

The Impact Caused by the U.S. Increasing Real Interest Rate on Volatility Index

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Abstract: This paper mainly focuses on the impact of the US interest rate hike on the volatility index after March 16, 2020. In this article, daily, weekly, and monthly volatility index data from 2010 to 2022 are extracted and the ARIMA model was used to determine and analyze the difference between actual value and fitted value of volatility index after increased rate. The study forecasts the effect of rate hikes on volatility index in short-, medium-, and long-term perspective. According to the ARIMA model, the interest rate hike has the greatest impact on the volatility index in the medium term, which is not obvious in the short term, and the impact of interest rate hike gradually decreases in the long term, and finally returns to the normal trend. Compared with other studies on the impact of interest rate hike on the overall economic activity, this paper only focuses on the impact of interest rate hike on the volatility index. Through the research of this paper, the policy makers can adjust the rate of interest rate hike according to the speed and amplitude of investors' response to the policy, so as to produce turbulence and panic on the stock market to a minimum extent.

Keywords: COVID-19 pandemic, Volatility Index, Real interest rate, U.S. Economy, ARIMA Model

1. Introduction

Since the outbreak of the COVID-19 pandemic, the United States economy has fallen into an unprecedented downturn, and in order to improve this situation, the United States has raised interest rates since March 16, 2020 [1]. According to the statistics from FRED, it clearly showed that in just a few months, the unemployment rate reached the highest point in these thirty years and the real GDP comes to the lowest level during this regressive period. In short, across the US, the coronavirus outbreak has changed the structure of the economy and the way people allocate their assets.

Why do lots of investors pay attention to VIX, and what is it indicated? According to the definition of volatility index, it represents the market's expectation for the relative strength of near-term price changes of S&P 500 index. Since it derives from almost today's price of SPX index, it can create an estimation of next 30 days' fluctuation [2]. In short, VIX can show the attitude of investors to the stock market, which means the VIX will go up when the stock market is poor, and it will go down when the stock market is strength. Now under the COVID-19 economic regression, VIX index is most likely going to the highest level [3].

Additionally, although the volatility index is an estimate, it greatly affects investors' expectations of the future short-term market direction. And thus, greatly influences the behavior of investors. For example, when the VIX is high, it can signal a potential increase in market volatility [4]. Investors may use VIX-linked products or options to hedge their portfolios against adverse market movements. In this case, some traders and investors use the VIX as a market-timing tool. Extremely low VIX levels might indicate complacency and potential market overheating, however extremely high levels might suggest a market bottom is approaching. Following this general rule, investors can avoid some potential risks and receive a higher return [5].

Moreover, one of the most important roles of VIX is it allows the investors to trade this index. Sophisticated investors and traders engage in volatility trading, taking advantage of perceived mispricing in options or VIX-related products. This can involve strategies, like comparing the historical and implies index, that profit from changes in market volatility [6].

Furthermore, VIX has often been associated with significant market events, so it is also called an indicator of market crises. According to the figure. 1, it clearly shows that during 2008 financial crisis and the COVID-19 pandemic, sudden increase in the VIX can serve as a warning sign of potential market disruptions. Besides, VIX can not only indicate the change in the whole market, but it can also assess financial stability. Elevated levels of VIX can indicate periods of financial stress and potential systems risks in the markets. Monitoring the VIX with other hedge tools can provide greater financial stability [7].

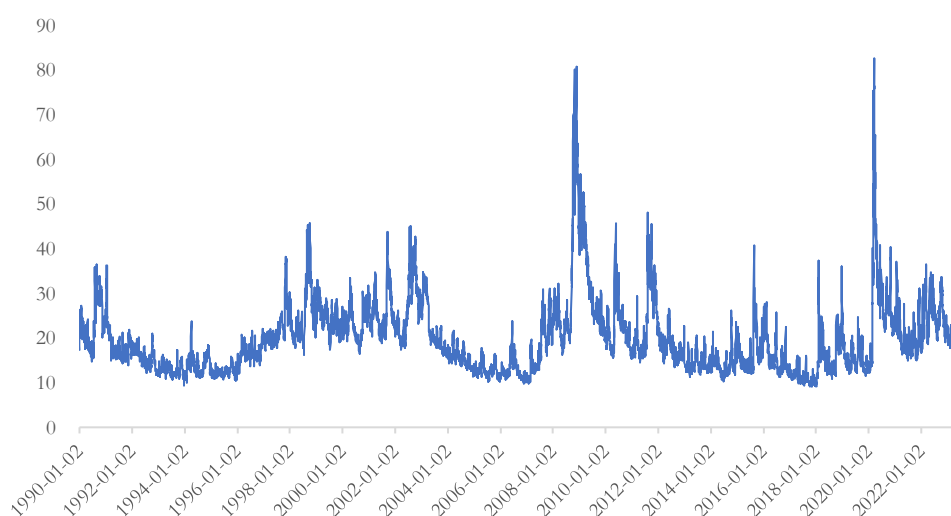


Figure 1: VIX Index

Data Source: <https://fred.stlouisfed.org/series/VIXCLS#>

Photo credit: Original

Based on the research there is a close association between increasing real interest rates and the VIX, which is involved in the cost of borrowing, market sentiment, global capital flows, and so on. When real interest increases, the opportunity cost of borrowing and investment becomes more expensive for both individuals and business. This can lead to reduced consumer spending and decreased business investment, potentially impacting corporate earnings and economic growth. If the investors interpret higher interest rates as a sign of potential economic slowdown or reduced earnings growth, they might become more risk-averse and uncertain, leading to a potential increase in the VIX [8]. What's more, due to the opportunity cost of investment is increasing, investors will be more likely to shift their allocations from riskier assets, such as stocks and futures to safer assets like bonds.

Besides, the perception of rising interest rates can influence market sentiment. If investors believe that higher rates are a response to a strengthening economy, it might not necessarily lead to increased volatility [9]. While, if investors thought rising rates because of central bank attempts to control inflation and economic regression, it could indicate potential challenges ahead and contribute to higher uncertainty and VIX level, since people will know they were under a regression period. Furthermore, increasing in U.S. interest rates can impact global capital flows. Higher interest rates indicate the U.S can attract capital from other countries in order to get better returns. This capital movement can lead to potential increase volatility [10].

These previous studies highlighted how the VIX affects the economic activity and habits of investors, as well as how the increasing real interest rate will influence the VIX and improve volatility. However, only a few studies discussed about how exactly the stock volatility of VIX reacts to changes in the real interest rate in U.S. To fill the void, this paper examines how increasing interest rate confirmed cases in U.S. influence the volatility index. As a result, the investors will have a clearer view about how to use VIX in an effective way and some irrational investments or strategies can be avoided [11].

The rest of this paper is structured as follows: information about the data source, data stability, and the model in this paper is covered in Section 2. Section 3 follows, with a discussion of the results from ARIMA model, as well as a full discussion about the empirical result and the conclusion.

2. Research Design

2.1. Data Source

To provide a more accurate and comprehensive picture of the VIX's relationship with rising interest rates, the study extracted daily closing stock prices, weekly closing stock prices, and monthly closing stock prices from 2010 to 2022, from the “Investing” [12]. To elaborate on influence brought by increasing real interest rates, this paper chooses the date March 16, 2020 as the first date of the rate hike, and data is transformed by the formula $\ln(1+x)$, continuing analysis in the logarithmic scale. With the updated edited data, Stata was used to analyses the data and construct models for further exploration.

2.2. Weak Stationary Test

When preparing to use the data for further processing, the first step is to test whether the data is stationary or not. According to the weak stationary test conducted in Stata, the P-value in Table 1 for changes in the VIX and increasing part of the interest rate in daily, weekly, and monthly are all equal to 0, which indicated statistically significant. Due to these findings, evidence is strong enough to build the model since all of the data is stationary.

Table 1: Weak stationarity test

	t	p
Daily		
Raw	-6.500	0.0000
1st order difference	-44.736	0.0000
Weekly		
Raw	-5.559	0.0000
1st order difference	-22.163	0.0000
Monthly		

Table 1: (continued)

Raw	0.0000	0.0094
1st order difference	-11.063	0.0000
2nd order difference	-16.554	0.0000

2.3. ARIMA Model

The ARIMA model can evaluate the volatility of the VIX after increasing the real interest rate.

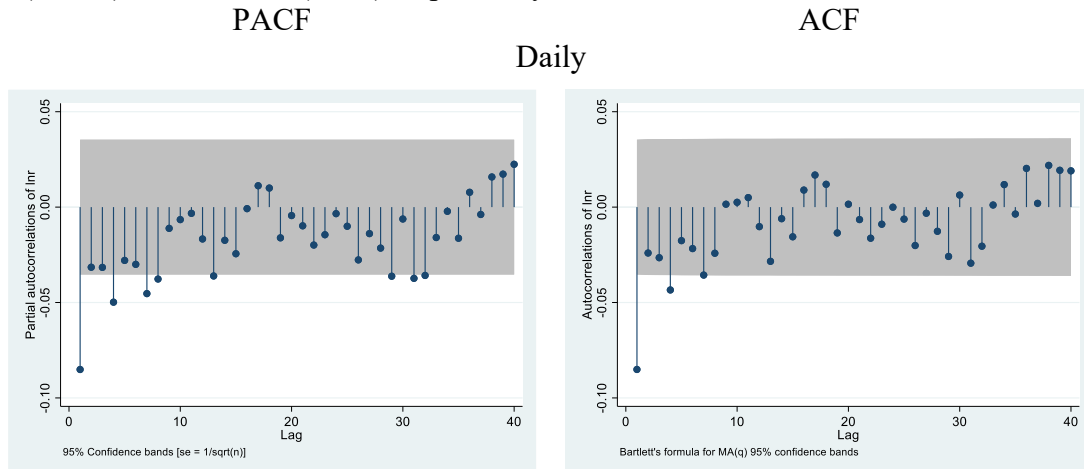
$$Return_t = \phi_0 + \sum_{i=1}^p \phi_i Return_{t-i} + a_t - \sum_{i=1}^q \phi_i a_{t-i} \quad (1)$$

The general expression of the ARMA model is displayed in equation (1). The AR(p) uses the past p period data to estimate today's output. And it is represented by the component $\phi_0 + \sum_{i=1}^p \phi_i Return_{t-i}$, while the rest of the equation is MA(q), which indicate the error part of the estimation. While, the ARIMA model is looked like ARIMA(p,d,q), and the d is the time of difference to the raw value.

3. Empirical Results and Analysis

3.1. ARMA Specification

Regarding the stock volatility in logarithm, PACF and ACF can be helpful to determine the AR(p) and MA(q). In each graph, the grey area is indicated as the critical area. In Figure 2, the first part for daily data, according to PACF graph, the value of p should be 7, and according to ACF graph, the value of q should be 4. In this case, for daily changes, the ARIMA model will be ARIMA (7,1,4). Following the same processes, based on the weekly and monthly graphs, the ARIMA model is ARIMA (10,1,5) and ARIMA (7,2,1) respectively.



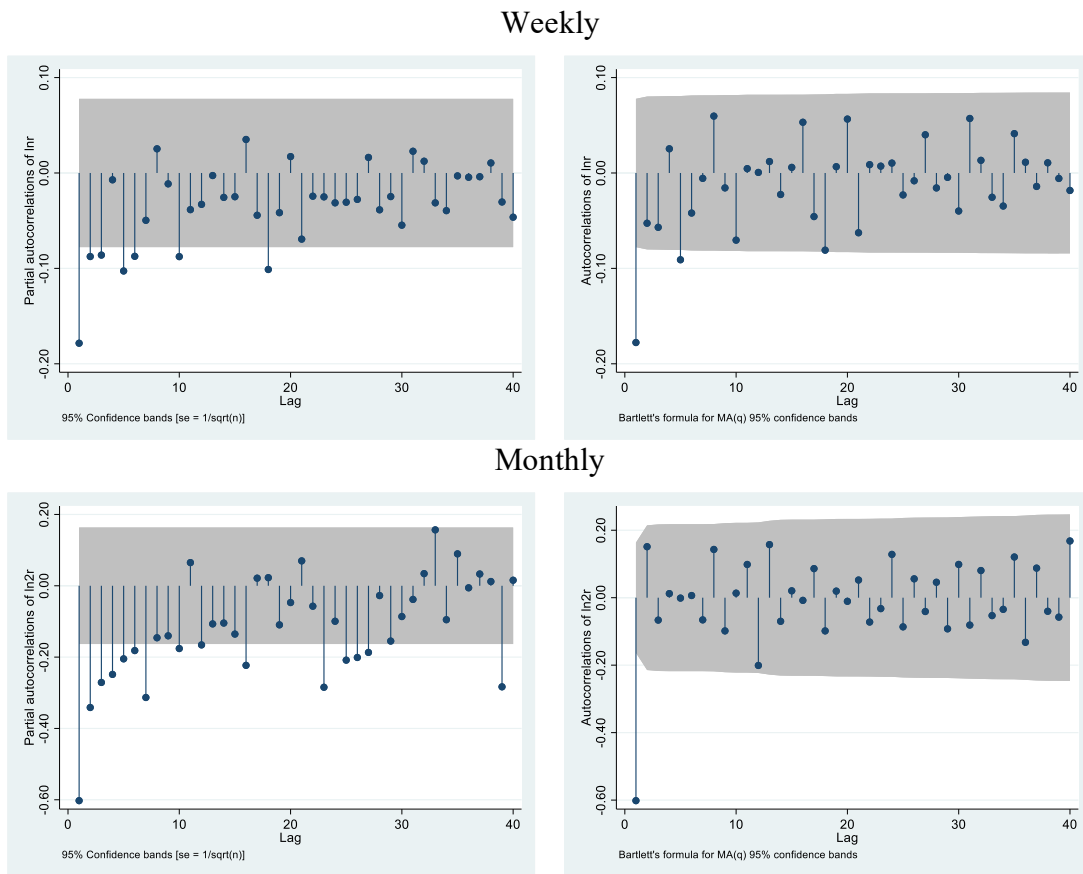


Figure 2: ARMA (p, q) identification
 Photo credit: Original

3.2. Residual Test

After building the ARIMA model, it is necessary to test the residual in order to check whether it is stationary or not. Based on Table 2, all the Q is large enough to reject the original hypothesis which is not statistically significant. In this case, it shows that the residual of this model is a white noise, stationary data.

Table 2: Residual test

Model	Portmanteau (Q) statistic	Prob > chi2
Daily-ARIMA(7,1,4)	31.0373	0.8443
Weekly-ARIMA(10,1,5)	12.0078	1
Monthly-ARIMA(7,2,1)	35.8398	0.6580

3.3. ARIMA Estimation Results

As described in Section 3.1 and 3.2, implementing ARIMA (7,1,4), ARIMA (10,1,5), ARIMA (7,2,1) are adequate to predict the fitted value in time series, hence the ARIMA model was built.

3.3.1. Daily Changes

According to Table 3 and Figure 3, they clearly indicated that in the short term there is a gap between actual value and fitted value of VIX.

Table 3: Actual and fitted value, Daily

	Actual value	Fitted value	Difference
2022-03-07	18.86		
2022-03-08	19.99		
2022-03-09	21.85		
2022-03-10	22.73		
2022-03-11	21.32		
2022-03-14	18.26		
2022-03-15	19.61		
2022-03-16	18.86	19.534463	-0.67446
2022-03-17	17.77	19.670549	-1.90055
2022-03-18	18.79	19.778906	-0.98891
2022-03-21	18.07	19.799131	-1.72913
2022-03-22	18.49	19.920841	-1.43084
2022-03-23	17.95	19.980774	-2.03077
2022-03-24	18.09	19.978817	-1.88882

It shows that after increasing the real interest rate on March 16, 2020, the VIX is still in a relatively stable pattern while the fitted value believe it should go up, due to the regression of economy. Based on the calculation, the difference between actual value and fitted value of daily VIX is -7.68%. While the difference is small mainly because this test focuses on a short period of time, it only examines the difference between the two values in the eight days after the announcement of the policy hike. In such a period, investors do not have enough time to react, so the degree of change in the fear level is small.



Figure 3: Actual value and fitted value, daily
 Photo credit: Original

3.3.2. Weekly Changes

Based on the weekly data of VIX changes, it gives a longer-term influence on VIX due to the increasing of real interest rates.

Table 4: Actual value and fitted value, Weekly

	Actual value	Fitted value	Difference
2022-01-09	19.19		
2022-01-16	28.85		
2022-01-23	27.66		
2022-01-30	23.22		
2022-02-06	27.36		
2022-02-13	27.75		
2022-02-20	27.59		
2022-02-27	31.98		
2022-03-06	30.75		
2022-03-13	23.87		
2022-03-20	20.81	23.767973	-2.95797
2022-03-27	19.63	22.687679	-3.05768
2022-04-03	21.16	23.052751	-1.89275
2022-04-10	22.7	23.740241	-1.04024
2022-04-17	28.21	23.095203	5.114797
2022-04-24	33.4	22.504197	10.8958
2022-05-01	30.19	23.283224	6.906776
2022-05-08	28.87	23.394893	5.475107
2022-05-15	29.43	22.179843	7.250157
2022-05-22	25.72	22.085037	3.634963

In the Figure 4, it shows two months after the U.S. government applied the policy, actual VIX is firstly lower than the fitted value and then increase dramatically and continue in a high level. According to the calculation, the difference between fitted value and actual value is 13.20%. Compared with the daily result, this test clearly shows a great difference between the fitted value and actual value. This test is the clearest indication of the impact of a rate hike on the volatility index, as investors have plenty of time to react to the policy during this time series. Therefore, the impact of interest rate hikes on people's investment habits and capital distribution has fully emerged.

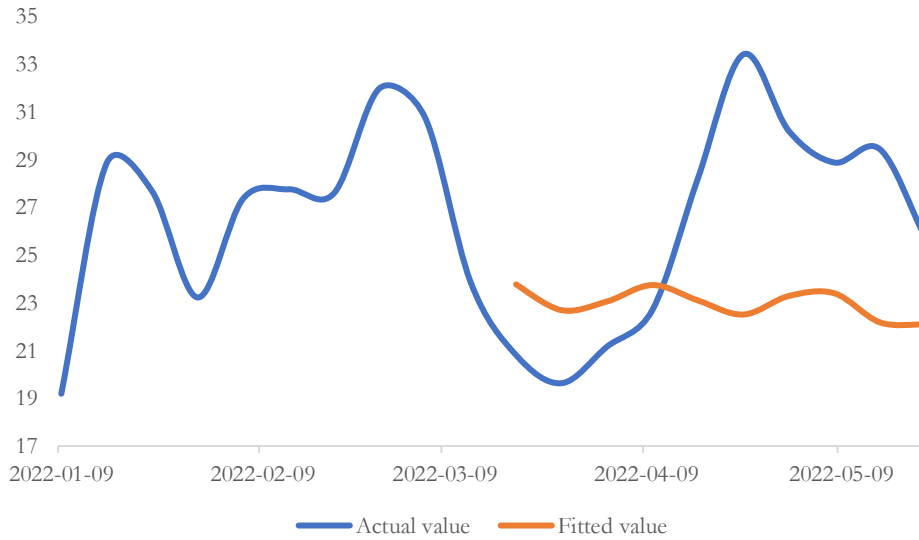


Figure 4: Actual value and fitted value, weekly
 Photo credit: Original

3.3.3. Monthly Changes

Finally, the monthly changes show the longest influence of increasing interest rates on VIX changes.

Table 5: Actual value and fitted value, Monthly

	Actual value	Fitted value	Difference
2021-08-01	16.48		
2021-09-01	23.14		
2021-10-01	16.26		
2021-11-01	27.19		
2021-12-01	17.22		
2022-01-01	24.83		
2022-02-01	30.15		
2022-03-01	20.56	27.477562	-6.91756
2022-04-01	33.4	26.574307	6.825693
2022-05-01	26.19	25.995883	0.194117
2022-06-01	28.71	25.275004	3.434996
2022-07-01	21.33	26.374082	-5.04408
2022-08-01	25.87	25.794566	0.075434
2022-09-01	31.62	26.98612	4.63388

According to Table 5, and Figure 5, they indicate that in the longer term, the difference between fitted value and actual value becomes smaller. This time series shows the impact of the policy within half a year after its promulgation. Through the figure 5, it indicates that in the first two months, investors are greatly influenced by the policy and the consequences of increasing interest rates. While, as time went on, investors gradually adjusted to the pattern of economic activity after the rate hike

and continued to make normal investments. So, the volatility index returned to a normal fluctuating pattern.



Figure 5: Actual value and fitted value, monthly
Photo credit: Original

4. Discussion

In comparison to other studies, this paper focuses on how the increasing real interest rate will influence the Volatility Index. While, based on the research most of the research is about the role of volatility index in economic crisis and how to use VIX to avoid investment risk. Although some articles investigate the changes of VIX after the rate hike policy. Their conclusions and topics are more related to the whole view of economic market instead of specific part like this paper. However, one similarity between us in analyzing stock market is that many authors also used similar models like ARIMA model, Weak stationary test, and so on, in order to determine the movement of stock market.

Through this paper, it shows precisely how the volatility index will change after U.S. government announced the policy of increasing interest rate. Through this paper, policymakers can tell how long and how far investors will react to a rate hike by the difference between the expected rate hike and the actual rate hike. It is therefore better to improve the intensity of interest rate hikes, so as to achieve a level that can stabilize the economy without causing widespread economic panic. On the other hand, through this paper, investors can clearly understand the specific impact of the interest rate hike on the fear index, such as the impact duration and impact magnitude. Through the data comparison in this article, this research can know how much impact the volatility index will have under the effect of interest rate hike, so as to improve my investment strategy.

5. Conclusion

The background of this paper is due to the dramatic economic regression, the U.S government decided to increase real interest rates to slow down the velocity of inflation and recover the country from bottom. The objective of this study is to find out how increasing real interest rates impact the VIX, with an emphasis on the period after the first-rate hike in March 16, 2020. To make the outcome more visual and intellectual, ARIMA model is introduced to show the relationship between these two

variables. The study leads to a conclusion after conducting empirical investigation. This article demonstrates the close association between increasing real interest rates and Volatility Index in different time series. According to the model, the increase in real interest will cause an unexpected boost in VIX within two months of the policy release, rather than a shorter-term shock. Although the VIX is influenced by countless factors in the economic market, this rate hike in 2020 has apparently detrimental effects in these 30 years. The impact on the longer-term future of VIX will eventually diminish just like the monthly data shows, following the general trend of the stock market. This article studies only one variable: the effect of interest rate changes on the volatility index over different time periods, and only one ARIMA model is applied, which may cause more error. In future studies, more variables can be added to explore the impact of different variables on the volatility index, and more prediction models can be added to make the prediction results more accurate.

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