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The Impact of the US Dollar Value and Interest Rates on the S&P 500 Returns

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Abstract

This paper examines the impact of the US dollar value and Interest Rates on the S&P 500 returns. By employing a correlation, regression, and GARCH (1,1) model to analyze the relationships between the variables over a period that expands from January 2013 to December 2023. The results show that the US dollar has a negative correlation, and the Interest Rates have a positive correlation with the S&P 500 returns. The findings of this study carry substantial implications for the investment community, portfolio managers, and policymakers, as they provide valuable insights that can inform and enhance investment decisions and risk mitigation strategies.

Keywords

US Dollar; Interest Rate; S&P 500; Correlation; Regression; GARCH (1,1) Model.

1. Introduction

The equity markets, commonly referred to as the stock market, have emerged as a crucial component of numerous economies across the globe. In the United States (US), the stock markets serve as a financial indicator of the economy's overall strength, and the Standard & Poor's 500 (S&P 500) is widely regarded as one of the most closely monitored stock market indices in the world of finance. As per Business Insider, the S&P 500 has recorded an average return of approximately 12.39% over the past decade, surpassing the historical average of 10.7% since the inception of the benchmark index 65 years ago[1]. Thus, the growing significance of the stock market has spurred the development of several theories to comprehend its functioning.

There are many factors which are linked to the stock market returns. One of them is the US dollar, which is an important international reserve currency. For instance, as of March 2018, the S&P 500 reported that 29 percent of the 500 companies' revenues are earned outside the US[2]. Therefore, a surge in the value of the U.S. dollar may have adverse effects on multinational enterprises. When the dollar gains strength, the worth of international sales in dollar terms typically reduces, which could lead to reduced earnings for these corporations (Hughen, 2013)[3]. As a considerable number of these multinationals feature in the S&P 500, a robust dollar may exert pressure on the overall index returns. In addition, the relationship between the S&P 500 and the dollar index has been extensively studied in the finance literature. Researchers Johnson and Soenen (2004) found a positive relationship between the two variables during the period from 1992 to 2002[4]. However, some found a negative relationship during the 1980s and 1990s (Baur & McDermott, 2010)[5].

Another important factor is the interest rate that the Federal Reserve Bank uses to implement monetary policy. According to Bernanke and Kuttner's 2005 study, a sudden 0.25 percentage point decrease in the federal funds rate by the Federal Reserve Bank results in a roughly 1% increase in the stock market return. The research also highlights that monetary policy has a significant impact on stock prices by affecting anticipated excess returns and that different sectors respond differently to unexpected changes in monetary policy[6]. Theoretically, a

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negative relationship exists between interest rates and stock prices. The reason behind this is that an increase in interest rates decreases the current value of future dividends' income, which ultimately leads to a decline in stock prices. On the other hand, low interest rates reduce the cost of borrowing, which encourages investments and economic activities, ultimately resulting in an increase in prices (Hamrita & Trifi, 2011)[7]. However, it is worth noting that the observation made between the years 2022 and 2024 reveals an intriguing phenomenon. Despite the gradual increase in interest rates, the price of the S&P 500 has reached an all-time high, indicating the market's resilience and strength. Such findings are of great academic interest and warrant further exploration and analysis.

Therefore, this paper aims to contribute to other studies by examining the recent impact of the US dollar's value and interest rate on the S&P 500 index from January 2013 to December 2023, aiming to understand the current market better. The paper is organized as follows: Section 2 presents the methodology approach and describes the data. Section 3 discusses the empirical findings of the relationship between the US dollar and Interest Rates on the S&P 500 returns. Finally, section 4 concludes and highlights some relevant remarks.

2. Methodology and Data

This study uses a correlation and regression analysis to better understand the impact of the US dollar value and interest rate on the S&P 500 index, given the interconnectedness of currency movements and interest rate changes with stock market performance. While the Pearson correlation coefficient measures the strength and direction of a linear relationship between two variables, the regression analysis goes beyond correlation by allowing one to model the relationship between a dependent variable and one or more independent variables. The Pearson correlation coefficient model takes the following form:

$$r = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\Sigma(x_i - \bar{x})^2 \Sigma(y_i - y)^2}} \tag{1}$$

Where r is the correlation coefficient, $\Sigma(x_i - \bar{x})(y_i - \bar{y})$ is the covariance of x and y, and $\sqrt{\Sigma(x_i - \bar{x})^2 \Sigma(y_i - y)^2}$ is the standard deviation of x and y.

Moreover, the regression model is formulated in the following form:

$$Y = \beta_0 + \beta_1 X + \varepsilon \tag{2}$$

Where Y is the dependent variable and X is the independent variable. β_0 is the intercept of the regression line, representing the expected value of Y when X is zero. β_1 is the slope coefficient, representing the change in Y for a one-unit change in X. ε is the error term, capturing the unobserved factors affecting Y that are not explained by X.

In addition, this paper applys the GARCH (Generalized Autoregressive Conditional Heteroskedasticity) (1,1) model, which is widely used in statistics and econometric analysis among researchers and academics in financial time series modeling. As financial time series data often exhibit volatility clustering, where periods of high volatility are followed by periods of low volatility. The GARCH model addresses this by modeling the conditional variance of the time series, allowing for time-varying volatility. The key idea is to capture the serial correlation in the squared observations, which is a characteristic feature of financial data. The GARCH (1,1) model is expressed as follows:

The mean equation:

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$$\epsilon_t = r_t - \mu \tag{3}$$

ϵ_t is the standardized residual at time t, calculated as the difference between the observed return (r_t) and the estimated mean (μ).

The conditional variance equation:

$$\sigma_t^2 = \omega + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \tag{4}$$

Where σ_t^2 is the conditional variance of the time series at time t. ω is the intercept term, representing the constant conditional variance. α_1 is the coefficient associated with the lagged squared residual term (ϵ_{t-1}^2), capturing the impact of past volatility shocks on the current conditional variance. β_1 is the coefficient associated with the lagged conditional variance term (σ_{t-1}^2), capturing the persistence of past volatility in the current conditional variance.

This section presents the definitions of three variables that have been used in this study. First, the S&P 500 index is widely regarded as the most dependable measure of large-cap U.S. equities. It includes 500 leading companies and constitutes approximately 83% of the total market capitalization of all regularly traded stocks on the New York, American, and NASDAQ exchanges (Siegel & Schwartz, 2006)[8]. Over time, the S&P 500 index has exhibited superior performance in comparison to the majority of actively managed investment portfolios and mutual funds, according to Bloomberg.

Second, the US dollar index is a metric that evaluates the value of the United States dollar in relation to a basket of six major world currencies. It is calculated by taking the weighted geometric average of the dollar's value as compared to the following currencies: Euro (EUR), Japanese Yen (JPY), British Pound (GBP), Canadian Dollar (CAD), Swedish Krona (SEK), and Swiss Franc (CHF). This index is a significant indicator of the overall strength of the U.S. dollar, according to Liu & Lv (2011)[9]. The data of both the S&P500 (Ticker: ^GSPC) and the US dollar index (Ticker: ^NYICDX) historical prices are collected on Yahoo Finance.

Lastly, the federal fund's effective rate is used as the interest rate at which depository institutions such as banks lend reserve balances. It is a key benchmark interest rate in the United States and plays a crucial role in the country's monetary policy. Central banks, such as the Federal Reserve in the United States, use interest rates to manage inflation, stimulate economic growth, and maintain currency stability (Friedman, 2000)[10]. Changes in interest rates can have a significant impact on consumer spending, business investment, and stock prices. The federal fund's effective rate data can be obtained from the Federal Reserve Economic Data.

The sample period covers from 2 January 2013 to 29 December 2023, and the daily continuous compounded returns of each variable are calculated using natural logarithms. S&P 500 return is abbreviated as SPX, US dollar return as USDX, and Interest rate as IRX.

2.1. Empirical Findings

2.1.1. Summary Statistics

Table 1 presents the summary statistics and Dickey-Fuller test results for SPX, USDX, and IRX. No definitive conclusion regarding the overall sign of skewness can be drawn as SPX and USDX exhibit negative skewness, whereas IRX shows positive skewness. Moreover, all variables display a positive kurtosis, indicating heavier tails and more peaked distributions compared to normal distributions. Lastly, the Dickey-Fuller test, incorporating both an intercept and a time trend, attests that the sample series was drawn from a stationary series. These findings set the stage for further exploration of potential relationships and dependencies among the S&P 500 index, the US Dollar index, and the Interest Rate in subsequent analyses.

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Table 1. Summary statistics of data

Statistic measures	SPX	USDX	IRX
Obs	2768	2768	2768
Mean	0.0004263	0.0000887	0.0012447
Std. dev	0.0108856	0.0043173	0.0930399
Min	-0.1276522	-0.0239877	-1.481605
Max	0.0896832	0.0203203	1.417066
Skewness	-0.8222969	-0.1192717	0.8084627
Kurtosis	19.55004	4.738259	68.9981
Dicker-Fuller	-55.299	-45.391	-60.19

2.1.2. Correlation Coefficient Analysis

Table 2. Pearson correlation coefficient results

Variable	SPX	USDX	IRX
SPX	1.0000		
USDX	-0.0980	1.0000	
IRX	0.0589	0.0165	1.0000

Table 2 shows the correlation analysis and reveals a negative correlation coefficient of approximately -0.0980 between SPX_returns and USD_returns, indicating a weak inverse relationship. Specifically, when the S&P 500 index experiences higher returns, the US Dollar Index tends to exhibit lower returns, and vice versa. On the other hand, we find a positive but weak correlation of about 0.0589 between SPX and IRX, suggesting a slight tendency for the S&P 500 returns to move in tandem with Interest Rate. The analysis also shows a weak positive correlation of approximately 0.0165 between the US Dollar Index and Interest Rate returns, indicating a minimal association between the two variables. These findings underscore the complexity of the interplay between financial markets, currency values, and interest rate differentials, highlighting the need for further in-depth analysis, possibly through regression models, to ascertain the significance and nature of these relationships and to better inform investment decisions.

2.1.3. Regression Analysis

Table 3. Regression analysis results

SPX	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
USDX	-.2496553	.0476376	-5.24	0.000	-.3430641	-.1562465
IRX	.007086	.0022105	3.21	0.001	.0027516	.0114204
_cons	.0004397	.0002057	2.14	0.033	.0000364	.0008429

Adj R-squared = 0.0126; F(2, 2765) = 18.60; Prob > F = 0.0000; R-squared = 0.0133.

As shown in Table 3, the regression analysis provides valuable insights into the relationships between S&P 500 returns, US dollar returns, and the Interest Rate changes. The overall model, as indicated by the F-statistic of 18.60, is statistically significant. The R-squared value of 0.0133 implies that the model explains approximately 1.33% of the variability in S&P 500 returns. Looking at the individual coefficients, the negative coefficient for USDX is -0.2496553, which is statistically significant, indicating that there is a significant inverse relationship between US Dollar returns and S&P 500 returns. This suggests that, on average, as the US Dollar Index returns decrease, S&P 500 returns tend to increase, and vice versa. The positive coefficient for IRX is 0.007086, which is also statistically significant, suggesting that there is a positive relationship between the Interest Rate changes and S&P 500 returns. However, it's essential to

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note that while statistically significant, the practical significance of these relationships may be modest given the small R-squared value. The intercept term (_cons) of 0.0004397 is also statistically significant, representing the expected S&P 500 return when all independent variables are zero. As a result, the regression analysis adds depth to the understanding of the relationships, confirming a statistically significant impact of both USDX and IRX on S&P 500 returns, albeit with limited explanatory power.

2.1.4. GARCH (1,1) model analysis

Table 4. GARCH (1,1) model results

SPX	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
USDX	-.2339037	.0291659	-8.02	0.000	-.2910678	-.1767396
IRX	.007718	.0007362	10.48	0.000	.0062752	.0091609
_cons	.0008602	.0001462	5.88	0.000	.0005735	.0011468
ARCH						
Arch.L1	.3774344	.0233336	16.18	0.000	.3317015	.4231674
Garch.L1	.6737228	.0362249	18.60	0.000	.6027233	.7447224
_cons	-3.17e-06	2.57e-06	-1.24	0.216	-8.20e-06	1.86e-06

Wald chi2(2) = 150.25; Prob > chi2 = 0.0000.

The results of the GARCH (1,1) model show several insights on the analysis. For the overall model fit, the chi-squared test indicates that the model is statistically significant. The ARCH (Autoregressive Conditional Heteroskedasticity) family regression analysis conducted on the S&P 500 index reveals insightful findings. The coefficients for USDX and the IRX demonstrate significant impacts on S&P 500 returns, with a negative coefficient for USD returns (-0.2339037) indicating that a stronger US dollar is associated with lower S&P 500 returns, while a positive coefficient for the interest rate (0.007718) suggests that a higher interest rate correlates with increased S&P 500 returns. Both p-values of USDX and IRX are highly significant. The ARCH and GARCH effects further highlight the presence of conditional heteroskedasticity in the residuals, indicating volatility clustering. Notably, while the ARCH constant term may not be statistically significant, the presence of significant coefficients for lag terms (L1) in both ARCH and GARCH processes suggests that past squared residuals contribute significantly to the current conditional variance, which again is the primary indicator of volatility clustering in the model. In order to ensure the robustness of the analysis, a diagnostic test was conducted to ascertain the model fit, followed by a normality test.

The model fit statistics, including Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC), were employed to evaluate the overall goodness of fit. The AIC and BIC values for the model were -17943.3 and -17907.75, respectively, based on 2,768 observations and 6 degrees of freedom. Lower AIC and BIC values indicate a better-fitting model. Therefore, the AIC and BIC values suggest that the current model, encompassing variables such as USD returns, interest rate changes, and ARCH effects, adequately captures the underlying dynamics of the S&P 500 index. These findings support the model's efficacy in explaining the observed variations in the data.

Lastly, by analyzing the normality test for residuals using the Shapiro-Wilk W test, which yielded a W statistic of 0.87627, with associated critical values of V = 197.076 and z = 13.597. The p-value for the test is 0.00000, indicating a rejection of the null hypothesis of normality. This result suggests that the residuals do not follow a normal distribution. It is important to note that the normal approximation to the sampling distribution of W is valid for 4 <= n <= 2000. As a result, the Shapiro-Wilk test provides evidence against the normality assumption for

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the residuals, indicating the presence of non-normality in the distribution. This finding prompts consideration for potential model refinements or the application of robust statistical methods in further analysis. However, while normality is an assumption of many statistical tests, including those used in GARCH models, violations of this assumption do not necessarily invalidate the model. GARCH models are more concerned with capturing volatility patterns rather than the distributional assumptions of the residuals.

3. Conclusion

This research study intends to investigate the intricate relationship between the US dollar value and the interest rate on the S&P 500 index. The aim is to contribute to existing studies on the current relationship between the three variables during the past decades, more specifically from January 2013 to December 2023. The analysis starts with an initial exploration of summary statistics, and Dickey-Fuller tests successfully establish the stationary nature of the sample series and lay the groundwork for subsequent investigations. The correlation analysis revealed nuanced relationships, with a weak inverse correlation between S&P 500 returns and US Dollar returns, a slight positive correlation between S&P 500 returns and Interest Rate changes, and minimal association between the US Dollar Index and Interest Rate returns. These findings underscore the intricate interplay between market indices and economic indicators, emphasizing the need for more in-depth analysis. In which the regression analysis delved deeper into these relationships, confirming statistically significant impacts of both USDX and IRX on S&P 500 returns. The negative coefficient for USDX implies an inverse relationship, suggesting that as the US Dollar weakens, S&P 500 returns tend to increase. Similarly, the positive coefficient for IRX suggests a positive relationship between Interest Rate changes and S&P 500 returns. However, the modest R-squared value indicates that the model explains only a small portion of the variability in S&P 500 returns. Therefore, we further investigate by using the GARCH (1,1) model, in which the results reinforce our previous two models, showing a negative correlation between the USDX and SPX and a positive correlation between IRX and SPX, which highlights the significance of USDX and IRX in influencing S&P 500 returns. The presence of conditional heteroskedasticity in residuals, as indicated by ARCH and GARCH effects, underscores the importance of considering past volatility patterns in understanding current market dynamics. To verify the robustness of the analysis, we employed the model fit statistics, including AIC and BIC, which support the adequacy of the model in capturing the underlying dynamics of the S&P 500 index. However, the normality test for residuals suggested a departure from a normal distribution, prompting consideration for potential model refinements or the application of robust statistical methods in future analyses. It is crucial to acknowledge that while normality is an assumption, its violation does not necessarily invalidate the model, particularly in the context of GARCH models primarily focused on capturing volatility patterns.

This research provides valuable insights into the complex relationships between financial market indices, currency values, and interest rate differentials. The findings highlight the multifaceted nature of these connections, providing a foundation for future research and informing investment strategies in a dynamic and interconnected global financial landscape. Further studies could investigate whether the relationships between the S&P 500 index, the US Dollar index, and Interest Rates vary over different time periods. This could provide insights into how economic conditions, policy changes, or global events influence the dynamics between these variables. Additionally, expand independent variables, such as oil prices, inflation, unemployment, consumer confidence, and government debt, and analyze how they interact with the US Dollar index and Interest Rates to influence stock market returns.

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