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The Relationship Between the Negative Monetary Policy and Stock Market: Evidence from Changes in S&P 500

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Abstract: Monetary policy and stock price are two significant factors in financial markets. They can influence each other through economic variables such as the interest rate. Researchers require to understand their dynamic relationship to better analyze the market while investors should put emphasis on the two factors' interaction to minimize the investment risk. This paper studies the relationship between the change in monetary policy and the stock price in the U.S. market under the background of the Federal Reserve's rate hike. The researcher mainly uses the S&P 500 retrieved from the website of investing and applies the ARIMA model in Stata to estimate the fitted value of the stock price. As a result, an apparent relationship between the Federal Reserve's rate hike and the stock price is observed. However, the result is slightly different from the researcher's original assumption; therefore, two assumptions are presented to explain the difference. One of the most important findings of this research is that the effect of the Federal Reserve's rate hike is becoming more and more obvious in the long run.

Keywords: monetary policy, interest rate, stock price, ARIMA model

1. Introduction

Monetary policy, which is usually formulated by the central bank, can affect economic variables by changing other economic factors such as the interest rate [1]. The interest rate regularly acts as a monetary policy instrument that can help the central bank stabilize one economy using expansive or restrictive policies [2]. Both the present real interest rate and the anticipated future real interest rate can be impacted by monetary authority [1]. Rifat, for instance, assumes that if the interest rate increases, investors tend to gather funds through the stock market to gain more money [1]. Some researchers present the historical relationship between monetary policy on interest rates and stock prices. Cotton generates images of the U.S. 10-year interest rate and the S&P 500 index from 1962 to 2022, the result turns out to be the long-term interest rate and stock prices are negatively associated [3]. However, due to the COVID pandemic, the stock price fails to be stable from 2021-03 to 2022-02, so the distinct relationship cannot be described [3]. Apart from that, Cotton also points out that many other factors can change or even reverse the association between interest rates and stock prices; thus, using historical trends to draw an exact and convincing conclusion is not possible [3]. Moreover, Uddin and Alam who use data from Dhaka Stock Exchange (DSE) also prove that the stock price and interest rate in the same period are negatively related [4]. Nevertheless, different from Cotton's finding, Bissoon et al. discover that the interest rate is relevant to stock prices both in the long run

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and short run based on an analysis of a sample of five open economies with a growing stock market from 2004 to 2014 [2]. Generally, most research approves that the change in monetary policy on interest rates will reversely impact the stock price.

A modification in monetary policy can influence stock prices while the interest rate can be served as a channel. To explain, the value of a stock on the stock exchange or stock market is known as the stock price, which is decided by market participants based on the supply and demand in the capital market [5]. The stock market can contribute significantly to one nation's economic growth and expansion; especially, the condition of one country's stock market can reflect the status of its economy meaningfully [6]. During a stock market boom, a growing stock market index is able to represent a favorable economic climate [6]. A large percentage of extant research have investigated the relationship between the alternation in monetary policy and stock prices. Suhaibu et al. indicate that financial markets act as the connecting points through which monetary policy actions are transmitted to the real economy, which means that monetary policy can impact the real economy through financial markets [7]. Doubtlessly, the stock market is an important component of financial markets; in this sense, the decision of central banks will initially impact the stock price and then expand to the whole economy. Several researchers discover using VAR models that restrictive monetary policy lowers stock prices while expansionary monetary policy rises stock prices [2]. Bissoon et. al introduce the cash flow model, which means that stocks' future cashflows are applied to calculate stocks' value, which is then discounted at the appropriate interest rate, to explain this dynamic relationship. When the economy is in expansion, the stock price is normally high since a lower discount rate exists; in this way, a boost will appear in the economic activity [2]. Likewise, Eldomiaty et al. explain this relationship between monetary policy on the interest rate and the stock market by suggesting that higher costs and lower returns are always created by the increase in interest rates and meanwhile, higher interest rates make the investment in bonds more profitable than in equities; as a consequence, the stock will be in shortage of demand and its price will decrease [8]. However, many researchers demonstrate a weak relationship between interest rates and stock prices [7]. Consequently, it is not difficult to infer that the interest rate and the stock price's interaction is not constantly negative or positive, which needs to be analyzed from case to case.

The main objective of this paper is to empirically analyze the influence of the monetary policy on the stock price in the U.S. market under the background of the Fed's rate hike. The paper applies the daily data of stock's closing price from the S&P 500 for the period from January 11th, 2016 to July 7th, 2023, and the weekly data from January 10th, 2016 to July 9th, 2023. Finally, the monthly data from January 1st, 2016 to July 1st, 2023 is processed. Moreover, this paper uses the ARIMA method.

2. Research Design

2.1. Data Source

The website of Investing provides various data on financial assets such as global stocks and stock indexes. This data source is reliable and able to support the research's data requirement on the U.S. market's stock price. In detail, the paper extracts the daily data of stock's closing price from the S&P 500 for the period from January 11th, 2016 to July 7th, 2023, the weekly data from January 10th, 2016 to July 9th, 2023, and the monthly data from January 1st, 2016 to July 1st, 2023. Subsequently, daily, weekly, and monthly data are separately imported and processed using the statistical software called Stata. In the procedure of processing data, the researcher denotes the time when the Federal Reserve first raises rates as t_0 (2022-03-16) and only uses the data before t_0 to establish the model. And the variable "close" (the closing price of the stock from the S&P 500) in the data set is transformed by the formula ln(1+close) which is the logarithmic form to further analyze.

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2.2. Augmented Dickey—Fuller (ADF) Unit Root Test

In this section, the researcher tests whether the selected data is stationary. The null hypothesis in the ADF test is that the time series is not stationary. If p-value> 0.1, the null hypothesis should be accepted; otherwise, it should be rejected. Based on the weak stationary test's results in Stata (shown in Table 1), the raw values of daily data, weekly data, and monthly data are not stationary since their p-value are all larger than 0.1. Therefore, the researcher continually calculates the three data sets' first-order differences. The result shows that the first-order values are all equal to 0, which means that they are stationary and do not have a unit root. In summary, the data is feasible, which makes the model reliable.

Table 1: Weak stationarity test.

	t	p
Daily		
Raw	-2.707	0.2333
1st order difference	-30.838	0.0000
Weekly		
Raw	-2.878	0.1699
1st order difference	-13.939	0.0000
2nd order difference	-24.793	0.0000
Monthly		
Raw	-2.462	0.3472
1st order difference	-7.933	0.0000

2.3. Autoregressive Integrated Moving Average (ARIMA) Model

ARIMA model is meaningful in forecasting a time series' future value based on its past value [9]. The general expression of the ARIMA model is shown below. ARIMA(p,d,q) is the representation of the model in which p and q should be determined orders, and d indicates the order of difference. Besides, if the time series is stationary after the difference, the ARIMA model can be used in the modeling process. The researcher applies the ARIMA model to predict the future value of daily, weekly, and monthly stock prices.

$$y_t = \mu + \phi_1 y_{t-1} + \cdots + \phi_p y_{t-p} - \theta_1 e_{t-1} - \cdots - \theta_q e_{t-q} + e_t \quad (1)$$

3. Empirical Results and Analysis

3.1. Order of ARIMA Model

Since the daily and monthly data are differenced once, their d in the ARIMA(p,d,q) model both equal 1; likewise, d in weekly data equals 2. To determine the order of AR(p) and MA(q) in the ARIMA model, the researcher uses Stata to generate PACF and ACF plots of daily, weekly, and monthly data, displayed in Figure 1. The PACF plot can be used to determine the order of AR, that is p; while the ACF plot can decide the order of MA, that is q. Through this method, it is obvious that daily, weekly, and monthly's orders of AR are 9, 7, and 7 respectively. And daily, weekly, and monthly's orders of MA are 9, 1, and 7 respectively.

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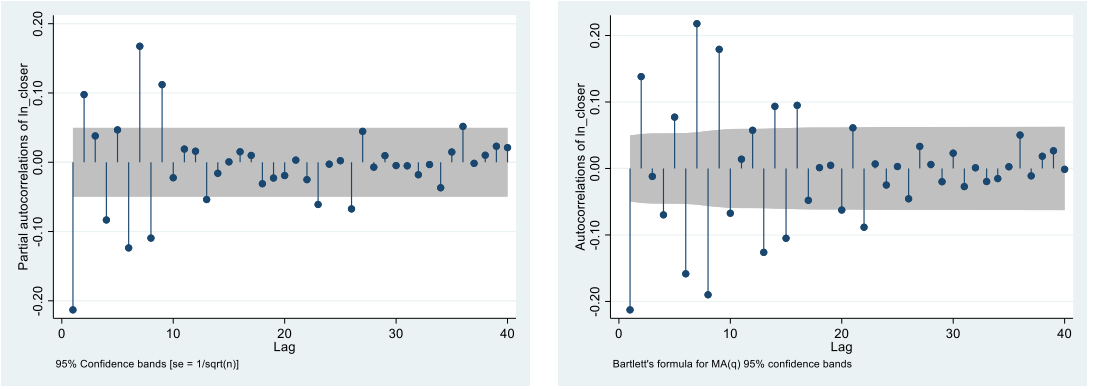
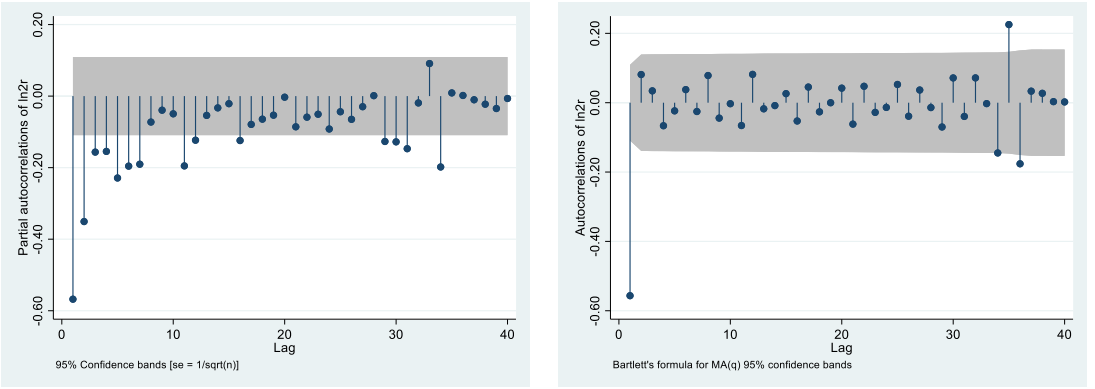
PACF ACF

Daily



Weekly



Monthly

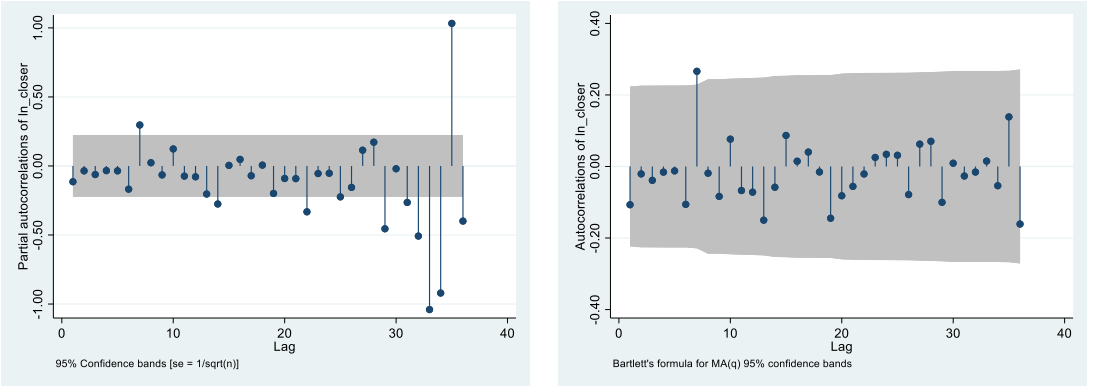


Figure 1: ARMA (p, q) identification.
Photo credit: Original.

After confirming the orders of ARIMA (p, d, q), the ARIMA equation of daily, weekly, and monthly can be written based on the general expression as below.

$$z_{t,1} = \mu + \phi_1 z_{t-1} + \phi_2 z_{t-2} + \cdots + \phi_9 z_{t-9} - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \cdots - \theta_9 e_{t-9} \quad (2)$$

$$z_{t,2} = \mu + \phi_1 z_{t-1} + \phi_2 z_{t-2} + \cdots - \phi_7 z_{t-7} - \theta_1 e_{t-1} \quad (3)$$

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$$z_{t,3} = \mu + \phi_1 z_{t-1} + \phi_2 z_{t-2} + \cdots + \phi_7 z_{t-7} - \theta_1 e_{t-1} - \theta_2 e_{t-2} - \cdots - \theta_7 e_{t-7} \quad (4)$$

These three equations represent three separate time series where zt,1, zt,2, zt,3 refers to daily, weekly, and monthly, respectively

Table 2: Residual test.

Model	Portmanteau (Q) statistic	Prob > chi2
Daily-ARIMA(9,1,9)	40.2517	0.4591
Weekly-ARIMA(7,2,1)	28.0130	0.9232
Monthly-ARIMA(7,1,7)	30.0740	0.8731

After writing the equations, the researcher uses Stata to conduct the residual test to check whether the residual between the ARIMA model and actual data is white noise. In this test, the null hypothesis is that the certain time series is white noise if the value is greater than 0.1, which means that there is no autocorrelation in the series. As the residual test's results shown in Table 2, the daily, weekly, and monthly ARIMA models' values in "prob>chi2" column are larger than 0.1, which means that the three series are all white noise and the model is suitable and adequate to predict the estimated value.

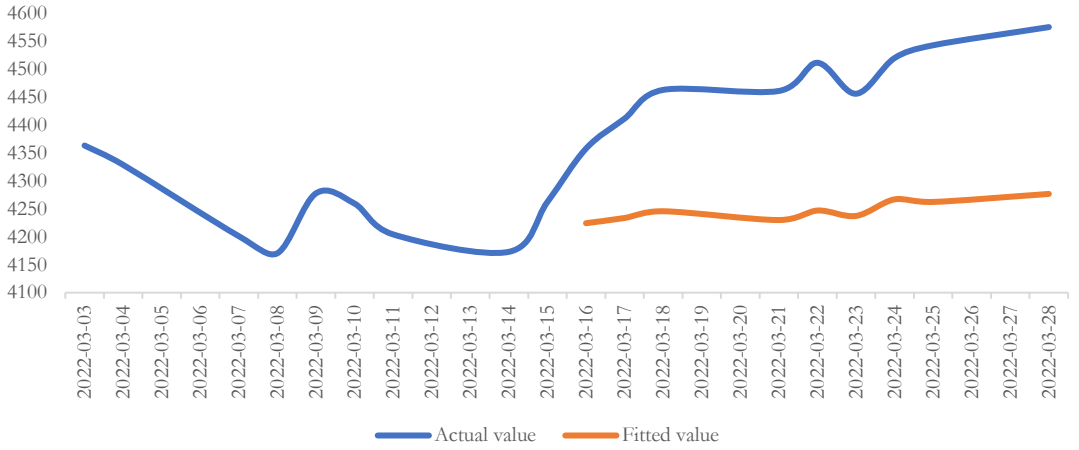

Figure 2: Actual value and fitted value, daily.
Photo credit: Original.

Finally, after determining the model's order and testing its residual, the image of the actual value and the fitted value predicted by the ARIMA model can be created, shown in Figure 1 (daily), 2 (weekly), and 3 (monthly). The actual value in the figure represents the actual value of the S&P 500's stock price released on the website of investing, and the fitted value is calculated by the ARIMA model.

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

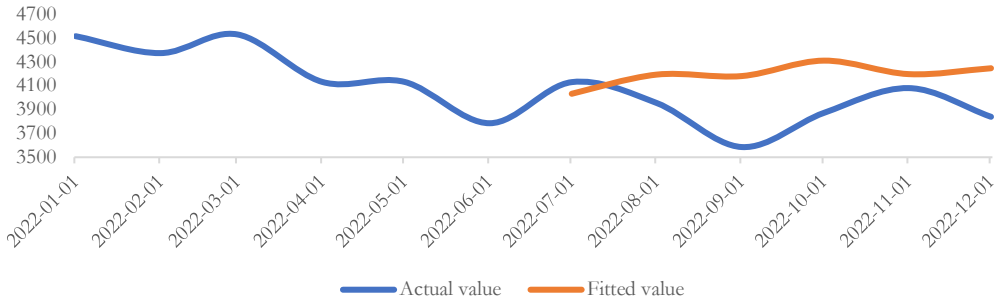

Figure 4: Actual value and fitted value, monthly.
Photo credit: Original.

3.2. Forecast Results and Interpretation

As shown in Figures 2, 3, and 4, daily, weekly, and monthly stock prices' actual and fitted values are not perfectly in the same trend. The researcher primarily estimates that the stock price is likely to decrease after the Federal Reserve first add rate on 2022-03-16; however, the actual stock price is in the increasing trend after 2022-03-16 both daily and weekly. To better interpret the trend of stock price's change over time, the researcher measures the change rate of the actual and fitted values' difference divided by the fitted value (shown in Table 3, Table 4, and Table 5) to calculate the average treatment effect (ATE). In Table 3, daily ATE turns out to be 5.43%; furthermore, the weekly and monthly ATE are -3.03% and -6.75% respectively. It is not difficult to observe that daily ATE value is positive while weekly and monthly are negative, and monthly's value is even smaller than weekly's (-6.75% < -3.03%). In this sense, the Federal Reserve's effect on adding the rate is becoming more and more apparent over time.

Table 3: Daily ATE.

	Actual value	Fitted value	Difference	ATE
2022-03-03	4363.49			
2022-03-04	4328.87			

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Table 3: (continued).

2022-03-07	4201.09			
2022-03-08	4170.62			
2022-03-09	4277.88			
2022-03-10	4259.52			
2022-03-11	4204.31			
2022-03-14	4173.11			
2022-03-15	4262.45			
2022-03-16	4357.95	4224.3943	133.5557	
2022-03-17	4411.67	4233.7218	177.9482	
2022-03-18	4463.09	4245.7921	217.2979	
2022-03-21	4461.18	4230.012	231.168	
2022-03-22	4511.61	4247.1011	264.5089	
2022-03-23	4456.23	4237.4186	218.8114	
2022-03-24	4520.16	4267.0843	253.0757	
2022-03-25	4543.04	4262.4413	280.5987	
2022-03-28	4575.52	4276.7648	298.7552	5.43%

The fitted value is increasing rather than decreasing as the researcher forecasts after the date of adding the rate. Therefore, it is not difficult to speculate that there are factors applied to prevent the decrease in stock price. For instance, the rate hike is too minor to stimulate the stock market's reaction, so it maintains the previous trend of increasing.

Table 4: Weekly ATE.

	Actual value	Fitted value	Difference	ATE
2022-01-30	4500.54			
2022-02-06	4418.64			
2022-02-13	4348.87			
2022-02-20	4384.62			
2022-02-27	4328.87			
2022-03-06	4204.31			
2022-03-13	4463.09			
2022-03-20	4543.04	4445.1651	97.8749	
2022-03-27	4545.86	4474.0754	71.7846	
2022-04-03	4488.28	4511.3858	-23.1058	
2022-04-10	4392.59	4503.6303	-111.04	
2022-04-17	4271.78	4493.1181	-221.338	
2022-04-24	4131.93	4506.6399	-374.71	
2022-05-01	4123.34	4515.2982	-391.9582	-3.03%

Apart from that, a time lag in the policy's effect may exist, which means that there will be a time difference between the point when a policy is implemented and when the economy reacts to the policy. The decrease in the stock price may delay due to a time lag so the price remains increasing for a while. Governments' manipulation of rates may not immediately result in the market's response since there is a period when businesses are aware of this change and make reactions, then these reactions will lead to more seeable alterations in the financial market [10].

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Table 5: Monthly ATE.

	Actual value	Fitted value	Difference	
2022-01-01	4515.55			
2022-02-01	4373.79			
2022-03-01	4530.41			
2022-04-01	4131.93			
2022-05-01	4132.15			
2022-06-01	3785.38			
2022-07-01	4130.29	4032.5688	97.7212	
2022-08-01	3955	4193.4061	-238.406	
2022-09-01	3585.62	4181.0795	-595.46	
2022-10-01	3871.98	4310.7253	-438.745	
2022-11-01	4080.11	4197.2898	-117.18	
2022-12-01	3839.5	4246.7233	-407.223	-6.75%

4. Discussion

Compared with other papers' focuses on the interaction of monetary policies on the interest rate and stock prices in growing stock markets in open economies, Dhaka stock exchange, African countries, etc., this research's object is the U.S. market's stock price measured by the S&P 500 index. Although several researchers such as Suhaibu et al. imply that sometimes the interest rate and stock prices only possess a weak relationship [7], most papers' discoveries are consistent with this research that the interest rate is significantly associated with stock prices. Even though the negative relationship is not obvious in the short run, which may be due to outside policy interventions, the long-run effects are increasingly clear. While researchers like Cotton emphasize that the relationship between the interest rate and stock price occurs merely in the long term [3], this paper perceives that their relationship can be observed both in the short term and long term even if the long-term effects are more noticeable. One of the most crucial findings is that the original reaction of stock prices to the change in the interest rate can be altered by government policies or other economic factors.

Through this research, policymakers should be aware of the potential changes in stock markets. For instance, a sharp decrease or increase in the stock price will probably make the financial market less stable, so policymakers are encouraged to apply regulations or policies to stabilize the market and reduce both the investors' and companies' losses. Further, investors in the stock market should be equipped with the ability to estimate future stock price and pay more attention to avoiding or minimizing potential risks. They should keep an eye on the updated information in the stock market to formulate the most profitable strategies since the market is rapidly changing. As shown in Figure 2, the stock price is on the trend of rising for the period from 2022-3-15 to 2022-3-17. If the investors purchase the stock during this period, the price is definitely higher than that on 2022-3-13, which is less cost-effective. However, if the investors learn about the Federal Reserve's rates hike and react to it ahead, the situation is likely to be inverted.

5. Conclusion

The purpose of this research is to investigate the relationship between the alternation in monetary policy and stock price in the U.S. market under the condition of the Federal Reserve's first interest rate rising on 2022-03-16. The ARIMA model is introduced for this purpose and the data is processed by Stata. Using this model, the researcher discovers that the alternation in monetary policy and stock price are significantly related, whereas the actual value and fitted value of daily, weekly, and monthly

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stock prices are not completely in the same trend. The researcher primarily predicts that the Federal Reserve's action of adding rates on 2022-03-16 will result in a decline in the stock price; nonetheless, the stock price initially increases for a while. Under this circumstance, two possible assumptions are put forward to explain this condition—the rate hike is so minor that cannot reverse the stock price's trend instantly or there is a time lag between the policy's publication and the according effects. Eventually, comparing the average treatment effect of daily, weekly, and monthly data of the S&P 500, the researcher maintains that the influence of the Federal Reserve's rate hike turns out to be more and more evident over time. Despite the fact that some policies may be formulated to resist the stock price to decrease temporarily, the interest rate hike does possess influences on the stock price in the long run.

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