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Empirical Study of the Fed's Interest Rate Policy's Short-term Impact on China's Stock Market-Based on the GARCH Model

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Abstract

This paper selects the data of the Shanghai Composite Index daily rate of return from November 1, 2002 to April 1, 2020 as the object. By introducing the Fed interest rate policy changes as dummy variables in the ARMA-GARCH and ARMA-EGARCH mean equations, the Fed interest rate policy changes' short-term impacts on China's stock market are studied. It's found that the adjustment of the Fed's interest rate policy has no obvious impact on the Chinese stock market when the direction of the change of the Fed's interest rate policy is not distinguished. When the direction is differentiated, the increase and decrease of the Fed's interest rate would have a positive correlation on the Chinese stock market. Subsequently, through the event research method using Bootstrap technology, this paper examines the excess return rate and cumulative excess return rate of the ten-day stock index before and after the change in interest rate policy, and found that when the direction of regulation is not distinguished, the effect of Fed policy changes on the excess return of the stock market is not obvious , When distinguishing the direction, whether it is interest rate cuts or interest rate increases, positive cumulative excess returns would appear. The explanation for this phenomenon is that under different macroeconomic backgrounds, investors have different expectations of events, and therefore they would make different decisions

Key words: Fed's interest policy, GARCH model, Bootstrap

Chapter1 Introduction

1.1 Introduction

1.1.1 Research background and significance

The establishment of Bretton Woods system built up US dollar's core position in the post-war international monetary and economic system. As the key currency for international settlement and the main currency of foreign exchange reserves, the US dollar plays an important role in international trade. After the breakdown of the Bretton Woods system, the new currency system adopted by the Jamaica Agreement in 1976 nominally weakened the status of the US dollar while the pricing model of oil and international commodities to some extent enhanced the US dollar’s foundation as international currency. The US dollar still accounts for vast majority of the world ’s foreign exchange reserves and act as a currency medium in international commodity exchanges, making US monetary policy adjustments not only affect the US domestic economy, but also generate outward spillovers effect through various channels.

Throughout the development of the world economy, the Fed usually adjusts interest rate policies according to the development of the US economy to smooth out economic fluctuations, which correspondingly increases the uncertainty of economic development and asset prices in other countries considering the role the US dollar plays in the international economics. In 2008, in response to the financial crisis, the United States implemented three rounds of quantitative easing monetary policy, which led to the spread of the US dollar around the world, pushing up the asset prices of various countries and causing the rise of deficits of other countries. When the signs of the US economic recovery are beginning to show, with inflation rising, the Fed turned the monetary policy to neutral and entered the interest rate hike cycle. Other countries were affected by the impact of the return of US capital, resulting in debt or currency crises, which also had severe impact upon their stock market. Since joining the WTO, China has continuously committed to improve the level of financial opening to the outside world. In November 2002, the "Interim Measures for the Administration of Domestic Securities Investment of Qualified Foreign Institutional Investors" was formally released. After years of development, China's financial opening level has continued to improve, and its interconnectivity with external markets has also continued to increase. In September 2019, the State Administration of Foreign Exchange lifted the restrictions on the total amount of QFI investment, and also canceled the filing and approval of QFII single investment quotas. China's capital market has fully liberalized the entrance of foreign investment and the

opening up has entered a new era. In April 2020, China's financial market became fully opened.

Under the current background of the full opening of the financial market, the influence mechanism of foreign interest rate on the Chinese economy and its transmission mechanism will become more complicated. Ignoring the impact of the Federal Reserve ’s monetary policy on China is likely to lead to excessive or insufficient regulation of China ’s financial macro policies. As a result, the effect of regulation and control is affected, and it is possible to aggravate the fluctuation of China's financial asset prices and undermine the stability of the financial market. From an asset management perspective, Chinese investors also need to pay close attention to the Fed ’s monetary policy risk, manage and price the Fed ’s monetary policy risk, and dynamically manage the investment portfolio.

To this end, studying the spillover effect of US interest rate policies on China's stock market has important theoretical value for revealing the regularity of changes in Sino-US economic and financial relations, and is also of great practical significance for China's improvement of macroeconomic control methods and effective response to external shocks: First, studying the spillover effect of the Fed ’s interest rate on the China’s stock market will help the monetary authorities to formulate and implement monetary policies in a targeted manner based on the unprecedented domestic and foreign economic situation and reduce the negative impact of the US monetary policy. Second, it is conducive to the reform of the central bank and enriches its monetary policy toolbox. It responds to different external shocks in a more flexible, diversified, and sophisticated manner, and resolves the systemic and non-systemic financial risks that follow. Third, it helps investors better understand the laws of the stock market and to deal with the possible impact of the Fed's interest rate adjustment, moreover, it provides relevant recommendations for timely risk control.

1.1.2 Research contents and method

Scholars around the world have conducted a lot of theoretical and empirical research on the impact of the Fed's interest rate policy adjustments on other countries 'stock markets, mainly focusing on the issues of the Fed's interest rate policy adjustments on the volatility spillover effect of other countries' asset prices, its transmission mechanism and the degree of the impacts. The focus of this article is not on the impact mechanism of the Fed's interest rate policy adjustment on the external stock market, but on the short-term impact of the Fed's interest rate policy adjustment on the Chinese stock market in the context of the opening of the financial market.

Specifically, this article mainly studies the following aspects:

1) Whether there is an expected shock effect caused by the market’s expectation before the adjustment;

2) How the market reacts after the adjustment is announced, and whether there will be a reverse adjustment of the market caused by the expected cashing in the previous period;

3) Subdivide the adjustment direction to verify the impact of market returns under different adjustment

directions;

4) Combine the macro environment, market sentiment and other factors to analyze the transmission mechanism of the effect.

In response to the above, this article mainly uses the following methods to proceed:

1) Literature research method. This article refers to great amounts of domestic and foreign literature on the spillover channels and spillover effects of US monetary policy. At the same time, it collects and studies the literature on the theoretical analysis and empirical analysis of monetary policy decomposition, drawing on the research direction, theoretical basis and methods. Based on the previous research results, it provides a theoretical basis for the research hypothesis, the choice of empirical methods, and the interpretation of empirical results.

2) Empirical research method. This paper mainly analyzes the content of the literature research method by adding the Fed interest rate policy adjustment as a dummy variable in the ARMA-GARCH model, which avoids the interference caused by asymmetry through other GARCH family models. The Bootstrap technology is used based on GARCH model to calculate the excess return of the stock index for a period of time around the change of the interest rate, and the T-test and other methods are used to make a significant judgment.

3) Qualitative analysis method. Combined with the macro background of the Fed's interest rate policy adjustment, the development status of the domestic stock market and the macroeconomic situation, a qualitative analysis of the empirical results is provided, and relevant recommendations are provided to the government and investors based on the empirical conclusions.

Chapter 2 Literature Review

The researches on the effects of interest rate policy on the stock market began from a domestic perspective. As early as 1930s, scholars began to pay attention to the mechanism of interest rate on the stock market, which gradually evolved into Keynes ’s liquidity preference theory, Friedman ’s new currency Quantitative theory etc. All these theories elaborated the effects of the change of interest rates on the stock market from a domestic perspective.

The theoretical analysis of the international spillover effect of interest rate policy started from the Mundell-Fleming (MF) model as well as the New Open Economy Macroeconomics Redux model, which turned the perspective from domestic to global. This chapter mainly summarizes the theoretical and empirical research literature on the impact of interest rates on the stock market, and explains some of the significant results, from domestic perspectives to international perspectives, from theoretical studies to empirical studies, in order to provide more inspiration for the research of this paper.

2.1.1Theoretical Research on the Effect of Interest Rate upon Stock Prices from Domestic Perspective

In theory, the adjustment of the Fed's interest rate policy is considered as a type of monetary policy, which is also one of the most important and commonly used means in monetary policy. Monetary policy in a narrow sense refers to the central bank ’s policies and measures that use various policy tools to regulate the money supply and interest rates, and ultimately achieve stable growth, employment promotion, full employment, and balance of payments. The interest rate policy refers to the use of interest rate instruments to adjust the level of interest rates and the structure of interest rates, thereby affecting the supply and demand of money, and ultimately achieving economic goals. The interest rate policy used by the Fed is mainly to reduce or increase the federal funds benchmark interest rate, in order to increase or decrease currency liquidity.

Research on the effect of interest rates on the stock market began with Keynes (1936). Keynes believes that interest rates have an indirect impact on the stock market by changing the return levels of different investment instruments. When interest rates increase, the returns of fixed-income products such as bonds increase, causing investors to change the flow of funds during resource allocation by selling stocks and purchasing bonds, which results in the fall of stock price. The opposite is also true when lowering interest rates. In addition, lower interest rates will cause the increasement of the opportunity cost of saving, which will drive some savings into the stock market, increasing the supply of capital in the stock market and the demand for stock purchases, thus pushing up stock prices. Then Keynes put forward the theory of liquidity preference, that is, the impact of interest rate policy on the overall stock market return depends on the relationship between the policy and public expectations. When the rate of interest rate reduction is greater than the public expectation, people think that the interest rate would rebound, so they first sell the stock and exchange it for currency, in order to buy in the future, which leads to the fall of the stock price; conversely, when the dimension of interest rate reduction is less than the public expectation, people expect the future Interest rates to fall even more, so stocks would be bought for future sale, resulting in the rising of current stock prices. When the interest rate adjustment meets public expectations, the stock price would not change.

Friedman (1956) explained the relationship between currency demand and asset portfolio in his new money quantity theory. He believed that changes in the money supply would change the original investment portfolio, causing investors to adjust the weight of currency and other assets. Subsequently, Tobin (1969) proposed in the asset selection theory that the stock market has substitution effects and cumulative effects under the influence of interest rate policies. The substitution effect means that when interest rates fall, stock returns would rise relatively, attracting investment funds to flow to places with high profits. Accumulation effect refers to that investors would tend to buy high-yield risk assets in order to accumulate wealth and invest more funds in the stock market. The superposition of the two effects causes the stock market capital supply to rise, thereby

pushing up stock prices.

2.1.2 Theoretical Research on the Effect of Spillover of Monetary Policy

The theoretical analysis of the international spillover effect of monetary policy is mainly based on the Mundell-Fleming (MF) model as well as the New Open Economy Macroeconomics Redux model. Regardless of the MF model or the Redux model, the spillover effect of foreign currency policies on the domestic economy is transmitted through the international financial market through the interest rate channel or through international trade through the trade output channel. Each transmission channel would produce two effects in opposite directions, namely income effect and expenditure transfer effect, so that the impact of foreign monetary policy on the actual output of the country would have a positive spillover effect or a negative spillover effect, which ultimately depends on the income effect and the magnitude of the transfer effect of expenditure. Therefore, for different countries, or even the same country at different times, the spillover effect of monetary policy exhibits different characteristics.

2.2.1 Empirical Research Abroad

Foreign scholars have used different empirical research methods to conduct in-depth research on the impact of changes in the Fed ’s interest rate policy on the stock markets of other countries. According to the research results, literature can be roughly divided into the following three categories.

The first type of researches focused on whether the Fed ’s interest rate policy adjustments have spillover effects on peripheral stock markets. Existing literature studied the impact of Fed monetary policy spillovers on asset price volatility in other countries’ financial markets from an empirical perspective. For example, Lastrapes (2007) studied the spillover effect of the Fed ’s monetary policy and analyzed that the stock prices of seven countries are affected by the US money supply. The conclusion is that there is a spillover phenomenon and a positive relationship. Wongswan (2006) found that the Fed ’s monetary policy adjustment has a significant impact on the price fluctuations of the Thai and Korean stock markets in a short period of time. Gupta et al. (2017) also found that the Fed's monetary policy adjustment significantly increases the risk of volatility in the UK and European financial markets. Based on the Qual-VAR model, Tillmann’s study confirmed that the US unconventional monetary policy has a significant spillover effect on emerging economies. However, Mann (2005) analyzed the spillover effect of the Fed's monetary policy on the stock prices of six countries, and found that US monetary policy variables can hardly explain the changes in international stock returns, which means there is no significant spillover effect.

The second type of research focuses on the transmission mechanism of the Fed's interest rate policy on the external stock market and the medium of transmission mechanism. Anaya et al. (2017) analyzed the spillover effect of US monetary policy on the economy and finance of emerging economies based on VAR model and

found out that the unconventional monetary policy of the United States significantly affects the economic and financial environment of emerging economies, and this spillover effect is mainly transmitted through capital flows. Lindner et al. (2019) studied the spillover effects of the monetary policies of developed countries such as the United States and found that the monetary policies of the United States and other countries are transmitted to other economies through the borrowing and lending behavior of international banks, thereby showing the spillover effect. Ammer et al. (2010) found that the impact of international monetary policy on a country's asset prices can be transmitted through interest rate and cash flow channels. Canova (2005) used data from Latin American countries and found that the spillover effect of the Fed ’s monetary policy can be transmitted through interest rate channels. Wongswan (2009) used the stock indexes of 15 countries and found that the Fed's unexpected interest rate cuts significantly increase returns in foreign stock markets, and this spillover effect is mainly transmitted through interest rates. However, Bernanke and Kuttner (2005) pointed out that the cash flow channel is more obvious than the discount rate channel for monetary policy transmission. Laeven and Tong (2012) used global stock prices to find that companies relying on external financing were more affected by the Fed ’s monetary policy, indicating that the cash flow channel plays an important role in the Fed ’s monetary policy spillovers.

The third category of literature makes some distinctions about the degree to which the Fed ’s interest rate adjustment affects the external stock markets. Sugimoto and Matsuk(2019) studied the spillover effect of mature economies' monetary policy on Asian stocks and other financial markets, and found that US monetary policy had the largest spillover effect on Asian financial markets. Thorbecke (1997) pointed out that the impact of changes in monetary policy on stocks of different company sizes, and found that the tightening of monetary policy in the United States had a significant negative impact on the stock prices of small companies while the stock prices of large companies were not significant. Ehrmann (2006) studied the impact of changes in the Federal Reserve ’s monetary policy on the international stock market by selecting representative stock markets, and found that for every 0.01% increase in the federal funds rate, the average return on the international stock market decreased by 3.8%. Daisy et al. (2010) studied the interaction between the monetary policy of the United States and Canada and the stock market by using the SVAR model. The empirical results found that the US stock market was more affected by monetary policy than the Canadian stock market. The higher the degree of openness, the more obvious the spillover effect of monetary policy is.

2.2.3 Domestic Empirical Research

Yuan Peng (2010) found out that the loose monetary policy of the United States had a significant reverse impact on the true return of the China’s stock market, and the short-term impact would calm down after a certain period of increase. Ba Shusong (2010) pointed out that the liquidity released by quantitative easing

policy would enter in emerging market countries in large quantities, and affect the economic development of emerging countries through capital inflows. Hot money inflows will not only affect asset price levels but may even cause economic bubbles. Xuancheng (2012) studied the impact of US monetary policy and stock market volatility on the Chinese stock market by constructing a VAR model and using Granger causality test and cointegration test. The empirical results show that before the financial crisis, the federal funds rate adjustment is the main channel that affects the Chinese stock market, and after the financial crisis, it is the stock market linkage channel that plays a leading role in the stock market. Fang Xianming and Tang Guanchen(2019) put the interest rate, exchange rate and stock price into a unified analysis framework to build the TVP-FAVAR model and found that China's interest rate showed a positive response under the impact of the Fed's rate hike, with a duration of nearly one year, and a certain degree of time lag; the real exchange rate of the RMB showed a negative response under the impact of the Fed's rate hike. The duration is slightly shorter than the duration of China's interest rate response, but there is no time lag; The impact of the Fed's interest rate hike on China's three financial asset prices exhibits obvious time-varying characteristics at different points in time. This time-varying characteristic is in line with the Fed's international macro environment in each round of interest rate hikes and China's domestic Economic development. Hou Yunfei et al. (2020) based on the quantile vector autoregressive model, using federal funds target interest rate from January 2008 to June 2019, data of China's macro economy, macro finance, financial markets and commodity market, systematically analyzed the risk spillover effect of US monetary policy on China's macro-economic and finance. The study found that US monetary policy has shown asymmetry in China's macroeconomic, macro-finance, financial market and commodity market risk spillover effects.

2.2.4 Research Review

In summary, most scholars think that the adjustment of the Fed's interest rate policy has a significant impact on its own stock market and external markets, but there are different conclusions about whether the impact is positive or negative. In the theory review, the liquidity preference theory believes that the relationship between the interest rate and the stock price is not determined, which mainly depends on the matching degree of the investor's expectations and the actual situation, that is, the trend of the stock market depends more on the public's expectations and its realization. In empirical research, most of the research abroad have also verified the traditional theory that the changes in the Fed's interest rate policy will have a significant impact on the rate of return of peripheral markets. All in all, whether it is a theoretical review or empirical research, there is no general conclusion about the way interest rates affect the stock market. Moreover, many empirical studies at home and abroad only use various methods to select sample data from different periods to measure the statistical connection between interest rate policy variables and stock market returns. There is a lack of analysis

on the essential reasons such as economic laws、investor expectations. Therefore, the relationship between changes in the Fed's interest rate policy and China’s stock market requires short-term shock and cumulative effects research under a specific macroeconomic background, and a reasonable explanation in conjunction with the specific market environment, which is time-sensitive and necessary. And there is room to further improve the goodness of fit and robustness in the selection and application of models, thereby enhancing the reliability of conclusions.

2.3 Research hypothesis

Following the previous literature review, this article focuses on the following questions: whether the Fed ’s interest rate adjustments have a short-term impact on the Chinese stock market on the day of the announcement, whether the increase in short-term shocks is due to the promulgation of interest rate cuts, resulting in an increase in risk appetite in the Chinese stock market, and whether the Chinese stock market will be affected by the difference in the realization of the expected time of interest rate cuts and whether where exists excess returns for a period of time around the event date.

In order to better explore the above, this article proposes the following assumptions based on previous research results and the Fed's interest rate cut policy over the years:

Hypothesis 1: The changes of Fed's interest rate have a significant impact on the overall daily yield of China's stock market, causing an instant shock on the day that the interest rate policy is announced. In addition, the impact and intensity of short-term shocks will be different due to the inconsistent direction of interest rate policy regulation.

Hypothesis 2: China's stock market has asymmetric effect on the "bad" and "good" news. After eliminating this interference, the introduction of the Fed's interest rate policy will still increase the stock index yield on the day.

Hypothesis 3: During the period before and after the change of Fed’s interest rate policy, the stock market would produce significant excess returns, and in the interest rate adjustment cycle, the short-term behavior of stock index returns and the cumulative effect are different.

Chapter 3 Model construction

3.1 Data and variables

3.1.1Research period

At the end of 2002, China launched the "Interim Measures for the Administration of Domestic Securities Investment of Qualified Foreign Institutional Investors", which allows approved qualified foreign institutional investors to remit a certain amount of foreign exchange funds under regulations and restrictions and these

exchanges could be converted into local currency. QFII could use strictly regulated special accounts to invest in the China's securities market, and their capital gains, dividends, etc. can be converted into foreign exchange remittances after approval. Since then, the QFII quota has been continuously increased until China 's financial market is fully opened in April 2020, and there are no longer restrictions on foreign capital inflows. Therefore, this article selects the QFII system from 2002 to the full opening of the financial market in April 2020 as the research period, and empirical analysis is carried out based on this.

3.1.2 Daily yield data

This article uses the daily closing index of the Shanghai Composite Index as the proxy variable in China's stock market: on the one hand, the Shanghai Stock Index has a wide range of constituent stocks, which is the index most familiar to investors in China; And it has strong cointegration relation with Shenzhen Stock Exchange. Therefore, the Shanghai Stock Index is very representative. Calculate its daily logarithmic return as the stock market's daily return, ie:

$$R_t = ln\left(\frac{P_t}{P_{t-1}}\right) = lnP_t - lnP_{t-1} \quad \text{Equation 1}$$

The Shanghai Composite Index comes from Wind Financial Data Terminal

3.1.3 Interest rate policy data

The Fed adjusted the market interest rate by lowering the target rate of the federal funds. From February 2002 to April 2020, the United States experienced a total of three more obvious monetary easing cycles, respectively: 2001-2003; 2008-2014; June 2019 to present, the total adjustment of the federal funds target interest rate 42 times, including 16 interest rate cuts and 26 interest rate increases.

Table 1 Events of Fed's interest rate adjustment

Number	Time	Federal Funds Target Rate	Amplitude	Yield of Shanghai Composite Index
1	2002/11/6	1.25%	0.5	-0.3645
2	2003/6/25	1%	0.25	-0.6843
3	2004/6/30	1.25%	-0.25	-0.6765
4	2004/8/10	1.5%	-0.25	0.3525
5	2004/9/21	1.75%	-0.25	-1.0019
6	2004/11/10	2%	-0.25	3.5918
7	2004/12/14	2.25%	-0.25	-0.1634
8	2005/2/2	2.5%	-0.25	5.3468
9	2005/3/22	2.75%	-0.25	-1.9601
10	2005/5/3	3%	-0.25	-2.4432

11	2005/6/30	3.25%	-0.25	-2.1765
12	2005/8/9	3.5%	-0.25	1.1985
13	2005/9/20	3.75%	-0.25	-0.6562
14	2005/11/1	4%	-0.25	-0.2626
15	2005/12/13	4.25%	-0.25	0.1326
16	2006/1/31	4.5%	-0.25	2.3513
17	2006/3/28	4.75%	-0.25	0.2215
18	2006/5/10	5%	-0.25	0.9489
19	2006/6/29	5.25%	-0.25	1.9722
20	2007/9/18	4.75%	0.5	0.0705
21	2007/10/31	4.5%	0.25	0.9764
22	2007/12/11	4.25%	0.25	0.2549
23	2008/1/22	3.5%	0.75	-7.2173
24	2008/1/30	3%	0.5	-0.8993
25	2008/3/18	2.25%	0.75	-3.9568
26	2008/4/30	2%	0.25	4.8164
27	2008/10/8	1.5%	0.5	-3.041
28	2008/10/29	1%	0.5	-2.9354
29	2008/12/16	0.25%	0.75	0.5417
30	2015/12/17	0.5%	-0.25	1.8148
31	2017/3/16	0.75%	-0.25	0.8384
32	2017/6/15	1%	-0.25	0.0581
33	2017/12/14	1.25%	-0.25	-0.3209
34	2018/2/1	1.5%	-0.25	-0.9725
35	2018/3/22	1.75%	-0.25	-0.5325
36	2018/6/14	2%	-0.25	-0.1849
37	2018/9/27	2.25%	-0.25	-0.5358
38	2018/12/20	2.5%	-0.25	-0.5213
39	2019/7/31	2.25%	0.25	-0.6718
40	2019/9/18	2%	0.25	0.2532
41	2019/10/30	1.75%	0.25	-0.5029

42	2020/3/3	1.25%	0.5	0.7393

The interest rate data are all from Oriental Fortune Choice Financial Terminal. Set D_t^k as a dummy variable representing the Fed 's interest rate adjustment, and k as an event that regulates interest rates. When an interest rate adjustment event occurs on a trading day, the current day is selected as the event occurrence date. The next trading day is regarded as the event occurrence date. $D_t^k = 1$on the day of the event, $D_t^k = 0$on the remaining trading days

3.2 Empirical methods and model design

3.2.1GARCH Model

For the verification of Hypothesis 1, it is necessary to establish a model that fits the Shanghai Composite Index daily rate of return data. In mainstream financial theory, it is assumed that the distribution of stock market returns is a positive distribution. However, in practice, the distribution of daily returns of high-frequency stocks is often different from the distribution of the positive and negative, with the characteristic of "peak and thick tail", and the daily return data generally has the phenomenon of "volatility cluster", that is, it appears in a certain period large volatility is often accompanied by greater volatility, more outliers, and plunge and plunge are more frequent, but will eventually converge to a certain range of the average rate of return.

For this kind of seasonal data, Engle (1982) proposed the ARCH model to analyze the heteroscedasticity characteristics of time series, which is the first theoretical model of volatility that defines volatility as the conditional standard deviation. The basic idea is:

(1) The perturbation sequence of return on assets $a_t = r_t - E(r_t|F_{t-1})$ is irrelevant, but not independent.

(2) The independency of a_t is described as $Var(r_t|F_{t-1}) = Var(a_t|F_{t-1})$, which could be described as a linear combination of a_t^2' hysteresis values.

Specifically, the ARCH(m) model is:

$$a_t = \sigma_t \varepsilon_t \quad \text{Equation 2}$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 a_{t-1}^2 + \cdots + \alpha_m a_{t-m}^2 \quad \text{Equation 3}$$

Among them ε_t is the independent and identically distributed white noise with zero mean unit variance, $\alpha_0 > 0, \alpha_j \geq 0, j = 1,2, \ldots m$ and some conditions need to be met by α_j to make $Var(a_t)$ finite, similar to the characteristic root condition of the stationarity of AR(p) sequences.

Because the coefficients α_j are non-negative, a larger historical value of a_{t-j}^2means that the conditional variance of α_t is larger. Therefore, under the framework of the ARCH model, large disturbances tend to appear after large disturbances. "Tendency" does not mean that there will be large disturbances, because the larger the conditional variance is, the larger the variance can only be said that the probability of a larger

occurrence becomes larger, not that there will be a large disturbance. This phenomenon can explain the volatility clustering of asset return.

However, the ARCH model has strict constraints on the model parameters. Even for ARCH(1), in order to be able to calculate the kurtosis, α_1 should belongs to $(0, \frac{\sqrt{3}}{3})$, abd high-order ARCH(m)'s constraints are more complicated. This is a limitation for the ARCH model with Gaussian innovation to express thick tail through excess kurtosis

To fix this problem, T. Bollerslev (1986) proposed the GARCH model. The GARCH model has better characteristics in terms of fitting financial time series data: except for the same as the ordinary regression model, the GARCH model further models the variance of the error witt excellent time-varying variance and the ability to handle thick tails , which is especially suitable for volatility analysis and prediction. Such analysis can play a very important guiding role in investors' decision-making.

The GARCH model is consisted of two equations, the first is the conditional mean equation, and the other is the conditional variance equation (used to iterate the volatility data of each period). The specific form is as follows, where (1) is the conditional mean equation of stock price returns, and (2) is the conditional variance equation of stock price returns:

$$Y_t = X_t * \xi + \varepsilon_t, \varepsilon_t | \Omega_{t-1} \sim N(0, \sigma_t^2) \quad (1) \qquad \text{Equation 4}$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i * \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j * \sigma_{t-j}^2 \quad (2) \qquad \text{Equation 5}$$

Among them, Y_t is the return rate of the security, X_t is the regression variable (may include the lag value of Y_t). The GARCH model defines the conditional variance σ_t^2 of stock returns as the first-order to q-order terms after the disturbance term ε_{t-i}^2 in the conditional mean equation and the first-order to A linear function of the p order term. The ARCH effect term is $\varepsilon_t = \sqrt{\sigma_t^2} * \mu_t, \mu_t \xrightarrow{i.i.d} N(0,1)$, where Ω_{t-1} is the effective information set up to period $t-1$ It can be seen from the equations of (1) and (2) that the conditional variance of the rate of return in the GARCH model depends on the lag of the conditional variance of the ARCH effect term and the residual of the mean equation (GARCH effect term).

3.2.2EGARCH Model

To test Hypothesis 2, to exclude the asymmetry of the impact of the residual rate of return on the stock market is necessary(when the stock market is negatively impacted, the conditional variance of the rate of return increases, resulting in greater volatility in the rate of return and the stock price while as stock price rising, the volatility is less). Although the GARCH model can effectively match the "spike and thick tail" characteristics of the distribution, the measurement of the impact of positive and negative shocks in the conditional variance equation of the GARCH model is piled up, and the control factor that characterizes the asymmetry of the

fluctuation of the conditional variance of return rate is not added. GARCH assumes that a_{t-j} influence volatility by affecting a_{t-j}^2, positive and negative disturbances would have the same effect on volatility, but the actual asset return has positive and negative disturbances that have different effects on volatility, and larger negative disturbances are more volatile than positive disturbances, which is different from GARCH. For the sake of measuring the asymmetry of the volatility of returns, that is, the leverage effect of volatility, scholars have improved on the basis of the standard GARCH model, and established EGARCH, GJR-GARC, APARCH, TARCH and other models. Among them, Nelson (1991) proposed The EGARCH model (exponential GARCH model) adds a negative impact leverage expression to the conditional variance equation to quantitatively study the asymmetry.

The basic form of the EGARCH model is as follows:

$$Y_t = X_t * \xi + \varepsilon_t, \varepsilon_t | \Omega_{t-1} \sim N(0, \sigma_t^2) \quad (1)$$ Equation 6

$$ln\sigma_t^2 = \alpha_0 + \sum_{j=1}^{\infty} \beta_j ln\sigma_{t-1}^2 + \sum_{i=1}^{q} (\alpha_i \left| \frac{\varepsilon_{t-i}}{\sqrt{\sigma_{t-i}}} \right| + \gamma_i \frac{\varepsilon_{t-i}}{\sqrt{\sigma_{t-i}}}) \quad (2)$$ Equation 7

Compared with other models, the left side of the EGARCH model is the logarithm of the conditional variance, which means that the constraint of the non-logarithmic model parameters is relaxed, the predicted value of the conditional variance should be non-negative, and the leverage effect is also defaulted. In the form of an index. As long as $\gamma \neq 0$, it indicates that the impact of the shock has an asymmetric effect. The existence and degree of leverage can be tested by the assumption that the parameter $\gamma < 0$. When γ is negative, it indicates that the sequence has a leverage effect, that is, negative residuals will cause greater fluctuations. Based on the above analysis, for the hypothesis 2 Validate the choice to use the EGARCH model.

3.2.3 Event Research Method

The GARCH model's measurement of the effect of the Fed's interest rate policy adjustment on China's stock market is mainly concerned with the current shock caused by the event day, and the significance and mode of impact are more by providing recognition of the existence of the shock effect. know. Considering the sensitivity of the Chinese stock market to the news surface and the possible changes in the macroeconomic environment during the period before and after the Fed's interest rate adjustment, this article chooses to use the event research method to study the relationship between the Fed policy and the Chinese stock market.

Ball & Brown (1968) and Fama et al. (1969) initiated event study method, which is conducted by selecting a specific event according to the purpose of the study, studying the changes in sample stock returns before and after the event, and then explaining the specific The impact of the event on the sample stock price change and the rate of return is mainly used to test the price change before and after the event or the degree of price response to the disclosed information. The event research method is based on the assumption of efficient

markets, that is, stock prices reflect all known public information. Since investors are rational, investors' responses to new information are also rational. Therefore, the hypothetical The normal return estimated when no event has occurred can obtain abnormal return. The degree of abnormal reaction of the stock price to the occurrence of an event or information disclosure can be measured by the abnormal return.

The generally applicable research steps are as follows.

1) Confirm the event as well as the period of the event. Applying the event research method must first define what kind of events the research work focuses on. This obviously depends on research assumptions. After defining the event of interest, it is also necessary to identify and determine the event window related to it, that is, the time period during which the event may have an effect on the dependent variable (stock price, profit). The date of the incident should naturally be included in the event window. Mostly the period of the event is wider than the date of occurrence, including the period before and after the event. Because the information for a period of time after the event can show the change of the dependent variable. Then investigating the stock price in the period before the incident, which is conducive to capturing the impact of the pre-event warning and the leakage of information before the incident.

2)Identify the estimated period as well as the post-event period. The purpose of determining the estimation period is to use the data in the period to estimate the value of the dependent variable when the event did not exist, the expected return value. Comparing the expected return value with the dependent variable during the event, we can obtain the abnormal return value brought by the event.

3) Determine the unit of analysis. After the event and various periods are clearly defined, it is necessary to determine the object (data source) for observation and data collection.

4) Calculation of the abnormal rate of return. The abnormal rate of return is the difference between the actual rate of return during the event and the expected normal rate of return when the event does not occur.

5)Accumulate abnormal rate of return. The former calculated abnormal rate of return is only for a certain event date. For the sake of better describing the impact of the event on stock returns, it is necessary to cumulatively calculate the cumulative abnormal return rate of the stock over time when studying the abnormal return rate of the stock during the event.

6)Statistical inspection. When the abnormal rate of return is calculated, a statistical test should be conducted to determine whether the event has affected the stock return at a certain level of significance. Statistical testing is an significant part of the event research method to make sure the scientific reliability of the event research method.

Generally speaking, by examining the abnormal return of a stock during a certain day during the event, it is not very helpful to infer the overall impact of the event during the event. It is usually necessary to conduct

statistical tests on the abnormal returns accumulated during the event to determine the impact of the event on the overall return of the stock.

Chapter 4 Empirical research results and interpretation

4.1 Empirical test of Hypothesis 1

The main focus of this section is to verify whether hypothesis 1 is true by constructing the GARCH model. In empirical research, there may be pseudo-ARCH or pseudo-GARCH phenomenon when building ARCH and GARCH family models. This requires sufficient attention to issues such as the authenticity of the model settings and the selection of the model that truly reflects the timing characteristics of the data.

Therefore, in this article, a systematic statistical test would be carried out during the modeling, and problems such as the suitability of the data would be analyzed by using the GARCH model, the judgment of the model's equation form, and the test of the model fitting effect, so as to filter out a more reasonable model. To give the predecessor the method of using ARMA-GARCH model for empirical testing, this article uses the following modeling and testing analysis steps:

4.1.1 Descriptive statistical analysis

The timing chart and distribution chart of the return index R_t from January 1, 2001 to May 12, 2020 in the Shanghai Composite Index are as follows:

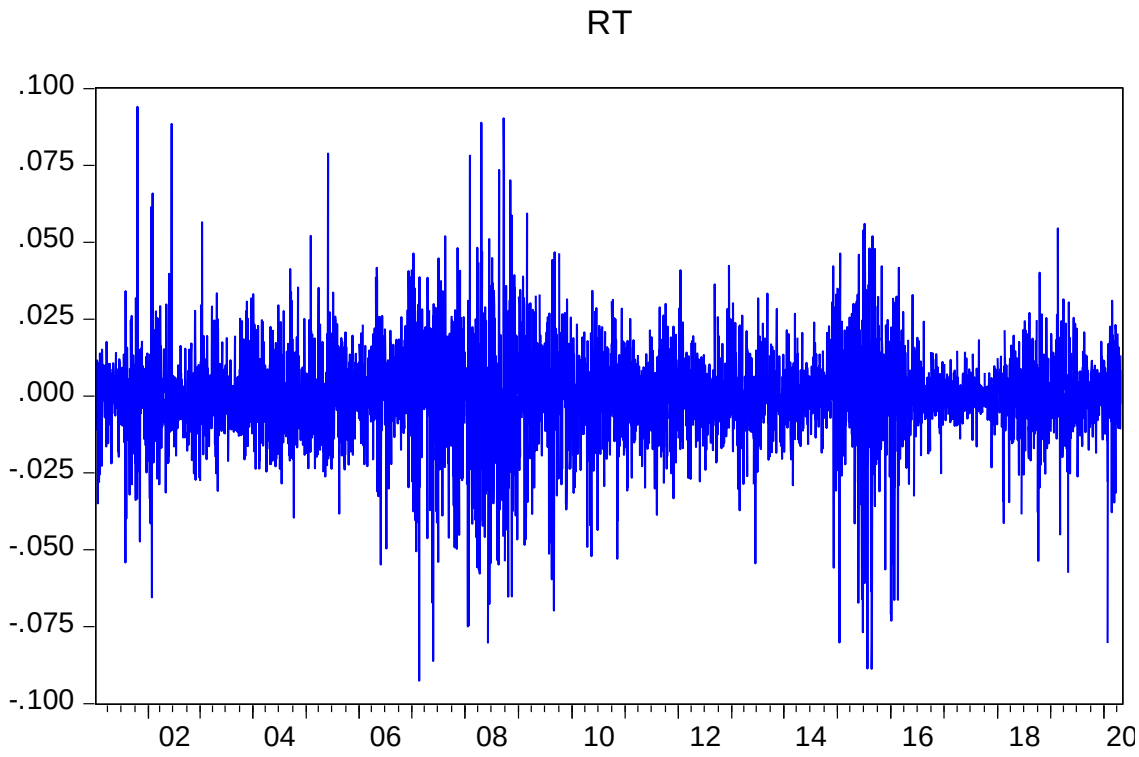

Figure 1 Time Series of Shanghai Composite Index Daily Rate of Return

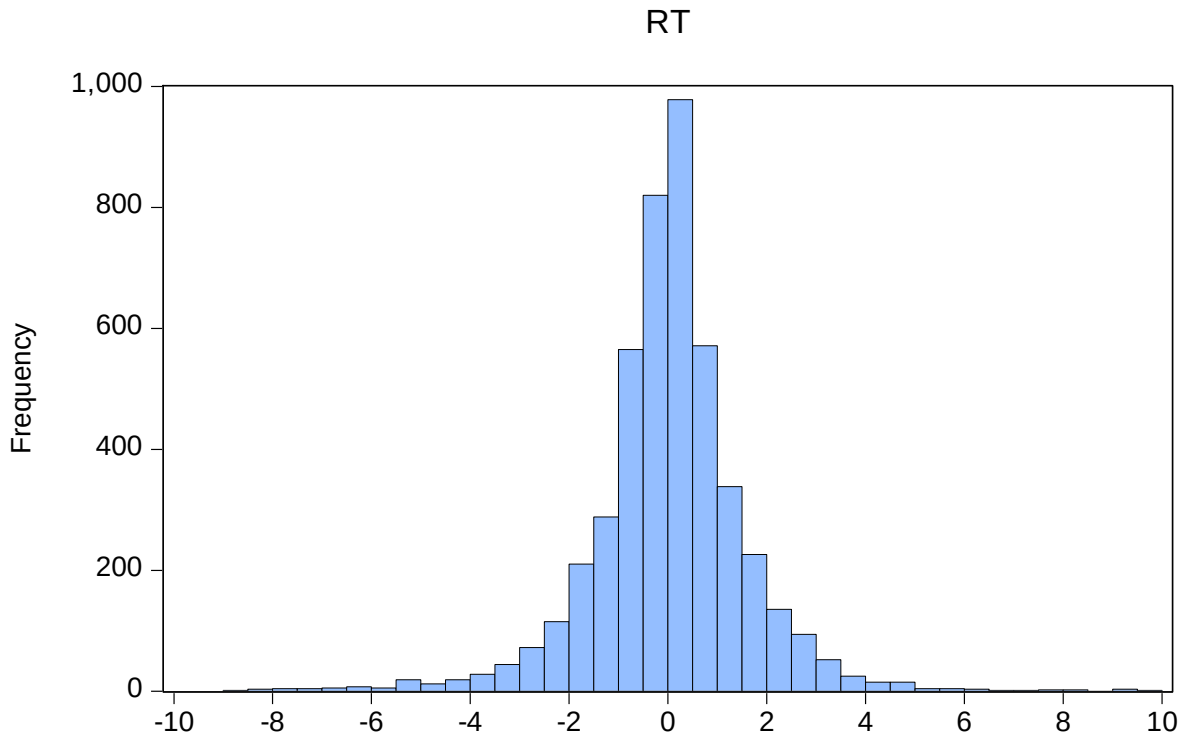

Figure 2 D*istribution map of Shanghai Composite Index Daily Rate of Return*

It can be seen from Figure 1 that the daily return rate data of the Shanghai Composite Index is relatively stable, and has the phenomenon of "volatility clustering" as mentioned above, and the phenomenon of alternating ups and downs often occurs at a certain stage immediately.

In Figure 2, the distribution diagram of the data series visually shows that its distribution is "peaky thick tail", further descriptive statistics are shown in the following table.

Table 2Descriptive Statistics of Daily Return Rate Data of Shanghai Composite Index

Title	Observations	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Prob.
R_t	4690	0.0679%	0.0156	-0.4020	7.8726	4766.118	0.00000

From the statistical results in Table 1, it can be seen that the average daily return of the Shanghai Composite Index is close to 0 throughout the study period. The main reason is that during this period, the completed “bull” and “bear” markets were experienced and frequent ups and downs of stock price could be seen in the consolidation phase. The skewness of the data series is -0.4020, and the kurtosis is 7.8726, which is significantly greater than 3, which further indicates that the data has a left-biased "spike thick tail" distribution. Moreover, the JB statistic of the data series is 4766.118, and the null hypothesis of normal distribution is rejected at 1% significance. Doing a quantile plot of normal distribution and t distribution finds that the daily return rate series does not conform to the normal distribution nor the t distribution. Huang Da et al. conducted research and found out that the Shanghai Composite Index daily rate of return data has a "thick tail" characteristic, which matched the generalized error distribution (GED distribution).

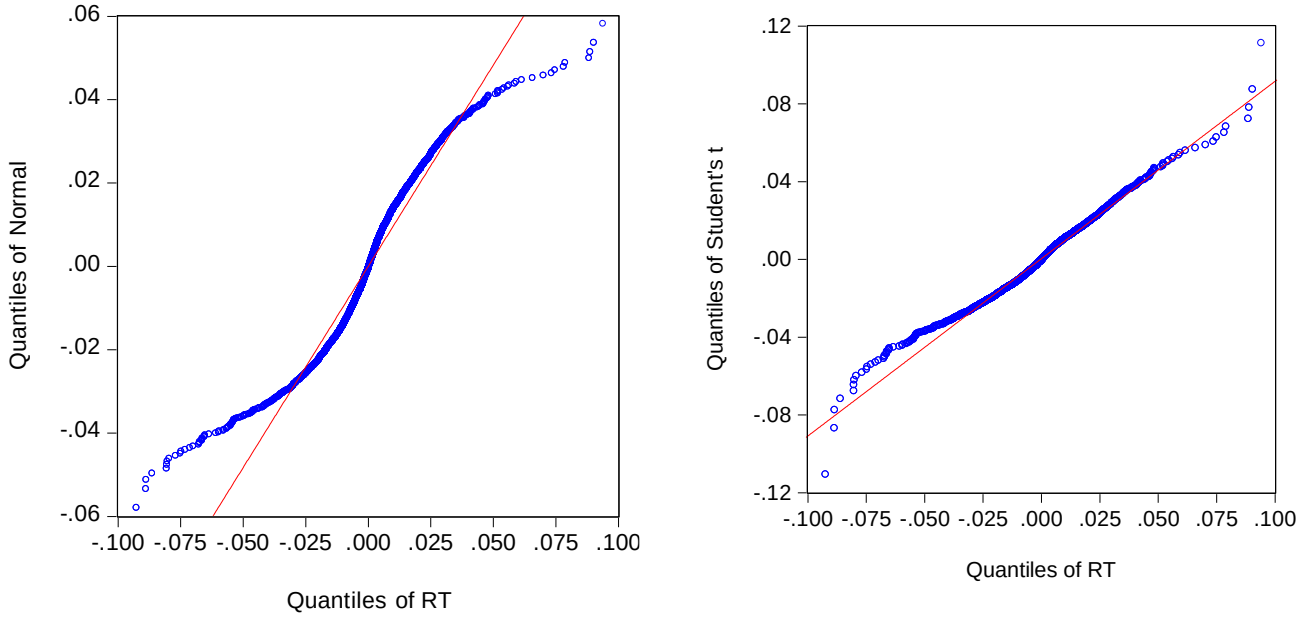

Figure 3 Quantile plot of normal distribution and t distribution

In summary, it can be preliminarily determined that the distribution characteristics of the time series characteristics of the Shanghai Stock Index daily return data are more in line with the requirements of the GARCH model.

4.1.2 Stationarity test

The standard method for testing the stability of time series data is the unit root test. Common unit root test methods are: ADF test, PP test, DFLGS test, KPSS test, NP test, and ERS test. Among them, the ADF test is to determine whether there is a unit root in the data structure by fitting the generated structure of the data itself (such as the assumption that the tested series may contain constant terms and trend variable terms), so it is widely used in empirical research, so This paper uses the ADF method for unit root test.

It can be seen from Figure 1 that the series does not contain linear transformation trends, and Table 2 shows that the series mean is close to 0, so in the ADF test, there is no constant term or trend term, and the unit is based on the AIC and SIC information criteria lag order Root test, the results are shown in the following table:

Table 3 ADF unit root test result

Method	t-Statistic	Prob.*	Lag	Maximum lag	Lag judgment
ADF	-15.9117	0.0000	14	24	AIC
ADF	-67.3118	0.0000	0	24	SIC

The null hypothesis of the ADF test is that the unit root of the data is non-stationary data. The results in Table 3 show that the null hypothesis is rejected, that is, the series is stationary.

It should be noted that: in empirical research, when selecting an alternative model from the perspective of the degree of statistical properties, which is necessary to determine the length of a lag distribution, the AIC

information criterion, BIC information criterion, HQIC information criterion, SIC information Guidelines. These guidelines all verify the fit of the model by introducing penalties for adding more coefficients that cause excessive information loss.

4.1.3 Determination of the form of the mean value equation

Plot the sequence autocorrelation coefficient (AC) graph and partial autocorrelation coefficient (PAC) graph as follows:

Table 4 Autocorrelation and Partial Correlation Graphs of Shanghai Stock Exchange Index Daily Yield Data

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.017	0.017	1.3668	0.242
		2	-0.024	-0.024	3.9760	0.137
		3	0.034	0.035	9.3225	0.025
		4	0.049	0.047	20.400	0.000
		5	-0.001	-0.001	20.404	0.001
		6	-0.050	-0.049	32.332	0.000
		7	0.034	0.033	37.767	0.000
		8	0.006	0.000	37.917	0.000
		9	0.004	0.009	37.995	0.000
		10	-0.005	-0.003	38.133	0.000

It can be seen from Fig. 4 that the autocorrelation coefficients of the sequence may be tailed or may be truncated at 4th, 6th, and 7th order, and the partial autocorrelation coefficients may be tailed or truncated at 4th, 6th, and 7th order. Consider using ARMA (1,1), ARMA (4,4) and ARMA (6,6) ARMA (7,7) without constant terms to fit, and use the significance of coefficients and AIC, SC criteria to model Form for further judgment. The empirical results of the five mean equations are as follows:

Table 5 Mean model fitting results

ARMA(1,1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	-0.880088	0.067061	-13.12361	0.0000
MA(1)	0.900944	0.061257	14.70761	0.0000
Info Criteria	AIC	-5.473322	SIC	-5.470570

ARMA(4,4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.239969	0.947243	0.253335	0.8000
AR(2)	-0.682089	0.580904	-1.174186	0.2404

AR(3)	0.110340	0.761301	0.144936	0.8848
AR(4)	0.030214	0.402009	0.075158	0.9401
MA(1)	-0.223038	0.947379	-0.235427	0.8139
MA(2)	0.658499	0.566864	1.161653	0.2454
MA(3)	-0.059730	0.732381	-0.081557	0.9350
MA(4)	-0.007239	0.353452	-0.020480	0.9837
Info Criteria	AIC	-5.474971	SIC	-5.463955

ARMA(6,6)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	-0.710987	0.360538	-1.972016	0.0487
AR(2)	0.281753	0.313046	0.900038	0.3681
AR(3)	0.099726	0.107060	0.931488	0.3516
AR(4)	0.596628	0.109317	5.457758	0.0000
AR(5)	0.684755	0.275889	2.481994	0.0131
AR(6)	-0.025069	0.288701	-0.086834	0.9308
MA(1)	0.729577	0.360547	2.023529	0.0431
MA(2)	-0.294220	0.313132	-0.939603	0.3475
MA(3)	-0.087012	0.117206	-0.742384	0.4579
MA(4)	-0.528637	0.115829	-4.563948	0.0000
MA(5)	-0.677794	0.259578	-2.611134	0.0091
MA(6)	-0.023794	0.275515	-0.086363	0.9312
Info Criteria	AIC	-5.478289	SIC	-5.461759

ARMA(7,7)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	-1.527730	0.407002	-3.753616	0.0002
AR(2)	-1.126768	0.415113	-2.714365	0.0067
AR(3)	-0.188020	0.253593	-0.741423	0.4585
AR(4)	0.738171	0.086777	8.506495	0.0000
AR(5)	1.324391	0.283769	4.667140	0.0000

AR(6)	1.201264	0.400713	2.997819	0.0027
AR(7)	0.379819	0.280097	1.356028	0.1752
MA(1)	1.546498	0.406864	3.801021	0.0001
MA(2)	1.133500	0.421487	2.689289	0.0072
MA(3)	0.198378	0.253930	0.781234	0.4347
MA(4)	-0.693820	0.091097	-7.616297	0.0000
MA(5)	-1.264766	0.270699	-4.672226	0.0000
MA(6)	-1.205348	0.384618	-3.133881	0.0017
MA(7)	-0.392883	0.288559	-1.361536	0.1734
Info Criteria	AIC	-5.478464	SIC	-5.461681

It can be seen from Table 4 that under the ARMA (1,1) model, the coefficients of each variable are significant, but under the significance level of 1% for ARMA (4,4) and ARMA (6,6), the coefficients of each variable cannot be rejected Null hypothesis. In addition, the AIC and SC values of the ARMA (1,1) model are smaller than ARMA (7,1), so the form of the mean model finally determined in this paper is ARMA (1,1).

4.1.4 Detection of ARCH effect

The ARMA (1,1) model is used to simulate the daily return data of the Shanghai Composite Index, and the equation residual plot is drawn as follows:

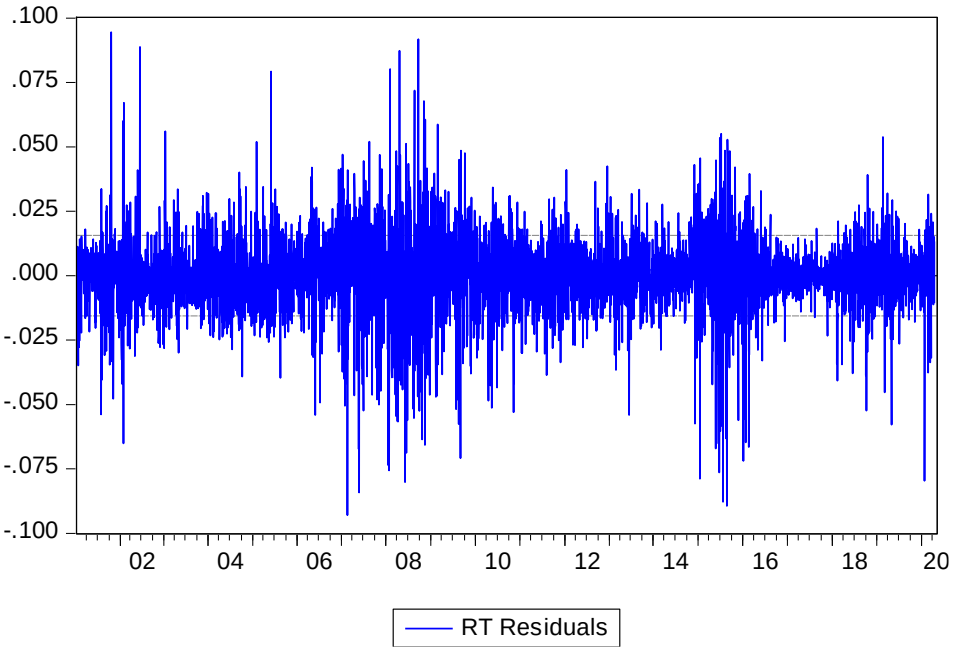

Figure 4 Residual plot of ARMA(1,1) model

It can be seen from Figure 5 that the residuals of the mean value equation have the phenomenon of fluctuation "cluster", which indicates that the error term may have conditional heteroscedasticity. Further using the ARCH LM test to confirm the ARCH effect of the residuals, the test

results are as follows:

Table 6 Breusch-Godfrey Serial Correlation LM Test:

F-statistic	5.281692	Prob. F(5,4682)	0.0001
Obs*R-squared	26.21899	Prob. Chi-Square(5)	0.0001

It can be seen from Table 4 that the p value of the F statistic of the ARCH LM test is far less than the 1% significance level, so the null hypothesis is rejected, which means that there is an ARCH effect in the residual sequence of the ARMA(1,1) model.

4.1.5 Outcome of Empirical Research

Based on the above judgment, consider using the GARCH model to fit the sequence data. The general financial time series data mostly use the GARCH (1,1) model. For the sake of robustness, this article uses the GARCH (1,1), GARCH (1,2), GARCH (2.1), and GARCH (2.2) models for serial data. After fitting, it is found that when the order of the GARCH term exceeds 1, the coefficients of the highest order term are not significant, and the values of AIC and SC are greater than the GARCH (1.1) model. Therefore, this article finally chose to use ARMA (1.1) -GARCH (1.1) model to analyze the data, the specific mathematical expression of the model is as follows:

$$R_t = c + \alpha R_{t-1} + \varepsilon_t + \chi\varepsilon_{t-1} + \psi_1 D_t^k \quad \text{Equation 8}$$

$$h_t^2 = \omega + \lambda\varepsilon_{t-1}^2 + \eta h_{t-1}^2 \quad \text{Equation 9}$$

Among them, in order to verify the overall impact of the hypothetical interest rate policy, $D_t^k$is a dummy variable representing the Fed 's interest rate adjustment; $\acute{h}_t$is the conditional variance, ε_t is the error term, and ε_t is the intercept term (this article takes zero); other parameters are model coefficients , Whereψ_1 is significantly different from 0, indicating that the adjustment of the Fed 's interest rate policy has a significant impact on the daily return of the Shanghai Composite Index.

In order to verify the effect of different interest rate adjustment (interest rate increase and interest rate reduction) interest rate policies on the Shanghai Composite Index daily rate of return, it is necessary to change the mean equation in Model 1 and replace the original policy dummy variables with no direction into a single direction Dummy variables that change. The conditional variance is consistent with that in Model 1. The new mean equation is as follows:

$$R_t = c + \alpha R_{t-1} + \varepsilon_t + \chi\varepsilon_{t-1} + \sum_{i=1}^{2} \psi_i D_{i,t}^k \quad \text{Equation 10}$$

Among them, $D_{i,t}^k$ is a dummy variable, $i = 1$ represents a rate hike, $i = 2$ represents a rate cut, and $\psi_i$is a coefficient of a dummy variable. Interest rate cuts will have a significant impact on the Chinese stock market.

In addition, through the analysis of descriptive statistics, this paper uses the generalized error distribution (GED) to describe the residuals of the above two models. The probability density function of the GED distribution is:

$$f(\varepsilon_t|F_{t-1}) = (vexp(-1/2|\frac{\varepsilon_t}{\lambda|^v}))/\lambda 2^{(\frac{v+1}{v}))}\Gamma(1/v), (0 \leqq v \leqq \infty) \quad \text{Equation 11}$$

Among them, $\lambda = (\frac{2^{\left(-\frac{2}{v}\right)}\Gamma\left(\frac{1}{v}\right)}{\Gamma\left(\frac{3}{v}\right)})^{1/2}$, $\Gamma(*)$s the Gamma function, v is GED shape parameters (can be used to control the thickness of the tail of the distribution. For example, when $v = 2$ is a standard normal distribution, $v < 2$ is a "thick tail" feature, $v = 1$is a double exponential distribution, etc.)

The fitting effects of model 1 and model 2 are as follows:

Table 7Model fitting result of ARMA(1,1)-GARCH(1,1)

Model 1 (Interest rate adjustment regardless of direction)					
Mean equation	Variable	Coefficient	Std. Error	z-Statistic	Prob.
	α	-0.818017	0.073597	-11.11480	0.0000
	χ	0.842809	0.069079	12.20059	0.0000
	ψ_i	0.002327	0.001389	1.675546	0.0938
Conditional variance equation	ω	1.66E-06	2.36E-07	7.046363	0.0000
	λ	0.078056	0.003847	20.28773	0.0000
	η	0.919182	0.003532	260.2111	0.0000
Model 2: Distinguish up and down of the adjustment					
Mean equation	Variable	Coefficient	Std. Error	z-Statistic	Prob.
	α	-0.819948	0.071924	-11.40027	0.0000
	χ	0.844829	0.067422	12.53053	0.0000
	ψ_1	0.004184	0.001563	2.676468	0.0074
	ψ_2	-0.001688	0.002824	-0.597927	0.0099
Conditional variance equation	ω	1.65E-06	2.36E-07	6.994687	0.0000
	λ	0.078048	0.003852	20.26256	0.0000
	η	0.919269	0.003527	260.6092	0.0000

It can be seen from Table 7:

The fitting result of Model 1 shows that if the adjustment direction is not distinguished, the Fed's interest rate policy dummy variable coefficient. The P value of ψ_i is 0.0938, indicating that the variable is not significant. Therefore, from a statistical point of view, the Fed's interest rate policy, without differentiation of direction,

has little impact on the stock market's daily rate of return.

The fitting result of Model 2 shows that the P value of the dummy variable coefficient ψ_1 of the Fed rate hike is 0.0074 and the P value of the dummy variable coefficient ψ_2 of the interest rate cut is 0.009 , which are all not significantly 0 at the 5% significance level. This shows that the Fed's interest rate hikes and interest rate cuts will have a short-term impact on the Chinese stock market. Among them, the rate increase will bring an average positive rate of return, while the rate cut will bring the average rate of return. This result shows that there is a certain asymmetric effect of the adjustment of the Fed's interest rate policy on the Chinese stock market, that is, the direction and degree of the Fed's interest rate hike and rate cut are different.

In order to increase the reliability of coefficient set and to better fit the model, the empirical results need to be verified and proofread. The ARCH LM test is performed on the residuals of Model 1 and Model 2, and the results are as follows:

Table 8 Result of ARCH LM test

Model1	F-statistic	0.137151	Prob. F(1,4686)	0.7111
	Obs*R-squared	0.137205	Prob. Chi-Square(1)	0.7111
Model 2	F-statistic	0.138828	Prob. F(1,4686)	0.7095
	Obs*R-squared	0.138883	Prob. Chi-Square(1)	0.7094

From Table 8, the residuals of Model 1 and Model 2 no longer have ARCH effect, and the overall fitting effect of the model is better.

4.1.6 Interpretation of empirical results

(1) The explanation for the empirical conclusion that "the Fed's interest rate policy as a whole has little impact on the daily yield of the Chinese stock market" is as follows:

In the 42 times of adjusting the federal funds target interest rate during the study period, the interest rate was reduced 16 times and the interest rate was increased 26 times. It was related to the macroeconomic background at the time of the relevant events, and there was no "one-sided" situation. Traditional theories show that raising interest rates is bad news, and cutting interest rates to release liquidity is good news. In theories such as liquidity preference, although the direction of influence is opposite to the traditional theory, in terms of the effects of interest rate hikes and interest rate cuts, the two are in a reverse relationship to each other. The partial verification of the direction of interest rate policy makes the impact of interest rate hikes and interest rate cuts cancel each other out, thereby weakening the overall significance of the impact on stock price returns. In addition, investors' expectations of interest rate policy may cause the impact of real interest rate changes to be digested in advance. In this case, changes in the Fed's interest rate policy will not have a significant impact on the Chinese stock market.

(2) The explanation for the empirical conclusion "after distinguishing between the adjustment directions of interest rate hikes and interest rate cuts, the short-term shock effect is more significant and positively correlated, and the significance and influence of interest rate hikes are stronger" are explained as follows:

First of all, as mentioned above, no matter which theoretical system is used for interest rate hikes and interest rate cuts, the way they affect stock index returns is opposite to each other. In the empirical study, the reverse relationship between the short-term impact of the Fed's upward and downward adjustments in the federal funds target interest rate on the Chinese stock market is theoretical.

Second, compared with the overall consideration, after distinguishing the direction of interest rate adjustment, the measurement of the influence of interest rate is relatively simple and pure. The reason why the short-term shock effect is more significant is that the Fed's interest rate policy will comprehensively affect the Chinese stock market through QFII inflows, foreign financial asset allocation ratios, company valuations and financial expenses. In addition, interest rate control is a very important part of the monetary policy mix, and monetary policy is often introduced in a package. The adjustment of the Federal Reserve's interest rate policy is based on a specific macroeconomic environment, and it will inevitably be accompanied by other supporting economic and monetary policies. In summary, after distinguishing the direction of interest rate regulation, whether the Fed raises interest rates or lowers them will have a significant short-term impact on China's stock index returns.

What violates the traditional interest rate is that the sign of the dummy variable coefficient shows that the Fed's interest rate adjustment has a positive correlation with the stock index yield on the event date. This article believes that the reason for this result is that the adjustment of interest rates would release a "reverse signal." When an interest rate increase is announced, it is often to suppress the level of inflation. This aspect means that the world economy is in a period of relatively prosperity, which leads investors to be optimistic about the future development prospects.

4.2 Empirical test of Hypothesis 2

In order to verify the second hypothesis, this paper selects the ARMA(1,1)-EGARCH(1,1) model to control the asymmetric effect, and adds policy variables to the conditional equations. The model settings are as follows:

$$R_t = \alpha R_{t-1} + \varepsilon_t + \chi \varepsilon_{t-1} \quad \text{Equation 12}$$

$$\ln(h_t^2) = \omega + \theta \left|\frac{\varepsilon_{t-1}}{h_{t-1}}\right| + \mu \frac{\varepsilon_{t-1}}{h_{t-1}} + \eta \ln(h_{t-1}^2) + \sum_{i=1}^{2} \psi_i D_{i,t}^k \quad \text{Equation 13}$$

Among them, the parameter setting and value of the mean value equation and the policy dummy variable are exactly the same as the variable description in Hypothesis 1. If $\mu \neq 0$ in the conditional variance equation, it means that the impact of information shock has an asymmetric effect, which is confirmed as the hypothesis of

$\mu < 0$ passes the test.

4.2.1 Empirical results

The fitting results of the model are as follows:

Table 9 Model fitting result of ARMA(1,1)-EGARCH(1,1)

Variables	Module 1（without dummy variable）	Module 2 （as a whole）	Module3 （with direction）
α	0.934302 （0.0000）	0.933763 （0.0000）	0.934627 （0.0000）
χ	-0.922258 （0.0000）	-0.921592 （0.0000）	-0.922488 （0.0000）
ω	-0.238679 （0.0000）	-0.239578 （0.0000）	-0.239155 （0.0000）
θ	0.174478 （0.0000）	0.175376 （0.0000）	0.175379 （0.0000）
μ	-0.029979 （0.0000）	-0.029964 （0.0000）	-0.029989 （0.0000）
η	0.987111 （0.0000）	0.987092 （0.0000）	0.987147 （0.0000）
ψ_1		0.001828 （0.1982）	0.003259 （0.0520）
ψ_2			-0.000976 （0.7197）

As can be seen from the p-value of μ in Table 9, at the 5% significance level, all three models have significant information asymmetry effects. All μ are less than 0, which also shows that investors are more responsive to bad news when they face the same amount of bad news and good news, which makes the Shanghai Composite Index daily rate of return fluctuate more when bad news appears, resulting in the so-called The "leverage effect". Take the result of the model fitted in Model 1 as an example, $\theta = 0.174478$, $\mu = -0.029979$, when $\varepsilon_{t-1} > 0$ ， which is good news, this information impact has a $0.174478 + (-0.029979) = 0.1444990$ times impact on the logarithm of the conditional variance: when $\varepsilon_{t-1} < 0$, the impact of bad news on the logarithm of the conditional variance is $0.174478 + (-0.029979) * (-1) = 0.204457$ times, which is more volatile than the good news.

However, regardless of whether the Fed's interest rate cuts are included in the model in the divided direction

or the undivided direction, the p value of the policy dummy variable ψ_i is large, indicating that its coefficient is not significant, that is, after eliminating the interference of the information asymmetry effect, the Fed interest rate control The policy did not significantly increase the volatility of the day's rate of return, which means that the changes in the Fed's interest rate policy resulted in the average level of high rate of return that day did not stem from the high rate of volatility of the rate of return.

4.2.2 Interpretation of empirical results

1) Explanation of the "asymmetric effect" of information in the stock market

According to the expectation theory in behavioral finance, an investor's response to the same scenario of investment outcomes depends on whether he is profitable or losing. The empirical results of the securities markets in many countries show that when the profit is equal to the loss, the majority of investors are more frustrated when they suffer losses than they are happy when they are profitable, that is, investors are more willing to take risks. In order to avoid losses, they are unwilling to take risks to maximize profits. Therefore, when there is "bad news", the stock market is at greater risk, and the volatility of stock prices also increases. From the perspective of corporate finance, the decline in stock prices will reduce shareholder equity and increase the leverage of the company, thereby increasing the risk of holding stocks. This leverage effect of many companies makes the stock market react more strongly to negative shocks, resulting in Stock market volatility has increased.

In addition, the asymmetric effect of the Chinese stock market is a type of positive feedback trading behavior. Positive feedback trading is based on adaptive expectations, that is, the increase or decrease of stock prices in the past has caused investors to anticipate further increases or decreases in stock prices, the most representative of which is chasing up and down. Moreover, this feedback mechanism is a response to the continuous trend of prices rather than accidental changes.

4.3 Empirical test of Hypothesis 3

4.3.1 Identification of the window period and its estimation

This article mainly focus on the short-term impact of the Fed's interest rate policy on the Chinese stock market. When the model constructed in the estimation period predicts normal returns in the window period, the forecast accuracy of the model will gradually decrease as the out-of-sample forecast period increases. Based on the above two considerations, this article chooses to take the date of occurrence and the four trading days before and after five trading days (a total of 10 trading days) as the event window. It should be noted that the literature shows that there is a certain calendar effect in the Chinese stock market. For example, Zhao Liuyan et al. (2004) empirical research shows that the Chinese stock market has significant negative Monday effects and positive

Friday effects. To avoid the disturbing factor of including the calendar effect across the week, reduce the impact across the week when the policy is promulgated on Friday.It is estimated to be an entire calendar year before the time window period

4.3.2 Selection of normal rate of return model

In former empirical studies, the widely used models for estimating its rate of return mainly include constant mean models, market models, and GARCH family models.

The constant mean model is simple in form, requiring that the sequence data is stable and has constant mean and variance. However, it does not take into account the "cluster family" characteristics of high-frequency time series data in financial markets. The market model is based on the interest rate where the return of the asset portfolio in the market and the return of the market portfolio are correlated. Equation, improve the constant mean income model once, and improve the fitting accuracy. However, the data selected in this article is approximately representative of the market mix, and it is not appropriate to use the market model. When verifying Hypotheses 1 and 2, it proves that the Shanghai Composite Index daily rate of return data is suitable for fitting with ARCH or GARCH family models, so in this paper you use the ARMA-GARCH model to estimate normal returns.

Although the fitting accuracy of the ARMA-GARCH model to the sample daily rate of return data and its variance is high, the premise assumption of its out-of-sample forecasting model is that the error of the expected difference conforms to the normal distribution, but in fact there are Linear fluctuations and other phenomena make this assumption untenable most of the time, and the prediction accuracy of the model is greatly reduced. In order to overcome such problems, Pascual et al. (2006) proposed that the GARCH model can be used to predict the Bootstrap method without adding any distribution assumptions (non-parameters) to improve the accuracy. Empirical research conducted by Li Jinfang and Wang Renzeng (2010) shows that applying Bootstrap method to GARCH-based models can effectively simulate the distribution path information of residuals. Zhao Shuran et al. (2012) used the non-parametric GARCH model to predict the volatility of the RMB exchange rate. The empirical results show that the model can effectively avoid the wrong form setting of the parametric GARCH family model and has a stronger predictive ability. Based on GARCH, this paper use Bootstrap method to predict the expected return more accurately.

4.3.3 Bootstrap method

The principle of Bootstrap is to use regenerated samples (random re-sampling of the sample's empirical distribution) to estimate the statistical characteristics of certain statistics of unknown probability measures again.

The core idea is that supposing estimate the statistic θ in a distribution $F(\beta; x)$), $\theta = \int g(x)dF(\beta; x)$, and

the overall distribution is unknown. According to the empirical distribution $\hat{F}(\beta;x)$ obtained from the sample, the overall distribution of $F(\beta;x)$ is estimated to be: $\hat{\theta} = \int g(x)dF(\beta;x)$. According to the limit theorem, the empirical distribution $\hat{F}(\beta;x)$ is a consistent estimate of $F(\beta;x)$. Based on this, even if the overall distribution is unknown, some statistics and their mean, quantile, etc. can be estimated approximately. The basic steps of Bootstrap estimation are as follows:

1) Using repeated sampling techniques to draw a certain number of samples from the original sample, this process allows repeated sampling.

2) Calculate the statistic T to be estimated based on the extracted samples.

3) Repeat the above N times (generally greater than 1000) to obtain N statistics T.

4) Calculate the sample variance of the above N statistics T to estimate the variance of the statistics T.

Based on the above analysis, the ARMA-GARCH model with Bootstrap method is selected to fit the normal rate of return, and the out-of-sample forecast of the daily rate of return during the time window period is made.

4.3.4 Statistical caliber of excess return rate

Taking the real return rate on the t-th day of the event window period as R_t, $\hat{R}_t$ represents the fitted value of the normal return rate on the t-th day of the event window period.

The excess rate of return and cumulative excess rate of return on day t are defined as:

$$AR_t = R_t - \hat{R}_t, \quad CAR_t = \sum_{s=T1}^{t} AR_s \qquad \text{Equation 14}$$

Among them, T1 indicates the start date of the window period. The excess return rate is used to reflect whether there is a clear reaction in the stock market on the day of the event. If the excess return rate is negative, it means that the adjustment of the Fed's interest rate policy has exerted a restraining effect on the Chinese stock market, and the event itself is bearish. Anyway, it is a positive event. The cumulative excess rate of return is mainly used to reflect whether the Chinese stock market has an early reaction and an ex-post reaction to the adjustment of the Fed's interest rate policy.

In order to consider the comprehensive impact of the Fed's interest rate policy on the stock market, we calculated the excess return and cumulative excess return rate of this event. The average excess return rate and average cumulative excess return rate on the tth day of the event window period are defined as:

$$AAR_t = \frac{1}{n}\sum_{i=1}^{n} AR_t^i, \quad CCAR_t == \frac{1}{n}\sum_{i=1}^{n} CAR_t^i = \sum_{s=T1}^{t} AAR_s \qquad \text{Equation 15}$$

Among them, AR_t^i represents the excess rate of return on the t-th day of the window period in the i-th event, and CAR_t^i represents the cumulative rate of excess return on the t-th day of the total window period of the i-th event, n Represents the total number of events accumulated.

4.3.5 Significance test

In this paper, the t-test method is used to determine whether the 43 Fed interest rate policy changes during the study period have a significant excess return before and after the announcement date, that is, to verify whether $AAR_t$and $CCAR_t$ are significantly different from 0. The original hypothesis is:

$H_0: AAR_t = 0$ or $H_0: CCAR_t = 0$ Equation 16

If the original hypothesis is rejected at the corresponding significance level, it means that the average excess rate of return or cumulative excess rate of return caused by the Fed rate adjustment event on day t is more significant, otherwise the effect is not obvious.

4.3.6 Empirical results

According to the empirical research steps adopted in the previous verification hypothesis one and two, a systematic analysis of the data in the 43 estimation periods found that except for the form of the mean value equation ARMA(p,q), the residuals of the mean value equation existed. ARCH effect, suitable for fitting using ARCH or GARCH family models. After trying different ARCH term and GARCH term order, according to the significance of each parameter coefficient and AIC and SIC criteria, finally determine the applicable model for each estimation period. Among them, 17 interest rate adjustment events are applicable to the ARCH(1) model, and the estimation period of the remaining events is appropriate to use the ARMA(p,q)-GARCH(1,1) model. Due to space limitations, this article takes the 20th interest rate adjustment event (September 18, 2007, the Federal Reserve lowered the federal funds target interest rate by 0.5 percentage points) as an example, and lists the model fitting results during the estimation period as follows:

Table 10 Fitting results of the yield model during the estimation period

Mean equation	Variable	Coefficient	Std. Error	t-Statistic	Prob.
	AR(1)	0.997934	0.005036	198.1477	0.0000
	MA(1)	-0.995556	0.006306	-157.8672	0.0000
Conditional variance equation	Constant term	0.071523	0.014665	4.876986	0.0000
	GARCH(1)	0.122775	0.012116	10.13366	0.0000
	ARCH(1)	0.854896	0.015107	56.59010	0.0000

As can be seen from Table 10, except that the constant term of the conditional variance equation is not significant, the coefficients of other variables are not significantly 0, and the model fits better. Combined with the Bootstrap method, the model fitting results of the event 20 window period are shown in the following table

Table 11Predicted value of excess return and cumulative excess return of event 20

Time	R_t	$\hat{R}_t$	AR_t	CAR_t

2007-09-12	1.1470	-0.03231	1.179306	1.179306
2007-09-13	1.9518	-4.02882	5.980621	7.159927
2007-09-14	0.7318	-2.26955	3.001353	10.16128
2007-09-17	2.0558	0.75391	1.30189	11.46317
2007-09-18	0.0705	2.200485	-2.12999	9.333185
2007-09-19	-0.5519	0.131474	-0.68337	8.649811
2007-09-20	1.3862	-0.01313	1.399334	10.04915
2007-09-21	-0.2814	-1.68687	1.405465	11.45461
2007-09-24	0.5562	-2.20693	2.763132	14.21774
2007-09-25	-1.0780	0.689774	-1.76777	12.44997

Follow the same steps to make the same estimates for the other 42 events, and based on this, calculate the average excess return rate, average cumulative excess return rate, estimated value and significance of the Fed's interest rate policy as a whole, and the event window period adjusted by direction Check the following table:

*Table 12Average excess return rate and average cumulative excess r*eturn rate

Period	AAR_t	$CCAR_t$	$AAR_t(up)$	$CCAR_t(up)$	$AAR_t(down)$	$CCAR_t(down)$
-4	-1.152	-1.152	-1.320	-1.320	-1.100	-1.100
-3	0.730	-0.422	-0.800	-2.120	-0.800	-1.900
-2	0.536	0.113	-1.160	-3.280	-0.625	-2.525
-1	-0.411	-0.298	0.900	-2.380	1.200	-1.325
0	0.523	0.226	1.200	-1.180	1.330	0.005
1	1.076	1.302	0.704	-0.476	0.863	0.868
2	-1.002	0.300	1.500	1.024	-1.115	-0.246
3	0.918	1.218	0.810	1.834	1.095	0.849
4	-1.134	0.084	1.109	2.943	0.900	1.749
5	1.391	1.475	1.030	3.973	1.300	3.049

It can be seen from the results in Table 11 that, irrespective of the direction of regulation, the period before and after the Fed's interest rate policy will not produce very significant and continuous excess returns and cumulative excess returns, especially the latter is very low in significance. And there is no obvious regularity. After considering the direction of regulation, the excess return is generally positive during the period before and after the interest rate increase event, and the significance is alternately fluctuating. That is, the significance of one period is often accompanied by the insignificance of the next period, but the significance increases after

several periods ahead of the event day. Reflected in the excess cumulative rate of return, the days before the interest rate increase have a lower significance and show the same pattern as the previous period of excess returns. Later, as the cumulative effect increased, the significance of excess returns became stronger and stronger in the days after the event

When the interest rate is cut, the excess rate of return shows a positive and negative alternation, which is more volatile. There are also alternations in the significance of each period, but it is often that the one period is not significant and the two periods are very significant. Reflected in the excess cumulative rate of return, it shows a behavioral law with strong head-to-tail significance and strong significance in the middle periods.

In summary, for Hypothesis 3, this paper finds that: regardless of the direction, the Chinese stock market before and after the Fed rate adjustment will not produce significant excess returns and cumulative excess returns; in each interest rate adjustment cycle, the short-term behavior law and accumulation of stock index returns are different, and the excess returns during the interest rate increase are basically positive, showing a significant and insignificant alternating phenomenon, and the significance is strengthened after the time occurs, so that the significance of the accumulated excess returns gradually strengthens; the excess returns during the interest rate reduction. Cumulative excess returns are characterized by a significantly weaker head and tail in the middle.

4.3.7 Interpretation of empirical results

1) Explanation of "regardless of direction, before and after the Fed policy changes will not produce very significant and sustained excess returns and accumulated excess returns": According to the analysis of the conclusion of Hypothesis 1, this article believes that excess returns and accumulation during the event The main reason why the excess return is not significant and stable is that the market already had some expectations before the event actually happened. Before the event, the funds had responded according to the expectations. As the boots landed and adjusted accordingly, sometimes there was an overshoot. After the incident, the Chinese stock market retreated, which weakened the statistical characteristics as a whole.

2) Interpretation of “excess return and accumulated excess return are significant under different control directions, but the short-term behavior law and cumulative effect of the stock market are different”: The Fed’s interest rate policy is a very important part of its basket of monetary policies, but it is not put forward in isolation. When studying its policy effects, it is necessary to consider the background factors such as the macroeconomic link during the policy introduction, the policy cycle before and after, the trend of the bull and bear markets in the stock market, and the general psychological expectations of investors, so that the empirical conclusions can be more realistic and accurate.

Chapter 5 Conclusions and recommendations

5.1 Summary of the article and main conclusions

This paper selects the period from the promulgation of China's QFII system in 2002 to the full opening of the financial market in April 2020 as the research period. The logarithmic return of the daily closing price of the above stock index as the research object, first in ARMA(1,1)-GARCH(1 1) In the model, the Fed's interest rate policy changes are added as dummy variables to verify the short-term impact of the Chinese stock market under the adjustment of the interest rate policy as a whole and in different directions. Subsequently, the ARMA(1,1)-EARCH(1,1) model was used to control the interference of the information asymmetry effect, and the interest rate policy dummy variable was added to the conditional variance item to verify whether it would significantly increase the fluctuation risk of the day's rate of return. Finally, the practice research method of adding Bootstrap technology is used to quantify and examine the excess return rate and cumulative excess return rate of the stock index within ten days before and after the interest adjustment date. Empirical research found:

1) Regardless of the direction of regulation, the overall short-term impact of the Fed's interest rate policy on the Chinese stock market is not significant.

2) Looking at different directions, the Fed's interest rate hikes and interest rate cuts have caused a significant short-term impact on the stock market. Among them, when the interest rate is raised, the impact on the stock market is more significant and the degree is stronger.

3) Without distinguishing the direction of regulation, the Fed’s interest rate policy will not produce significant excess and accumulated excess returns during the period before and after the change. But in the case of distinguishing the direction of regulation, the Fed's interest rate hikes and interest rate cuts will lead to significant excess and cumulative excess returns in the Chinese stock market in the days before and after the event day.

4) Without distinguishing the direction of regulation, the Fed’s interest rate policy will not be affected by significant excess and accumulated excess returns before and after the change. However, in the case of distinguishing the direction of regulation and control, both the rate hike and the rate cut period will show significant excess and accumulated excess returns in the days after the event.

5) The excess rate of return during the interest rate increase is basically positive, and there is a significant and insignificant alternating phenomenon, and the significance after the event is strengthened, so that the significance of the accumulated excess return gradually increases; while the excess during the rate reduction period The returns are positive and negative, showing large fluctuations, more significant times than

insignificant times, and the cumulative excess returns show a characteristic of weaker head and tail in the middle.

At the end of the empirical part, this article divides the interest rate adjustment cycle, combining the macroeconomic environment and stock market trends in each cycle, it can explain the empirical results from the perspective of public expectations. The study finds that investors in the stock market have a significant reverse signal effect on the Fed's interest rate information, especially when the bull market is moderate with a good macroeconomic situation, and the bear market is benefiting from the depression, investors will basically adjust the first reverse cycle. Reverse thinking of policies hinders the effect of interest rate policies in the short term. However, as long-term regulation and control will become stronger, the cumulative effect of interest rate policies will gradually increase, creating convenience for supporting the implementation of other policies and regulating the stock market.

5.2 Related suggestions

Investors are the most important participants in the stock market. There are many retail investors in the Chinese stock market, which is different from the characteristics of institutional investors as the theme in the developed European and American capital markets. Affected by the news, retail investors are less resistant to risks under the circumstances of abnormal stock market fluctuations before and after the introduction of major policies. In response to this, this article makes the following recommendations to investors, especially the majority of retail investors:

1) The characteristics of the Chinese stock market currently affected by the news are still relatively obvious. With the full opening of China's financial market, the possibility of being hit by external positive or negative news is also increasing. By directly or indirectly affecting global liquidity and Chinese liquidity, changes in the Fed's interest rate policy have a significant impact on the Chinese stock market in most cases. Therefore, investors should take the initiative to understand and pay attention to changes in the Fed's relevant policies, determine whether the direction of regulation implies future policy changes, and whether the regulation space is in line with expectations when the regulation takes place in conjunction with the macroeconomic background, and use this to make necessary impacts on possible impact reaction.

2) When analyzing the short-term impact of the Fed's interest rate policy on the Chinese stock market, we should focus on analyzing the existing policy mix in the regulatory cycle and the expected impact of people's hearts. The cumulative effect of current interest rate policies, that is, investors should not be isolated Looking at each interest rate adjustment event, it is necessary to rationally identify and adjust the Fed's interest rate policy adjustments in light of the macroeconomic environment and consistent market expectations.

3) There is a significant "asymmetric reaction" to bad news and good news in China's stock market. Investment growth responds more strongly when faced with bad news, leading to greater volatility in the stock market. This feature reminds investors that they should have a stronger sense of risk, effectively screen long and short news and strengthen risk management and control. However, the Fed's interest rate policy will not cause a significant amplification effect on the fluctuation of the Shanghai Composite Index in the short term, that is, it will not increase the overall investment risk of the stock market in the short term, so investors, especially retail investors, face the short-term impact of interest rate policy It should cultivate a good investment mentality and philosophy, and have a certain understanding of the herding effect. If you cannot make an effective judgment on the impact of interest rate policy and future development direction, it is recommended that you do not need to make an excessive response in the short term to avoid the "following the herd" behavior.

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Summary

1.1 Introduction

1.1.1 Research background and significance

In April 2020, China's financial market became fully opened. Under the current background of the full opening of the financial market, the influence mechanism of foreign interest rate on the Chinese economy and its transmission mechanism will become more complicated. Ignoring the impact of the Federal Reserve ’s monetary policy on China is likely to lead to excessive or insufficient regulation of China ’s financial macro policies. As a result, the effect of regulation and control is affected, and it is possible to aggravate the fluctuation of China's financial asset prices and undermine the stability of the financial market. From an asset management perspective, Chinese investors also need to pay close attention to the Fed ’s monetary policy risk, manage and price the Fed ’s monetary policy risk, and dynamically manage the investment portfolio.

To this end, studying the spillover effect of US interest rate policies on China's stock market has important theoretical value for revealing the regularity of changes in Sino-US economic and financial relations, and is also of great practical significance for China's improvement of macroeconomic control methods and effective response to external shocks: First, studying the spillover effect of the Fed ’s interest rate on the China’s stock market will help the monetary authorities to formulate and implement monetary policies in a targeted manner based on the unprecedented domestic and foreign economic situation and reduce the negative impact of the US monetary policy. Second, it is conducive to the reform of the central bank and enriches its monetary policy toolbox. It responds to different external shocks in a more flexible, diversified, and sophisticated manner, and resolves the systemic and non-systemic financial risks that follow. Third, it helps investors better understand the laws of the stock market and to deal with the possible impact of the Fed's interest rate adjustment, moreover, it provides relevant recommendations for timely risk control.

Chapter 2 Literature Review

2.1 Literature review

In most cases, the adjustment of the Fed's interest rate policy has a significant impact on its own stock market and external markets, but there are different conclusions about whether the impact is positive or negative. In empirical research, most of the research abroad have also verified the traditional theory that the changes in the Fed's interest rate policy will have a significant impact on the rate of return of peripheral markets. All in all, whether it is a theoretical review or empirical research, there is no general conclusion about the way interest rates affect the stock market. Moreover, many empirical studies at home and abroad only use various methods to select sample data from different periods to measure the statistical law between interest rate policy variables

and stock market returns. There is a lack of analysis on the essential reasons such as economic laws、investor expectations. Therefore, the relationship between changes in the Fed's interest rate policy and China's stock market requires short-term shock and cumulative effects research under a specific macroeconomic background, and a reasonable explanation in conjunction with the specific market environment, which is time-sensitive and necessary. And there is room to further improve the goodness of fit and robustness in the selection and application of models, thereby enhancing the reliability of conclusions.

2.2 Research hypothesis

Hypothesis 1: The cut of Fed's interest rate will have a significant impact on the overall daily yield of China's stock market, causing an instant shock on the day that the interest rate policy is announced. In addition, the impact and intensity of short-term shocks will be different due to the inconsistent direction of interest rate policy regulation.

Hypothesis 2: China's stock market may have an asymmetric effect on the "bad" and "good" news. After eliminating this interference, the introduction of the Fed's interest rate policy will still increase the stock index yield on the day.

Hypothesis 3: During the period before and after the change in interest rate policy, the stock market will produce significant excess returns, and in the interest rate adjustment cycle, the short-term behavior of stock index returns and the cumulative effect are different.

Chapter 3 Empirical research

3.1 Data and variables

3.1.1Research period

This article selects the QFII system from 2002 to the full opening of the financial market in April 2020 as the research period, and empirical analysis is carried out based on this.

3.1.2 Daily yield data

This article selects the daily closing index of the Shanghai Composite Index as the proxy variable in China's stock market. Calculate its daily logarithmic return as the stock market's daily return, ie:

3.1.3 Interest rate policy data

The Fed adjusted the market interest rate by lowering the target rate of the federal funds. From February 2002 to April 2020, the United States experienced a total of three more obvious monetary easing cycles, respectively: 2001-2003; 2008-2014; June 2019 to present, the total adjustment of the federal funds target interest rate 42 times, including 16 interest rate cuts and 26 interest rate increases.

3.2 Empirical methods and model design

3.2.1GARCH Model

T. Bollerslev (1986) proposed the GARCH model, which has good characteristics in terms of fitting financial time series data. Except for the same as the ordinary regression model, the GARCH model further models the variance of the error, that is, it has excellent time-varying variance and the ability to handle thick tails. , Especially suitable for volatility analysis and prediction, such analysis can play a very important guiding role in investors' decision-making.

3.2.2EGARCH Model

Compared with other models, the left side of the EGARCH model is the logarithm of the conditional variance, which means that the constraint of the non-logarithmic model parameters is relaxed, the predicted value of the conditional variance must be non-negative, and the leverage effect is also defaulted. For the hypothesis 2 the EGARCH model should be used.

3.2.3 Event Research Method

The event study method was initiated by Ball & Brown (1968) and Fama et al. (1969).

The generally applicable research steps are as follows:1) Define the event and the period of the event. 2)Define the estimated period and the post-event period. 3) Determine the unit of analysis. 4) Calculation of abnormal rate of return. 5)Accumulate abnormal rate of return. 6)Statistical inspection.

Chapter 4 Empirical research results and interpretation

4.1 Empirical test of Hypothesis 1

The focus of this section is to verify whether the hypothesis 1 is true by constructing the GARCH model. In empirical research, there may be pseudo-ARCH or pseudo-GARCH phenomenon when building ARCH and GARCH family models. This requires sufficient attention to issues such as the authenticity of the model settings and the selection of the model that most truly reflects the timing characteristics of the data.

Therefore, in this article, we will carry out a systematic statistical test during the modeling, and analyze the problems such as the suitability of the data to use the GARCH model, the judgment of the model's equation form, and the test of the model fitting effect, so as to filter out a more reasonable model. To give the predecessor the method of using ARMA-GARCH model for empirical testing, this article uses the following modeling and testing analysis steps:

4.1.1 Descriptive statistical analysis

The daily return rate data of the Shanghai Composite Index is relatively stable, and has the phenomenon of "volatility clustering" as mentioned above, and the phenomenon of alternating ups and downs often occurs at a certain stage immediately.

In Figure 1, the distribution diagram of the data series visually shows that its distribution is "peaky thick tail", further descriptive statistics are shown in the following table.

Table 1Descriptive Statistics of Daily Return Rate Data of Shanghai Composite Index

Title	Observations	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Prob.
R_t	4690	0.0679%	0.0156	-0.4020	7.8726	4766.118	0.00000

From the statistical results in Table 1, it can be seen that the average daily return of the Shanghai Composite Index is close to 0 throughout the study period. The main reason is that during this period, the completed “bull” and “bear” markets were experienced and frequent ups and downs of stock price could be seen in the consolidation phase. The skewness of the data series is -0.4020, and the kurtosis is 7.8726, which is significantly greater than 3, which further indicates that the data has a left-biased "spike thick tail" distribution. In addition, the JB statistic of the data series is 4766.118, and the null hypothesis of normal distribution is rejected at 1% significance. Doing a quantile plot of normal distribution and t distribution finds that the daily return rate series does not conform to the normal distribution nor the t distribution. And Huang Da et al. Verified that the Shanghai Composite Index daily rate of return data has a "thick tail" characteristic, which is more in line with the generalized error distribution (GED distribution).

In summary, it can be preliminarily determined that the distribution characteristics of the time series characteristics of the Shanghai Stock Index daily return data are more in line with the requirements of the GARCH model.

4.1.2 Stationarity test

It can be seen from Figure 1 that the series does not contain linear transformation trends, and Table 2 shows that the series mean is close to 0, so in the ADF test, there is no constant term or trend term, and the unit is based on the AIC and SIC information criteria lag order Root test, the results are shown in the following table:

Table 2 ADF unit root test result

Method	t-Statistic	Prob.*	Lag	Maximum lag	Lag judgment
ADF	-15.9117	0.0000	14	24	AIC
ADF	-67.3118	0.0000	0	24	SIC

The null hypothesis of the ADF test is that the unit root of the data is non-stationary data. The results in Table 3 show that the null hypothesis is rejected, that is, the series is stationary.

4.1.3 Determination of the form of the mean value equation

From the sequence autocorrelation coefficient (AC) graph and partial autocorrelation coefficient (PAC) graph, it can be seen that the autocorrelation coefficients of the sequence may be tailed or may be truncated at 4th, 6th, and 7th order, and the partial autocorrelation coefficients may be tailed or truncated at 4th, 6th, and 7th

order. Consider using ARMA (1,1), ARMA (4,4) and ARMA (6,6) ARMA (7,7) without constant terms to fit, and use the significance of coefficients and AIC, SC criteria to model Form for further judgment.

Under the ARMA (1,1) model, the coefficients of each variable are significant, but under the significance level of 1% for ARMA (4,4) and ARMA (6,6), the coefficients of each variable cannot be rejected Null hypothesis. In addition, the AIC and SC values of the ARMA (1,1) model are smaller than ARMA (7,1), so the form of the mean model finally determined in this paper is ARMA (1,1).

4.1.4 Detection of ARCH effect

The ARMA (1,1) model is used to simulate the daily return data of the Shanghai Composite Index, and the residuals of the mean value equation have the phenomenon of fluctuation "cluster", which indicates that the error term may have conditional

heteroscedasticity. Further using the ARCH LM test to confirm the ARCH effect of the residuals, the test results are as follows:

Table 2 Breusch-Godfrey Serial Correlation LM Test:

F-statistic	5.281692	Prob. F(5,4682)	0.0001
Obs*R-squared	26.21899	Prob. Chi-Square(5)	0.0001

It can be seen from Table 2 that the p value of the F statistic of the ARCH LM test is far less than the 1% significance level, so the null hypothesis is rejected, which means that there is an ARCH effect in the residual sequence of the ARMA(1,1) model.

4.1.5 Outcome of Empirical Research

Based on the above judgment, consider using the GARCH model to fit the sequence data. The general financial time series data mostly use the GARCH (1,1) model. For the sake of robustness, this article uses the GARCH (1,1), GARCH (1,2), GARCH (2.1), and GARCH (2.2) models for serial data. After fitting, it is found that when the order of the GARCH term exceeds 1, the coefficients of the highest order term are not significant, and the values of AIC and SC are greater than the GARCH (1.1) model. Therefore, this article finally chose to use ARMA (1.1) -GARCH (1.1) model to analyze the data.

The fitting result of Model 1 shows that if the adjustment direction is not distinguished, the Fed's interest rate policy dummy variable coefficient. The P value of ψ_i is 0.0938, indicating that the variable is not significant. Therefore, from a statistical point of view, the Fed's interest rate policy, without differentiation of direction, has little impact on the stock market's daily rate of return.

The fitting result of Model 2 shows that the P value of the dummy variable coefficient ψ_1 of the Fed rate hike is 0.0074 and the P value of the dummy variable coefficient ψ_2 of the interest rate cut is 0.009 , which are all

not significantly 0 at the 5% significance level. This shows that the Fed's interest rate hikes and interest rate cuts will have a short-term impact on the Chinese stock market. Among them, the rate increase will bring an average positive rate of return, while the rate cut will bring the average rate of return. This result shows that there is a certain asymmetric effect of the adjustment of the Fed's interest rate policy on the Chinese stock market, that is, the direction and degree of the Fed's interest rate hike and rate cut are different.

In order to increase the reliability of coefficient set and to better fit the model, the empirical results need to be verified and proofread. The ARCH LM test showed that the residuals of Model 1 and Model 2 no longer have ARCH effect, and the overall fitting effect of the model is better.

4.1.6 Interpretation of empirical results

(1) The explanation for the empirical conclusion that "the Fed's interest rate policy as a whole has little impact on the daily yield of the Chinese stock market" is as follows:

In the 42 times of adjusting the federal funds target interest rate during the study period, the interest rate was reduced 16 times and the interest rate was increased 26 times. It was related to the macroeconomic background at the time of the relevant events, and there was no "one-sided" situation. Traditional theories show that raising interest rates is bad news, and cutting interest rates to release liquidity is good news. In theories such as liquidity preference, although the direction of influence is opposite to the traditional theory, in terms of the effects of interest rate hikes and interest rate cuts, the two are in a reverse relationship to each other. The partial verification of the direction of interest rate policy makes the impact of interest rate hikes and interest rate cuts cancel each other out, thereby weakening the overall significance of the impact on stock price returns. In addition, investors' expectations of interest rate policy may cause the impact of real interest rate changes to be digested in advance. In this case, changes in the Fed's interest rate policy will not have a significant impact on the Chinese stock market.

(2) The explanation for the empirical conclusion "after distinguishing between the adjustment directions of interest rate hikes and interest rate cuts, the short-term shock effect is more significant and positively correlated, and the significance and influence of interest rate hikes are stronger" are explained as follows:

First of all, as mentioned above, no matter which theoretical system is used for interest rate hikes and interest rate cuts, the way they affect stock index returns is opposite to each other. In the empirical study, the reverse relationship between the short-term impact of the Fed's upward and downward adjustments in the federal funds target interest rate on the Chinese stock market is theoretical.

Second, compared with the overall consideration, after distinguishing the direction of interest rate adjustment, the measurement of the influence of interest rate is relatively simple and pure. The reason why the short-term shock effect is more significant is that the Fed's interest rate policy will comprehensively affect the Chinese

stock market through QFII inflows, foreign financial asset allocation ratios, company valuations and financial expenses. In addition, interest rate control is a very important part of the monetary policy mix, and monetary policy is often introduced in a package. The adjustment of the Federal Reserve's interest rate policy is based on a specific macroeconomic environment, and it will inevitably be accompanied by other supporting economic and monetary policies. In summary, after distinguishing the direction of interest rate regulation, whether the Fed raises interest rates or lowers them will have a significant short-term impact on China's stock index returns.

4.2 Empirical test of Hypothesis 2

In order to verify the second hypothesis, this paper selects the ARMA(1,1)-EGARCH(1,1) model to control the asymmetric effect, and adds policy variables to the conditional equations.

4.2.1 Empirical results

The fitting results shows that the p-value of μ in Table 9, at the 5% significance level, all three models have significant information asymmetry effects. All μ are less than 0, which also shows that investors are more responsive to bad news when they face the same amount of bad news and good news, which makes the Shanghai Composite Index daily rate of return fluctuate more when bad news appears, resulting in the so-called The "leverage effect". Take the result of the model fitted in Model 1 as an example, $\theta = 0.174478$, $\mu = -0.029979$, when $\varepsilon_{t-1} > 0$ ， which is good news, this information impact has a $0.174478 + (-0.029979) = 0.1444990$ times impact on the logarithm of the conditional variance: when $\varepsilon_{t-1} < 0$, the impact of bad news on the logarithm of the conditional variance is $0.174478 + (-0.029979) * (-1) = 0.204457$ times, which is more volatile than the good news.

4.2.2 Interpretation of empirical results

1) Explanation of the "asymmetric effect" of information in the stock market

According to the expectation theory in behavioral finance, an investor’s response to the same scenario of investment outcomes depends on whether he is profitable or losing. The empirical results of the securities markets in many countries show that when the profit is equal to the loss, the majority of investors are more frustrated when they suffer losses than they are happy when they are profitable, that is, investors are more willing to take risks In order to avoid losses, they are unwilling to take risks to maximize profits. Therefore, when there is "bad news", the stock market is at greater risk, and the volatility of stock prices also increases. From the perspective of corporate finance, the decline in stock prices will reduce shareholder equity and increase the leverage of the company, thereby increasing the risk of holding stocks. This leverage effect of many companies makes the stock market react more strongly to negative shocks, resulting in Stock market

volatility has increased.

In addition, the asymmetric effect of the Chinese stock market is a type of positive feedback trading behavior. Positive feedback trading is based on adaptive expectations, that is, the increase or decrease of stock prices in the past has caused investors to anticipate further increases or decreases in stock prices, the most representative of which is chasing up and down. Moreover, this feedback mechanism is a response to the continuous trend of prices rather than accidental changes.

4.3 Empirical test of Hypothesis 3

4.3.1 Determination of the window period and its estimation

This article mainly studies the short-term impact of the Fed's interest rate policy on the Chinese stock market. When the model constructed in the estimation period predicts normal returns in the window period, the forecast accuracy of the model will gradually decrease as the out-of-sample forecast period increases. Based on the above two considerations, this article chooses to take the date of occurrence and the four trading days before and after five trading days (a total of 10 trading days) as the event window. It should be noted that the literature shows that there is a certain calendar effect in the Chinese stock market. For example, Zhao Liuyan et al. (2004) empirical research shows that the Chinese stock market has significant negative Monday effects and positive Friday effects. To avoid the disturbing factor of including the calendar effect across the week, reduce the impact across the week when the policy is promulgated on Friday.It is estimated to be an entire calendar year before the time window period

4.3.2 Empirical results of bootstrap method

According to the empirical research steps adopted in the previous verification hypothesis one and two, a systematic analysis of the data in the 43 estimation periods found that except for the form of the mean value equation ARMA(p,q), the residuals of the mean value equation existed. ARCH effect, suitable for fitting using ARCH or GARCH family models. After trying different ARCH term and GARCH term order, according to the significance of each parameter coefficient and AIC and SIC criteria, finally determine the applicable model for each estimation period. Among them, 17 interest rate adjustment events are applicable to the ARCH(1) model, and the estimation period of the remaining events is appropriate to use the ARMA(p,q)-GARCH(1,1) model. Due to space limitations, this article takes the 20th interest rate adjustment event (September 18, 2007, the Federal Reserve lowered the federal funds target interest rate by 0.5 percentage points) as an example.Except that the constant term of the conditional variance equation is not significant, the coefficients of other variables are not significantly 0, and the model fits better. Combined with the Bootstrap method, the model fitting results of the event 20 window period are shown in the following table

Follow the same steps to make the same estimates for the other 42 events, and based on this, calculate the average excess return rate, average cumulative excess return rate, estimated value and significance of the Fed's interest rate policy as a whole, and the event window period adjusted by direction Check the following table: Irrespective of the direction of regulation, the period before and after the Fed's interest rate policy will not produce very significant and continuous excess returns and cumulative excess returns, especially the latter is very low in significance. , And there is no obvious regularity.

After considering the direction of regulation, the excess return is generally positive during the period before and after the interest rate increase event, and the significance is alternately fluctuating. That is, the significance of one period is often accompanied by the insignificance of the next period, but the significance increases after several periods ahead of the event day. And tend to be stable. Reflected in the excess cumulative rate of return, the days before the interest rate increase have a lower significance and show the same pattern as the previous period of excess returns. Later, as the cumulative effect increased, the significance of excess returns became stronger and stronger in the days after the event

When the interest rate is cut, the excess rate of return shows a positive and negative alternation, which is more volatile. There are also alternations in the significance of each period, but it is often that the one period is not significant and the two periods are very significant. Reflected in the excess cumulative rate of return, it shows a behavioral law with strong head-to-tail significance and strong significance in the middle periods.

In summary, for Hypothesis 3, this paper finds that: regardless of the direction, the Chinese stock market before and after the Fed rate adjustment will not produce significant excess returns and cumulative excess returns; in each interest rate adjustment cycle, the short-term behavior law and accumulation of stock index returns The effects are different, and the excess returns during the interest rate increase are basically positive, showing a significant and insignificant alternating phenomenon, and the significance is strengthened after the time occurs, so that the significance of the accumulated excess returns gradually strengthens; the excess returns during the interest rate reduction The government is uncertain and exhibits large fluctuations, with more significant times than insignificant times. Cumulative excess returns are characterized by a significantly weaker head and tail in the middle.

4.3.7 Interpretation of empirical results

1) Explanation of "regardless of direction, before and after the Fed policy changes will not produce very significant and sustained excess returns and accumulated excess returns": According to the analysis of the conclusion of Hypothesis 1, this article believes that excess returns and accumulation during the event The main reason why the excess return is not significant and stable is that the market already had some expectations before the event actually happened. Before the event, the funds had responded according to the expectations.

As the boots landed and adjusted accordingly, sometimes there was an overshoot. After the incident, the Chinese stock market retreated, which weakened the statistical characteristics as a whole.

2) Interpretation of "excess return and accumulated excess return are significant under different control directions, but the short-term behavior law and cumulative effect of the stock market are different": The Fed's interest rate policy is a very important part of its basket of monetary policies, but it is not put forward in isolation. When studying its policy effects, it is necessary to consider the background factors such as the macroeconomic link during the policy introduction, the policy cycle before and after, the trend of the bull and bear markets in the stock market, and the general psychological expectations of investors, so that the empirical conclusions can be more realistic and accurate.

Chapter 5 Conclusions and recommendations

5.1 Summary of the article and main conclusions

This paper selects the period from the promulgation of China's QFII system in 2002 to the full opening of the financial market in April 2020 as the research period. The logarithmic return of the daily closing price of the above stock index as the research object, first in ARMA(1,1)-GARCH(1 1) In the model, the Fed's interest rate policy changes are added as dummy variables to verify the short-term impact of the Chinese stock market under the adjustment of the interest rate policy as a whole and in different directions. Subsequently, the ARMA(1,1)-EARCH(1,1) model was used to control the interference of the information asymmetry effect, and the interest rate policy dummy variable was added to the conditional variance item to verify whether it would significantly increase the fluctuation risk of the day's rate of return. Finally, the practice research method of adding Bootstrap technology is used to quantify and examine the excess return rate and cumulative excess return rate of the stock index within ten days before and after the interest adjustment date. Empirical research found:

1) Regardless of the direction of regulation, the overall short-term impact of the Fed's interest rate policy on the Chinese stock market is not significant.

2) Looking at different directions, the Fed's interest rate hikes and interest rate cuts have caused a significant short-term impact on the stock market. Among them, when the interest rate is raised, the impact on the stock market is more significant and the degree is stronger.

3) Without distinguishing the direction of regulation, the Fed's interest rate policy will not produce significant excess and accumulated excess returns during the period before and after the change. But in the case of distinguishing the direction of regulation, the Fed's interest rate hikes and interest rate cuts will lead to significant excess and cumulative excess returns in the Chinese stock market in the days before and after the

event day.

4) Without distinguishing the direction of regulation, the Fed's interest rate policy will not be affected by significant excess and accumulated excess returns before and after the change. However, in the case of distinguishing the direction of regulation and control, both the rate hike and the rate cut period will show significant excess and accumulated excess returns in the days after the event.

5) The excess rate of return during the interest rate increase is basically positive, and there is a significant and insignificant alternating phenomenon, and the significance after the event is strengthened, so that the significance of the accumulated excess return gradually increases; while the excess during the rate reduction period The returns are positive and negative, showing large fluctuations, more significant times than insignificant times, and the cumulative excess returns show a characteristic of weaker head and tail in the middle.

At the end of the empirical part, this article divides the interest rate adjustment cycle, combining the macroeconomic environment and stock market trends in each cycle, it can explain the empirical results from the perspective of public expectations. The study finds that investors in the stock market have a significant reverse signal effect on the Fed's interest rate information, especially when the bull market is moderate with a good macroeconomic situation, and the bear market is benefiting from the depression, investors will basically adjust the first reverse cycle. Reverse thinking of policies hinders the effect of interest rate policies in the short term. However, as long-term regulation and control will become stronger, the cumulative effect of interest rate policies will gradually increase, creating convenience for supporting the implementation of other policies and regulating the stock market.

5.2 Related suggestions

Investors are the most important participants in the stock market. There are many retail investors in the Chinese stock market, which is different from the characteristics of institutional investors as the theme in the developed European and American capital markets. Affected by the news, retail investors are less resistant to risks under the circumstances of abnormal stock market fluctuations before and after the introduction of major policies. In response to this, this article makes the following recommendations to investors, especially the majority of retail investors:

1) The characteristics of the Chinese stock market currently affected by the news are still relatively obvious. With the full opening of China's financial market, the possibility of being hit by external positive or negative news is also increasing. By directly or indirectly affecting global liquidity and Chinese liquidity, changes in the Fed's interest rate policy have a significant impact on the Chinese stock market in most cases. Therefore,

investors should take the initiative to understand and pay attention to changes in the Fed’s relevant policies, determine whether the direction of regulation implies future policy changes, and whether the regulation space is in line with expectations when the regulation takes place in conjunction with the macroeconomic background, and use this to make necessary impacts on possible impact reaction.

2) When analyzing the short-term impact of the Fed’s interest rate policy on the Chinese stock market, we should focus on analyzing the existing policy mix in the regulatory cycle and the expected impact of people’s hearts. The cumulative effect of current interest rate policies, that is, investors should not be isolated Looking at each interest rate adjustment event, it is necessary to rationally identify and adjust the Fed's interest rate policy adjustments in light of the macroeconomic environment and consistent market expectations.

3) There is a significant "asymmetric reaction" to bad news and good news in China's stock market. Investment growth responds more strongly when faced with bad news, leading to greater volatility in the stock market. This feature reminds investors that they should have a stronger sense of risk, effectively screen long and short news and strengthen risk management and control. However, the Fed's interest rate policy will not cause a significant amplification effect on the fluctuation of the Shanghai Composite Index in the short term, that is, it will not increase the overall investment risk of the stock market in the short term, so investors, especially retail investors, face the short-term impact of interest rate policy It should cultivate a good investment mentality and philosophy, and have a certain understanding of the herding effects.