A Literature Study of the Stock Market Volatility

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Abstract. This review explains and explores the performance of stock volatility in financial markets and historical research to understand the operation of financial markets. From finding the meaning of the existence of the financial market to understanding what the stock volatility is, gradually understanding the measurement methods of various stock volatility, and finally comparing the actual application of stock volatility in financial markets with different development levels. Through specific enumeration of GARCH family analysis methods and combined with application case analysis, such as ARCH model and GARCH model, it is found that these models are only suitable for measuring stock volatility under certain conditions in order to obtain a better fitting effect. For the financial market, it is necessary to build a more perfect financial legal system, continue to strengthen the transparency of the financial market, and increase the openness of the financial market to show a more healthy stock stability rate. In addition to the internal factors of the financial market, it is also necessary to consider the external impact of macro and micro factors on the financial market so as to affect the stock volatility, which is one of the development directions of the financial academia.

Keywords: Stock volatility; GARCH family; Model application.

1. Introduction

The term "financial market," also referred to as the "capital market," relates primarily to business cash loans, foreign currency trading, dealing in negotiable securities, the issue of bonds and stocks, and trading in precious metals like gold. When it comes to the effect of financial market, investment-saving transformation can be facilitated due to the liquidity that financial markets naturally provide. Secondly, the financial market allocates resources and funds to the most efficient sectors through competitive price determination, thereby increasing the output of the whole society and improving the efficiency of resource utilization. Thirdly, the financial market can quickly reflect the state of economic operation. A healthy financial market frequently reflects a healthy actual economy. Fourthly, the financial market has increasingly taken over as the primary method for the government to control the economy due to its significant role in linking savings-investment and altering resource allocation, as well as the sensitivity of financial market organizations to market changes.

A measure of the unpredictability of asset returns and a way to express the risk level of financial assets, stock volatility is the specific volatility of the prices of financial assets. Higher stock volatility results in more erratic financial asset price fluctuations and greater asset return uncertainty; lower stock volatility results in smoother financial asset price fluctuations and greater asset return certainty. In an economic perspective, the following three factors account for the majority of stock volatility. The first is how systemic risk affects a particular industrial sector's macroeconomic parameters. The second is what is known as unsystematic risk, which is the effect of a specific incident on a specific organization. The impact of adjustments to investors' psychological state or expectations on stock prices is the final factor.

When all the stock volatility comes together, it becomes the overall stock market volatility. After years of exploration and analysis, most people agree that there are two main effects of stock market volatility on financial markets. When huge market shocks lead to violent stock market fluctuations, the first to be affected are money funds and securities markets. In the traditional financial market, currency funds serve as an important channel for market flow and circulation transactions. When the stock market is hit, it can quickly be transmitted to the currency funds to cause turmoil. Since more investors are afraid of being affected by the stock market crash, they will consider withdrawing from the stock market for the volatility of the stock market. This will cause the capital flowing into the

stock market to shrink, and the corresponding capital will be more inclined to flow into the more stable financial market. However, on the other hand, if the development level of monetary funds in the financial market is higher, then the impact of stock market volatility can be mitigated, and the stock market can be stabilized while protecting the interests of investors.

The second to be affected is the influence on investors' investment and financial tendency. Specifically, the volatility of stock prices will affect investors' psychological expectations for future trends. This is because the fluctuation of the market trend is a reflection of the human nature of the main participants in the stock market. But the other way around, Stock price volatility also affects investors' psychological expectations. When the state of economic development and stock market are prosperous, investors' confidence in the stock market increase greatly, and they are relatively optimistic about the future market. When the stock market falls, investors' psychological expectations will be more pessimistic, which in turn affects investors' bearish thinking and leads to further declines in the stock market.

2. Measurements of Stock Volatility

Over the years, many methods of measuring volatility have been proposed. They can be roughly divided into actual volatility, historical volatility, implied volatility and future price volatility, etc. These volatility measurement methods can measure stock market volatility from multiple perspectives and levels and predict the possible direction of the stock market in the future. Therefore, this article understands the laws of volatility by clarifying these volatility measures.

2.1 Real Volatility

According to a rigorous definition, actual volatility refers to a way of assessing volatility that measures the degree of volatility in the return on investment throughout an option's validity period. Parametric method and non-parametric method are the two divisions that can be made. The return decomposition theory and the quadratic change theory serve as the basic foundation for real volatility. The term "parametric technique" refers to the measurement of volatility using a particular parametric model in which the volatility variable is included. ARMA, GARCH, and SV models are examples of typical models. The term "non-parametric approach" describes a specific way of direct calculation using daily transaction data. Typical are income variance, absolute value of daily return, etc. However, the above methods cannot accurately measure the volatility, and there is a large error with the actual situation. The reason may be that the information of the sample is insufficient.

2.2 Historical Volatility

Historical volatility is derived by analyzing past statistical analysis. The specific operation is to first assume that the future is a continuation of the past, and then to estimate volatility by using historical methods. From the above method, it can be seen that historical volatility reflects the past fluctuation of the stock price of the target in the stock market. However, because stock price fluctuations are affected by many factors, it is difficult to predict stock price fluctuations, which leads to generally inaccurate to use historical volatility to predict stock prices.

There are a number of issues that should be considered when using historical volatility. The first consideration is the frequency of data for historical volatility estimates. Volatility results are different due to the choice of different data frequencies. The second is to consider the selection of the estimated sample interval. Through a large number of sampling experiments, it is found that increasing the number of samples in the estimation period can reduce the standard error of prediction. But it is not wise to blindly increase the sample size, because the most recent data has a higher weight. The final concern is the price choice for estimating volatility. The price of the underlying asset has the opening price, closing price, high price, and low price. Different prices have different historical volatility. No matter what underlying asset price is used, only when the historical volatility is equal to the actual volatility can it be explained great.

2.3 Implied Volatility

The implied volatility cannot be obtained directly from the original data, but the warrant transaction price in the market is brought into the theoretical price model of the warrant, so as to deduce the volatility value. In terms of specific operations, it is not difficult to obtain the implied volatility. The implied volatility of the unknown variable can be solved as long as the option price, underlying stock price, strike price, interest rate, expiration period, and volatility are provided and included in the option pricing model.

In general, despite their strong correlation, warrant stocks' indicated volatility is higher than historical volatility. The implied volatility of the applicable warrants is high if the historical volatility of the underlying stock is high; conversely, if one side is low, both sides are also low. The implied volatility, which is a reflection of the relationship between supply and demand in some ways, will also be impacted by the relationship between supply and demand. The price of a stock will rise when there is great investor demand for it, and the implied volatility will rise as well, sometimes even exceeding the real volatility of the underlying stock.

2.4 Expected Volatility

When determining the theoretical value of an option, option pricing models use predicted volatility, which is the outcome of statistical techniques used to forecast real volatility. So from a particular perspective, the volatility that people utilize when theoretically pricing options in actual transactions is the expected volatility. It should be noted, though, that the forecast volatility is not the same as the historical volatility because the former is determined by how well people comprehend actual volatility, whilst the latter is determined by computing past data. In the measurement of forecast volatility, there are mainly moving average method, exponential smoothing method and GARCH model method. In addition, there are stochastic volatility models and their extended models, autoregressive moving average models, etc, which are used to estimate the volatility of financial assets.

3. How Volatility Behaves in Different Markets

There are many financial markets at different levels of development in the world, such as the difference between the financial markets of developed countries and the financial markets of developing countries. Due to different profit expectations, capital market openness, capital market development, and investor structure differences in different markets, the performance of stock volatility in different financial markets is different. By analyzing the characteristics of volatility in developing and developed countries in detail, it is better understand the characteristics of volatility in financial markets.

3.1 Characteristics of Volatility in the Developing Countries

By analyzing the characteristics of the stock return series in developing countries, it is easy to understand the characteristics of the stock volatility series from the side. Summarizing the research results of the existing literature, it can be found that the stock volatility in developing countries is relatively high, and the stock market volume is relatively small. Lucas (1998) chad observed that developed countries have more stable growth rates during a long time. However the developing countries' growth rates tend to fluctuate sharply.

By observing the volatility of GDP growth, Miklós Koren and Silvana Tenreyro (2007) identify three possible reasons [1]. The first reason is poor countries focus on fewer and much more unstable sectors. Second, poor countries are more vulnerable to frequent and severe aggregate shocks, making them more susceptible to changes in macroeconomic policy. Finally, macroeconomic changes in underdeveloped nations are more closely tied to shocks that influence their professional sectors. The special task of Miklós Koren and Silvana Tenreyro is to measure the contribution of each source to the total volatility by breaking down volatility into its constituent parts. There is also some other

evidence that the degree of sectoral concentration does not simply decrease with the increase of development, but shows a trend of first decrease and then increase with the increase of development.

3.2 Characteristics of Volatility in the Developed Countries and the Special Case of the US Stock Market

In contrast to developing countries, stock markets in developed countries have less volatility. This is because compared with the stock markets in developing countries, the stock markets in developed countries have developed over a long period of time, resulting in more mature stock markets in developed countries.

A more mature stock market means stable growth in the future, better investment protection, better financial opening, much smaller exposure than developing countries and it is easier for investors to manage their expectations. The market reaction will be milder, which lead to the stock volatility relatively small. Besides that, as a country develops, its production structure shifts from more volatile to less volatile sectors. At the same time, developed countries have a stronger ability to resist risk shocks, and the covariance between the shocks suffered by his economic sector and the macro shocks received does not change with the level of development.

By comparing the U.S. stock market with foreign stock markets, Söhnke M. Bartram, Gregory Brown and René M. Stulz (2012) have been found that the stock market of the United States, which is the most active stock market in the world, is more volatile than those of similar foreign companies despite being both a developed one [2]. This is because the United States is the most developed capital market, which naturally has an attractive effect on other markets and has always maintained the vitality of the U.S. stock market.

4. Empirical Analysis of Stock Market Volatility Using GARCH Models

In the long course of development of econometrics, models such as ARCH and its derivatives have been developed to try to solve the volatility value in the stock market. After a lot of research, these models can solve the stock market volatility very well in most cases, although they also failed in some cases. However, after the expansion of these models, they can gradually adapt to some special situations and illustrate some characteristics of volatility. Through a detailed understanding of such models, we can get a glimpse of the characteristics of stock market volatility.

4.1 The Establishment and Application of ARCH Model

Professor Robert Engel of California Institute of Technology, San Diego proposed the ARCH model for the first time in the Journal of Econometrics in 1982. Specifically, the ARCH model is an autoregressive conditional heteroscedastic model. From a practical point of view, it is to use time series information to reflect the difference in variance in a certain way. As an epoch-making theory, the ARCH model has developed rapidly in a short period of time once it was launched, and is widely used to verify financial theories and forecast and make decisions on future financial markets.

In Professor Robert Engel's (1982) paper, he pointed out that previous traditional econometric models only assumed a constant single-period forecast variance but had never been tested [3]. To solve this problem, professor Robert Engel uses time series information and introduces an autoregressive model and finally arrives at the ARCH model. The first application of the model was to estimate the mean and variance of inflation in the UK. After detailed calculations, it was found that the ARCH effect of the data was significant, and the estimated variance increased significantly during the turbulent 1970s. Combined with the actual data, it was found that the fitting effect was good.

4.2 The Establishment and Application of GARCH Model

Bollerslev (1987) presented the GARCH model on a further foundation [4] after Professor Engle (1982) suggested using the ARCH model to study the heteroscedasticity of time series. A regression model specifically designed to evaluate financial data is the GARCH model. In addition to the same

place as the original model, the GARCH model adds modeling of the variance of the error, improving the fitting accuracy. Therefore, the GARCH model is more accurate than the original model in the analysis of stock volatility and the prediction of future prices. Having such a stock analysis tool can play a very important guiding role for investors to invest in stocks. In various senses, the actual significance of the model exceeds the analysis and prediction of financial market values.

The relationship between India's inflation rate and inflation uncertainty was investigated by John Thornton (2005) using the GARCH model [5]. It was found that during the period 1957-2005, there was a significant positive correlation between India's monthly inflation level and the degree of change in the inflation rate. Thus, it can be concluded that, in a sense, inflation uncertainty will have a negative impact on real output. Therefore, the author mentioned that the RBI should maintain currency stability as one of the main directions of his monetary policy.

4.3 The Establishment and Application of GARCH-E Model

After a large number of observations on the stock market, it is found that compared with positive news, negative news is more likely to cause more volatility [6]. This phenomenon is officially named the leverage effect. In order to solve the defect that the GARCH model is affected by the leverage effect, an asymmetric model is proposed on the basis of the original model. Among them, the GARCH-E model, as one of the classic asymmetric models, was first proposed by Nelson [7]. The GARCH-E model ensures that the observed conditional variance is positive which can reflect the leverage effect.

The Dow Jones Index was used from 1897 to 1986 by William Brock, Josef Lakonishok, and Blake LeBaron (1992) to test the two most popular trading principles at the time, trading zone break-by and moving averages [8]. The authors used bootstrapping techniques to increase the scope of the conventional statistical study, and the results were unexpected. They discovered that purchase signals consistently outperform sell signals in terms of returns, and that buy signal returns are also less erratic. Meanwhile, bringing market data into the GARCH-E model does not fit the actual situation very well. This shows that the GARCH-E model is not easy to explain the leverage effect very well, and it is not very close to the Dow Jones index in 1897-1986. The model still has room for improvement.

4.4 The Establishment and Application of GARCH-E Model

In the real world, the risk of financial assets will change with time, and the rate of return required by investors will also change with the risk of financial assets. At the same time, in the actual operation of financial assets, no matter what asset it is, at least it will obtain a risk-free rate of return and a risk premium on this basis, so the risk premium is a modeling variable that needs to be considered. The GARCH-M model, which adds the risk premium factor to the GARCH model, was proposed by Engle et al. in 1988 [9]. The conditional variance, which is the white regression function of the lagged values of the underlying variables, is used in the model as a function of the conditional mean.

Kevin B. Grier and Mark J. Perry (2000) did some tests by using the GARCH-M model [10]. Hypotheses about the role of uncertainty on average inflation and output changes in the United States from 1948-1996 were tested and found that there was no evidence to support higher inflation and output uncertainty increase average inflation. From the perspective of the results, the evidence of the GARCH-M model is a good illustration of the validity and reliability of the model.

5. Conclusion

This paper is dedicated to deeply understanding the formation and influencing factors of stock market volatility by understanding and analyzing the principles and practical applications of the GARCH family model. By emphatically discussing the ARCH model, GARCH model, GARCH-E model and GARCH-M model in the article, it reveals the important significance of the GARCH family model in the analysis of financial fluctuations. As one of the most important achievements in financial econometrics in the past three decades, the ARCH model established the prosperity and

development of the subsequent GARCH family models. Although the ARCH model has shortcomings such as not being able to reflect the leverage effect and not considering the risk premium, its depth of theoretical research and breadth of practical application are unmatched, and the shortcomings are complemented by the subsequent development of the GARCH family model. As a further development of the ARCH model, the GARCH model is a model specially designed for financial analysis. By adding the return coefficient, the GARCH model includes a wider range of financial analysis. However, the model will cause oscillations due to the fact that all coefficients are greater than zero in order to ensure non-negativity. Although there are various defects, the GARCH model, as an important breakthrough of the ARCH model, still has special significance for investors. The GARCH-E and GARCH-M models are further improved on the basis of the GARCH model to solve the defects of the original model. The former is to solve the problem that GARCH cannot measure the leverage effect, and the latter is to more finely fit the risk premium. Both models reflect the complexity and diversity of stock volatility. Stock volatility is affected by many factors, and the development of the GARCH family model is to try to explain which factor affects the volatility most.

For developing countries, the financial market management is not perfect, there are weak regulatory frameworks, the market is controlled by a few market makers and other defects. And these defects will affect the stock market volatility and uncertainty of the market. In this paper, the comparison between the markets of developing countries and the markets of developed countries shows that in order to stabilize the volatility, developing countries must enhance market transparency, reduce information asymmetry, strengthen the construction of financial legal systems, improve supervision and management systems and so on. In addition to the internal factors of conditional volatility, there are various external factors that can affect stock volatility, such as macro and micro economic factors. What's more, The company's own performance will also have a profound impact on stock volatility. For example, if a company's performance has been relatively stable, its stock volatility will also be relatively stable. Therefore, how to take macro and micro factors into the new GARCH model needs further research.

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