Research on the link between RMB Exchange Rate and Tesla's Stock Price: A Long-term Perspective

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Abstract

After China's exchange rate reform, the exchange rate has changed more frequently. The foreign exchange market has an increasing impact on the securities market. This paper analyzes the link between Tesla's stock price and exchange rate of the renminbi against US dollar by establishing VAR model and ARMA-GARCHX model. In the empirical analysis, this paper uses Tesla's daily stock price from June 29, 2010, to June 9, 2023 and the daily exchange rate in the same period as the research data. And the unit root test, impulse response analysis and ARMA GARCHX estimation are used to test the data. Through empirical analysis, this paper concludes that the exchange rate will indeed have an impact on Tesla's stock price, and this impact is mainly negative. Compared with other studies in the same field, the research object selected in this paper is more detailed and specific. This study helps to predict the change of Tesla's share price and preserve the stability of financial markets in the event of exchange rate changes, and investors, policy makers and Tesla itself can also adjust their strategies and plans according to this law. Policy makers can apply the conclusions of this paper to affect the stock market by manipulating exchange rate changes.

Keywords: Exchange rate; Stock Price; VAR Model; ARMA-GARCHX Model

Introduction

Tesla has developed rapidly since its listing on the Nasdaq Stock Exchange on June 29, 2010, and now has become the world's largest new energy vehicle company. Tesla's share price has been rising all the way, with a record 13 consecutive days of rising in June 2023 raising Tesla's share price by more than 40% and a market value in-crease of nearly $240 billion [1]. Tesla's rapid development is closely related to Tesla's super factory in Shanghai, China. Since Tesla's Shanghai Super factory was put into operation in 2020, Tesla's global delivery in 2021 has increased by more than 80%, and Tesla's Shanghai Super factory's delivery in 2023 is expected to exceed the total delivery of Tesla's factories in other countries, At the same time, the Chinese market contributes more than 30% of Tesla's sales, which shows that the Chinese market is very important to Tesla. Moreover, with the gradual opening of China's financial market after the reform and opening-up, the flow of international capital is becoming more and more frequent, so the impact of exchange rate is becoming more and more significant. Especially after China's exchange rate reform, the RMB exchange rate has changed from unilateral appreciation to two-way volatility. And the volatility and uncertainty have increased significantly, which may lead to changes in Tesla's stock price. The study of the link between Tesla's stock price and exchange rate helps to explore and analyze the link between exchange rate market and stock market, which is important to preserve the good operation of financial markets.

The first part of this paper is introduction. This part will introduce the research background, significance, and research purposes. The second part is literature review. In this part, there is a collation and analysis of the relevant literature. The third part is the experiment design. This part will introduce the data sources and model settings of this paper. The fourth part is the empirical analysis part, which will use VAR model and ARMA-GARCHX model to carry out the empirical test and summarize the results of the empirical test. The fifth part is the discussion part, which analyzes the research conclusion of this paper. The last part is a summary of the main research results of this paper.

Literature Review

In the field of Finance, there are two mainstream assumptions to explain the link between exchange rates and the prices of stocks. First, DOM Busch R and Fischer S. put forward the flow-oriented hypothesis. He believes that the exchange rates can lead to changes in the stock prices of companies by affecting trade in goods [2]; Second, Branson put forward the stock-oriented hypothesis. He considers that the change of capital account is an important way for exchange rate to affect the stock price of enterprises [3]. Kim and Yang found that capital inflows will increase asset prices and affect stock prices by studying Asian financial markets [4]. Kumar built the nonlinear Granger causality test and NARDL test to analyze India's exchange rate, petroleum price and stock price. His results show that there is an unidirectional and non-linear causal link between exchange rate and stock price [5]. Shahrestani and Rafei studied the impact of petroleum price and exchange rate on stock price of Tehran stock exchange under different state transitions through MS-VAR model. The results show that there are different state probability transitions between the prices of stock and exchange rates [6]. Wong used the MGARCH model to analyse the relation between the prices of stocks and exchange rates in seven countries, including Japan, the Philippines, and the United Kingdom [7]. The results proved that there was a negative correlation between exchange rates and the prices of stock. Aloui and Aïssa used the Vine-Copula model to explore the multivariate dependency link between U.S. crude, exchange rate, and stock returns. They pointed out that there was a negative Kendall dependency link between stock returns and dollar exchange rate, but also a positive tail dependency relationship [8]. Zhu et al. constructed the financial index under the same framework of exchange rate, interest rate and stock price, and found that there was a statistical causal relationship between the three [9]. However, not all studies show a significant connection between the prices of stocks and exchange rates. Adeniyi and kumeka studied the connection between exchange rates and the prices of stocks of 54 listed companies in Nigeria and found that for most listed companies, the link between stock prices and exchange rates is not prominent [10]. Liang from the two countries relative sensitivity factors of common stock of the stock prices point explains the connection between the prices of stocks and exchange rates, finding that rising exchange rates may have a negative influence on the prices of stocks in a long period time [11].

From the above literature, we can see that most of the literature believes that exchange rate will affect stock prices. Several papers have also pointed out that rising exchange rates will have a negative influence on the prices of stocks. However, the research object of the above literature is the whole stock market, and there is no research on the stock of a specific listed company. In this paper, I collect data, establish models, empirical analysis. And I summarize the results of empirical analysis, pointing out how to use the research results of this paper.

Research Design
Data Source

This paper uses Tesla's daily stock price from June 29, 2010, to June 9, 2023, and the daily exchange rate in the same period as the research data. Tesla's daily share price comes from stock price data released on the NASDAQ Exchange, and the daily exchange rate comes from data released by the Bank of China on the Renminbi to US Dollar Exchange Rate. Besides, the time series data cannot be directly analyzed quantitatively, so it is necessary to take logarithms to eliminate the influence of Heteroscedasticity in time series data. Among them, lNTESLA is Tesla's log stock price, LNER is the log exchange rate, LNTESLAR is Tesla's log stock price yield, and LNERR is the log exchange rate yield.

Weak Stationarity Test

Because many economic data are not stable in real life, it is requisite to first conduct ADF unit root test on the data first in order to ensure that the data used in the empirical study is stable and prevent false regression of time variable data (Table 1).

	t	p
Price		
Tesla	-1.772	0.7183
USD to RMB	-2.053	0.5722
Return		
Tesla	-39.767	0.0000***
USD to RMB	-39.665	0.0000***

Table 1: Weak Stationarity Test: ADF test.

From the unit root test, it's clear to see that Tesla's log and exchange rate data accept the original assumption that there is a unit root, indicating that this series is a nonstationary time series, which means Tesla's log stock price data and log exchange rate data are unstable. After the first order difference, Tesla's log stock price yield data and log exchange rate yield data are obtained. It can be seen that Tesla's log stock price yield and log exchange rate yield data reject the original hypothesis at the significant level of 1%, which proves that the data after the first order difference is stable. Therefore, this paper selects these two sets of stable data for empirical analysis.

VAR Model Setting

This paper selects vector auto-regressive model to empirically test the link between Tesla's stock price and exchange rate. Vector auto-regressive model or VAR model for short, is a very commonly used econometric model, which can be used to analyze the dynamic relationship between variables in multiple time series. There are two variables in the data selected in this paper, so the binary VAR model is selected, and the model formula is shown in the table below:

$$Y_t = C_1 + \sum_1^n \alpha_i Y_{t-i} + \sum_1^n \beta_i X_{t-i} + \varepsilon_1, t = 1.2 \dots, n \qquad (1)$$

$$X_t = C_2 + \sum_1^n \alpha_i X_{t-i} + \sum_1^n \beta_i Y_{t-i} + \varepsilon_2, t = 1.2. \dots, n \qquad (2)$$

ARMA-GARCHX Model Setting

ARMA-GARCHX model needs to model the mean and variance respectively, because the residuals in ARMA model are white noise and have no research significance, so the residuals should meet the GARCH process; In the GARCH model, the mean equation is a constant, which also has no research significance, so the mean should meet ARMA. The APMA model is shown in the table below:

$$x_t = \emptyset_0 + \sum_{i=1}^p \emptyset_i x_{t-i} + \alpha_i - \sum_{i=1}^q \emptyset_i \alpha_{t-i} \qquad (3)$$

$\emptyset_0 + \sum_{i=1}^p \emptyset_i x_{t-i}$ represents the AR model, which is used to describe the impact of historical values on current values. And $\alpha_i - \sum_{i=1}^q \emptyset_i \alpha_{t-i}$ represents the MA model, which uses past volatility to estimate the future and the last part of the model.

The GARCH model is as follows:

$$\sigma_t^2 = \alpha_0 + a_1 \alpha_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \qquad (4)$$

In the equation (4), term $a_1\alpha_{t-1}^2$ is ARCH part and $\beta_1\sigma_{t-1}^2$ represents GARCH part.

Empirical Results and Analysis

Order of VAR Model

Then, this part will determine the optimal number of lag periods. The test results of the number of lag periods of truss's stock price yield and exchange rate yield are as follows. From the test results, it can determine that the optimal number of lag periods is 12 (Table 2).

Lag	LL	LR	p	FPE	AIC	HQIC	SBIC
0	22211.9			3.9e-09	-13.6845	-13.6831*	-13.6807*
1	22218.2	12.653	0.013	3.9e-09	-13.6859	-13.6819	-13.6746
2	22222.9	9.3683	0.053	3.9e-09*	-13.6863*	-13.6796	-13.6676
3	22225.8	5.7764	0.216	3.9e-09	-13.6856	-13.6762	-13.6594
4	22227.5	3.5351	0.473	3.9e-09	-13.6842	-13.6722	-13.6505
5	22229.6	4.2207	0.377	3.9e-09	-13.6831	-13.6683	-13.6418
6	22231.3	3.311	0.507	3.9e-09	-13.6816	-13.6642	-13.6329
7	22235.3	7.9197	0.095	3.9e-09	-13.6816	-13.6615	-13.6254
8	22240.6	10.673	0.030	3.9e-09	-13.6824	-13.6596	-13.6187
9	22243.1	5.0496	0.282	3.9e-09	-13.6815	-13.656	-13.6103
10	22245.6	4.9334	0.294	3.9e-09	-13.6806	-13.6524	-13.6018
11	22245.8	0.3511	0.986	3.9e-09	-13.6782	-13.6473	-13.592
12	22251.7	11.924*	0.018	3.9e-09	-13.6794	-13.6459	-13.5857

Table 2: Likelihood ratio test and information criterion.

Impulse Response

Before impulse response, we need to test the stability of the model. The test results are as Fig. 1.
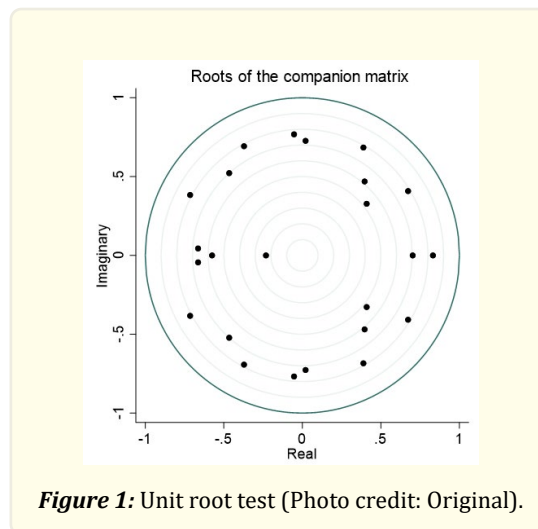

Figure 1: Unit root test (Photo credit: Original).

From the test results, it's clear to see that all points are distributed in the unit circle, which means that the model established by the time series data used in this paper is stable. So it can be used for impulse response analysis. The impulse response results are as Fig. 2.

Figure 2: Impulse and response (Impulse variable: USD to RMB)
(Photo credit: Original).
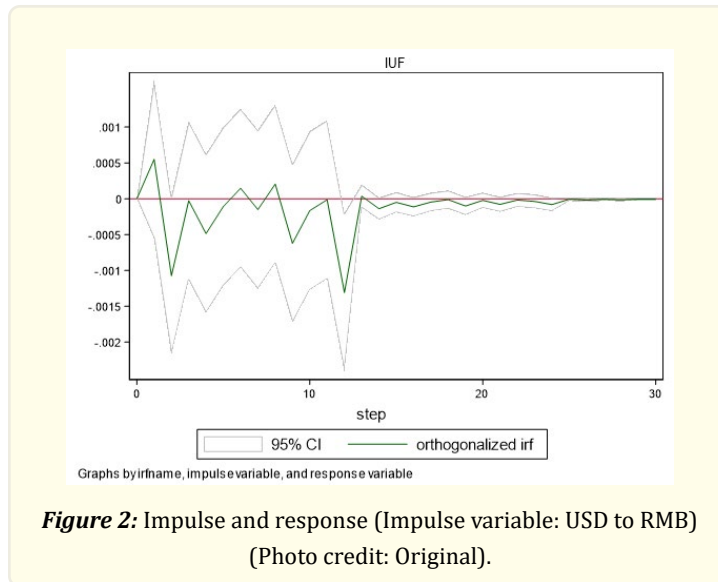
From the results of impulse response (Fig. 2), it can be concluded that LNERR has a negative correlation with LNTESLAR in this period. The negative impact of phase 12 is the largest, reaching the lowest point of - 0.014. While the positive impact of phase 2 is the largest, reaching the highest point of 0.0005, showing a complete convergence after phase 25. Impulse response results can show that increasing LNERR by one unit in the current period will mainly have a negative impact on the future period of LNTESLAR.

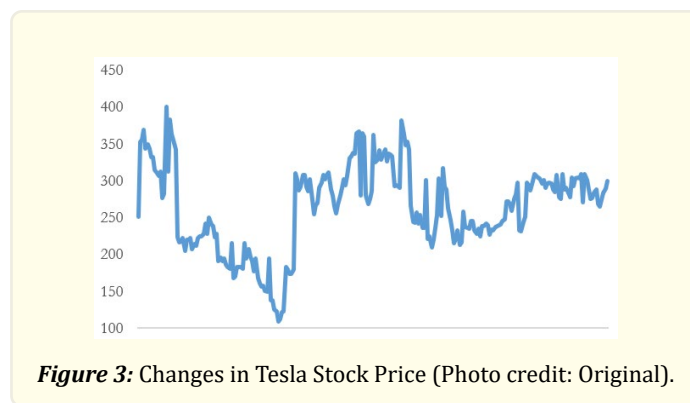*Figure 3:* Changes in Tesla Stock Price (Photo credit: Original).

Fig. 3 shows Tesla's stock price changes in 2022. From the chart, it's easy to find that Tesla's stock price has a significant downward trend after the Federal Reserve began raising interest rates for the first time in March 2022. This is the same as the conclusion reached above, the Fed's interest rate hike will lead to the depreciation of the RMB, which will raise the RMB exchange rate and Tesla's stock price will fall.

ARMA Specification

Before using the ARMA GARCHX model to predict, we need to find the best the lag orders for AR(p) and MA(q). PACF and ACF can be used to derive the lag orders of AR (P) and MA (q), as shown in Fig. 4.

Photo credit: Original.
Figure 4: ARMA (p, q) identification.
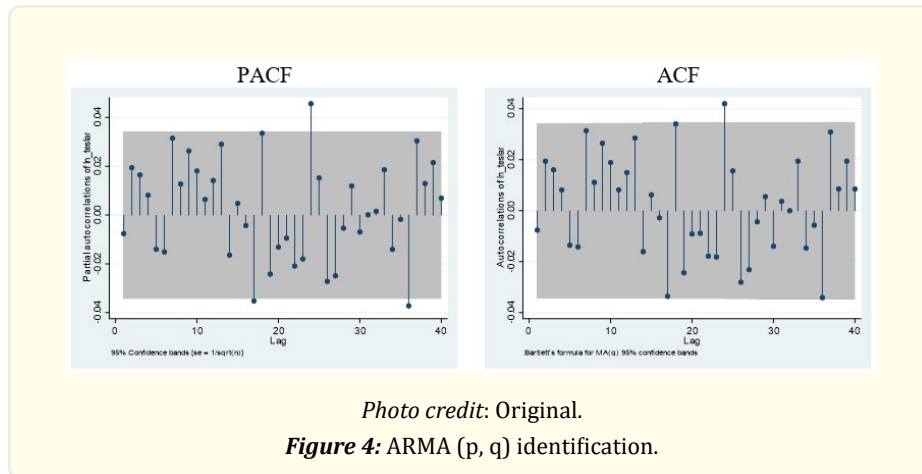
As can be seen from the above figure, the first part exceeding the critical value in PACF and ACF diagrams is 24, so the optimal order of AR (P) and MA (q) is 24 and the values of P and Q are 24.

ARMA-GARCH Estimation Results and Variance Equation

Tables 3 shows the ARMA-GARCHX model estimation results and the variance equation. From the table, it's easy to find that all the GARCH and ARCH terms both have p-values less than 0.05 in the variance equation. The results mean the GARCH and ARCH terms are significant. Furthermore, all the Logs but L1 in column (3) have p-values less than 0.05, proving they are significant and the estimating has statistical significance. The results show that the exchange really will affect the volatility of Tesla stock price to a certain degree.

	(1)		*(2)*		*(3)*	
	Coef.	*p*	*Coef.*	*p*	*Coef.*	*p*
Exchange rate						
L0	284.1006	0.000	293.5648	0.000	-319.2692	0.000
L1	-11.74465	0.000	-233.2797	0.000	-85.0995	0.445
L2			-11.75571	0.000	362.2137	0.000
ARCH	0.0440537	0.000	0.0413848	0.000	0.0409543	0.000
GARCH	0.9504988	0.000	0.9513231	0.000	0.9500162	0.000
Constant	-11.74465	0.000	-11.75571	0.000	-11.79292	0.000

Table 3: ARMA-GARCHX regression, external variable: exchange rate.

Summary of Empirical Results

To sum up, it's true that the exchange rate of renminbi to US dollar will affect Tesla's share prices. From the test results of the impulse response, we can find the influence of the exchange rate on Tesla's stock price is mainly negative. But the impact of the first period is positive. From the results of ARMA-GARCHX estimates, we can also see that the exchange rate will have a positive effect on Tesla's share

price at the beginning of the period and a negative effect on Tesla's share price later. Therefore, it can be concluded that exchange rate changes mainly affect Tesla's stock price negatively, more in the medium term and long term, and positively in the short term at the beginning of the period.

Discussion

Compared with other studies, this paper selects a specific company stock as the research object, while most of the existing literature takes the financial market of the whole country as the research object, and the research object of this paper is more detailed. The conclusion of this paper is roughly the same as that of the existing literature. This paper also finds that the rising exchange rate does influence Tesla's stock price, and the impact is mainly negative. However, this paper finds that Tesla's stock prices are affected positively by the rising exchange at the beginning of the period in the process of empirical research, which can fill the gap of some related research in a certain way.

Because the exchange rate will affect the stock price, company director and investors need to pay more attention to the change of exchange rate so that they can eliminate the influence of exchange rate fluctuations on the company's operation so that they may avoid losses to the company or themselves. For policy makers, the conclusions of this paper can help them better regulate financial markets. Policy guidance can affect the stock price of listed companies by regulating the exchange rate, to regulate the market. When policy makers need to raise the share prices of Listed Companies in the short term, they can raise the exchange rate; When policy makers need to raise the share prices of Listed Companies in the medium and long term, they can lower the exchange rate. The conclusions of this paper can help investors make profits in the stock market. According to the conclusion of this paper, when the exchange rate rises, stock prices may ascend in the short term and decline in the medium and long term. Therefore, investors can make their own investment choices according to this law.

Conclusion

The objection of the study is to find the link between Tesla's stock prices and exchange rates. Besides, the paper also wants to analysis what kinds of impact will the change of exchange rate have on Tesla's share price. VAR and ARMA-GARCH models are introduced for the purpose, this study uses VAR models to explore the impulse response and the ARMA-GARCH model is used to assess the stock returns and conditional variances. After the empirical analysis, this paper has led to some conclusions.

Firstly, this paper demonstrates that the exchange rate does influence Tesla's stock price. The influence of exchange rate on the prices of stocks is mostly negative. Secondly, in the short run at the beginning of the period, the rising exchange rate will affect stock prices of Tesla negatively; in the medium term, the exchange rate will have a negative influence on stock prices of Tesla. And the impact is diminishing over time. Changes in exchange rates will influence stock prices, and thus financial markets. The research results of this paper can help to explain the impact of exchange rate on financial markets, so the use of the conclusions of this paper can help to preserve the regular operation of the financial market and promote the rapid development of financial markets.

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