

The Impact of the US Increasing Interest Rate on Internet Industry: A Short-term Perspective

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Abstract. On March 16, 2022, Federal Reserve released the news that it was going to raise interest rate by 25 basis points, which officially commenced the year-long interest rate hikes. During this a year and half period starting from March 16, 2023, to July 26, 2023, Federal Reserve raised interest rate 11 times and brought the Federal Funds Rate reached 5.25% to 5.50%. This is the largest interest rate hike since 2000s and has had a significant impact on various areas, including the internet industry. This paper selected Dow Jones Internet (DJUSNS) index as an indicator to analysis how market reacts to interest rate hikes in the internet industry and uses ARIMA model to predict how DJUSNS would behave without the increasing in interest rate. This study predicts the possible future of the internet industry and provides investors who are interested in internet industry with market trends and investment opportunities. The paper concludes that the internet industry is negatively impacted by interest rate increases, primarily attributed to the following two factors: increase in the cost of capital and the decrease in investment returns.

Keywords: US, Interest rate, Stock market, Internet industry, ARIMA model, Federal Reserve.

1. Introduction

The rise of the internet industry can be traced back to the late 1980s and early 1990s, although early forms of the internet could be dated back to earlier decades. APPANET, the internet's forerunner, was first used in 1969 and built by the Defense Advanced Research Projects Agency, which was mainly used for research and military purposes. Worldwide Web browser, the first web browser written in 1990, made it easier for ordinary people to browse the web pages, which promoted the commercialization of the Internet in the early 19th century because some businesses saw the potential of the Internet. In the mid-nineties, the internet industry began to boom, which is known as the "dot-com bubble". Investors invested a significant amount of money into internet start-ups, but in the 2000s the internet stock market crashed, causing many companies to fail. 'Creative destruction' is a legitimate part of capitalism; downturns are to be endured until innovation again fuels overall growth [1]. At the beginning of the 21st century, the internet industry recovered rapidly and gradually developed. After several decades of recovering, companies such as Google and Microsoft were rising, and social media internet applications such as Instagram and Twitter also began to rise, occupying a dominant position in the internet industry which makes the internet industry returned to its previous significant role in the financial market. However, in 2022, when Federal Reserve first imposed a rise in interest rate, the whole financial market was impacted, including the internet industry.

Federal Reserve, first established in 1913, is responsible for managing the U.S. money supply, maintaining financial stability, and supervising the banking system. It adjusts the interest rate to implement monetary policy to influence different aspects of the U.S. economy. During the pandemic, the Federal Reserve is prompted to adjust the interest rate once again due to the disruption of supply chain and increasing demand. Starting from March 17, 2022, to July 26, 2023, the Federal Reserve increased the interest rate 11 times with the least amount of 25 basis points to contain rapid inflation. The continuous increase in interest rate has brought significant effects on various areas, including the internet industry.

The remaining parts of the paper are structured as follows: Part 2 is the Research Design, which includes the motivation for the interest rate hikes and its potential economic consequences. The

following section Part 3 is the research design, which involves using unit root test to exam the reliability of the DJUSNS and introducing the ARIMA model to analyze it. After that, the fourth part displays order estimation and interpretation of the results obtained from its determined order. In the last section of this paper, the conclusion of this article will be presented, along with a shortcoming of this article and further improving areas.

2. Research Design

2.1. Data Source

DJUSNS, a sub-index of Dow Jones U.S. Total Stock Market Index, is created and maintained according to an objective and transparent methodology with the fundamental aim of providing reliable, accurate measures of U.S. equity performance [2]. The study collected extracted daily, weekly, and monthly closing price of DJUSNS from 2010 to Oct 2, 2023, and set March 16, 2023, the first time that Federal Reserve increase the interest rate, as time 0. The rationale for setting March 16, 2023, as time 0 is to use the data before interest rate hikes to build the model to forecast the stock price of DJUSNS without the effect of interest rate hikes. To elaborate, first transform the closing price for DJUSNS into logarithmic form by the formula $\ln(1+x)$ to analyze on a logarithmic scale. Then, DJUSNS stock returns in logarithmic scale are obtained by dividing the \ln of its closing price of a unit by its previous unit, then subtracting one from the received value.

2.2. Unit Root Test

Before building the ARIMA model, a weak stationarity test is required. Using the ADF test in Stata, the MacKinnon approximate p-value is 0 for 1st order difference for daily and weekly data, and p-value for 2nd order difference is 0 for monthly data. Therefore, the null hypothesis, unit root exists, is rejected, which indicates that the time series is stationary.

Table 1. Weak stationarity test

	t	p
Daily		
Ln price	-2.698	0.2369
1st order difference	-41.632	0.0000
Weekly		
Ln price	-3.758	0.0188
1st order difference	-18.419	0.0000
Monthly		
Ln price	-3.340	0.0599
1st order difference	-9.995	0.0000
2nd order difference	-16.406	0.0000

2.3. ARIMA Model

$$x_t = \phi_0 + \sum_{i=1}^p \phi_i x_{t-i} + a_t - \sum_{i=1}^q \theta_i a_{t-i} \tag{1}$$

The general expression of ARIMA model is shown by equation (1) above. It combines three components of auto regression (AR), integrate (I), and moving average (MA) to fit the characteristics of different time series data. AR, $\phi_0 + \sum_{i=1}^p \phi_i x_{t-i}$, is to model the autocorrelation of the time series, and its order p determines how many observations of the past value are used to predict the future value; MA, the rest of the equation, represents the white noise of the time series, and its order q shows indicates how much of the prediction error of the past value is used to predict the future value I is the times of difference performed to make the time series stationary, and its order d indicates the number of times needed to difference to make the time series stationary.

3. Empirical Results and Analysis

3.1. Order Estimation

PACF (Partial Autocorrelation Function) and ACF (Autocorrelation Function) are assessed to find the optimal orders for q and p , respectively. Any points in the graph that exceed the upper and lower limits can be considered as valid orders. The component d of ARIMA is assessed through the stationary test.

PACF

ACF

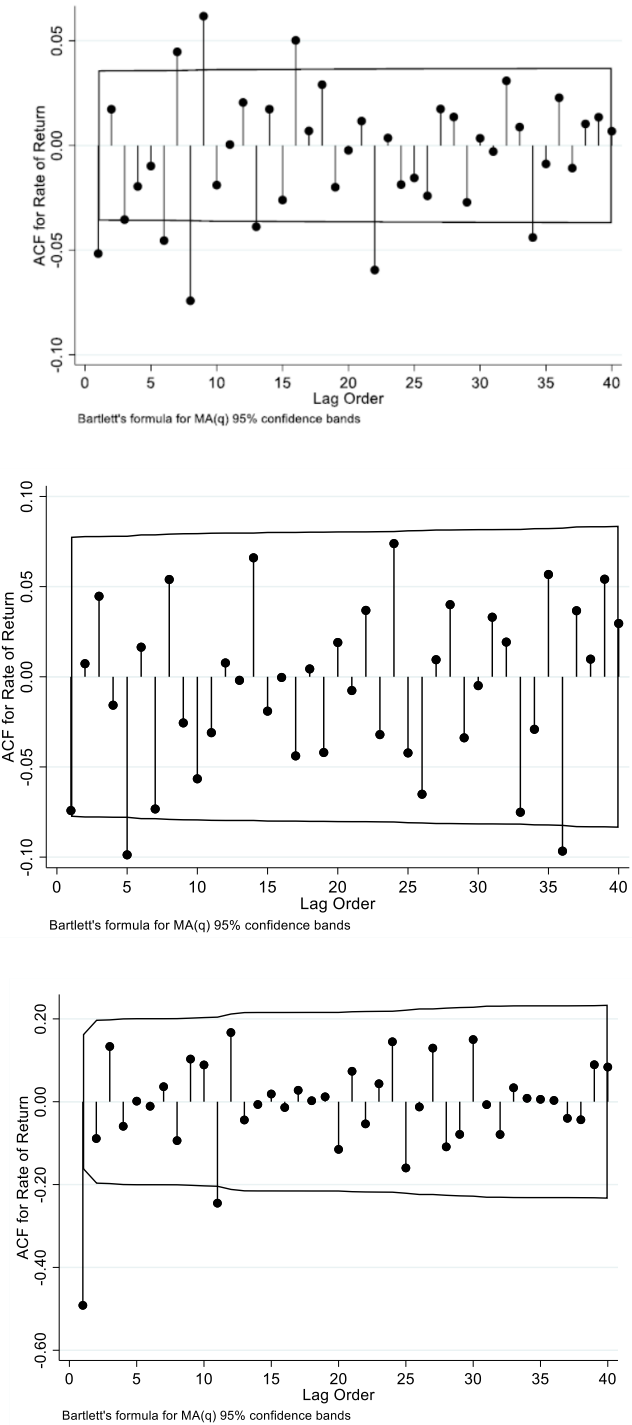
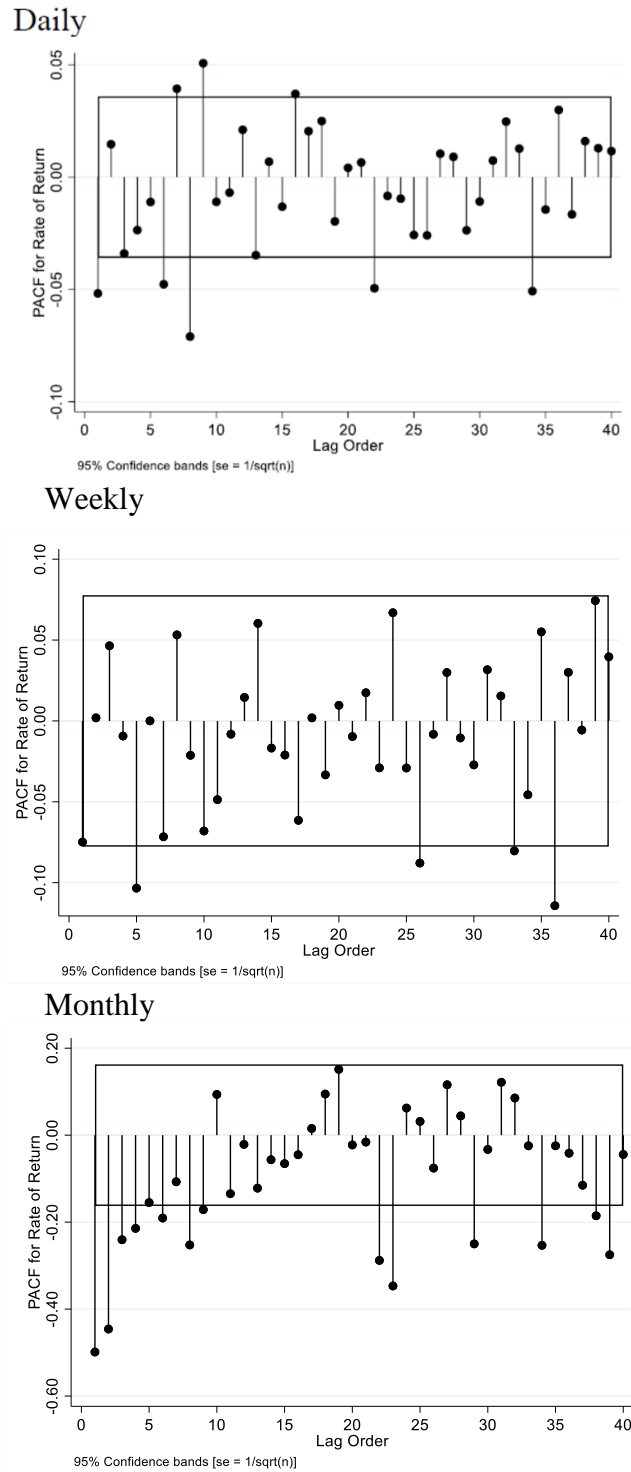


Figure 1. ARMA (p, q) identification

Photo credit: Original

Figure 1 Daily part PACF test reveals that Lag 1, 6, 7, 8, and 9 all exceed the limits set, which indicates that they can all be used as orders. If lag 1 is chosen to be the order, the model can only forecast one period ahead. To predict values further into the future, lag order with greater value should be chosen. Therefore, 9 is the desired lag order. ARIMA's component p and q could be determined by the same logic using the figure 1 above.

The component d could be determined using Table 1. Because it is the number of times needed to difference the data to remove trends and seasonality, the order could be obtained by looking for the order where p-value is 0. For daily data, since 1st order difference's p-value is 0, the order for d should be 1. Similarly, the values of d for weekly and monthly data are 1 and 2, respectively.

From the above material, it could be concluded that the expression for Daily-ARIMA model is ARIMA (9,1,9); for Weekly-ARIMA model is (5,1,5); for Monthly-ARIMA model is (8,2,1).

Following the determined orders for the three ARIMA models, it is vital to test whether the model is stationary or not. If the ARIMA models are stationary, their residuals must be white noise. All three models are tested by chi-square test in Table 2. The p-value for Daily-ARIMA (9,1,9) is greater than 0.1, which accepts the hypothesis that the residual is white noise. For Weekly-ARIMA (5,1,5) and Monthly-ARIMA (8,2,1), p-values are both less than 0.1, indicates that residuals are not white noise. As a result, the Daily-ARIMA model is sufficient whereas Weekly-ARIMA and Monthly-ARIMA are not. But since only the trend of DJUSNS's stocks prices is needed, the results of stock prices do not necessarily have to be precise, and a slight margin of error is acceptable.

Table 2. Residual test

Model	Portmanteau (Q) statistic	Prob > chi2
Daily-ARIMA(9,1,9)	43.2930	0.3326
Weekly-ARIMA(5,1,5)	81.4425	0.0001
Monthly-ARIMA(8,2,1)	64.9599	0.0075

3.2. Predicted Results and Explanation

After estimating the models, the results are contained in Figure 2, 3 and 4. From the estimation of actual value and fitted value in Figure 2, after the time 0, the actual value for DJUSNS was significantly above the fitted value, indicating that increase in interest rate would bring about a positive impact on the internet industry in the short term, which is contrary to the intuition is that consumption and output would be lowered by a surprise hike in the monetary policy, which causes risk aversion to rise, and explains the large empirical drop in the aggregate stock market and the large increase in bond yields[3]. There may be two potential reasons for the continued upward trajectory of the stock index. First, the magnitude of the interest rate hike might be insufficient to trigger a downturn in the stock index. Second, there could be a policy lag, where it takes some time for investors to react to the implemented policies.

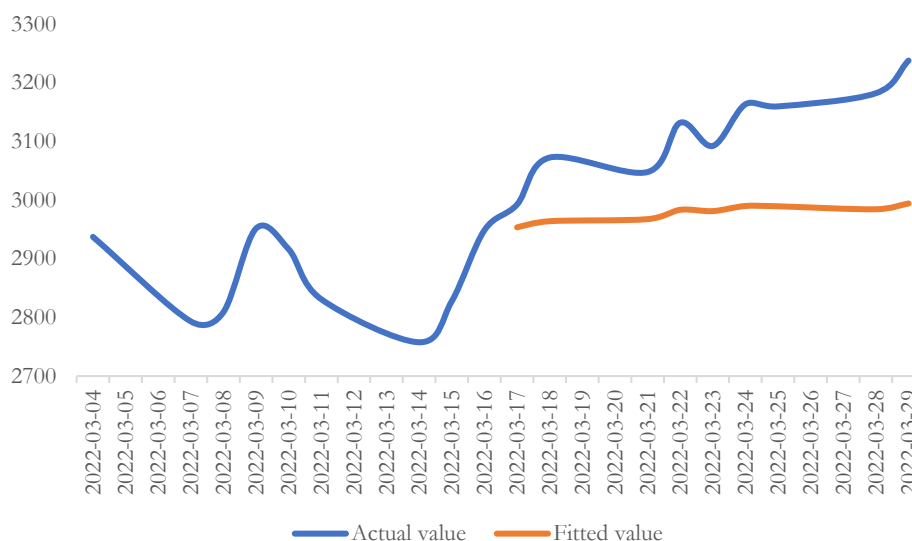


Figure 2. Actual value and fitted value, daily

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Then this paper studies the result of Figure 3. Since the second interest rate hike occurred on May 5, 2022, not within the March and April, the result displays in Figure 3 remains unaffected by the interest rate hikes. In light of that, by furthering analyzing Figure 3, this paper could make further inferences to determine whether continued upward trajectory of the stock index is caused by insufficient magnitude of the interest rate hike or the policy lag. From Figure 3 with a longer time interval, despite the fact that the actual value surpasses the fitted value in the short term, the long-term perspective reveals that actual value diminishes compared to the fitted value. This could be explained by the inefficiency of the policy lag, which states that the monetary actions affect the state of economic only after a lag that is both long and variable [4]. The DJUSNS’s price did not immediately reflect the precise value of interest rate hikes when it was released. Instead, as Ball and Brown stated, the market price only response gradually to surprise information like interest rate hikes, which would result in an abnormal return [5]. As illustrated in Figure 3, the fitted value was lower than the actual value, but as the market reacts, the actual value continues to decrease. Therefore, it can be inferred that the interest rate hikes will lead to a reduction in actual value, causing a negative impact on the internet industry, which aligns with the statement that both the interest rate and growth of interest rate are negatively correlated with share price and growth of share price, respectively. [6].

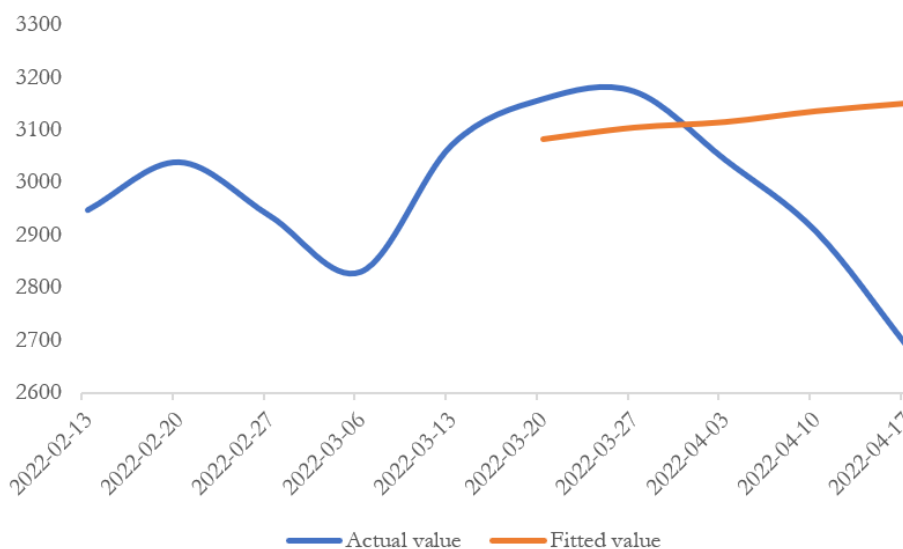


Figure 3. Actual value and fitted value, weekly

Photo credit: Original

To further substantiate the inference, a longer time window is required. Figure 4 displays the actual stock price and estimation of stock price measured on the monthly interval. The fitted value consistently surpasses the actual value, it could be concluded from this part the current monetary policy could be responsible for a significant fraction of current stock price change [7], which is in accordance with the inference the paper previously made.

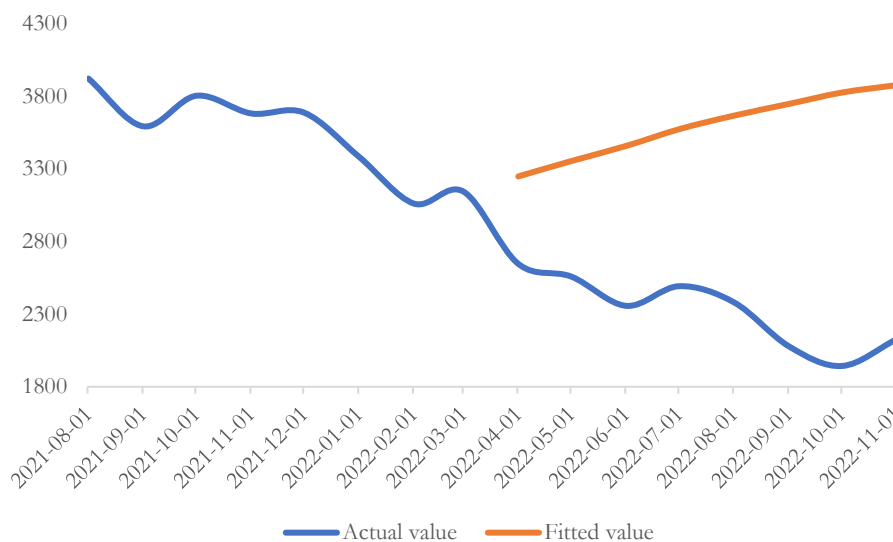


Figure 4. Actual value and fitted value, monthly

Photo credit: Original

From the three figures above, the fitted value is lower than the actual value in the beginning, then surpasses the actual value in the long term. However, when converted to data with a larger time span, fitted value would be consistently higher than the actual value which could be explained by the policy lag due to the inefficiency of market.

After impacting so many different sectors by increasing the interest rate, the Federal Reserve will be unable to engineer a "soft landing" as many financial analyses expected [8]. The increase in interest rate will simultaneously cause an increase in the cost of capital and the decrease in investment returns, which could be two main factors that make the internet industry continuously go down. The tightening of monetary policy leads to an escalation in borrowing costs because higher interest rates could lead to higher interest rates in the interest rate market, and money would also flow from the stock market to the bond market [9]. This could cause start-up internet companies to not expand their operation with insufficient funds. Furthermore, as borrowing costs rise, investors may seek investment with higher returns, which leads a portion of investors to abandon investment in the internet industry. This aligns with the statement that statistically significant negative effects of interest rates on stock returns in the developed countries [10].

4. Conclusion

The internet industry has been significantly affected by a total of 11 times of interest rate hikes conducted by the Federal Reserve. This paper mainly focuses on the influence of the increase in interest rates conducted by the Federal Reserve on the internet industry in both the short term and long term. The ARIMA model was used in this article to predict the fitted value of Dow Jones Internet index (DJUSNS). The actual value is greater than the fitted value in the short term, indicating that the interest rate hikes are positively correlated with the internet industry in the short term. However, when takes it to the long run, actual value is lower than the fitted value, indicating that the interest rate hikes negatively affect the internet industry. The short run phenomena could be explained by the inefficiency of the market, and the long run phenomena could be explained by increasing borrowing costs of capital.

This study offers an insight into the impact of interest rate hikes received by the internet industry. It provides the investor with a different prospect to make investment decisions in this sector.

Further research could compare the influence of interest rate hikes to other sectors with its impact on the internet industry, discover the commonalities between them, then conclude the overall trend of the entire market.

References

- [1] Goodnight, G T, Green S. Rhetoric, risk, and markets: The dot-com bubble [J]. Quarterly journal of speech, 2010, 96 (2): 115 - 140.
- [2] Dow Jones U.S. Total Market Index Overview [EB/OL]. (2022-08-30) [2023-10-23]. <https://www.investopedia.com/terms/d/dow-jones-total-market-index.asp>.
- [3] Pflueger C, Rinaldi G. Why does the fed move markets so much? a model of monetary policy and time-varying risk aversion [J]. Journal of Financial Economics, 2022, 146 (1): 71 - 89.
- [4] Friedman M. The lag in effect of monetary policy[J]. Journal of Political Economy, 1961, 69 (5): 447 - 466.
- [5] Ball R, Brown P. An empirical evaluation of accounting income numbers [M]//Financial Accounting and Equity Markets. Routledge, 2013: 27 - 46.
- [6] Uddin G. The impacts of interest rate on stock market: empirical evidence from Dhaka Stock Exchange [M]//The Impacts of Interest Rate on Stock Market: Empirical Evidence from Dhaka Stock Exchange: Uddin, Gazi. [SI]: SSRN, 2017.
- [7] Rozeff M S. Money and stock prices: Market efficiency and the lag in effect of monetary policy [J]. Journal of financial Economics, 1974, 1 (3): 245 - 302.
- [8] Nersisyan Y, Wray L R. Is It Time for Rate Hikes? The Fed Cannot Engineer a Soft Landing but Risks Stagflation by Trying [R]. Levy Economics Institute, 2022.
- [9] Kang J. The Impact of the Fed's Interest Rate Hike on the Financial Industry: Focusing on the Exchange Market and Capital Market [J]. Highlights in Business, Economics and Management, 2023, 15: 52 - 57.
- [10] Assefa T A, Esqueda O A, Mollick A V. Stock returns and interest rates around the World: A panel data approach [J]. Journal of Economics and Business, 2017, 89: 20 - 35.