The Impact of Equity Refinancing Methods of Technology Listed Companies on Stock Price Volatility

-- Based on GARCH model

Hongwei Zhao*

School of Hunan University of Science and Technology, Xiangtan, 411201, China

*Corresponding author: Hongwei Zhao

Abstract: Current research on equity refinancing primarily focuses on the analysis of equity financing preferences and causes, the cost of equity financing, and the efficiency of equity financing. However, there is a notable gap in research concerning the volatility of stock returns and the associated risks of equity refinancing. This paper addresses this gap by describing the theory of refinancing as established by previous scholars and focusing on two common types of equity refinancing: share placements and issuances. The study investigates the impact of these refinancing methods on the volatility of stock returns for A-share listed technology companies in China. For the sample selection, this paper uses the daily closing prices of several A-share technology-listed companies in 2020 that adopted share issuances or allotments. It emulates the compilation method of the CSI 300 index to create a refinancing technology index as a variable and employs the GARCH model for empirical analysis. This approach allows for an examination of how the volatility of stock returns changes under different equity refinancing methods. The empirical analysis leads to the following conclusions: 1. Both share issuances and allotments affect stock prices increase the volatility of stock returns; 2. The impact of allotments on stock return volatility is relatively small compared to that of share issuances, which cause more dramatic changes in stock prices. 3. Equity refinancing has a significant short-term positive impact on the volatility of stock returns, with the effect of share issuances being greater than that of share allotments.

Keywords: Listed Companies, Equity Refinancing, Volatility, GARCH Models.

1. Introduction

The core areas of contemporary Chinese research on equity refinancing include analyzing equity financing preferences and causes, investigating the cost of equity financing, and exploring various aspects of equity financing efficiency [1]. However, current theoretical research predominantly focuses on the direct impact of refinancing on stock prices or yields. There is a significant lack of studies addressing the risks associated with equity refinancing and the subsequent volatility of stock yields.

Nowadays, China’s capital market is becoming increasingly open. However, due to significant issues with heterogeneous financing, the correlation between value and price is often irrational, leading to complex fluctuations in stock prices caused by various factors [2]. The overall path to value return in the stock market needs further exploration by China’s securities market. The pandemic’s impact in 2020 also severely affected the financial market, exposing long-standing financial and economic issues. These issues include financial market collapses, economic stagnation in several countries such as the US and Europe, regulatory problems within the securities industry, and other factors that are currently influencing China's stock market or could contribute to a global economic crisis.

Simultaneously, in light of the variability of factors beyond the predictable features of risk, the relative paucity of research on stock return volatility is crucial to preserving the robust growth of China's stock market. Additionally, China's listed companies-particularly those in the science and technology sector-have strong autonomous selectivity when it comes to financing and refinancing behaviors following the establishment of the Science and Innovation Board, the Growth Enterprise Market, and the Small and Medium-sized Enterprises Board [3]. However, due to the immaturity of the securities market and the lack of relevant experience, it is essential to conduct thorough theoretical research to guide listed companies in choosing the best refinancing methods to ensure the healthy development of the securities market.

Accurate theoretical research is essential to sustaining the growth and stability of the securities market and assisting listed companies in selecting the best refinancing options. Secondly, analyzing stock price yield fluctuations following a refinancing method is crucial for managing the risks faced by listed firms. This research also lays the foundation for the continued growth of listed companies [4].

2. Relevant Theories

In 1970, Akerlof G.A [5] proposed the theory of information asymmetry, suggesting that in certain conditions, one party in a market transaction possesses more complete information about the transaction items than the other party, leading to a disadvantage for the latter in terms of information. This concept has since become known as information asymmetry theory. Information asymmetry gives rise to disparities in knowledge between parties, resulting in issues such as moral hazard and adverse selection. Modern economics continues to build upon this premise. When a public company undergoes equity refinancing, shareholders and management typically possess different levels of information. Consequently, external investors often struggle to access valuable insider knowledge and may face increased risks in the secondary market.

By easing the MM theory's assumptions and taking
transaction costs into account, Myers and Majluf (1984) presented the Pecking order theory [6], which is based on the asymmetric information theory. When a publicly traded firm needs to refinance, it will typically use the Pecking order theory while taking other aspects like enterprise value into account. If western businesses adhere to the Pecking order idea, their stock price and enterprise value will likely stay relatively steady and not fluctuate significantly.

Scholes’ (1972) Price pressure hypothesis [7] posits that refinancing leads to an increase in the number of shares, and since the demand curve for shares slopes negatively, an increase in shares results in a decrease in share price. Therefore, if a firm refines with a higher number of newly issued shares, the stock price is likely to decline. Moreover, the increased issuance of shares leads to an oversupply in the market, sending an unfavorable signal to investors. Consequently, negative expectations arise, causing a further decline in share price.

Currently, numerous domestic studies examine the impact of refinancing methods on listed companies. Xiao Xian (2013) discovered significant differences in the assets and size of listed companies depending on the refinancing method employed, such as issuance and share placement. Additionally, she noted that the share price effect resulting from additional issuance is relatively superior to that of share placement [8]. Chen Kunkun's empirical study on the share price effect of directed issues concluded that the short-term share price effect of listed companies in directed issues is significantly positive. Moreover, the share price effect on the date of the announcement of the increase in fluctuation is relatively smooth. The proportion of non-circulating shares of listed companies is also positively correlated with the stock price effect. This is because when the number of shares increases, secondary market investors perceive it as a positive signal, leading to short-term stock price increases [9]. Ye Zhiqiang and Zhang Shuming found that the stock prices of listed companies significantly rose before and after a year of directed issuance, exhibiting an "inverted U-shaped" volatility timing effect [10].

Lei Jingshan (2013) observed that the volatility of yield caused by share placement is stronger compared to additional issuance [11]. Geng Juan and Liu Yichao (2019) utilized the GARCH model to fit stock returns based on the CSI 300 index. They found that the time series of returns did not follow a normal distribution and exhibited typical characteristics of volatility. Moreover, they determined that the GARCH (1,1) model provided the best fit and could offer better short-term predictions of future returns [12].

3. Empirical Study

3.1. Empirical Design

In this paper, utilizing the daily closing prices of technology sector listed companies from 2020 to 2024, focusing on those that underwent refinancing through additional share issuance and share placement in FY2020. We compile a refinancing technology index based on the CSI 300 index, where the index represents the logarithmic yield [13]. In this paper, the stock return is defined as the difference between the natural logarithm of the daily closing price and the natural logarithm of the previous day's closing price, expressed as follows: \( R_t = \log P_t - \log P_{t-1} \), where \( R_t \) denotes the logarithmic yield at moment \( t \), \( P_t \) is the closing price at moment \( t \), \( P_{t-1} \) is the closing price at moment \( t-1 \).

Observing the corresponding changes in stock returns after the implementation of the refinancing methods and employ the GARCH model for regression analysis to examine the impact of these two refinancing method choices on the volatility of listed companies' stock prices. At the same time, to demonstrate that refinancing indeed significantly affects stock price volatility, we select the SSE index and SZSE index of the same year as the control group for comparison. The results illustrate that the choice of refinancing method does exert an impact on the volatility of stock returns.

3.2. Introduction to the GARCH Model and Correlation Tests

3.2.1. Introduction to the Model

Engle (1982) first proposed the autoregressive conditional heteroskedasticity (ARCH) model to explore time series volatility, and was able to accurately simulate changes in the volatility of time series variables. Bollerslev in 1986 on the basis of the ARCH model proposed a generalized ARCH model, also known as the GARCH model. The GARCH model is able to portray well the characteristics of financial volatility. The GARCH model is able to characterize the financial returns of time series very well and is now an important tool for studying volatility. Its innovation replaces multiple lags with one or two lags. The GARCH model is composed of two parts: the mean equation and the variance equation.

3.2.2. Fundamental Principles

In this paper, with reference to Gu Xin [14], GARCH (1,1) model is used in the basic form:

\[
R_t = x t + \mu_t, \quad \sim N(0, \sigma^2)
\]

\[
\sigma_t^2 = \alpha_0 + \alpha_1 \mu_{t-1}^2 + \gamma_1 \sigma_{t-1}^2 + \varepsilon_t
\]

Where the mean equation in: \( R_t \) and \( x_t \) denotes the dependent and independent variables, \( \mu_t \) denotes the random disturbance term, which does not obey the normal distribution. The variance equation in: \( \sigma_t^2 \) denotes the conditional variance, \( \omega \) denotes the mean term, \( \mu_{t-1}^2 \) denotes the lagged residuals squared (ARCH term), \( \sigma_{t-1}^2 \) denotes the prior forecast variance (GARCH term), \( \alpha_1 \) denotes the return coefficient, and \( \gamma_1 \) denotes the lagged coefficient.

The GARCH model is guaranteed to be smooth if \( \alpha_1 + \gamma_1 \) is greater than 0 and less than or equal to the 1 condition. The closer its sum is to 1, the stronger the volatility aggregation. The larger the lag coefficient is, the more it indicates that the shock to the conditional variance will not disappear until a considerable amount of time has elapsed, thus exhibiting persistence characteristics.

3.2.3. ARCH Effect Test

The ARCH effect test is most commonly used as the ARCH-LM test. An auxiliary regression equation is created:

\[
\mu_t^2 = \alpha_0 + \alpha_1 \mu_{t-1}^2 + \alpha_2 \mu_{t-2}^2 + \ldots + \alpha_q \mu_{t-q}^2 + \varepsilon_t
\]

where: \( \mu_t^2 \) denotes the residual.

The original hypothesis of the test is whether there is an
ARCH effect in the residual series, i.e., whether all the regression coefficients in the model are zero at the same time:

\[ H_0 = \alpha_0 = \alpha_1 = \alpha_2 = \alpha_3 = \cdots = \alpha_q = 0 \]

That is, there is no ARCH effect.

Test statistic:

\[ LM = TR^2 \sim \chi^2(q) \] (4)

Where: \( T \) is the number of sample data for the auxiliary regression equation; \( R^2 \) is the sample coefficient of determination for the auxiliary regression equation.

Discriminative criteria: if \( LM > \chi^2(q) \), then reject \( H_0 \), that the residual series exist ARCH effect; if \( LM < \chi^2(q) \), then accept \( H_0 \), that the residual series does not exist ARCH effect.

In addition to this, the existence of ARCH effect can be tested with the help of Box-Pierce test, Ljung-Box test.

3.2.4. Explanation of the Effect of Excluding Other Factors on Stock Volatility

This paper focuses on investigating the influence of equity refinancing on stock return volatility and does not delve into discussions regarding debt and debt financing. However, it takes into account the potential impact of a company’s own gearing ratio on stock return volatility. Lei Jing Shan (2013) conducted a study using the Shanghai and Shenzhen 300 stocks as sample stocks, selecting 300 stocks and categorizing them into 13 industries. Through a comparison of their gearing ratio and the variance of their stock returns, it was concluded that there is no correlation between the gearing ratio and stock returns. Therefore, this paper solely examines the impact of refinancing on stock returns and does not consider the influence of other potential factors such as gearing ratio.

3.3. Sample Data Selection and Modeling

3.3.1. Sample Selection and Data Processing

In the process of selecting the sample data, the data for the period that has the greatest impact on the analyzed stock market is selected, taking into account other factors that can interfere with the stock price. During the selection of the sample period, attention should be paid to the introduction of relevant domestic decrees and major policies, and the period of these major releases of information should be avoided. During the selection of data, companies with an interval of more than twenty business days between the publication of the annual report and the issuance of new shares should be selected. In order to exclude the influence of other financing factors on the results of the research, listed companies that refinanced their equity during the year and did not carry out any other fund-raising activities in the following year were selected.

Based on the above premise, the paper finally selects the daily closing price data of the companies that carried out equity refinancing (issuance and allotment) in the year 2020 in the technology sector as the sample, among which the issuance of additional shares is Runbang shares (002483.SZ), Huahong Science and Technology (002645.SZ), Guanghong Science and Technology (300735. SZ), Zhaoyi Innovation (603986.SH), Sitong shares (603838.SH), in the stone technology (300684.SZ) six companies; the use of share placement of seagull shares (603269.SH), Zhaoyi Innovation (603633.SH), wave information (000977.SZ), aerospace science and technology (000901.SZ) five companies.

3.3.2. Compilation of the Refinancing Technology Index (RTI)

The equity refinancing technology index is compiled using the daily closing prices of the selected technology companies as a sample, following the methodology of the CSI 300 index compilation. This prevents the emergence of results that are contingent due to the specificity of individual companies. Therefore, an investigation is conducted into how equity refinancing affects the return volatility of this index.

Index compilation technique:

The Equity Refinancing Technology Index is computed using the Paix-weighted composite pricing index algorithm, which is based on the CSI index compilation technique and weighted by adjusted equity.

Index Calculation Formula:

\[
\text{Reporting Period Index} = \left( \frac{\text{Adjusted Market Capitalization of Constituents for the Reporting Period}}{\text{Base Period}} \right) \times 1000
\]

\[
\text{Total Adjusted Market Capitalization} = \sum (\text{Market Price} \times \text{Number of Adjusted Equity of Sample Stocks}).
\]

4. Empirical Analysis

4.1. Additional Stock

4.1.1. Statistical Characterization of the Effect of Stock Yield Increments

Taking the logarithmic returns of the compiled stock increase refinancing technology index (RTI) for the period 2020.1-2024.1 yields the following yield volatility series plot.

![Log Returns Time Series](image)
The volatility graph of the Additional Stocks RTI reveals that the time series of the Additional Stocks Technology Index yield fluctuates sharply around zero from 2020 to 2024. This volatility exhibits typical clustering and persistence, as shown in Fig. 1. Secondly, the graph provides initial support for our model selection. Additionally, it can be observed that during the first year of implementing refinancing, the fluctuations in the technology index yield time series are more intense. Therefore, it is preliminarily concluded that listed companies experience increased stock return volatility during the year of additional issuance.

![Figure 2. Histogram of additional stocks yield distribution](image)

**Table 1. Returns series statistics**

<table>
<thead>
<tr>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Jarque-Bera</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6270</td>
<td>8.2313</td>
<td>2695.0891</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

From the above list of statistics, we derive the following: the skewness value is 2.79, the kurtosis value is 0.097, the JB statistic is 297.48, and its p-value is 0.00. The probability of rejecting the null hypothesis based on these data is nearly 0, indicating that the return on the tech index of the additional shares does not follow a normal distribution. Consequently, the STI returns of the additional sample stocks exhibit peaks and thick tails, demonstrating clustered volatility. This behavior suggests that the STI returns can be effectively modeled using the GARCH model.

### 4.1.2. ADF Test

**Table 2. ADF test and reference values**

<table>
<thead>
<tr>
<th>ADF Statistic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-27.5964</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Critical Values

<table>
<thead>
<tr>
<th></th>
<th>1%</th>
<th>5%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADF Statistic</td>
<td>-3.4380</td>
<td>-2.8650</td>
<td>-2.5680</td>
</tr>
</tbody>
</table>

It can be concluded from the above graph: The ADF statistic is -30.72 while the p-test value is 0 less than 0.05. The original hypothesis is rejected at 1% level. It can be concluded that there is not a unit root. Hence the test result that the series is significantly smooth is concluded.

### 4.1.3. Determination of Mean Value Equation - ARIMA

**Table 3. Optimal ARIMA equation fitting**

| Best ARIMA Order: | (1, 0, 0) |
| Best AIC:         | -3723.8260 |

### 4.1.4. ARCH Effect Test

The ARCH effect test was conducted with the help of Box-Pierce test,
Figure 4. Residuals of the yield series and the squared residuals plot

From the graph, it is understood that the standardized residual distribution of the series is within the range around 0, which is characteristic of an arch effect, and for further verification, it is verified with the help of Box-Pierce test of the magnitude of its p-value.

<table>
<thead>
<tr>
<th>Table 4. ARCH effect test p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box-Pierce test p-values</td>
</tr>
</tbody>
</table>

Based on the p-value in the above graph, it can be seen that the test negates the original hypothesis and shows that there is an ARCH effect. So, the GARCH model can also be fitted well.

4.1.5. ARIMA-GARCH Model Fitting of the Returns on Additional Refinancing Technology Indexes (RTI)

We use the GARCH model to simulate the return on the Allotment Equity Refinancing Technology Index and derive the GARCH (1,1) model as follows:

\[
R_t = 5.25E-05 + 0.0997AR(1) 
\]

\[
\sigma_t^2 = 8.59E-05 + 0.1224\mu_{t-1}^2 + 0.7899\sigma_{t-1}^2
\]

Observing the ARCH term and GARCH term coefficients in the above figure, respectively, are greater than 0 less than 1 and the sum of the two is less than 1, from which we can conclude that the GARCH (1, 1) process is smooth and more persistent fluctuations in returns.

4.2. Allotment of Shares

4.2.1. Statistical Characterization of the Effect of Yield Allotments

Taking the logarithmic returns of the compiled add-on refinancing tech index for the period 2020.1-2024.1 yields the following yield volatility series plot.

<table>
<thead>
<tr>
<th>Table 5. ARIMA - GARCH Model Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dep. Variable:</td>
</tr>
<tr>
<td>Mean Model:</td>
</tr>
<tr>
<td>Vol Model:</td>
</tr>
<tr>
<td>Distribution:</td>
</tr>
<tr>
<td>Method:</td>
</tr>
</tbody>
</table>

| Mean Model | coef | std err | t | P>|t| | 95.0% Conf. Int. |
|------------|------|---------|---|------|-----------------|
| const | 5.25E-05 | 0.0010 | 0.0410 | 0.9680 | [-0.002, 0.003] |
| ar.L1 | 0.0997 | 0.0180 | 5.6220 | 0.0000 | [0.065, 0.134] |
| sigma2 | 0.0011 | 2.24E-05 | 48.0540 | 0.0000 | [0.001, 0.001] |

| Volatility Model | coef | std err | t | P>|t| | 95.0% Conf. Int. |
|------------------|------|---------|---|------|-----------------|
| omega | 8.59E-05 | 2.34E-05 | 3.68E+00 | 2.33E-04 | [4.016e-05, 1.317e-04] |
| alpha[1] | 0.1244 | 4.52E-02 | 2.7540 | 5.89E-03 | [3.888e-02, 0.2131] |
| beta[1] | 0.7899 | 5.52E-02 | 14.321 | 1.64E-46 | [0.6821, 0.8983] |

Figure 5. Plot of volatility of RTI series for allotment effect
We can conclude from the graph of the volatility of the yield of the Additional Stocks Technology Index that the time series of the yield of the Additional Stocks Technology Index fluctuates sharply around the zero value during the period from January 2020 to January 2024, and there is a clustering and persistence in the fluctuation of the yield, which is in line with the characteristics described by the GARCH model.

Secondly, we can also describe the graph can initially support our model selection. From the above graph, we can also observe that the time series fluctuation of the return of the technology index is the most intense during the first year when the refinancing behavior is implemented. Thus, it is initially concluded that listed companies will increase the greater volatility of stock returns during the year when they implement stock additions.

![Figure 6. Histogram of additional stocks yield distribution](image)

Table 6. Returns series statistics

<table>
<thead>
<tr>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Jarque-Bera</th>
<th>Jarque-Bera P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0247</td>
<td>2.3633</td>
<td>225.6034</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Based on the above statistics, we derive the following: the skewness value is 3.66263, the kurtosis coefficient is 0.1468, the JB statistic is 504.6309, and its p-value is 0.00. The probability of rejecting the null hypothesis based on these data is close to zero, indicating that the stock returns during the issuance period do not follow a normal distribution. Consequently, the STI return series of the additional issue sample exhibits peaks and thick tails, showing clustered volatility. This suggests that STI returns can be effectively modeled using the GARCH model.

4.2.2. ADF Test

Table 7. ADF test and reference values

<table>
<thead>
<tr>
<th>ADF Statistic</th>
<th>p-value</th>
<th>Critical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>-17.46246338962283</td>
<td>4.5892617486144524e-30</td>
<td>3.438 2.865 2.568</td>
</tr>
</tbody>
</table>

From the above table, it can be concluded that the ADF statistic is -17.4625 and the p-value of the test is less than 0.05. And the original hypothesis is rejected at 1% level of significance, there is no unit root in the series and hence the series is relatively smooth.

4.2.3. Determination of Mean Equation - ARIMA

![Figure 7. Autocorrelation and partial autocorrelation plots of yield series](image)

Table 8. Optimal ARIMA equation fitting

<table>
<thead>
<tr>
<th>Best ARIMA Order:</th>
<th>(2, 0, 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best AIC:</td>
<td>-4091.4144</td>
</tr>
</tbody>
</table>

4.2.4. ARCH effect test

![Figure 8. Residuals of best ARIMA Model](image)
From the figure, it can be seen that the standardized residual distribution of the series is within the range around 0, which is characteristic of an arch effect, and for further verification, with the help of Box-Pierce test of the size of its p-value.

<table>
<thead>
<tr>
<th>Table 9. ARCH effect test p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box-Pierce test p-values</td>
</tr>
<tr>
<td>2126.62</td>
</tr>
</tbody>
</table>

Based on the p-value in the above graph, it can be seen that the test negates the original hypothesis and shows that there is an ARCH effect. So, the GARCH model can also be fitted well.

### 4.2.5. ARIMA-GARCH Model Fitting of Returns on Allotment Refinancing Technology Index

We use the GARCH model to simulate the return on the Allotment Equity Refinancing Technology Index and derive the GARCH (1,1) model as follows:

\[
R_t = 7.64E - 05 + 0.9784AR(1) - 0.9429AR(2) - 0.9530MA(1) + 0.8934MA(2)
\]

\[
\sigma_t^2 = 1.27E - 05 + 0.0994\mu_{t-1}^2 + 0.8807\sigma_{t-1}^2
\]

Observing the coefficients of the ARCH and GARCH terms in the above figure, they are greater than 0 and less than 1 respectively and the sum of the two terms is less than 1. From this we can see that the GARCH (1, 1) process is smooth and the t-test is highly significant.

### 4.3. Control Groups

The table above indicates that the results of the model test for the return on additional shares and allotments during refinancing are significantly more pronounced compared to the CSI Technology 100 Index. This suggests that refinancing exerts an impact on the volatility of stock returns for listed companies, subsequently influencing their respective stock prices.

<table>
<thead>
<tr>
<th>Table 11. Comparison of model coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicators</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>Allotment Refinancing Index</td>
</tr>
<tr>
<td>CSI Technology 100 Index</td>
</tr>
<tr>
<td>SSE (Shanghai Stock Exchange)</td>
</tr>
<tr>
<td>SSEI (Shenzhen Stock Exchange)</td>
</tr>
</tbody>
</table>

### 5. Conclusion

The empirical results suggest that the equity refinancing
activities of A-share listed technology companies significantly impact the volatility of their stock returns. Whether through share allotments or stock issuances, equity refinancing leads to a short-term expansion effect, increasing the stock price risk for the listed companies. Additionally, in the short-term following these actions, the volatility of stock returns for these companies increases.

When listed companies use share allotments or issue additional shares for refinancing, the volatility of the refinancing technology index return following the allotment of new shares is relatively low, resulting in minimal sequence effects and stock price return volatility. However, the volatility of the refinancing technology index after the issuance of additional shares is more pronounced, contributing to a larger sequence effect.

The A-share refinancing of science and technology listed companies has a significant short-term positive impact on stock return volatility, increasing stock price risk. The equity refinancing behavior of technology companies in China's A-share market will bring a significant positive impact on stock return volatility in the short term after the refinancing behavior occurs, in which the degree of impact of additional refinancing is greater than that of allotment refinancing.

References