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# Risk Measurement of Stock Markets in BRICKS Countries

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***Abstract***

*Stock markets usually have very distinct volatility characteristics. In this paper, we use daily closing price from 2011 to 2015 of stock markets of BRICS countries. We take the logarithmic percentage rate of return of stock index as samples (including the Shanghai composite index, Russia's RTS index, the index of SENSEX30 and the Brazilian IBOVESPA stock index), and use of the ARCH and GARCH, EGARCH models to do empirical analysis, estimating the stock market volatility risk in BRICS countries.*

***Key words: BRICS, Stock markets, Volatility, Risk, GARCH.***

**1. Introduction:** Currently, the risk control and portfolio management in stock markets have always been regarded as the key problem and relishes. Especially in the recent a period of time, China's stock market begin to rally in the round, from the beginning of more than one thousand eight hundred points all the way up, and have already broke through the four thousand - point mark. From this, we can find that the stock markets in the developing countries are very unstable. After the excavation of the data, we can find that the stock market risk in BRICS countries is also great. Russia's RTS index rose by more than 500% from 2003 until now, and dived to 490 points like a roller coaster. The index of SENSEX30 in India, and the Brazilian IBOVESPA stock index performed slightly stable, but they were in a massive fall during the year of 2007-2008. The stock market were considered been influenced by international financial crisis under the global integration.

With the data we have found in the stock markets of developing countries, we find the high yield tends and high risk in the stock market, and also in Europe and the United States market. The outbreak of the subprime crisis 2007 has spread to many countries, not only the United States, but also many European countries. The entanglement, as a result of risk control, was once viewed as the key problem. And how to control the stock market risk has become a hot issue in the world. However, the empirical study of the stock market risk usually focuses on the European countries, the United States and other developed economies, which may be due to Europe and the United States, have the world's economic and financial center. However, developing countries, which have got fast developing speed and greater risk, are not taken seriously in the empirical research. Therefore, in order to quantitative compare the size of the stock market risk in a better way; these countries are

needed to be applied to some mathematical models, including the use of covariance, beta, a variety of tools to calculate risk. The capital asset pricing model (CAPM), the Monte Carlo simulation and Garch-VaR model have been used more commonly. In all of these models, Garch-VaR model is the most frontier one, which has been widely used in many fields of economics, especially in the financial time series analysis. Therefore, based on the above reasons, we use GARCH-VaR model to do empirical study of the stock markets in BRICS countries.

Comparing with other risk analysis models which are used on the stock markets, the innovation of this paper lies in two ways. In theory, in historical literature, people like to do empirical research with Shanghai index, Shenzhen index to evaluate the risk of Chinese stock market, and use NASDAQ and the Dow Jones Index to evaluate the risk of American stock market. There is not much research on the stock markets in emerging countries like BRICS less risk. Therefore, one innovation of this paper is to discuss the stock markets risk of BRICS countries. About the methods, we use a novel GARCH-VaR model to analyze the stock market of the BRICS countries, which is another innovation of this paper. People use GARCH-VaR model to do correlation analysis of the stock markets in BRICS countries without the risk analysis. Therefore, the use of GARCH-VaR approach to do risk analysis of BRICS countries is another innovation of this paper.

In today's world, the European and American securities markets are still dominant without any disputation, whether from in terms of the market scale or the influence of the markets. But also there is no denying that the BRICS countries (Brazil, Russia, India and China) are representative emerging economies with especially fast development, and the securities markets are becoming mature. These countries should be considered seriously. Unfortunately, research of the securities market in these countries is in a shortage. Not only that, but also the engine of world economic growth is driven by the BRICS countries. At the same time, relative to the mature markets such as Europe and the United States, the stability of the securities market in BRICS countries are in terms of volatile and directly proportional to the risks and benefits returns, which attract a steady of hot money into the world. Therefore, more attention to these markets and more analysis of the risk assessment are necessary and worthy.

**2. Stock markets in BRICS countries:** If you want to know what comes to a country's securities market, then you have to focus the country's economy. According to the actual economic conditions of the European and American countries, most of the stock market fluctuations are caused by the real economy, such as the great depression of the world in 1927, the global financial crisis in 2007, and so on. Stock markets tend to be a barometer of the real economy, and therefore the study of stock market has to be established to understand the world economy better.

China is the second largest economy in the world; it is also one of the four ancient civilizations. In the long river of history, China has long dominated the world leading economy position. But after entering the modern time, due to a series of internal and

external war, the stock of all of China's economy has been running out. China had to start from scratch. China's real economic boom started from 1978 after the reform and open policy. China opened its door to the world with export-led growth model, and China's GDP had got the average annual growth rate of over 9% over the past 30 years. And in recent years, due to the world economy, and sustainability of China's economic growth pattern, the country is facing a strategic transformation, from extensive economic growth mode to intensive mode of economic growth. Transition made the GDP growth become slower, to the expected annual growth rate of 7%. But in the long run, due to the changes brought about by the growth model "dividend" will be far more than the cost of the economic growth pattern transformation.

Russia is the world's ninth largest economy, with GDP of $2.10902 trillion. It said that Russia's GDP was in the low-ranking of BRICS countries, but the Russia's per capita GDP ranking is far better than India and China. In addition, Russia has a big military power and resources, and Russia is famous for its resource exports and arms exports with relatively weak light industry. For Russia's economy relies heavily on the export of resources, it is affected by the global economy greatly. In a few years after the financial crisis, the sluggish in many countries around the world, led directly to Russia's economic slowdown. In the recent ten years, Russia had been affected by the domestic drought, soaring food prices and inflation of around 9%. All of this cast a shadow on the Russian economy. From the perspective of recent situation, Russia's political intervention for Ukraine's led to the western economic sanctions, the devaluation of rubble. Although there are signs of stabilization in the near future, the future development prospect is still worrying.

India and China both are ancient civilizations; there are many similarities between India and China. For example, they are all developing countries. They had a glorious past and a big population, modem into a semi-colonial and semi-feudal society, entered the high-speed development of channel in recent years, and so on. In addition, India also has many highly qualified graduates. Not only that, India is the eighth largest economy in the world with GDP of $2.11728 trillion and an average annual growth of 5.6 %. Be worth what carry is, according to the international monetary fund (IMF) forecasts, India's economic growth rate could reach 7.5% this year, more than the forecasted 6.8 % of Chinese GDP. And a lot of international organizations have an optimistic attitude for India's future economic growth. However, India's economy also has many "weakness" cannot be ignored, such as imperfect infrastructure, the huge population base, Kashmir unrest and so on. These are the restriction of its economic development. How to get rid of its own population pressure, religion, the burden of public quality, maintain high-speed growth, will be the urgent problems of India.

Brazil's Gross National Product (GNP) is the top one in Latin America and the seventh in the world. Compared with other BRICS countries except Russia, Brazil started early. As early as the sixties and seventies in the last century, Brazil had been considered as one of the less developed countries. However, the high inflation rate of Brazil restricted the further development of its economy and Brazil fell into the trap of Latin America. After a series of

reform measures, such as health care reform, smaller government, etc., the Brazilian finally came out of the trough. Some opposition, however, worried about the party corruption and doubted about economic take-off for sustainability.

Although people have a bright prospect for the BRICS, we have to notice the risk factors in the process of the development, such as policy risk, religious risk and war risk. Among them, the greatest influence comes from the geographical and armed conflict, which often lead to a country's economic recession even so backwards. The Kashmir region in India and the Russian border area, etc., would seriously affect the development of a country's economy and influence a country's financial markets. Followed by the development of the economic structure defects, which is the common fault of the all developing countries. Enterprises are labor-intensive in China and India, which both have big population, export-led economy relies heavily on the development of export products without added value of science and technology, and there is no innovation, which restricts the development of the economy for a long time. Brazil and Russia are resource-rich countries with resources export oriented and export of resources, and they also rely on the development of world economy. Not only that, Russia is a country with a grave shortage of light industry. The structural flaws are soft rib of the BRICS, which restricted the BRICS countries continued economic growth. Finally, the population problem is also a big problem. India, Brazil and China are the world's most populous country with large population burden. In addition, Brazil and China have entered into an ageing population stage. India, with the high birth rate, multiple children for one family which often makes the social overall low level of education, also will create a very adverse effect on GDP. Russia, by contrast, sparsely populated with low birth rate, but the lack of human resources to a certain extent restricts the development of the country. Generally speaking, there are many development prospects of the BRICS, and the market risk cannot be ignored.

**3. Literature Review:** In the early nineties, VaR model has been wide use in economic research. The introduction of the VaR model started in 1997, but most of the literature focused in the introduction of the VaR model without bias in the empirical research. Among them, Niu (1997) did some research on bank risk management. In this research, the origin of the VaR method are introduced in detail, and the characteristic, the algorithm and widely used in the bank's risk management. At the same time, Niu also pointed out the two limitations of the VaR method. Firstly, the VaR model could evaluate the market risk in the case of steady state, but for some extreme situation its risk measurement accuracy is often not enough. Secondly, the VaR method needs to use a large amount of data as a support, and have better prediction effect for a lot of trading some financial assets. However, it has less accurate for a longer time axis and trading less borrowing assets. Besides, Zheng (1997) also introduced the VaR model and mainly focused on financial risk management and the application of VaR method. In addition to the VaR model theory, they also introduced the areas which the VaR model can be applied in emphatically, including risk control, performance evaluation and financial supervision, which is very prescient. Zheng also expounds the necessity of the application of VaR model into Chinese markes. One of the

reasons is that, the internationalization of China must also take the risk control and foreign standards into account. The other reason is that, for the question that how to control the risk of market effectively within the development of market economy, there is no doubt that the VaR model gives a good answer.

After that, the VaR model is widely used in the securities investment fund. Ye Ping (2009) did research on China's funds market, and found that the open-end fund in China has very obvious "rush" and "fat tails" phenomenon, the T distribution or GED distribution can more accurately measure the VaR value. And during the study of VaR, Ye Ping argued that the development of securities market in China is not perfect enough with obvious signs of "policy market", and the risk control appears more necessary for this market. Using the VaR model to calculate the corresponding risk value could limit the risk and control the risk of fund big positions. In the same way, the VaR method can be promoted not only in fund investment but also in the capital operation of insurance company management. Lu Wei (2012) found that China's insurance companies on the capital operation management also have many drawbacks, such as capital utilization ratio is not high, low income and lack of long-term investments. Therefore, Lu Wei took the data of Pingan as sample, demonstrated how to use the VaR model to allocate the insurance funds more reasonable and how to carry out performance evaluation and combinatorial optimization. Currently, the VaR method is used in the banking sector commonly to evaluate the credit risk of the bank and help Banks better distribution of assets under management. Xiao (2005) argues that the VaR model can help to improve the bank risk management of the assets in the initiative and reduce the cost of risk supervision, which can be done through bank loan classification standards. For example, Xiao argues that different kinds of assets can be used to evaluate the risk and it is necessary to measure the bank returns, and the risk values is implemented by the VaR value.

However, the VaR measure needs to use conditional variances, since the simple linear regression equation cannot describe the financial sequence well. Therefore, there is much research on index of Shanghai with the method of GARCH model. With the data of the Shanghai index, and Shenzhen index yield of fitting in the past, calculate the conditional variances to ensure our value at risk could examine the risk of stock market. In these papers, Ni (2008) uses the GARCH-GED method and T-GARCH method to verify that the GARCH model has good effect for China's stock market risk management. Not only that, according to the T-GARCH model result of the stock market in China, there is obvious profit leverage, the impact of the good news is greater than that of bad news to the stock market. Gong et al. (2005) do the comparative analysis in the calculation of the VaR model, and find that the result of P-GARCH model is often superior than the result of the GARCH model. Thus, they concluded that the heteroscedastic model with the consideration of the condition of asymmetric conditions effect is better than the simple GARCH model which does not consider the condition of asymmetric. With the parameters of the GARCH (1, 1) model and nonparametric GARCH (1, 1) model, Wang et al. (2007) calculate the dynamic VaR value of the Shanghai stock index, and came to the conclusion that the stock market

VaR value calculated by the asymmetric GARCH model parameters can avoide the error of the estimation results due to the inaccurate set by the distribution of the disturbance. This is because the simple GARCH model ignores many important features of the securities market, such as the impact of asymmetry and so on. Wang et al.(2011) apply the calculation of VaR method into different sections of stock market. With the analysis of 10 plates of Shanghai market, they draw the conclusion: the liquidity premium of China's stock market come from the transaction frequency and indirectly lead to the frequent trading of small and medium-sized investors and large volumes are big at the root of the Chinese stock market volatility. Meng et al. (2013) do the research is also the BRICS countries, but the research emphasis on the four countries of the stock market is different. Meng et al. (2013) focus mainly on the dependency of the stock market in the four BRICS countries, rather than the stock market risk. With the copulas-GARCH model to research, they found the correlation of fluctuations between BRICS stock markets and proved strong volatility spillover effect among these countries.

The relatively simple and useful method is us beta coefficient to describe the market risk. However, the beta coefficient is too abstract, and thus the scope of application is not widespread. By contrast, the model is the CAPM model and VaR model are more popular in the international market. The first is the capital asset pricing model; the model is based on markowitz portfolio selection (1952). Markowitz describes the benefits and risks with the mean variance and out of the way precisely. Followed by the scholars William Sharpe, John Lintner, Jack Treynor and Jan Mossin (1964), the modern capital asset pricing model was set up within markowitz theory, and the model for the first time defined the expected return as the risk-free return with systemic risk multiplied by excess returns. Then, Black et al. confirmed the validity of the beta. In addition to the CAPM model, the VaR model is another international popular model. Similar with CAPM model, the VaR model is also originated from the theory of variance - covariance Markowitz with quantitative analysis of variance, thus the modern theory of risk was created. And then J.P.M outraged consortium created the most famous of the VaR model (Risk Metrics) in the 1990s, which brought the rich practical applications of the model.

For the use of VaR model, however, one of the most important thing is to estimate conditional variances, and the best method is to use GARCH model to forecast. GARCH model was developed based on the the autoregressive conditional variance model (ARCH) proposed by Engle (1982). Bollerslev extended it to a common GARCH model at present. Compared with the domestic investment research analyst, foreign research institute do research in securities analysis with the family of GARCH model. Foreign experts' development of the ARCH model type and the application of GARCH model for time series analysis are more comprehensive, especially on the research of the financial sector, which has deep into the all aspects, not only for U.S. stocks and the stock market risk analysis. Ajitha et al. (2013) once estimated the risk of the s&p 500 and nasdaq index respectively in different ways (historical experience and GARCH model method), and the comparison of results show that the method of GARCH model for predicting volatility significantly better

than the method of historical experience. At the same time, Ajitha admits that, for a specific market to specific analysis, the relation of data cannot treat as the same in all markets. In addition, they also think that the method of VaR model in options trading, demand forecasting, etc will have good performance.

Korkmaz (2002) also used the GARCH model and EWMA model, and had carried on the comparative analysis to ISE30 index as the target, by calculating the index of the volatility and volatility of individual stock returns to compare the advantages and disadvantages of two kinds of model. According to the results of GARCH model, its calculation accuracy is obviously better than that of EWMA. This is similar to the research result of Mohammad (2002) and Edilberto (2010). Mohammad used the GARCH model, GARCH-M model and EGARCH model to predict the future trend of the S&P 500. From the historical trend of the S&P 500 with more than 3000 data, the establishment of the model is found after EGARCH model to fit GARCH-M model and the simplest GARCH model has relatively larger error. Edilberto (2010) studied of Brazil and the dow Jones index, he found that in a normal situation, EGARCH model is significantly superior to the ARCH model, which is similar to the previous research results.

By using asymmetric GARCH (1, 1) model, Rim Khemiri (2011) compared the market risk of four major index in the world, including the standard &poor's (S&P 500), Amsterdam index (AMSTOE), Hong Kong (Hong Kong) and the London index (the FTSE100). The result shows that Hong Kong stock market has the most rush thick shadow, and the volatility of the stock market is the largest. Comparing among the four markets, the S&P 500 index is most close to the normal distribution with less volatile and the most sound. The London and Amsterdam index are in the middle, and the Amsterdam's average income is the highest among the four countries.

Emerging world countries such as China's securities market has a very short development history. For example, the study of the VaR model was only introduced into China from 1997, at that time people still took it in the stage of theoretical understanding and promotion, and the consciousness of risk control is not strong caused by congenital disadvantage. In recent years, although many countries have begun to use VaR theory to credit assets of the commercial Banks configuration (Qian, 2009), but overall, the proportion of commercial Banks using VaR model is still very low. Not only that, the analysis of the stock market risk is only stay in the Shanghai and Shenzhen index in the comparison of yield and risk (Liu, 2005), and other aspects research. Foreign countries, such as Europe and the United States and other countries, have more one step ahead. In addition to using more complex GARCH family models to predict the VaR value, they also widen the research scope of VaR, not just stay on the benefits of research. Such as the correlation of the stock market risk analysis under the globalization, seasonal stock market risk analysis and so on. Arguably, there is also a trend of future research in emerging countries and developing countries, research often cannot just stay on the study of the stock market to estimate the stock market volatility risk, many other factors (such as

globalization, seasonal) should also be considered into the analysis of the volatility, which will make the results more reliable. Not only that, the use of GARCH-VaR model will go deep into the all aspects of society predictably, and the birth of each portfolio will accompany with the risk control model. Among them, as the most frontier GARCH model in the calculation of risk will have more attention.

**4. Methodology:** In recent years, the most popular risk management practicing model is the value at risk model, also known as value at risk. Value at risk (VaR) model measures the largest loss that the financial assets may suffer within a certain confidence interval. This model was presented by Markowitz in 1952. He adopted the mean-variance method to calculate the volatility of financial portfolio returns. From then on, people began to quantitatively calculate the risk of financial market portfolio. And after that, the Engle (1982) found the classical subschema theory and the actual difference namely heteroscedasticity in many cases, and consequently the autoregressive conditional heteroscedastic model was put forward in order to eliminate the volatility clustering, which makes the VaR estimates more accurate. It is worth mentioning that, compared with other risk measurement model, the VaR model can express the risk of a financial asset very explicit, and other risk measurement model has many flaws. For example, in CAPM model, if it is not only a single asset risk measurement, the beta is too abstract and difficult to form the perceptual knowledge, which can be offset in the VaR model. In other words, the value of the VaR is the abstraction of a set of financial assets of financial risk, and could express the actual loss, therefore gets more and more widely attention. For the calculation of VaR value, based on the definition of Jorion, VaR can be expressed as the future value of the asset minus under a certain confidence level of the minimum value in the future. VaR measures the most likely cause of loss, also is the "worst case", under a certain confidence level. And when calculating VaR value, you must use the price of the asset, the conditional variance and confidence level. The expected value of the asset minus the final one will be expected at the lowest possible value within a certain confidence interval obtained the value at risk (VaR).

In general there are three ways to measure the VaR. The first one is a Delta-normal distribution method, this method assumes that the data approximately obey the normal distribution, and according to the degree of confidence and quantize to calculate the value at risk. The advantage of this method is easy to calculate, and to calculate the risk value from the Angle of the combination. The second one is historical simulation method. It is very similar to the first method. The history simulation method is to estimate the future profit and loss with the portfolio of income distribution. This estimation method has assumptions that assets have fat-tailed features and the change of the market in the future and the past are completely consistent, and this is not conforming to the reality. The third one is the Monte Carlo simulation. Similar to the second method, the historical simulation method is carried out in accordance with the history of quantize estimates that the Monte Carlo simulation is using random computer simulations to estimate the random pattern. Although the Monte Carlo simulation method is the most accurate, but due to its large amount of calculation,

computer simulation requires a lot of sampling process, and thus hard to promote the use. In this paper, we use GARCH model to calculate the VaR value.

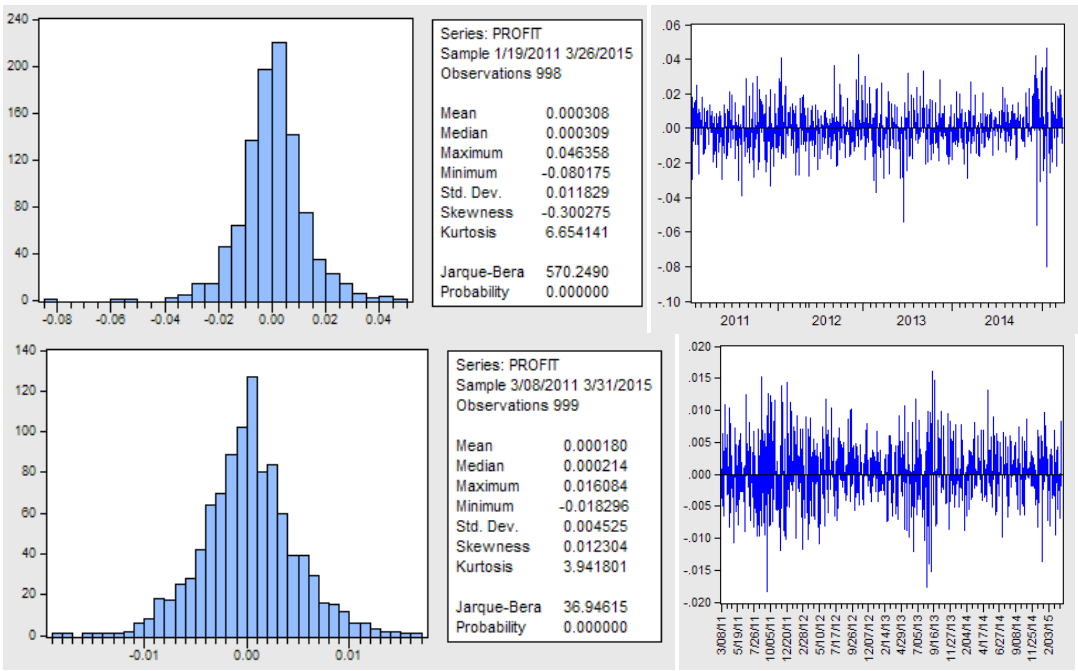
## 5. Data and results:

**5.1 Data analysis:** This paper takes the data for the closing price of the BRICS stock index as sample data, including China's Shanghai index, Russia's RTS stock index, SENSEX30 and the Brazilian IBOVESPA stock index from the great wisdom stock system. We use EVIEWS6 software foyer to make the results more accurate and comparative. The data we choose is roughly in the same period of 2011-2015. Since the securities market opening date and the National Day holiday period vary slightly in different countries, we use distinct period. When calculating the yield and the calculation of VaR, there is sample loss, and we use samples of 998, which does not affect the accuracy of measurement.

Since our study focuses on the four index yield, as a result, we calculate the yield of the indexes to show the situation of logarithm yield, which expressed as:

$$R_t=\log P_t-\log P_{t-1}$$

$R_t$ is the logarithm yield of indexes, $P_t$ is the BRICS index day closing index. We use EVIEWS to test the normality and heteroscedasticity, and the results are shown in Figure1 followed.



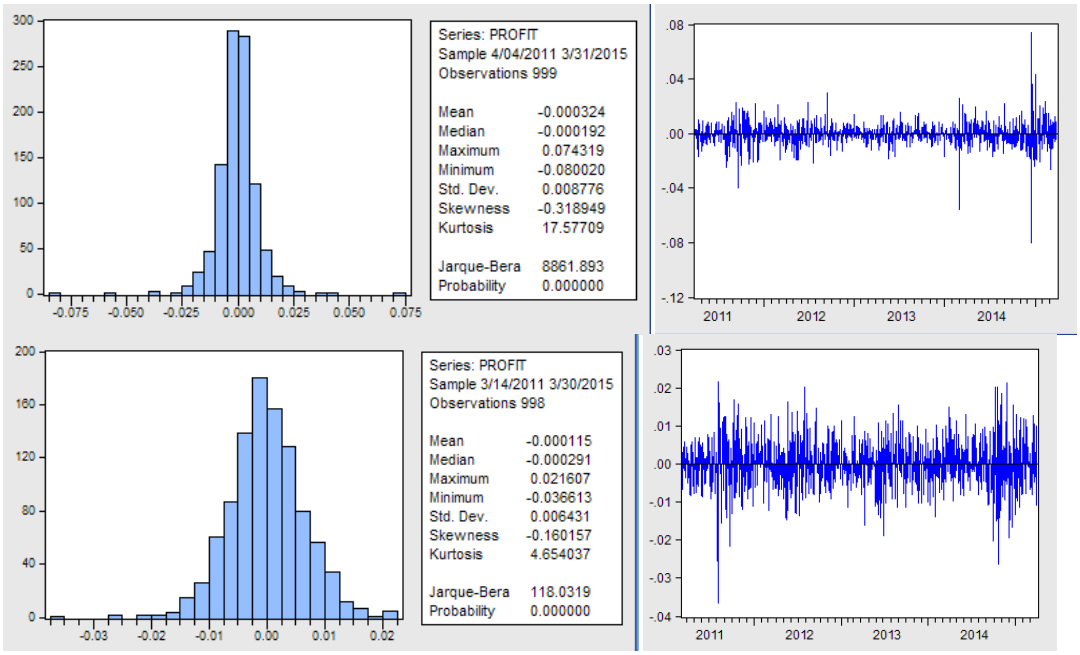



Figure1 Data analysis Results

According to Figure 1, results of the Shanghai composite index can be seen from the above results. The Shanghai index volatility has obvious heteroscedasticity namely large fluctuations, with large fluctuations in small fluctuations with small fluctuations. Not only that, the Shanghai composite index yields also exist obvious rush fat-tailed features, its kurtosis is 6.65, significantly greater than the normal distribution of kurtosis value 3, and the skewness value of the Shanghai composite index is 0.3, belong to the left with the mean of 0.000308. The average yield of Shanghai index is not high. Indian also has heteroscedasticity as that of the Chinese stock market, the high yield and low yields have gathered. However, relative to the peak fat-tailed features of Chinese stock market, the India index is closer to normal distribution. The kurtosis is 3.941801, which is relatively close to the normal distribution of 3, right slightly, the mean is 0.000180, close to zero. And the average income is not high also. Stock index in Russia also has great volatility and the characteristics of the present clustering. The characteristics of rush thick tail and the kurtosis reached 17, is far higher than that of the normal distribution. Similarly, there also have left characteristics, and the mean value is -0.000324, which means that Russia's income is very low and negative. Brazil's stock index has kurtosis value of 4.65, and has obvious peak thick tail like the other three indexes. Similarly, it also has left and volatility clustering features with the mean value of 0.000115, and the average yield is negative. In order to find whether the BRICS indexes yield are stable, we do ADF unit root test of the four indexes, as followed.

Table 1 ADF unit root test

| | | t-Statistic | Prob |
|---|---|---|---|
| Shanghai securities composite index | | -31.17200 | 0.000 |
| SENSEX30 Index | | -29.17013 | 0.000 |
| RTS Index | | -30.84821 | 0.000 |
| IBOVESPA Index | | -32.26584 | 0.000 |
| Test critical values: | 1% level | -3.436689 | |
| | 5% level | -2.864227 | |
| | 10% level | -2.568253 | |

According to the results of Table 1, we can find that the Shanghai index is 31.17200, far less than the critical value of 1%, 5% and 10%, which means that the data is smooth and reject the null hypothesis that there is no unit root. ADF statistic of SENSEX30 index is 29.17013, which is far less than the critical value of 1%, 5% and 10%,, which means that the data is smooth and reject the null hypothesis that there is no unit root. ADF statistic of Russia's RTS stock index is 30.84821, which is far less than the critical value of 1%, 5% and 10%, which means that the data is smooth and reject the null hypothesis that there is no unit root. ADF statistic of Brazilian IBOVESPA stock index is 32.26584, which is far less than the critical value of 1%, 5% and 10%, which means that the data is smooth and reject the null hypothesis that there is no unit root.

**5.2 The regression results of GARCH model and calculation:** From the analysis results of the previous data, the yield of Shanghai stock index has rush fat-tailed features. Since there is no linear relationship of the stock yields, we use stock index closing price as sample for analysis. According to the results above, it is thought that the T distribution should be used for linear regression, using the normal distribution may lead to larger error. From the analysis results, the Shanghai securities composite index does not have the phenomenon of significant autocorrelation. First of all, we establish a general linear regression model:

$$Logp_t=Logp_{t-1}+U_t$$

In order to verify the existence of the ARCH effect, we need to test the ARCH-LM effect of the equation and find the higher order ARCH effect. Therefore, we need to establish a GARCH model. With many experiments, we found the GARCH (1, 1) model has a good fitting effect with the minimum AIC value. After establishing a GARCH (1, 1) model, we do regression and the results for the Shanghai composite index are shown in Table 3.

Table 3 The regression results of GARCH model

| Distribution | γ | $a_o$ | α | β | AIC | $R^2$ |
|---|---|---|---|---|---|---|
| GARCH-N | 1.000013 | 4.45E-06 | 0.048214 | 0.919254 | -6.097123 | 0.992832 |
| GARCH-T | 1.000021 | 3.7E-06 | 0.034483 | 0.940592 | -6.161578 | 0.992833 |
| F-Statistic | 1.801020 | | Prob.F(1994) | | 0.1453 | |
| Obs*$R^2$ | 5.395445 | | Prob.Chi-Square(1) | | 0.145 | |
| EGARCH-N | -0.302261 | 0.113173 | 0.004320 | 0.975522 | -6.094322 | 0.992833 |
| EGARCH-T | -0.260695 | 0.085356 | 0.001389 | 0.977604 | -6.157445 | 0.992833 |

| | | | |
|---|---|---|---|
| F-Statistic | 2.013921 | Prob.F(1994) | 0.1103 |
| Obs* $R^2$ | 6.029378 | Prob.Chi-Square(1) | 0.1102 |

From the estimated results of GARCH model we find estimates are significant. And the distribution of T-performance is superior to the normal distribution which is better than that of the original equation. And $a_{o+}\alpha+\beta<1$, meet the constraint conditions. We test the first-order ARCH-LM of GARCH (1, 1) model again, it can be seen that the model has no ARCH effect. According to the formula of VaR, we get statistical values of VaR results as shown in Table 4.

Table 4 GARCH-VaR statistics

| | Model | Mean | Maximum | Minimum | Standard deviation |
|---|---|---|---|---|---|
| Shanghai securities composite index | GARCH-N | 55.088 | 161.743 | 33.805 | 18.534 |
| | GARCH-T | 56.328 | 149.733 | 36.131 | 17.959 |
| | EGARCH-N | 55.091 | 145.456 | 30.508 | 18.011 |
| | EGARCH-T | 56.133 | 134.983 | 33.384 | 17.081 |
| SENSEX30 Index | GARCH-N | 401.340 | 675.289 | 254.476 | 77.243 |
| | GARCH-T | 402.035 | 687.989 | 245.796 | 79.893 |
| | EGARCH-N | 396.730 | 612.981 | 260.318 | 75.160 |
| | EGARCH-T | 397.008 | 617.935 | 254.752 | 78.150 |
| RTS Index | GARCH-N | 48.074 | 127.524 | 31.072 | 13.441 |
| | GARCH-T | 47.661 | 107.952 | 30.177 | 13.275 |
| | EGARCH-N | 46.725 | 86.452 | 27.874 | 11.382 |
| | EGARCH-T | 46.528 | 86.742 | 25.592 | 12.105 |
| IBOVESPA Index | GARCH-N | 1566.195 | 3015.471 | 1061.381 | 319.973 |
| | GARCH-T | 1563.670 | 2849.120 | 1069.910 | 307.187 |
| | EGARCH-N | 1550.881 | 2771.114 | 1035.260 | 301.598 |
| | EGARCH-T | 1549.692 | 2707.713 | 1044.916 | 296.122 |

**5.3 Robustness testing of VaR:** In this paper, we have calculated the VaR value of BRICS stock markets within variety models. In this section, we are trying to analyze the effectiveness of the BRICS stock markets mainly. We use the failure test method to test the BRICS data with the confidence level of 95%, and the results are shown in Table 5. In the process of VaR measurement, there must be some VaR values lower than the 95% confidence interval, and the tests for the VaR values will be transformed to that if the exceed 95% of the range is belong to a particular probability problem. Kupiec (1995) testing method is based on the theoretical basis. The critical value of LR statistic under the confidence level of 95% is 3.841. In addition to the Shanghai composite index of GARCH (1,1)-T distribution, EGARCH (1,1)-the Gauss distribution, and EGARCH (1,1)-T distribution didn't pass the test, all the other results have passed the inspection. Therefore, we concluded that the VaR values calculated are effective.

Table 5 Robustness testing results

| | Model | Failure days | Failure rate | LR statistic |
|---|---|---|---|---|
| Shanghai securities composite index | GARCH-N | 72 | 0.072 | 3.6195 |
| | GARCH-T | 81 | 0.081 | 7.4594 |
| | EGARCH-N | 82 | 0.082 | 7.9130 |
| | EGARCH-T | 83 | 0.083 | 8.3782 |
| SENSEX 30 Index | GARCH-N | 42 | 0.042 | 1.4214 |
| | GARCH-T | 39 | 0.039 | 2.7468 |
| | EGARCH-N | 34 | 0.034 | 3.7055 |
| | EGARCH-T | 31 | 0.031 | 3.7954 |
| RTS Index | GARCH-N | 54 | 0.054 | 0.3286 |
| | GARCH-T | 64 | 0.064 | 3.8054 |
| | EGARCH-N | 51 | 0.051 | 0.0209 |
| | EGARCH-T | 48 | 0.048 | 0.0852 |
| IBOVESPA Index | GARCH-N | 56 | 0.056 | 0.7307 |
| | GARCH-T | 57 | 0.057 | 0.9889 |
| | EGARCH-N | 44 | 0.044 | 0.7884 |
| | EGARCH-T | 43 | 0.043 | 1.0806 |

**6. Comparative analysis of VaR results:** From the perspective of the statistic results of LR, only the GARCH (1, 1)-Gauss distribution for the Shanghai securities composite index passed the inspection. According to the measurement results of the GARCH (1, 1) model, the mean value of VaR is 55.0881, the largest VaR value is 161.7435, the minimum value is 33.8054, and the standard deviation is 18.5341, which is the largest one. From the point on the choice of model, whether we use normal distribution in GARCH (1, 1) model or EGARCH (1, 1) model, its standard deviation is greater than that of T distribution, which means that the VaR calculated values fall under volatile. Not only that, results using estimated with T-distribution have the biggest drop accordingly. From the point of failure number and failure rate, the actual failure number of each model is greater than the estimates in theory, and thus underestimated the risk.

Based on the LR statistic and the critical value of 3.841 under the 95% confidence level, all the four models for SENSEX30 stock index have passed the inspection. From the point of the final results, the standard deviation for the Indian market volatility with the T distribution model is larger. Using the VaR model to estimate India's biggest loss index, average value is around 400. Among them, the estimated results with GARCH model do slightly greater than the estimated using EGARCH model do. From the perspective of a model to estimate the failure number and failure rate, all models overestimate the risk value, more conservative.

From the point of view of LR statistic results, four models of Russia's RTS index are passed the inspection. And from the estimates of the model, using EGARCH model method to estimate the VaR value is significantly less than the value of using GARCH method. Not

only that, the VaR sequence volatility is also smaller accordingly. From the point of using different distribution, estimated value of T-distribution is less than that of the normal distribution. From the perspective of the number of failures, GARCH (1,1) normal distribution model, GARCH (1,1) T distribution and the EGARCH (1,1) model of normal distribution model of the actual failure number is greater than what we forecast, and thus underestimated the risk. Failure rate of EGARCH (1, 1) model with T distribution is less than what we forecast, and thus overestimated the risk, from the perspective of the risky situation of Russian stock market actual, we believe that using EGARCH (1, 1) T distribution model is appropriate.

From the point of LR statistic, under the confidence level of 95%, the four models for the Brazilian IBOVESPA stock market index passed the inspection. From the point of the measurement results of VaR, VaR values estimated are around 1550. Maximum VaR value is estimated in the GARCH (1,1) with normal distribution, and minimum value of VaR estimated is in the EGARCH (1,1). The VaR results with the EGARCH (1, 1) model are significantly lower than that of the GARCH (1, 1) model. From the perspective of the standard deviation of estimated VaR value, results of EGARCH (1,1) model with normal distribution or T distribution are less than that of GARCH (1,1), which means the model of VaR value is stable. From the point of failure tests, the actual failure times of results estimated with GARCH (1, 1) model are beyond the expected number and underestimate the risks. But the actual failure number of EGARCH (1, 1) model is less than what we forecast, and thus overestimate the risk value.

**7. Conclusion:** This paper focus on earnings volatility empirical research for the stock markets in BRICS countries. With the establishment of GARCH (1,1) model and the asymmetric model EGARCH (1,1) model, we calculate the BRICS stock markets gains in the hands of the conditional variance, and the corresponding value at risk, and finally we use LR statistic to determine the effectiveness of the model. Results show that, the Indian stock market is the most attractive market among the four markets, since it has the characteristics of high yield and low volatility, which is in accord with the reality. From the statistics of recent years, India's stock markets are only chanting. The stock market and its economy share the achievements of India's economic development, while the Chinese market is very accord with the characteristics of high yield high risk. A few years ago, China's stock market went downturn, completely contrary to China's economic growth. But in recent years, the stock market suddenly turns cattle with rare stock index growth rate in the world. Therefore, the Chinese stock market is not in conformity with those risk aversion preference, but for the intervention of speculative hot money or speculators. Compared with the previously mentioned two countries, Russian stock market and Brazilian stock market are relatively not so attractive. Russia is also a high-risk countries stock market, the stock market is closely related to economic, or even can be said that it is close related to be the price of energy. However, unlike China, Russia does not apply as much control policies. Thus, in Russia, investment risk is great. Finally, about the Brazilian stocks, properties of Brazilian stock market seem slightly better than that of Russia. Brazilian stocks are greatly

influenced by resource prices, which are the same as Russian. Unlike Russia, the market risk in Brazil is not so high, and due to the openness of the Brazilian market, the degree of marketization, which totally controlled by policy in China, is also higher than the other three BRICS countries.

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