

Negative Monetary Policy and Changes in Apple's Stock Price: Evidence from ARIMA Model

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Abstract. The Federal Reserve has raised interest rates repeatedly to lower inflation, which has had an enormous influence on the stock market. This paper analyzes the influence of the Federal Reserve's interest rate increase on Apple's stock price and gives investor advice. This study used the ARIMA model to analyze the daily, weekly, and monthly data from January 3, 2011 to June 30, 2023. It demonstrates that the impact of the Federal Reserve's interest rate increase on the performance of Apple's stock varies over time, switching between negative and favorable correlations. Rates and returns are inversely associated in the ultra- and medium-short terms. Rates and returns have a favorable correlation over the short run. This alternation shows the diverse expectations investors have for the stock market's future at various points in time. In contrast to other studies, this paper focuses on how the Fed rate hike affects the stock return of a U.S. consumer electronics company, whereas existing articles discuss the impact of the Fed rate hike on a particular industry. This paper suggests that investors should take appropriate risk management measures in the ultra-short term and be cautious about company stocks; in the short term, pay attention to the market's future expectations, and consider buying when the pace of interest rate hikes slows down or when the hikes are lower than expected; in the short to medium term, investors should consider diversifying their funds into different industries, different companies, and even different asset classes.

Keywords: Federal reserve, Interest rate hike, Inflation.

1. Introduction

The outbreak of new coronary pneumonia on the global economy has caused a huge impact, the impact of the epidemic is unprecedented [1]. 2020 since the outbreak of the global epidemic in February 2020, the real economy of all countries has generally been in the doldrums, the capital markets continue to fluctuate dramatically, the governments of major economies and central banks have launched various types of monetary and fiscal policies to try to promote economic recovery. Since 2008, the Federal Reserve has once more implemented a combination of zero interest rates and quantitative easing policy to combat the epidemic's negative effects on the global economy and trade as well as the U.S. financial market liquidity. This policy was launched in an effort to address the current market liquidity crisis and to prevent the epidemic's negative effects from spreading to the economy's fundamentals.

Following the introduction of the historical context in 2008, this round of easing is not the beginning of the financial institutions of the crisis, but the new crown epidemic on the impact of the real economy. Looking at the differences between the Fed's March 2020 launch of the policy itself, the Fed's launch of quantitative easing after the 2008 financial crisis epidemic compared to the four rounds of quantitative easing at the time, each time the amount of the implementation of the amount of the limit, but the epidemic impact of the easing policy does not provide for the corresponding amount of the quantitative easing did not "quantitative" [2].

Quantitative easing spurred the U.S. economy toward recovery, but a rebound in demand put pressure on the supply chain. Since the Federal Reserve launched its unlimited quantitative easing monetary policy, global asset prices of all types, including stocks, credit, commodities, gold, house prices, and even bitcoin, have seen substantial growth. The U.S. economy is gradually returning to normal and displaying indications of overheating given to the fiscal and monetary stimulus. US Treasury bonds have been sold off as a result of the loose monetary policy, which has raised US bond

rates, especially since March 2021 when the yield on the US 10-year Treasury bond exceeded the key level of 1.6%, an indicator that is often considered to be a "bellwether" for inflationary expectations [3].

In February 2022, the crisis in Ukraine hit global energy, food and fertilizer supplies, triggering a surge in commodity prices. At the same time, U.S. inflation has reached historically high levels. Fed Governor Lael Brainard emphasized that the current U.S. inflation rate is too high and its priority should be to lower inflation [4]. On March 17, the Fed held a rate meeting and decided to implement the first interest rate hike since December 2018, and the target range for the federal funds rate was raised from near-zero to 0.25% to 0.5% by 25 basis points. On May 5, the Fed announced that it had a 50-basis point increase in the target range for the federal funds rate. On June 16, the Federal Reserve increased the federal funds rate target range by 75 basis points, marking the Fed's largest rate rise since 1994 [5]. High inflation prompted the Fed to have to raise the federal funds rate, thereby reducing the money supply.

The federal funds rate rise by the Fed will affect the stock market. According to Chiang's paper, the U.S. market may experience panic as a result of the Federal Reserve's announcement to raise interest rates, which would reduce market returns. On the basis of data from 12 industrialized nations, Chiang also analyzed at the correlation between real stock returns and real stock returns, noting that the relationship between stock market volatility and inflation is positive whereas there is a negative correlation between volatility in the stock market and actual returns on stocks. These results confirm the negative relationship between inflation and real stock returns in the US and 11 other international markets [6]. Similarly, in line with Chiang's most recent research, Bouri and Nekhili et al. used data from the S&P 500 composite index and its 11 sectoral indices to get the conclusion that high inflation raises interest rates and has a negative impact on S&P 500 securities [7].

In addition, Yilmazkuday's empirical results show that the more COVID-19 cases, the lower the S&P 500 index. Second, the higher number of COVID-19 cases is associated with higher term premia, suggesting that COVID-19 pandemics increase future policy uncertainty [8]. The World Health Organization's weekly COVID-19 Epidemiological Update of June 29, 2022, reported more than 4.1 million cases during the week of June 20-26, 2022, an 18% increase from the previous week. The number of new deaths per week was similar to the previous week, with more than 8,500 deaths reported [9]. Compared to the 2020 figures of tens of thousands of infections per day in the U.S., the volatility in the stock market due to uncertainty over increased health issues and decreased ecological activity is decreasing or even negligible.

It is worth noting that the Russian-Ukrainian conflict that erupted in February 2022 hindered the international economy's path to recovery from COVID-19 to the broken ring, and the sharp spike in the price of commodities, such as crude oil, led to an increase in the rate of inflation. By analyzing the effects of the sudden rise in crude oil prices on the performance of stock prices and the rates at which the G7 countries' currencies are exchanged, Bagchi and Paul concluded that, apart from the TSX, NASDAQ, and the U.S. dollar, found renowned long-run memory impacts of Brent crude oil prices on all stock price returns as well as on currency exchange rates of all G7 countries [10].

Overall, there is a relatively large body of research on the effects of hyperinflation as well as pandemics on the stock market as a whole or on a particular index, but comparatively little study has been done on how Federal Reserve hikes in interest rates affect a specific publicly listed company's stock price. To fill this gap, this paper uses empirical data to examine how Fed rate hikes affect Apple's stock volatility. The specific reason for analyzing this relationship is to understand the volatility pattern of Apple's stock returns after the Fed's interest rate hike and to provide relevant recommendations for investors and institutions. As a result, some irrational investments or strategies can be avoided.

The remainder of the paper is structured as follows: The paper's data sources, data stability, and models are discussed in section 2 of the text. This is followed by a comprehensive discussion of the results of the ARIMA model and the analysis of stock returns in Section 3. Section 4 then discusses

the implications of the research and how investors should apply the findings of this paper. Finally, Section 5 briefly reiterates the conclusions.

2. Research Design

2.1. Data Sources

Stock prices fluctuate at every point in time, so its opening, high and low prices are not a good reference for the overall prediction of stock prices, this paper selects the daily, weekly and monthly closing price data of Apple stock from January 3, 2011 to June 30, 2023 as the object of the study and the information, and the data is obtained from the Choice financial terminal, use Excel software to organize the data, and then import it into Stata. To avoid the violent impact of the war between Russia and Ukraine on the stock market in a short period, this paper will set June 16, 2022 as the time T0.

2.2. Weak Stationarity Test

This research first generates the log price of the stock and differencing to get the log return, then the model needs to be tested for smoothness, the original hypothesis is that the model is not smooth. After putting the data into Stata for the ADF test, the results, as demonstrated in Table 1, show that the p-value of the logarithmic returns is 0, which is less than 0.1, for daily, weekly, and monthly time series chosen to be of order 1 and above, so the original hypothesis can be rejected, which means that the model is smooth. Whereas, the original series significance p-value is greater than 0.1 and the original hypothesis cannot be rejected, demonstrating that the original series is non-smooth.

Table 1. Weak stationarity test

		t	p
Daily			
Raw		-3.088	0.1090
1st order difference		-55.673	0.0000
Weekly			
Raw		-2.041	0.5791
1st order difference		-17.170	0.0000
2nd order difference		-31.485	0.0000
Monthly			
Raw		-2.166	0.5091
1st order difference		-8.508	0.0000
2nd order difference		-14.127	0.0000

2.3. ARIMA Model Setup

2.3.1 ARMA Model

The autoregressive moving average (ARMA) model is an organic combination of the moving average (MA) model and the autoregressive (AR) model. AR model is a model based on the past observations of the research object and the present disturbance value through the linear combination of the model, to carry out the predictive analysis. AR(p) model form is expressed as:

$$return_t = \phi_1 return_{t-1} + \phi_2 return_{t-2} + \dots + \phi_p return_{t-p} + \varepsilon_t \quad (1)$$

Where, $return_t$ is the smooth time series, ε_t is the error, $\phi_i (i=1, 2, \dots, p)$ denotes the coefficient to be determined by the AR model, and p denotes the order of the AR model. MA model is a model based on the past disturbance value of the research object and the present disturbance value through the linear combination of the model, to carry out the predictive analysis. MA(q) model is expressed in the form of:

$$return_t = \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q} \quad (2)$$

Where, $return_t$ is the smooth time series, ε_t is the error, $\theta_i (i=1,2,\dots,q)$ denotes the coefficient to be determined by the MA model, and q stands for the order of the MA model. The ARMA model is based on the combination of the AR model and the MA model, mainly used to describe the smooth stochastic process. The following is how the ARMA (p, q) model is represented:

$$return_t = \phi_1 return_{t-1} + \phi_2 return_{t-2} + \dots + \phi_p return_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \dots - \theta_q \varepsilon_{t-q} \quad (3)$$

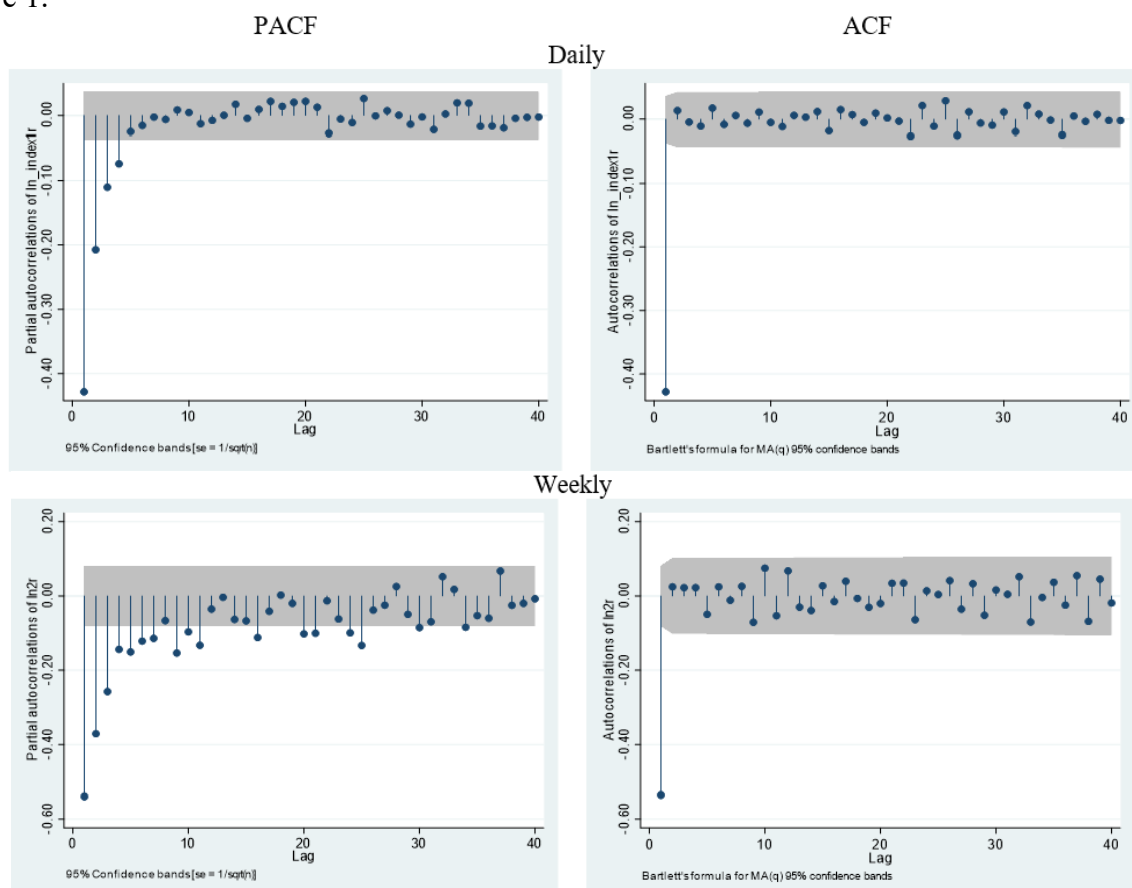
2.3.2 ARIMA Model

ARIMA model is born based on the ARMA model, which can be used to analyze the non-stationary series and build the model after differential processing to make the series stable. In the ARIMA (p, d, q) model, p is the order of autoregressive, and q is the number of moving average terms, and d is the number of differential orders of the time series for the smoothing process.

3. Empirical results and analysis

3.1. Definitive Order

The original time series data in this study are acquired as a smooth series after first-order differencing, in accordance with the analysis above, hence the ARIMA (p, d, q) model is selected for identification. After the series is smoothed, it is necessary to perform model order determination to determine the values of p , d , and q . Since in the smoothing process, the first-order difference of the original series is to obtain a smooth series, it can be first determined that $d=1$. The appropriate p and q values in ARIMA (p, d, q) can usually be determined from plotting autocorrelation (ACF) and partial autocorrelation (PACF) plots. Since the first-order differencing of the weekly and monthly data could not determine the appropriate p -values and q -values, the sequences were subjected to second-order differencing to determine their values, in other words, $d=2$, and the results are shown in Figure 1.



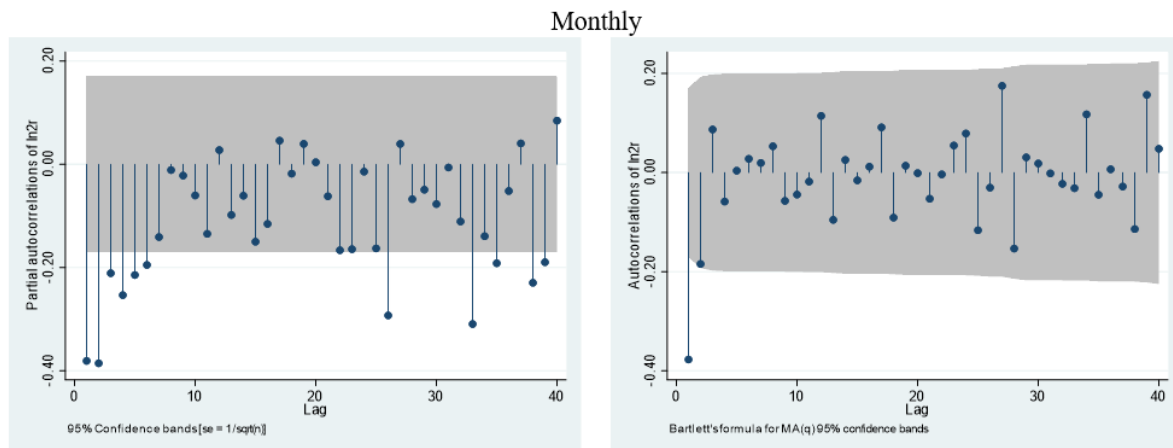


Figure 1. ARMA (p, q) identification, Photo credit: Original

Finally, the white noise test is an important step in time series analysis because if the series is not white noise, there may be some trend, seasonality, or other cyclical components that need to be considered and dealt with. The white noise test can help to confirm whether further data transformation or model fitting is needed to make the time series analysis results more reliable and accurate. From Table 2, the p-values of daily, weekly and monthly data are all greater than 0.1, which means that the original hypothesis is accepted that there is no correlation between the residuals, indicating that the residual terms belong to the white noise series, and that the valid information in the residual terms has been completely extracted, and the model is basically perfect.

Table 2. Residual test

Model	Portmanteau (Q) statistic	Prob > chi2
Daily-ARIMA(4,1,1)	20.6365	0.9952
Weekly-ARIMA(11,2,1)	29.7745	0.8814
Monthly-ARIMA(6,2,1)	42.2649	0.3734

3.2. Prediction Results and Interpretation

According to the above test results, it can be seen that the ARIMA model fitting effect is more satisfactory, so the established ARIMA (4,1,1), ARIMA (11,2,1) and ARIMA (6,2,1) models can be used to predict the stock prices. Since this ARIMA model is suitable for short-term forecasting and has high accuracy in short-term forecasting, it is chosen to forecast the stock prices for the next 4, 11 and 6 setting units respectively, and the results of the forecasts are shown in Figures 2, 3 and 4.

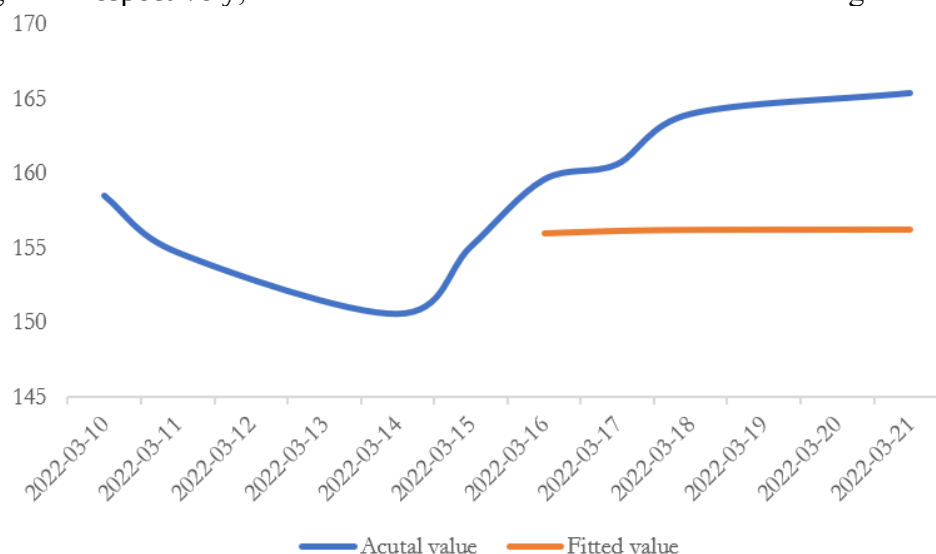


Figure 2. Actual value and fitted value, daily, Photo credit: Original

As can be seen from the figures, the relationship between stock returns and Fed rate hikes is time-varying, alternating between negative and positive correlations. As can be observed from the ultra-short term (frequency of 1 to 4 days) impact in Figure 2, the rate is negatively correlated with Apple's stock price. The impact of the Fed's rate hike on Apple's stock price is somewhat of a one-time shock.

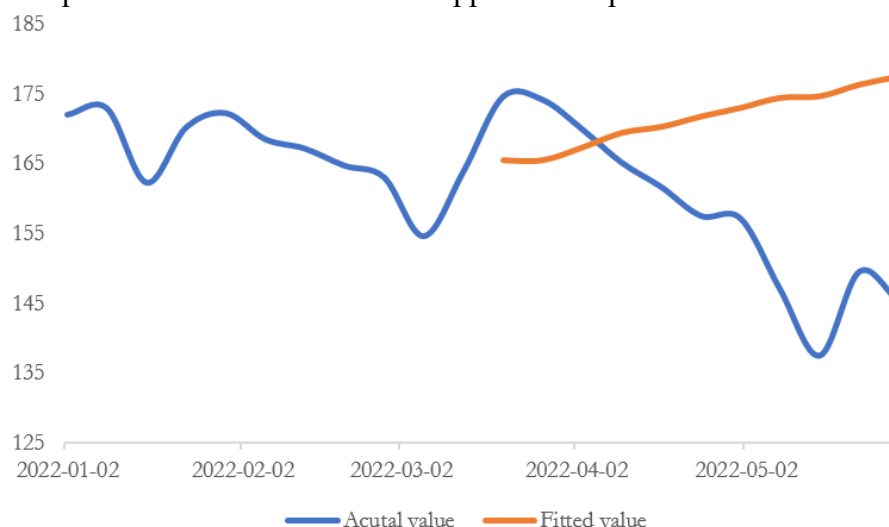


Figure 3. Actual value and fitted value, weekly, Photo credit: Original

Similarly, as can be seen in Figure 4, the Federal Reserve's increase in interest rates significantly lowered the price of Apple's stock. six months later, and its impact on Apple's stock price grew as the number of rate hikes increased. Along with the continued tightening of U.S. monetary policy, higher interest rates may make stocks less attractive relative to other investment vehicles (e.g., bonds), and investors may shift to lower-risk investment options, leading to a sell-off in the stock market. Moreover, high interest rates can increase borrowing costs, leading to less investment and slower expansion by firms, and the profits of firms may fall, leading to a fall in stock prices.

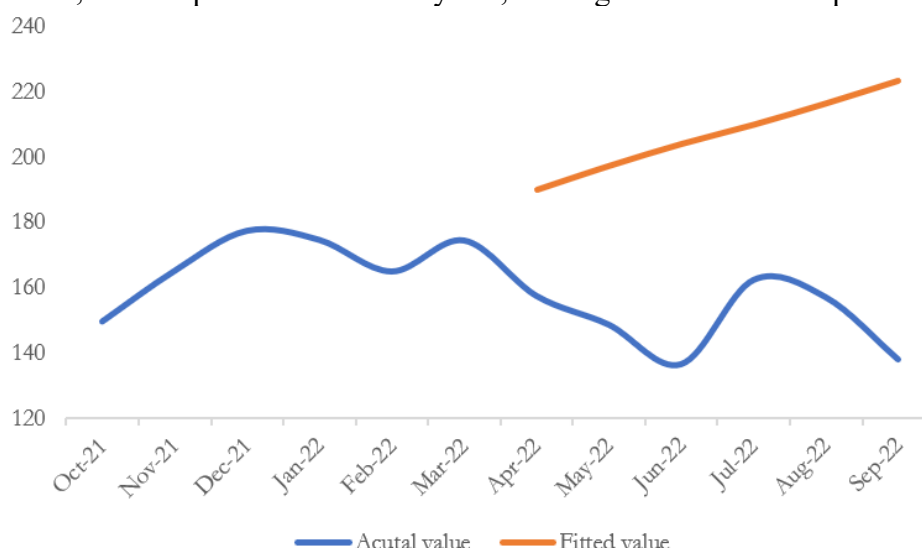


Figure 4. Actual value and fitted value, monthly, Photo credit: Original

However, as can be seen in Figure 3, the Fed's interest rate hike led to a rise in Apple's stock over a two-month period. According to Sameer Samana, senior global market strategist at the Wells Fargo Investment Institute, the reason for the strong rally in July was that investors developed favorable expectations for the future. Although a hefty rise, the Federal Reserve's benchmark interest rate increase of 0.75% was less than the initial expectation of 1% among some analysts [11]. In addition, Fed Chairman Jerome Powell made comments about the slowing pace of rate hikes[11]. This doesn't mean that a Fed rate hike will make a company's stock go up. The essential reason for the rise is because of the shift in investor sentiment. However, the combination of Figure 4 and the current

historical data on Apple's stock price shows that the Federal Reserve's interest rate hike has had a negative impact on Apple's stock price.

4. Discussion

In contrast to other studies, this paper focuses on how the signal of a Fed rate hike affects the stock returns of a U.S. company, whereas existing articles discuss the impact of inflation or pandemics on the stock market as a whole or on a particular industry. Existing articles are based on the S&P 500 index study, while this paper takes Apple, which is the most heavily weighted company in the S&P 500 index, and draws conclusions that are consistent with existing studies.

Based on the findings of this paper, investors can consider the following points to apply the forecast results and understand the relationship between the stock market and the Fed's interest rate hike.

Firstly, according to the ultra-short-term prediction result of the ARIMA model, the Fed's interest rate hike may lead to stock price decline within a few days. Based on this prediction result, investors can be cautious about Apple's stock in the ultra-short term and avoid buying blindly, especially for ultra-short-term traders. Investors can use this finding to capitalize on market volatility and take appropriate risk management measures, such as setting stop-loss points, to protect their investment capital.

Secondly, based on the short-term forecast results of the ARIMA model, Federal Reserve's interest rate hike causes Apple's stock price to ascend in the short term. Investors can use this forecast to modestly increase their position in Apple Inc. stock to capitalize on the expected market upside potential. It is worth noting that the upside potential here is due to the weakening of the rate hike, which has created favorable expectations for market investors, rather than a direct result of the rate hike. However, it is still necessary to be cautious of market risks and avoid excessive optimism.

Finally, based on the medium-short term forecast results, the Fed interest rate hike will have a more intense negative impact on Apple's stock price. Investors should not put all their eggs in one basket. Instead of putting all their eggs in one basket, investors should consider diversifying their funds into different industries, different companies, and even different asset classes such as bonds and gold. Diversification does not completely eliminate investment risk, but it can reduce the impact of specific asset or industry volatility on a portfolio.

5. Conclusion

The outbreak of COVID-19 forced the Federal Reserve to implement an easy monetary policy. This uncapped quantitative easing policy and the outbreak of the Russo-Ukrainian war caused inflation to soar. In order to reduce inflation, the Federal Reserve had to increase the federal funds rate, thus reducing the money supply.

The purpose of this thesis is to study how Apple Inc. has been affected and impacted in the ultra-short, short and medium-short term respectively, against the backdrop of high inflation that has led to a series of interest rate hikes by the Federal Reserve, and to give three suggestions to investors in the market. This paper mainly uses the ARIMA model to analyze the relevant data, and the empirical investigation has led to important findings. The study shows that the Federal Reserve's interest rate hike on Apple's stock return varies over time, switching between negative and positive correlations. In the short and long term, Fed rate hikes and returns show a negative correlation. It indicates that the Fed rate hike will reduce the return of the company's stock (plus the recommendation); in the medium term, the Fed rate hike and the return show a positive correlation. It indicates that the Fed rate hike will instead lead to an increase in the company's stock. Some researchers believe that the positive impact of interest rate hikes on stocks is due to the fact that raising short-term interest rates increases investor confidence. However the exact reflective mechanism is yet to be studied and elucidated.

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