Research on the Dynamic Changes in Tesla Stock Price with this turn's Interest Rate Policy

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Abstract. Since the Federal Reserve's action of a series of interest rate increases in response to high inflation, the U.S. equity market as a whole and individual stocks have been under pressure from soft landing and recession concerns, which is reflected in stock prices. In this article, the impact of the Federal Reserve rate increase on Tesla stock returns will be evaluated. The applied VAR model will contribute to the analysis of the dynamic returns of stock returns. The results of the research will present the actual extent of the impact of the rate increase policy on the stock in quantitative terms, as Tesla is one of the top 10 multinational companies in terms of market capitalization has increased the reliability of the data model. The results imply that the Federal Reserve's decision to raise interest rates has an extremely negative impact on stock yields and that this impact diminishes over time. For policymakers, this monetary policy can be effective in the short run effectively suppressing asset prices rather than absorbing more liquidity for their capital markets. For investors, the period of interest rate hikes is not the appropriate time to invest since company profits will be affected by the strength of the local currency which will not meet the expected standards.

Keywords: Monetary Policy; Tesla; Net Benefit.

1. Introduction

Since COVID-19 exploded in 2020, accommodative monetary policies have generated significant inflation challenges across the supply chain and commodity prices in the U.S. The CPI as an indicator of inflation includes housing, utility, apparel, used car prices, other asset prices such as stocks and bonds, as well as energy services, food, and beverages which account for more than 30% of the total, and measurements being referenced among other sectors. Based mainly on the CPI data to reflect inflation as a benchmark, the inflation rate for the year from August 2021 to August 2022 exceeded well beyond the Fed's initially announced expectation of 2%, which even reached 9.1% released on July 13, 2022 [1]. Given the high inflation data, which had not been seen in decades, the Federal Reserve decided to implement an interest rate increase at its March 2022 meeting and subsequently raise rates more aggressively to contain the impact of inflation on the economy. The benchmark federal interest rate has been raised by 250 basis points since March 2022 and will continue to increase by a minimum of 50 basis points or 75 basis points until the Fed's expectations of a soft landing are accomplished. The increase in interest rates in the country will suppress inflation and revert to acceptable expectations from a macro perspective, furthermore, it injects more liquidity into the domestic financial markets in the long run since the increase in interest rates makes it an increasingly attractive investment benchmark.

However, in the short term, domestic asset prices are under pressure since the previous low-interest rate environment allowed corporations to undertake greater debt to innovate or operate while maintaining higher valuations (PE ratio). Alam and Uddinanalyed analyzed the relationship between interest rates and stock prices in 15 developed and developing countries by using the Random walk model. The results show that interest rates are significantly and negatively correlated with stock prices in all countries and would generate significant benefits when countries control their interest rates [2].

Indeed, stock prices generally indicate investors' expectations for the future, hence the early reactions of asset markets to interest rate increases in anticipation of inflation data have occurred in 2021. When the CPI reached 6% in December 2021, the S&P 500 and Nasdaq reached their peak and started to decline. The relative decline in the S&P 500 from the June 2022 low is 23.98% compared

to the 2021 peak, which illustrates the short-term timing of the asset market's reaction to the interest rate hike and the escape of capital from the secondary market [3]. Using the structural vector autoregression method, Bjørnl et al. evaluated the interdependence between U.S. monetary policy and the S&P 500 index. The outcome demonstrates that the setting of interest rates and stock prices are significantly interdependent. Furthermore, actual stock prices drop by 7 to 9 percent instantly when an adjustment in monetary policy causes the federal funds rate to increase by 100 basis points [4].

As interest rates are associated with corporate debits and loans which eventually impact corporate earnings. After examining the impact of interest rate changes on common stock returns, Flannery and James discovered that the interest rate sensitivity of common stock returns is related to the maturity composition of the nominal contracts held by the firm [5]. Although debt is a factor in the volatility of stocks by affecting their performance, the effect of interest rate increases on individual stocks cannot be quantified exactly as it would be on the S&P 500. Hajilee and Masser's analysis of interest rates and stock market volatility indicates that monetary policy has an inevitable and complicated impact on the market. Since the stock market is oriented toward the future, except changes in interest rates, it responds strongly to information. Almost any variation in interest rates or discount rates can have an impact on the cash flows and financial leverage of various equities. The cost of financing a company's investment projects is affected by changes in interest rates, although a higher interest rate has a negative impact on the stock market, it supports long-term economic growth. This is revealed by measuring the impact of monetary policy changes on financial variables [6].

The complexities resulting from the policy of interest rate increases are also compounded by the exchange rate and multi-national corporate factors as global integration increases. Engel and West mentioned that the real value of the dollar will strengthen in the early stages of interest rate increases but will gradually weaken in the later stages. Decomposing the forces driving the real exchange rate into a long-term real interest rate component and a residual "level" risk premium component reveals that very little of the movement is directly attributable to the real interest component, suggesting that most of the movement is due to the residual risk premium component [7]. In which a stronger dollar advance will directly affect the earnings of U.S. domestic companies abroad.

Implications of interest rates that are directed at equity value or corporations in a particular sector are key areas of current focus. The purpose of this study is to expand and examine the dynamic changes in one of the most acclaimed corporations based on interest rate increases. Considering the correlation between interest rates and the S&P 500 is supported by Bjørnl et al. data, Tesla is selected as the examination benchmark to evaluate the dynamic impact of interest rate changes on the company’s stock price. Tesla is initially one of the ten largest U.S. corporations by market capitalization and has sustained a significant market share. With factories positioned in the US, Germany, and China, Tesla has been valued by the market based on its ability to deliver all-electric vehicle models on a quarterly basis. This enables a more comprehensive reflection of the influence of changing exchange rates and rising interest rates on the stock price in the domestic market since the corporation’s businesses span multiple countries. In addition, Tesla is not only categorized as an automobile manufacturer, and multinational company, but also has a high PE ratio in the technology sector. The selection of the target combines all the above influences to implicitly represent other companies like Toyota that have multinational operations in manufacturing, Walt Disney which has operations in multiple countries, and Apple which has multinational production in technology. The article collects data from the first day of 2022 to the end of the trial, which indicates that dynamic returns were generated during the rate increase process rather than tracking stock prices throughout the rate increase process until it was completed.

The second section of the article will include data sources, unit root testing, and VAR model setup under research design. The third section will examine the empirical results in terms of the impulse response, stability condition of VAR estimates, and data prediction. The study's purpose is the significance of the article, interpretations for policymakers, and applications of the findings from the investor's perspective will all be especially in comparison in the fourth section of the discussion

section. The last section will also contrast the differences and related contributions of other literature in the field. The latest findings will then be discussed in the conclusion section.

2. Research Design

2.1 Data Source

All the data collected in this article are from the Yahoo finance data center which includes the adjusted closing price of Tesla for all opening days from January 1, 2022, to July 29, 2022, as well as the real-time exchange rate of CNY to USD during the same period [8]. As a comprehensive information provider for the global financial industry, Yahoo Finance's adjusted closing stock prices accurately represent the value of any corporate activities such as stock splits or dividends to minimize data level inaccuracies. Even though the data is gathered starting on January 1, 2022, the matched combination of stock price and exchange rate movements will only be present on trading days. The research excludes stock volatility and exchange rate fluctuations on non-trading days and classifies and rematches the remaining data to the dates. Although stock price changes are unavailable on non-trading days, the adjusted combination of stock price and exchange rate data will be modified to prevent being influenced by the original series mismatch, hence reducing the mistake in the research's results. In the data processing, two variables will be included: the exchange rate as index1 and the adjusted closing price of Tesla as index2. Stata operates as the major algorithm in the study to assist in data processing and resolving issues identified throughout additional study inquiries.

2.2 Unit Root Test

The unit root test (1) is used to determine whether the series contains a unit root and a check of data stationarity conditions. It can demonstrate that the presence of a unit root process in the series is not stationary and will produce a pseudo-regression in the regression analysis because the presence of a unit root is a non-stationary time series. If the data results are not stationary, the study will require improvements to the model and data selection objectives. From (2) the null hypothesis of the test indicates when β=1, the sequence has a non-stationary unit root. The substitutive hypothesis is $\beta < 1$, which indicates the sequence under test is stationary.

$$X_t = C_t + \beta X_{t-1} + \sum_{j=1}^{p-1} \emptyset j \triangle X_{t-j} + e_t \quad (1)$$

$$H0: \beta = 1 \longleftrightarrow H_a: \beta < 1 \quad (2)$$

The unit root DF test and the ADF test both reject the existence of a unit root when H0 is significant or accept the existence of a unit root when it is not significant. Table 1 is the test results of the processed ADF test data. The p-value is the probability that the original hypothesis is positive, the minimum significance level at which the original hypothesis is rejected will be tested, and the smaller the value stands for more significance. In Table1 the top is the logarithmic price, whereas the bottom is the logarithmic yield. The results of the data reveal that the p-value of the original data series in the stationarity test is outside the acceptable range. This means that stationarity does not exist at the 95% confidence interval. In contrast, the data significance of the log series shows that both the log yield of Tesla's stock and the log series of the exchange rate are trusted at a significance level of ***. The article will use the effectiveness of the data to construct the model.

Table 1 ADF test

Variables	t-statistic	p-value
	Price	
Tesla	-1.936	0.6360
Exchange rate	-1.828	0.6910
	Yield	
Tesla	-8.072	0.0000***
Exchange rate	-8.562	0.0000***

Note: ***, **, and * represent significance levels of 1%, 5%, and 10%, correspondingly

2.3 VAR Model Specification

The Vector Autoregression Model is based on economic and financial theory for constructing models to detect relationships between variables. The model is used to estimate the dynamic relationships of joint endogenous variables without any prior constraints, and the structure allows for flexible time-varying qualities (9). This paper will observe the following bivariate VAR model based on the quantitative impact that a shift in the error term generates on the two variables in the model, as well as the persistence of the impact to observe it over a longer term. The current article is modeled as follows (3) both variables are $\mathrm{Index1}-\mathrm{I1}$ which stands for currency, and $i\mathrm{dex2}-\mathrm{I2}$ stands for the stock price of Tesla.

$$I_{1t} = Ø_{11} I_{1,t-1} + Ø_{12} I_{2,t-1} + \alpha_{I1^t} \tag{3}$$

$$I_{2t} = Ø_{21} I_{1,t-1} + Ø_{22} I_{2,t-1} + \alpha_{I2^t} \tag{4}$$

The simplified form will be presented as (5). The explanatory variables of the model are not included in any of the present period variables, which contribute to the estimation and prediction of future trends. In the process of performing calculations using Stata, there will be no "x" variables besides index 1 and index 2 due to the choice of this group of variables, which means in each model the constant term α is automatically included.

$$\begin{bmatrix} I_{1,t} \\ I_{2,t} \end{bmatrix} = \begin{bmatrix} Ø_{11} & Ø_{12} \\ Ø_{21} & Ø_{22} \end{bmatrix} \cdot \begin{bmatrix} I_{1,t-1} \\ I_{2,t-2} \end{bmatrix} + \begin{bmatrix} \alpha_{I1,t} \\ \alpha_{I2,t} \end{bmatrix} \tag{5}$$

The establishment of impulse response graphs on the VAR model is also one of the important procedure. The impulse graphs are going to highlight the interactions within and among the variables in the VAR since the number of estimates is relatively large. In equation (6), "ψ" represents the impaction of a unit change of "ε_{t-C}" as one of the variables, which is referred to as the impulse response function. Since it is the response of the variable when subjected to a new standard deviation, a standard impulse response graph should gradually converge to 0. If the impulse plot has a diverging pattern, it indicates that the effect of the interest rate increase on Tesla's stock price has not disappeared as expected in the model, while the opposite means that the model is significant. In order to ensure the significance of the model, it is necessary to ensure the number of variables that have an interactive relationship with the results and the effective number of lagged variables. As the variables are too large, the degrees of flexibility of the model will be reduced, while too smaller variables will lead to large errors in the parameters.

$$\frac{\partial I_t}{\partial \varepsilon_{t-C}} = \psi_C \tag{6}$$

3. Empirical Result

3.1 VAR Model Result

In this section, the vector regression system will include two stationary series which are log Tesla stock price and log exchange rate. The results of the (Table 2) model provided by Stata provide the statistics such as LR and AIC.LR is the way to determine the maximum lag of order k. When the LR statistic is not large enough, it means that the lag of order is not high enough. The closer the AIC statistic represents the more appropriate the lag order of each VAR model.

Table 2 VAR model identification

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	793.071				1.8e08*	-12.1703*	-12.1524*	-12.1262*
1	795.951	5.7614	4	0.218	1.8e-08	-12.1531	-12.0993	-12.0208
2	797.291	2.6788	4	0.613	1.9e-08	-12.1122	-12.0225	-11.8916
3	797.667	.75225	4	0.945	2.0e-08	-12.0564	-11.9309	-11.7476
4	798.613	1.8919	4	0.756	2.1e-08	-12.0094	-11.8481	-11.6124
5	801.243	5.2609	4	0.262	2.1e-08	-11.9884	-11.7912	-11.5031
6	802.459	2.432	4	0.657	2.2e-08	-11.9455	-11.7125	-11.372
7	805.229	5.5402	4	0.236	2.3e-08	-11.9266	-11.6577	-11.2649
8	806.285	2.1117	4	0.715	2.4e-08	-11.8813	-11.5766	-11.1313
9	810.422	8.2739	4	0.082	2.4e-08	-11.8834	-11.5428	-11.0452
10	815.428	10.011*	4	0.040	2.3e-08	-11.8989	-11.5225	-10.9725
11	816.615	2.3742	4	0.667	2.5e-08	-11.8556	-11.4433	-10.841
12	818.676	4.1215	4	0.390	2.5e-08	-11.8258	-11.3776	-10.7229

3.2 Stability Condition of VAR Estimates

The stability condition of VAR estimates is also an indispensable part of the process of confirming the efficiency of the model. The parameters of the vector autoregression form the roots of the companion matrix in Figure 1 below. The roots of the companion matrix indicate that the VAR estimates are stable, and the VAR model is stable and satisfied when all points are located within the circles. The visual graphics also provide an intuitive aid to the data processing procedure.

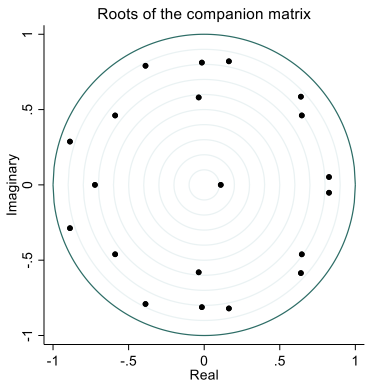

Figure 1 VAR stability

3.3 Impulse Response Graph of the VAR model

The theoretical analysis perspective determines that a Federal Reserve interest rate increase will lead to higher demand for the US dollar in international lending and international financial markets as well as an increase in its exchange rate by the stronger US dollar. Nevertheless, the impact of a higher exchange rate on the corporation exists in two aspects. Firstly, the study assumes that the short

term is rigid in the prices of the firm's products (prices are difficult to adjust in the short term). As a major multinational corporation operating globally, Tesla's main revenues, financial reports, and other business sectors are denominated in U.S. dollars. The appreciation of the dollar implies a depreciation of operating income overseas. From that aspect, the Federal Reserve's interest rate increase may be a negative for Tesla. According to the other side, the international financial market will increase its demand in U.S. dollars, which will provide liquidity to the stock market or bond market, increase the demand for stocks, and raise the price of Tesla's stock. Based on the above analysis, it is not possible to directly determine the net effect of the impact of the Federal Reserve's interest rate increase on Tesla's stock price or return.

From the model results (Figure 2), this article discovers that a 1% increase in exchange rate yields in period t=0 has a negative net effect on the impact of Tesla yields, specifically, period t=0 exhibits a negative effect of about 1% and a maximum positive effect of about 0.5. The effect decays rapidly in subsequent periods. From the theoretical analysis, it is established that a Fed rate increase leads to higher demand for international lending and international financial market dollars, and further leads to higher exchange rates.

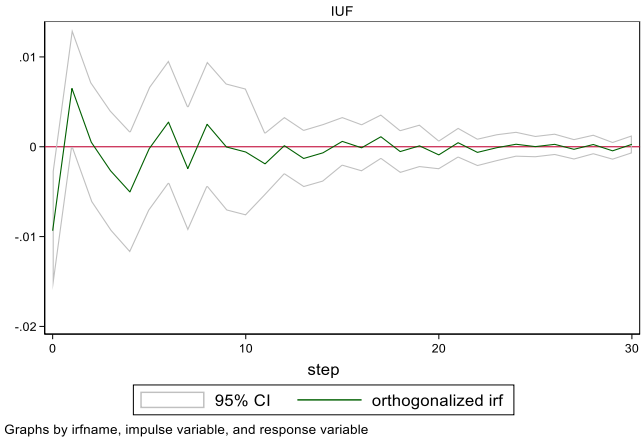

Figure 2 Impulse and response

3.4 Forecast of Price

The basic model estimation results (Figure 3) further compute the interval of change in Tesla's stock price for the next 50 periods, with the middle curve being the forecast and the curve above and below the forecast being the interval estimate. The results suggest that in the short-term future Tesla's stock price may decrease if the exchange rate rises further but will be decreasing with a narrow slope over a longer period.

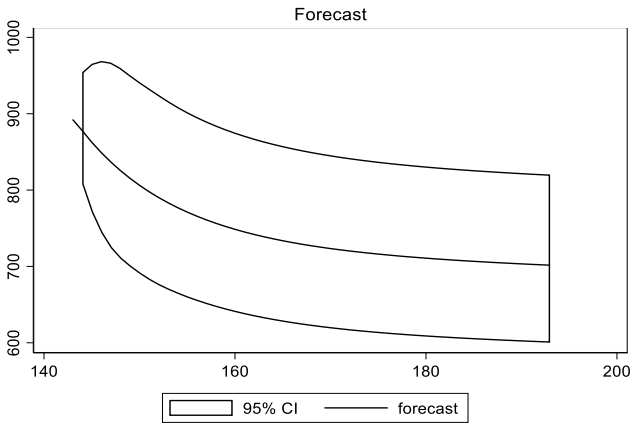

Figure 3 Prediction

4. Discussion

4.1 Discussion on Model

This article presents an analysis of the dynamics of Tesla stock when subjected to a Federal Reserve interest rate increase through effective data collection and model establishment. The results of the terminal data provide a quantification of the dynamic changes in the degree of impact of interest rate increases on stock prices and the expected future impact at both levels. Regardless of whether the rate increase attracts more liquidity from international financial markets, the short-term effect on Tesla's stock price is negative. The VAR model suggests that the negative net effect of the Tesla return begins to present at every 1% increase in exchange rate returns during the t=0 period of the interest rate increase process, and the maximum positive benefit value is 0.5. The influence decreases gradually with the extension of the time dimension.

In contrast to the existing literature in this area, this article similarly mentions the analysis of the impact of the interest rate increase policy on the stock market. However, a stand-alone analysis of stock prices of representative companies is included on top of the existing analysis. This field has included analysis of the performance of the S&P 500 and the NASDAQ over the rate increase period, but the analysis is limited to multinational corporations. The uniqueness of Tesla makes the article more compelling for real-time analysis of multinational corporations and companies whose financial reporting is affected by exchange rate changes.

The implications of the study illustrate that interest rate increases pressure the equity prices, which means that this monetary policy can be effective in depressing asset prices in the short run. Moreover, interest rate increases are not effective in absorbing new liquidity to increase the stock price for the U.S. in the short term. The decision is effective for policymakers in terms of its implications for asset prices. For investors, the period before or during the interest rate increase is not an appropriate investment opportunity. Furthermore, Tesla's Q2 2022 earnings report also revealed that the impact of the rate increases on both the dollar exchange rate and bitcoin price affected its earnings performance [10]. As a popular invested benchmark. Tesla's negative effect during the interest rate hike indicates that other companies in the same industry or those that do not receive the same attention from the market are experiencing greater pressure.

4.2 Bias

Although the model effectively analyzes the dynamic changes to Tesla as a result of the Federal Reserve's interest rate increase, the model results may have the following bias. From a data perspective, since Tesla's overseas factories include China and Germany, the data collection should have included two sets of comparisons between the exchange rate of the German currency to the US dollar and the Chinese currency to the US dollar. However, due to the excessive inflation and volatility of the Eurozone economy and financial system caused by the Russian-Ukrainian war, the error is modified by the fact that only China, a relatively stable exchange rate market during this time is taken. The inclusion of the German currency against the U.S. dollar would exacerbate the impact of the interest rate increase on stock prices by exposing the model to an unstable variable. The bias of the stock price collection is derived from the company's choice. Although Tesla is sufficiently representative of companies in the manufacturing technology industry in the capital markets which satisfy both the multinational and exchange rate-affected test objectives. However, the stock inherently suffers from two biases during the data collection period. First, Tesla's CEO announced on April 15, 2022, that it would acquire the famous social networking site Twitter [11]. Although the deal did not happen, Tesla's stock was affected by volatility beyond the interest rate increase during the remaining trading days of April due to the use of the stock by its CEO for mortgage and loan actions.

5. Conclusion

In this article, the dynamics of Tesla's stock price are analyzed against the background premise of the Federal Reserve's interest rate increase. The increase in interest rates leads to an increase in demand for the local currency- the U.S. dollar in the international market, which would inject liquidity into the investment market. However, in the short term, the impact on Tesla's stock price is negative. The quantitative results of the model indicate that the relationship between interest rate increase and Tesla stock price is negatively correlated and at t=0 the net effect of exchange rate return on the return of Tesla stock is negative. As a result of the scope of its multinational operations, Tesla's financial reporting is denominated in U.S. dollars. The appreciation of the U.S. dollar leads to a depreciation of foreign operating income, and this effect will diminish over time. The net effect of Tesla's stock price or yield impact does not support the assumption that the U.S. will contribute to more liquidity in its stock market, and the impact of its interest rate increase gives a predicted stock price range of $600 to $900 on the floating curve in Figure 3. The effectiveness of the model constitutes a persuasive opinion for both policymakers and investors.

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