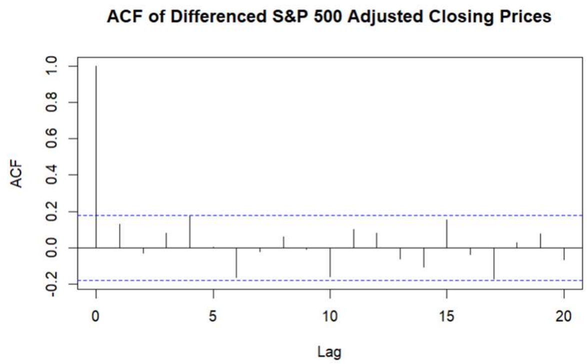
```
   > print(adf_test_interest)

        Augmented Dickey-Fuller Test

   data:  monthly_data_clean$InterestRate
   Dickey-Fuller = -2.0226, Lag order = 4, p-value = 0.5672
alternative hypothesis: stationary
```

After Differencing

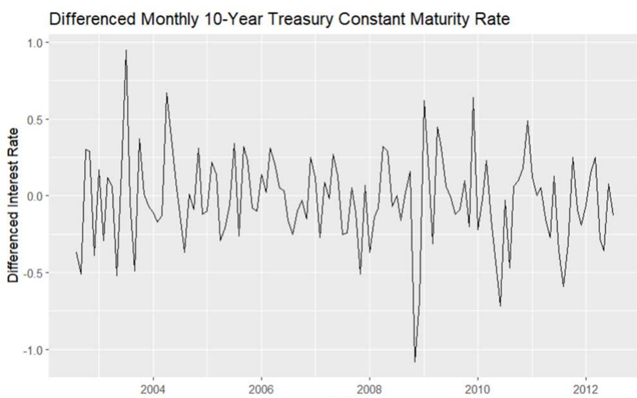


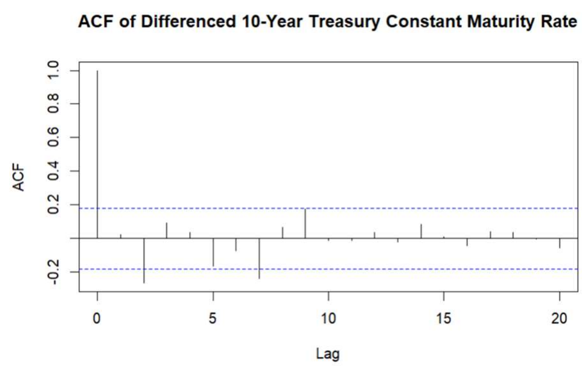



```
> print(adf_test_stock_diff)

	Augmented Dickey-Fuller Test

data:  monthly_data_diff$StockPrice_diff
Dickey-Fuller = -3.9151, Lag order = 4, p-value = 0.01579
alternative hypothesis: stationary
```






```
> print(adf_test_interest_diff)

	Augmented Dickey-Fuller Test

data:  monthly_data_diff$InterestRate_diff
Dickey-Fuller = -5.8151, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary
```

ADF Test for both differenced datasets gave a p-value less than 0.05, we reject the null hypothesis, indicating that the series is stationary.

Descriptive Statistics

Statistic	***Stock Price differenced***	***Interest Rate differenced***	***Stock Price***	***Interest Rate***
Mean	**3.963559**	**-0.02516949**	**1183.58**	**3.745042**
SD	**51.33595**	**0.295978**	**189.2154**	**0.8722112**
Skewness	**-1.040745**	**-0.09134391**	**-0.262696**	**-0.7610093**
Kurtosis	**4.826736**	**4.460024**	**2.30865**	**2.874008**
Median	**13.92499**	**-0.025**	**1191.5**	**3.94**
Q1	**-20.39499**	**-0.185**	**1053.895**	**3.315**
Q3	**40.35001**	**0.1475**	**1321.67**	**4.455**

Stock Price: The average stock price during the analyzed period is 1183.58, with significant variability shown by a standard deviation of 189.22. The distribution is slightly skewed to the left (skewness of -0.26), meaning there are more frequent high values. The kurtosis of 2.31 suggests a few extreme values. The median stock price is 1191.5, indicating a fairly symmetric distribution around the mean. The middle 50% of the data (between Q1 and Q3) ranges from 1053.90 to 1321.67, showing moderate variability.

Interest Rate: The average interest rate is 3.75 with low variability (standard deviation of 0.87). The distribution is also left-skewed (skewness of -0.76), indicating more frequent high values. A kurtosis of 2.87 suggests some extreme values. The median interest rate is 3.94, close to the mean, indicating symmetry. The middle 50% of the data ranges from 3.32 to 4.46, showing low variability.

Differenced Stock Price: On average, stock prices slightly increased month-over-month by 3.96 units, but with significant variability (standard deviation of 51.34). The distribution is left-skewed (skewness of -1.04) and has heavy tails (kurtosis of 4.83), suggesting more extreme changes. The median monthly change is 13.92, with the middle 50% of changes ranging from -20.39 to 40.35.

Differenced Interest Rate: The average monthly change in interest rates is slightly negative (-0.03), indicating a general decrease. The changes have low variability (standard deviation of 0.30) and are nearly symmetric (skewness of -0.09). The distribution has heavy tails (kurtosis of 4.46), suggesting extreme changes. The median change is -0.025, with the middle 50% ranging from -0.185 to 0.148.

Correlation Analysis

```
Pearson's product-moment correlation

data:  monthly_data_diff$StockPrice_diff and monthly_data_diff$InterestRate_diff

t = 4.2156, df = 116, p-value = 4.957e-05

alternative hypothesis: true correlation is not equal to 0

95 percent confidence interval:

 0.1966811 0.5115396

sample estimates:

     cor

0.3644824
```

Interpretation

- **Correlation Coefficient**: The correlation coefficient r=0.3644824r = 0.3644824r=0.3644824, suggesting a moderate positive correlation between changes in stock prices and changes in interest rates. This indicates that when interest rates increase, stock prices tend to increase as well.
- **Hypotheses**:
  - H0: There is no correlation between the two time series.
  - H1: There is a correlation between the two time series.
- **Test Statistic**: The test statistic value is 4.2156, which follows the t-distribution with 116 degrees of freedom if H0 is true.
- **P-value**: The p-value is 4.957e-05, which is much less than 1%.

Since the p-value is less than 1%, we reject H0 at the 1% level of significance. This means that at the 1% level of significance, there is a significant correlation between changes in stock prices and changes in interest rates.

The correlation analysis indicates a moderate positive relationship between changes in stock prices and changes in interest rates. This finding suggests that during the period analyzed, when interest rates change, stock prices tend to move in the same direction to a moderate extent. (S&P 500 Historical Data, 2020; Market Yield on U.S. Treasury Securities, 2024)

Linear Regression

```
Call:
lm(formula = StockPrice_diff ~ InterestRate_diff, data = monthly_data_diff)
Residuals:
   Min      1Q  Median      3Q     Max
-213.28  -22.05    3.51   32.14  100.52
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)       5.555      4.436   1.252    0.213
InterestRate_diff   63.218     14.996   4.216 4.96e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 48.01 on 116 degrees of freedom
Multiple R-squared:  0.1328,     Adjusted R-squared:  0.1254
F-statistic: 17.77 on 1 and 116 DF,  p-value: 4.957e-05
```

Let *yt* be the change in stock prices and let *xt* be the change in interest rates.

Yt =5.555+63.218 *xt* + *ut*

Interpretation of Coefficients:

Intercept (β0=5.555): Average change in stock prices with no change in interest rates. Not statistically significant (p-value = 0.213).

Slope (β1=63.218): Statistically significant (p-value < 0.001). A unit change in interest rates results in an average change of 63.218 units in stock prices.

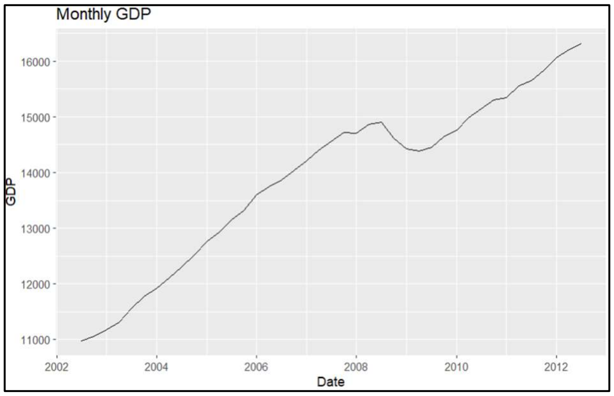
Model Fit:

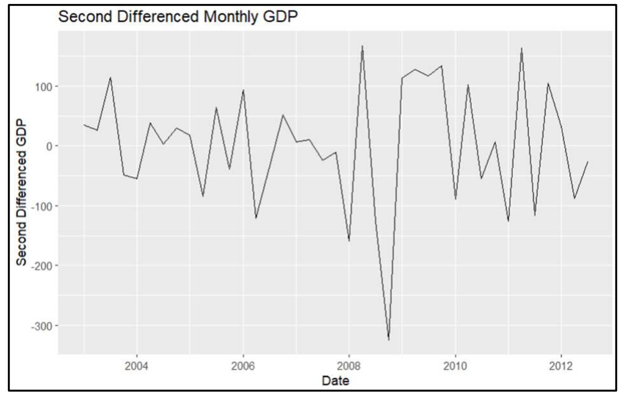
R-squared (0.1328): About 13.28% of the variability in stock price changes is explained by changes in interest rates.

Adjusted R-squared (0.1254): Around 12.54% of the variability in stock price changes is explained by the model.

Linear regression shows that between 2002 and 2012 changes in interest rates have a significant positive effect on changes in stock prices. A unit change in interest rates causes an average change of 63.218 units in stock prices. The model explains 13.28% of the variability in stock price changes.

Multivariate Regression & GDP





Here are undifferenced and differenced time series plots of GDP growth in US taken from FRED.

GDP: GDP directly impacts corporate earnings and consumer spending, which are crucial drivers of stock market performance. When GDP grows, businesses generally see higher profits due to increased consumer demand, leading to higher stock prices. Conversely, a declining GDP can signal economic troubles, reducing corporate earnings and stock market valuations. Thus, GDP serves as a comprehensive indicator of economic conditions that significantly influence stock market trends.

```
Augmented Dickey-Fuller Test

data:  gdp_monthly_diff$GDP_diff

Dickey-Fuller = -2.3092, Lag order = 3, p-value = 0.4521

alternative hypothesis: stationary
```

```
Augmented Dickey-Fuller Test

data:  gdp_monthly_diff2$GDP_diff2

Dickey-Fuller = -3.7003, Lag order = 3, p-value = 0.03825

alternative hypothesis: stationary
```

After first differencing, an Augmented Dickey-Fuller (ADF) test was conducted, resulting in a p-value greater than 0.05, indicating that the series was not stationary. Consequently, the series was differenced once more. To ensure the series was stationary, another ADF test was carried out on the twice-differenced data, yielding a p-value of 0.03. This p-value, being less than 0.05, indicates that the series is now stationary.

```
Call:
lm(formula = StockPrice_diff ~ InterestRate_diff + GDP_diff2,
   data = monthly_data_diff)
Residuals:
    Min      1Q  Median      3Q     Max
-114.184  -29.241    5.291   28.456   81.686
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)        9.16558    7.66925   1.195 0.239859
InterestRate_diff -17.41729   28.54808  -0.610 0.545625
GDP_diff2          0.33879    0.08007   4.231 0.000153 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 46.72 on 36 degrees of freedom
Multiple R-squared:  0.3462,	Adjusted R-squared:  0.3098
F-statistic:  9.53 on 2 and 36 DF,  p-value: 0.0004768
```

Let yt be the change in stock prices, xt be the change in interest rates and zt be the change in GDP The estimated model is:

$Y_t = 9.166 - 17.417 x_t + 0.339 z_t + u_t$

Intercept (β_0=9.166): Average change in stock prices when both interest rates and GDP changes are zero. Not statistically significant (p-value = 0.240).

InterestRate_diff (β_1=−17.417): Change in stock prices per unit change in interest rates. Not statistically significant (p-value = 0.546).

GDP_diff2 (β_2=0.339): Statistically significant (p-value < 0.001). A unit change in GDP results in an average change of 0.339 units in stock prices.

R-squared (0.3462): About 34.62% of the variability in stock price changes is explained by changes in interest rates and GDP.

The multivariate regression analysis shows that in the period of July 2002 to July 2012 changes in GDP significantly impact stock prices, while changes in interest rates do not have a significant effect when GDP is accounted for. This suggests that economic growth, as measured by GDP, is a key driver of stock price changes, highlighting the importance of economic conditions in influencing the stock market.

Why use linear regression

Linear regression is used to understand the relationship between a dependent variable (stock prices) and one or more independent variables (interest rates and GDP). It helps to quantify the strength and direction of these relationships. Linear regression is appropriate here because:

1. **Linearity**: The relationships between the variables are assumed to be linear.
2. **Continuous Variables**: The dependent and independent variables are continuous.
3. **Exploratory Analysis**: It allows us to explore and quantify how changes in interest rates and GDP affect stock prices.

Linking with Theory

1. Traditional Theory: The traditional financial theory, particularly the Dividend Discount Model (DDM) and the Discounted Cash Flow (DCF) model, suggests an inverse relationship between interest rates and stock prices. Higher interest rates increase the discount rate, leading to lower present values (stock prices), while lower interest rates reduce the discount rate, increasing the present value of future cash flows and boosting stock prices.
2. Observed Results: The correlation analysis found a moderate positive relationship (r = 0.364) between changes in interest rates and changes in stock prices, deviating from the expected inverse relationship. The univariate regression analysis showed a statistically significant positive relationship between interest rate changes and stock price changes. However, the multivariate regression, incorporating GDP, indicated that GDP had a significant positive impact on stock prices, while the effect of interest rates was not statistically significant.
3. Economic Context: The period analyzed (2002-2012) includes the 2008 financial crisis and subsequent economic recovery. During this time, economic policies, including monetary easing, may have influenced both interest rates and stock prices in ways that deviate from traditional expectations. Investor behavior can also affect the relationship, as during periods of economic recovery, investor optimism about future economic prospects can drive stock prices up, even if interest rates are rising from very low levels.
4. Broader Economic Factors: The multivariate regression highlighted the significant role of GDP in influencing stock prices, aligning with the theory that economic growth (reflected in GDP) is a key driver of corporate profits and, consequently, stock prices. This suggests that while interest rates are important, their impact might be overshadowed by broader economic conditions captured by GDP.

Reconciliation with Theory The deviation from the traditional inverse relationship suggests that the stock market is influenced by a complex interplay of factors. While interest rates are crucial, other economic indicators like GDP, investor sentiment, and specific economic events (e.g., financial crises) significantly shape market dynamics.

Conclusion

In conclusion, this study analyzed the relationship between interest rates and stock prices in the United States from 2002 to 2012. The results show that there is a moderate positive correlation between changes in interest rates and changes in stock prices, which deviates from the traditional inverse relationship predicted by financial theory. The linear regression analysis reveals that changes in interest rates have a statistically significant positive effect on changes in stock prices, but this effect is not significant when GDP is accounted for. The multivariate regression analysis highlights the significant role of GDP in influencing stock prices, suggesting that economic growth is a key driver of corporate profits and stock prices.

The findings of this study have important implications for investors, policymakers, and financial analysts. Firstly, they suggest that the relationship between interest rates and stock prices is more complex than previously thought, and that other economic factors such as GDP, investor sentiment, and specific economic events play a significant role in shaping market dynamics. The 2008 financial crisis, which was marked by a sharp decline in interest rates and a subsequent recovery in stock prices, provides a notable example of this complexity. Secondly, they highlight the importance of considering the broader economic context when analyzing the relationship between interest rates and stock prices. Finally, they suggest that investors and policymakers should be cautious when making predictions about the impact of interest rate changes on stock prices, as the relationship is not as straightforward as previously thought.

Overall, this study contributes to the existing body of knowledge on the relationship between interest rates and stock prices, and provides valuable insights for investors, policymakers, and financial analysts.

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Appendix

```
# Load necessary libraries

library(tidyverse)

library(lubridate)

library(quantmod)

library(moments)


# Load S&P 500 data

sp500_data <- read_csv("C:/Users/Ahmed Almahari/Desktop/a/SPX.csv")


# Load DGS10 data

dgs10_data <- read_csv("C:/Users/Ahmed Almahari/Desktop/a/DGS10 (1).csv")


# Convert DATE columns to Date type

sp500_data$DATE <- as.Date(sp500_data$DATE, format="%m/%d/%Y")

dgs10_data$DATE <- as.Date(dgs10_data$DATE, format="%Y-%m-%d")


# Select relevant columns and rename for clarity

sp500_data <- sp500_data %>%
```

```
  select(DATE, ADJ_CLOSE) %>%
  rename(StockPrice = ADJ_CLOSE)

dgs10_data <- dgs10_data %>%
  rename(InterestRate = DGS10)

# Ensure InterestRate is numeric
dgs10_data$InterestRate <- as.numeric(dgs10_data$InterestRate)

# Ensure both datasets are on the same frequency (monthly)
sp500_monthly <- sp500_data %>%
  mutate(year = year(DATE), month = month(DATE)) %>%
  group_by(year, month) %>%
  summarize(StockPrice = last(StockPrice, na.rm = TRUE)) %>%
  ungroup() %>%
  mutate(DATE = make_date(year, month, 1)) %>%
  select(DATE, StockPrice)

dgs10_monthly <- dgs10_data %>%
  mutate(year = year(DATE), month = month(DATE)) %>%
  group_by(year, month) %>%
  summarize(InterestRate = last(InterestRate, na.rm = TRUE)) %>%
  ungroup() %>%
  mutate(DATE = make_date(year, month, 1)) %>%
  select(DATE, InterestRate)

# Merge datasets on DATE
monthly_data <- inner_join(sp500_monthly, dgs10_monthly, by = "DATE")

# Remove rows with missing values
```

```
monthly_data_clean <- na.omit(monthly_data)

# Inspect the merged data to ensure proper aggregation
print(head(monthly_data_clean))
summary(monthly_data_clean)

# Plot Stock Price Time Series
ggplot(monthly_data_clean, aes(x = DATE, y = StockPrice)) +
 geom_line() +
 labs(title = "Monthly S&P 500 Adjusted Closing Prices",
    x = "Date",
    y = "Stock Price")

# Plot Interest Rate Time Series
ggplot(monthly_data_clean, aes(x = DATE, y = InterestRate)) +
 geom_line() +
 labs(title = "Monthly 10-Year Treasury Constant Maturity Rate",
    x = "Date",
    y = "Interest Rate") +
 scale_y_continuous(limits = c(min(monthly_data$InterestRate, na.rm = TRUE),
max(monthly_data$InterestRate, na.rm = TRUE)))

# Plot ACF for Stock Prices
acf(monthly_data_clean$StockPrice, main="ACF of S&P 500 Adjusted Closing Prices")

# Plot ACF for Interest Rates
acf(monthly_data_clean$InterestRate, main="ACF of 10-Year Treasury Constant Maturity Rate")

# Load necessary library for ADF test
library(tseries)
```

```
# Conduct ADF test for S&P 500 Adjusted Closing Prices
adf_test_stock <- adf.test(monthly_data_clean$StockPrice, alternative = "stationary")

# Conduct ADF test for 10-Year Treasury Constant Maturity Rate
adf_test_interest <- adf.test(monthly_data_clean$InterestRate, alternative = "stationary")

# Print the results
print(adf_test_stock)
print(adf_test_interest)

# Differencing to achieve stationarity
monthly_data_diff <- monthly_data_clean %>%
  mutate(
    StockPrice_diff = c(NA, diff(StockPrice)),
    InterestRate_diff = c(NA, diff(InterestRate))
  ) %>%
  na.omit()

# Inspect the differenced data to ensure proper aggregation
print(head(monthly_data_diff))
summary(monthly_data_diff)

# Plot differenced Stock Price Time Series
ggplot(monthly_data_diff, aes(x = DATE, y = StockPrice_diff)) +
  geom_line() +
  labs(title = "Differenced Monthly S&P 500 Adjusted Closing Prices",
       x = "Date",
       y = "Differenced Stock Price")
```

```
# Plot differenced Interest Rate Time Series
ggplot(monthly_data_diff, aes(x = DATE, y = InterestRate_diff)) +
  geom_line() +
  labs(title = "Differenced Monthly 10-Year Treasury Constant Maturity Rate",
       x = "Date",
       y = "Differenced Interest Rate")

# Plot ACF for differenced Stock Prices
acf(monthly_data_diff$StockPrice_diff, main="ACF of Differenced S&P 500 Adjusted Closing
Prices")

# Plot ACF for differenced Interest Rates
acf(monthly_data_diff$InterestRate_diff, main="ACF of Differenced 10-Year Treasury Constant
Maturity Rate")

# Conduct ADF test for differenced S&P 500 Adjusted Closing Prices
adf_test_stock_diff <- adf.test(monthly_data_diff$StockPrice_diff, alternative = "stationary")

# Conduct ADF test for differenced 10-Year Treasury Constant Maturity Rate
adf_test_interest_diff <- adf.test(monthly_data_diff$InterestRate_diff, alternative = "stationary")

# Print the results of ADF tests
print(adf_test_stock_diff)
print(adf_test_interest_diff)

# Descriptive statistics for undifferenced data
descriptive_stats_undiff <- monthly_data_clean %>%
  summarize(
    StockPrice_Mean = mean(StockPrice, na.rm = TRUE),
    StockPrice_SD = sd(StockPrice, na.rm = TRUE),
    StockPrice_Skewness = skewness(StockPrice, na.rm = TRUE),
```

```
    StockPrice_Kurtosis = kurtosis(StockPrice, na.rm = TRUE),
    StockPrice_Median = median(StockPrice, na.rm = TRUE),
    StockPrice_Q1 = quantile(StockPrice, 0.25, na.rm = TRUE),
    StockPrice_Q3 = quantile(StockPrice, 0.75, na.rm = TRUE),
    InterestRate_Mean = mean(InterestRate, na.rm = TRUE),
    InterestRate_SD = sd(InterestRate, na.rm = TRUE),
    InterestRate_Skewness = skewness(InterestRate, na.rm = TRUE),
    InterestRate_Kurtosis = kurtosis(InterestRate, na.rm = TRUE),
    InterestRate_Median = median(InterestRate, na.rm = TRUE),
    InterestRate_Q1 = quantile(InterestRate, 0.25, na.rm = TRUE),
    InterestRate_Q3 = quantile(InterestRate, 0.75, na.rm = TRUE)
  )

print(descriptive_stats_undiff)



# Descriptive statistics for differenced data
descriptive_stats_diff <- monthly_data_diff %>%
  summarize(
    StockPrice_diff_Mean = mean(StockPrice_diff, na.rm = TRUE),
    StockPrice_diff_SD = sd(StockPrice_diff, na.rm = TRUE),
    StockPrice_diff_Skewness = skewness(StockPrice_diff, na.rm = TRUE),
    StockPrice_diff_Kurtosis = kurtosis(StockPrice_diff, na.rm = TRUE),
    StockPrice_diff_Median = median(StockPrice_diff, na.rm = TRUE),
    StockPrice_diff_Q1 = quantile(StockPrice_diff, 0.25, na.rm = TRUE),
    StockPrice_diff_Q3 = quantile(StockPrice_diff, 0.75, na.rm = TRUE),
    InterestRate_diff_Mean = mean(InterestRate_diff, na.rm = TRUE),
    InterestRate_diff_SD = sd(InterestRate_diff, na.rm = TRUE),
    InterestRate_diff_Skewness = skewness(InterestRate_diff, na.rm = TRUE),
    InterestRate_diff_Kurtosis = kurtosis(InterestRate_diff, na.rm = TRUE),
```

```
  InterestRate_diff_Median = median(InterestRate_diff, na.rm = TRUE),
  InterestRate_diff_Q1 = quantile(InterestRate_diff, 0.25, na.rm = TRUE),
  InterestRate_diff_Q3 = quantile(InterestRate_diff, 0.75, na.rm = TRUE)
 )

print(descriptive_stats_diff)

# Correlation test between differenced stock prices and differenced interest rates
cor_test_result <- cor.test(monthly_data_diff$StockPrice_diff, monthly_data_diff$InterestRate_diff,
method = "pearson")

# Print the correlation test results
print(cor_test_result)



# Univariate Regression: StockPrice_diff ~ InterestRate_diff
univariate_model_diff <- lm(StockPrice_diff ~ InterestRate_diff, data = monthly_data_diff)
summary(univariate_model_diff)

# Load GDP data
gdp_data <- read_csv("C:/Users/Ahmed Almahari/Desktop/a/GDP.csv")

# Convert DATE column to Date type
gdp_data$DATE <- as.Date(gdp_data$DATE, format="%Y-%m-%d")

# Ensure GDP data is on the same frequency (monthly)
gdp_monthly <- gdp_data %>%
 mutate(year = year(DATE), month = month(DATE)) %>%
 group_by(year, month) %>%
 summarize(GDP = last(GDP, na.rm = TRUE)) %>%
```

```
  ungroup() %>%
  mutate(DATE = make_date(year, month, 1)) %>%
  select(DATE, GDP)

# Merge GDP data with existing dataset
monthly_data <- monthly_data %>%
  inner_join(gdp_monthly, by = "DATE")

# Remove rows with missing values
monthly_data_clean <- na.omit(monthly_data)

# Conduct ADF test for undifferenced GDP data
adf_test_gdp <- adf.test(gdp_monthly$GDP, alternative = "stationary")

# Print the result
print(adf_test_gdp)

# Differencing GDP to achieve stationarity
gdp_monthly_diff <- gdp_monthly %>%
  mutate(GDP_diff = c(NA, diff(GDP))) %>%
  na.omit()

# Conduct ADF test for differenced GDP data
adf_test_gdp_diff <- adf.test(gdp_monthly_diff$GDP_diff, alternative = "stationary")

# Print the result
print(adf_test_gdp_diff)

# Second differencing GDP to achieve stationarity
gdp_monthly_diff2 <- gdp_monthly_diff %>%
```

```
  mutate(GDP_diff2 = c(NA, diff(GDP_diff))) %>%
  na.omit()

# Conduct ADF test for second differenced GDP data
adf_test_gdp_diff2 <- adf.test(gdp_monthly_diff2$GDP_diff2, alternative = "stationary")

# Print the result
print(adf_test_gdp_diff2)

# Plot original GDP data
ggplot(gdp_monthly, aes(x = DATE, y = GDP)) +
  geom_line() +
  labs(title = "Monthly GDP",
       x = "Date",
       y = "GDP")
# Plot second differenced GDP data
ggplot(gdp_monthly_diff2, aes(x = DATE, y = GDP_diff2)) +
  geom_line() +
  labs(title = "Second Differenced Monthly GDP",
       x = "Date",
       y = "Second Differenced GDP")

# Merge the second differenced GDP data with the existing differenced data
monthly_data_diff <- monthly_data_diff %>%
  inner_join(gdp_monthly_diff2 %>% select(DATE, GDP_diff2), by = "DATE")

# Multivariate Regression: StockPrice_diff ~ InterestRate_diff + GDP_diff2
multivariate_model_diff <- lm(StockPrice_diff ~ InterestRate_diff + GDP_diff2, data = 
monthly_data_diff)
summary(multivariate_model_diff)
```