Estimation of volatility for Hong Kong Growth Enterprise Market

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Abstract. In equity market, the volatility index is often derived from the options of the underlying assets, like VIX and VHSI. However, we can not calculate the volatility index for the markets which do not provide options products. In this paper, we try to solve this problem by developing the GARCH-type based model to measure the volatility in Hong Kong Growth Enterprise Market (HKGEM). The experiment results show that the proposed model can estimate the volatility effectively for HKGEM. Therefore, we can use the volatility modeled by GARCH to measure the financial risk for stock market. This result can provide decision support for investment in the financial markets with no options products.

Keywords: Volatility, GARCH, EGARCH, HKGEM

1. INTRODUCTION

Since the subprime crisis in US in 2008, academics, practitioners and regulators are paying more and more attention in modeling and forecasting financial markets volatility. Furthermore, the financial world has witnessed the financial disaster in Chinese stock market in 2015. These financial disasters further highlighted the significance of modeling and forecasting volatility in financial risk management. In recent years, the accurate forecasts of financial volatility still remain unsolved since the complexity of financial time series.

It has been widely accepted that the returns volatility of financial time series are characterized by a number of stylized facts, such as persistence, volatility clusters, asymmetry and so on. Since the generalized conditional heteroskedasticity (GARCH) model was created by Bollerslev (1986), this tool has become a popular tool for volatility modeling and forecasting. For example, Hartman (2005), Engel and Kennethen and Mark (2009) have indicated the connection between the exchange rate and econometric variables such as a nation's GDP, money supply and foreign reserves.

However, GARCH model has some drawbacks. One of them is it fails to capture the asymmetric volatility. In order to overcome this problem, the asymmetric GARCH models including the Exponential GARCH (EGARCH) of Nelson (1991) and the threshold GARCH by Glosten, Jagannathan, and Runkle (1993) (GJR-GARCH) are proposed. These models treat volatility more flexible by accommodating the asymmetric volatility to positive or negative shocks.

Although modeling volatility of stock index has been extensively studied popular stock markets such as S&P 500 and Heng Seng Index (HSI), few researchers has paid attention to the lower volume market, such as Hong Kong Growth Enterprise Market (HKGEM). In this paper, we mainly resort to GARCH and EGARCH model to estimate the index volatility of HKGEM.

The remainder of this paper is organized as follows. Section 2 reviews the HKGEM stock market. In Section 3, three GARCH family models are proposed and the empirical experiment is conducted in Section 4. Finally, Section 5 concludes the paper.

2. HKGEM STOCK MARKET

Hong Kong is the gateway to mainland China and has close business links with other economies in Asian region. Since it is a strategically important this high-growth region, Hong Kong has developed into an internationally renowned financial center during past years, providing an opportunity to raise funds for many Asian companies as well as multinational corporations. However, companies with the growth potential, especially those in emerging companies (those companies with good business concept and growth potential) are not necessarily able to take advantage of these opportunities. Many of these companies also failed to comply with the Hong Kong Stock Exchange prior market (i.e. board of the Stock Exchange) according to predetermined profit / aspects of business records and therefore can not get listed status. HKGEM is specially designed to fill this vacancy and set seam.

GEM offers fund-raising channels for companies having growth potential. It is not necessary to have good profit track record for companies to be listed on GEM. As a result, companies with growth potential can raise funds through market for development purposes, so that they can grasp the opportunities of growth in the region. For international companies with growth potential, they can improve product visibility listing on the GEM to strengthen their business in China and Asia.

Moreover, GEM provides investors with an investment choice of "high-growth, high-risk". For a company with growth potential (especially those who do not have record profits), the future performance is susceptible to great uncertainty. Because of the higher risk, the GEM is designed for professional and well-informed investors. The philosophy of GEM is "caveat emptor" and all the risks have to been borne by investors themselves.

In addition to providing a capital raising channel, GEM's special identity promotes the development of high-tech industries in Hong Kong and the region. GEM is opened to all companies with growth potential market, no matter what the scale is. Among these companies, the technology industry companies are most appealing because the nature of business coincide with the clear-cut gem "growth" theme. By providing capital raising channels as well as giving a clear positioning to high-tech companies, the GEM plays a complementary effect with Hong Kong Government to promote local technology business.

Finally, GEM promotes the development of venture capital investment. For venture capitalists, the GEM is not only sales channels for investment, but also a good place to further raise funds, helping venture capitalists to invest more and making investments in earlier stages of development to benefit the whole industry.

3. THE GARCH-BASED VOLATILITY MODELS

The GARCH-type model can be classified into two categories: symmetric model and asymmetric model. In symmetric model, the future volatility of the market is only based on magnitude of the financial time series. Whereas the future volatility modeled by asymmetric models depends on not only the magnitude, but also the sign of the financial time series.

In this study, we mainly explore both symmetric (GARCH) and asymmetric (EGARCH) models to model the volatility of HKGEM market.

3.1 The Generalized Autoregressive Conditional Heteroscedastic (GARCH) Model

GARCH model is the generalized version of Engle (1982)'s ARCH model In this study, we firstly apply GARCH model to study the features of volatility of HKGEM. In fact, the conditional variance of GARCH model is based on its own past lags. That means in GARCH(p,q) model, the current conditional variance is dependence on p past conditional variance and q past innovations. The form of GARCH(p,q) model is as follows:

$$\sigma_t^{\,2} = \omega + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 \qquad (1)$$

where p is the number of past σ^2 lags and q is the number of past ε^2 lags. And q determines the current σ^2. In this paper, we choose both p and q equal to 1 and the GARCH(1,1) model becomes:

$$\sigma_t^{\,2} = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \qquad (2)$$

$$r_t = \mu + \varepsilon_t \qquad (3)$$

where $\omega > 0$, $\alpha_1 \geq 0$ and $\alpha_1 \geq 0$, which ensure σ^2 is strictly positive. r_t is the return of an asset at curren t time. μ is the average return. ε_t is the residual ser ies, defined as,

$$\varepsilon_t = \sigma_t z_t \qquad (4)$$

where z_t is an *i.i.d.* random variable with mean 0 and variance 1.

The GARCH model specifies the conditional variance is determined by a constant term, last period squared residuals ε_{t-1}^2 and last period forecast variance σ_{t-1}^2. Thus, we can model current variance by forming a long term average, the last modeled variance and the information of volatility from the last period.

3.2 The Exponential GARCH (EGARCH) Model

Although GARCH is able to model some of the volatility characteristics, like clustering and fat tail. However, it is poor at modeling the leverage effect. Because the conditional variance is just related to the past magnitude and does not consider the role of sign. In order to capture the asymmetry of the leverage effect, we introduce the widely used EGARCH model. This model was first developed by Nelson. The form of this model is as follows:

$$\log\sigma_t^2 = \omega + \sum_{i=1}^{p}\beta_i \log\sigma_{t-i}^2 + \sum_{j=1}^{q}\alpha_j\left[\frac{|\varepsilon_{t-j}|}{\sigma_{t-j}} - E\left\{\frac{|\varepsilon_{t-j}|}{\sigma_{t-j}}\right\}\right] + \sum_{j=1}^{q}\gamma_j\left(\frac{\varepsilon_{t-j}}{\sigma_{t-j}}\right) \quad (5)$$

where coefficient γ_j is expected to be negative. Under same magnitude of variation, the positive return will bring less influence to volatility then the negative one. In our study, we assume the innovation follows Gaussian distribution. Then,

$$E\left\{\frac{|\varepsilon_{t-j}|}{\sigma_{t-j}}\right\} = E\{|z_{t-j}|\} = \sqrt{\frac{2}{\pi}} \quad (6)$$

To capture the asymmetric of the GEM index volatility, we use the EGARCH(1,1) model in this study. The form of EGARCH(1,1) is as follows:

$$\log\sigma_t^2 = \omega + \beta_1 \log\sigma_{t-1}^2 + \alpha_1\left[\frac{|\varepsilon_{t-1}|}{\sigma_{t-1}} - \sqrt{\frac{2}{\pi}}\right] + \gamma_1\left(\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right) \quad (7)$$

$$r_t = \mu + \varepsilon_t \quad (8)$$

4. EMPIRICAL EXPERIMENT

4.1 Basic summary of the statistics

In this study, we use daily return of the GEM index from November 03, 2003 to May 31, 2016, making a total of 3103 observed data series. These data are downloaded freely from the official website of HKGEM.

When modeling financial time series, most researchers choose to model the log return of the financial time series. In this paper, we also get the log return by taking the natural logarithm of the first difference of the current GEM index and the previous index. The following formulation shows the way to calculate log return.

$$r_t = 100 \times \left(\frac{E_t}{E_{t-1}}\right) \quad (9)$$

where E_t and E_{t-1} are the GEM index at time t and t-1, respectively, r_t is the log return of the GEM index. Table I shows the summary of the end of day index of HKGEM.

Table 1. Statistics of daily HKGEM index

	Mean	Max.	Min.	Std.D
GEM index	768.6076	1.7939e+03	341.5500	339.6286

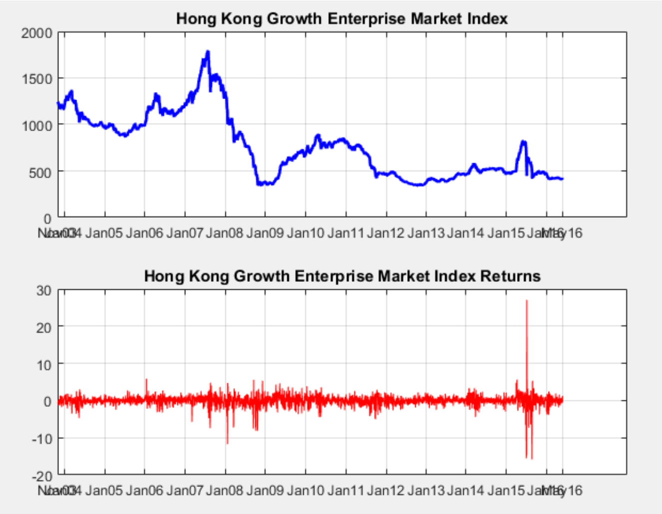

Figure1 : Plots of HKGEM index and return series

Table 2 describe the properties of daily return of HKGEM index. It is obvious that the return series do not follow normal distribution. Since the skewness does not equal to 0 and kurtosis is greater than 3. Furthermore, the the Jarque-Bera (J-B) test also confirms that the index return series are not are normal distributed. In order to further conduct our experiment, the Augmented Dickey-Fuller (ADF) test is applied to study whether the return series are stationary. Table 2 also shows that ADF test rejects the null hypothesis that the unit root exist, which means the index return series are stationary. Figure 1 presents the HKGEM index series and return series.

Table 2: Statistics of HKGEM index return series

	Mean	Max.	Min.	Std.D	Skewness	Kurtosis	J-B	ADF	ARCH-LM
Index return	-0.0348	27.0650	-15.8398	1.4807	0.1420	54.0312	3.3671e+05		

4.2 Results of heteroscedasticity test

The last column of Table 2 shows the results of ARCH-LM test. By investigating the residuals of returns series, we check whether the series exhibit conditional heteroscedasticity. It is clear that the results reject the null hypothesis and confirm the existence of ARCH effects.

4.3 Estimation of GARCH(1,1) model

In this study, we mainly use the Maximum Likelihood method to estimate the parameters of selected models. In table 3, the three parameters of GARCH(1,1), including constant ω, ARCH term α and GARCH term β, are estimated. The significance of ARCH term α displays the volatility clustering for the variance series. Since both ARCH term α and GARCH term β are significant, the present value of volatility is affected by past conditional variance and past squared residuals. In this way, the future volatility will be able to be forecasted by present volatility.

Table 3. Estimation results of GARCH(1,1) model

	ω	β	α	$\alpha+\beta$	μ
Index return	0.0517	0.8076	0.1739	0.9815	0.0032

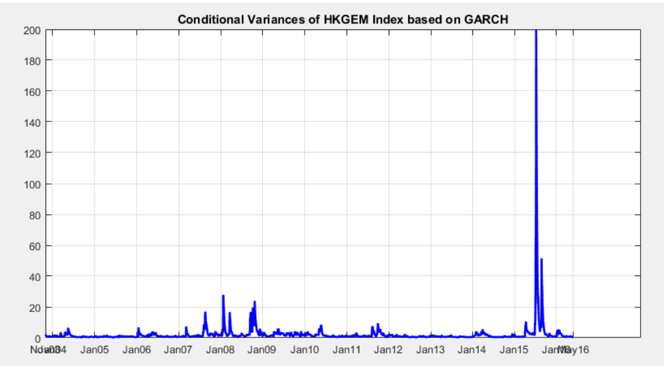

Figure 2: Conditional volatility of HKGEM index based on GARCH

Moreover, we can find that the sum of ARCH term α GARCH term β is smaller but very close to 1, indicating that the volatility in HKGEM market is quite persistent. Since the variance is not stationary in GARCH(1,1)，the shocks of index volatility are high and endless. Figure 2 plots the inferred volatility of GARCH(1,1) model.

4.4 Estimation of EGARCH(1,1) model

Table 4 shows the estimated parameters of EGARCH(1,1), including the constant ω, ARCH term α, GARCH term β and the EGARCH term γ. EGARCH term γ is negative, meaning that HKGEM index volatility is asymmetric. The negative γ suggests that the negative shocks affect the volatility more seriously than the positive shocks, indicating that the existence of leverage effect of HKGEM index return series. Figure 3 plots the inferred volatility of EGARCH(1,1).

5. CONCLUSION

This paper tries to study the behavior of Hong Kong Growth Enterprise Market and the characteristics of its volatility by both symmetric and asymmetric GARCH-type models with total 3103 daily observations from November 03, 2003 to May 31, 2016. The empirical results show that both GARCH and EGARCH can capture most of stylized facts about HKGEM index return series such as fat tail and volatility clustering. From the empirical experiment, we can also find that the volatility of this stock market index is highly persistent.

Table 4. Estimation results of EGARCH(1,1) model

	ω	β	α	γ	μ
Index return	0.0282	0.9519	0.3248	-0.0569	-0.0246

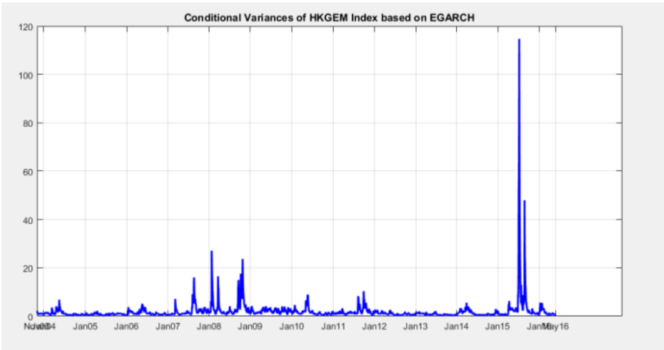

Figure 3: Conditional volatility of HKGEM index based on EGARCH

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