

Stock Exchanges Comparison between Mainland China and H.K. Based on the SVL Model

Jiahui Lin

School of Economics, Jinan University, Guangzhou, China

Email: karfy@sina.cn

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Abstract

In this paper, we consider the leverage effect on the CSI 300 Index yield and Hong Kong Hang Seng Index yield. It is modeled by the SV model with leverage. In this model, we compare the mainland and the Hong Kong stock market with stock market long-term effect, the degree on fluctuation reply and leverage effect so on. The analysis results show that the leverage stochastic volatility model can well fitting rate of return on the CSI300 index and the Hang Seng index in Hong Kong; The Shanghai and Shenzhen stock market volatility and leverage effect obviously stronger than the Hong Kong stock market.

Keywords

Volatility, Time Series Model, SV Model, Leverage, GARCH, MCMC Estimation

1. Introduction

In financial applications, a very important topic is to grab statistical properties of the yield of assets through the model. In the past few decades, the stock yield model has made great progress. From the initial Black-Scholes-Merton model's constant volatility, more complex and finer models are presented to capture the characteristics of stock prices. These features include the significant events of the stock market impact, fluctuations in the price of agglomeration, leverage effect, etc. There are two basic models for describing volatility: the ARCH conditional heteroscedasticity model proposed by [1], and the stochastic volatility model proposed by [2]. The ARCH model considers volatility to be a deterministic function of past volatility and asset returns, while the SV model considers vola-

tility as a dynamic latent variable. In practice, SV is more flexible than SV model, because SV is more flexible. Although the SV model can well describe most of the volatility behavior, the actual economic operation is more complex, so set a more sophisticated model into the practical application, the leverage effect is a large part of them. [3] compared the two kinds of SV models with leverage effects. A model is the application of Euler-discretization on continuous model obtained by discretization model, while another model is supported by [4]. The difference between the two is whether are related over the same period reflected in the leverage effect. The empirical results show that the leverage model performs better in the non-same period. The paper [5] constructed a stochastic volatility model with leverage effect and thick tail random error and jumping effect, using S & P index and Tokyo Stock Price index. Through the empirical comparison of different SV models, found in the New York stock market and the Tokyo stock market, thick tail distribution, leverage effect and jumping effect is significant.

The article [6] extended the Meta model into a binary SV model with leverage. This effect is cross here, not only reflected in the same between market return and volatility, but also between different markets. Through the empirical analysis of the composite index of different industries in New York stock market, it is found that the cross leverage effect is significant and the cross leverage effect between different industries is asymmetric. Utility index of leverage effect is very strong. On the one hand, compared with other composite index, the volatility is more susceptible to the influence of the yield. On the other hand, the utility index returns are very strong against the volatility of other industry indices, while the volatility of the composite index of other industry indices to the public opinion composite index is limited very much.

Also, domestic scholars have done a lot of research on the SV model of stock price. The article [7] first applied the basic SV model and its extended ASV (asymmetric stochastic volatility) model to predict the volatility of the Shenzhen stock market, and based on the symmetric and asymmetric evaluation criterions, compared with the predictive effect of the SV model and the common ones. This paper [8] established the SV family model to verify the predictability of the Shanghai stock market. It was found by the empirical results that the Shanghai stock market has a leverage effect, long memory and volatility persistence. Paper [9] worded for capturing the stock returns effect of good news and bad news under the asymmetric, the threshold effect and state-related leverage are introduced into SV model at the same time, and a double lever threshold SV (THSV-DL) model is proposed, modeling the volatility of asset returns.

2. An Introduction to the Model and Estimation Method

2.1. SVL Model Introduction

For stocks, it can often be observed a phenomenon is: if it changes in the market up or down, its volatility in the downward sliding process is higher than the volatility in the upward movement, which is called the leverage effect. Leverage is

important for the stock market, nevertheless the leverage effect of the exchange rate market is much lower. Compared with the basic SV model, the leverage effect SV model has an additional parameter, that is, the correlation coefficient. The model is as follows:

$$y_t | \theta_t, \rho = \exp\left(\frac{\theta_t}{2}\right) \varepsilon_t \quad (1)$$

$$\theta_{t+1} | \theta_t, \mu, \varphi, \tau, \rho = \mu + \varphi \times (\theta_t - \mu) + \tau \times \eta_{t+1} \quad (2)$$

$$\begin{pmatrix} \varepsilon_t \\ \eta_{t+1} \end{pmatrix} \sim i.i.d \ N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\right) \quad (3)$$

y_t represents the yield at time t , while θ_t represents the logarithmic fluctuation at time t . μ indicates the long-term effects of logarithmic fluctuations, depicting the extent of long-term logarithmic volatility. φ is said the reversion the logarithmic fluctuations, which reflects the extent to which the current volatility is affected by future volatility. ρ indicates the degree of leverage. When ρ is zero, the model above is the basic stochastic volatility model, which depicts the characteristics such as time-varying and agglomeration of fluctuation, but for the financial market, especially the common volatility in the stock market cannot depict asymmetric phenomenon. When less than 0, the above model called SVL model, which has the leverage stochastic volatility model, this model by income shocks ε_t and volatility impact η_{t+1} is negatively related to the asymmetry of volatility.

2.2. Idea about MCMC

There are the methods of estimating SV model parameters as follows: MCMC simulation, quasi-maximum likelihood (QML), generalized moment estimation (GMM), etc. The MCMC method is better and more flexible among them, since that on the one hand, MCMC simulation parameter estimation accuracy is superior to other methods; on the other hand, in the estimation parameters it can be predicted the forecast value at the same time. In this paper, MCMC simulation is used to infer the above model and predict the fluctuation.

The basic idea of the MCMC method is to establish a stable distribution $\pi(\theta)$ of the Markov chain, samples $\pi(\theta)$ were obtained by random sampling, based on these samples to do a variety of statistical inference. The key is to construct a stationary distribution $\pi(\theta)$ with a specified value. In general, it is followed three steps: (1) select a suitable Markov chain, the transfer probability of $p(*,*)$, so that the corresponding smooth distribution in $\pi(\theta)$; (2) by observing a certain point $\theta^{(0)}$ from the sample, using the Markov chain in (1) that produce point sequence $\theta^{(1)}, \theta^{(2)}, \dots, \theta^{(n)}$; (3), for an m and a sufficiently large n ,

$$E(\theta) = \frac{1}{n-m} \sum_{t=m+1}^n \theta^{(t)}. \quad (4)$$

At this point, $E(\theta)$ performs as the point of the estimation of θ .

3. Empirical Analysis

3.1. Sample Datas

This paper selects the Hong Kong's Hang Seng Index (110000) and the CSI 300 Index (000300) from January 2014 to July 2016, with a total of 587 trading days per index. Take the return on assets

$$r_t = \frac{P_t - P_{t-1}}{P_{t-1}} * 100\% , \quad (5)$$

where p_t is the closing price of t .

3.2. Exploratory Analysis

Figure 1 shows the timing chart of CSI 300 stock index and the Hang Seng index in Hong Kong yield time-sequence diagram. Observation above, we can see two index yield is basically additional fluctuations in 0, there is no obvious up or down trend, sequence is smooth. Compare two diagrams can be found that volatility of difference is obvious. Virtual is equal to the line for index, the Hang Seng Index in Hong Kong are basically within the range of fluctuation, yield more than only a few. While the CSI 300 index fluctuation volatility is significantly larger than the Hong Kong Hang Seng Index, whereas yield is more than many, has more than 2013/7, 2015/1, 2015/1. In addition, we can find that large fluctuations are always present. In the case of the CSI 300 Index, for example, there was a particularly large fluctuation in 2013/7, 2015/1, 2015/7, and there was a large fluctuation around these times, and in the period 2014/1, 2014/7, during this period, when fluctuations are small, and no extreme volatility particularly big.

The following **Table 1** shows the basic statistical results of the CSI 300 and the Hong Kong Hang Seng Index, where the variable y_{hs} represents the CSI 300 stock index yield and y_{hk} represents the Hang Seng Index yield. Similar to

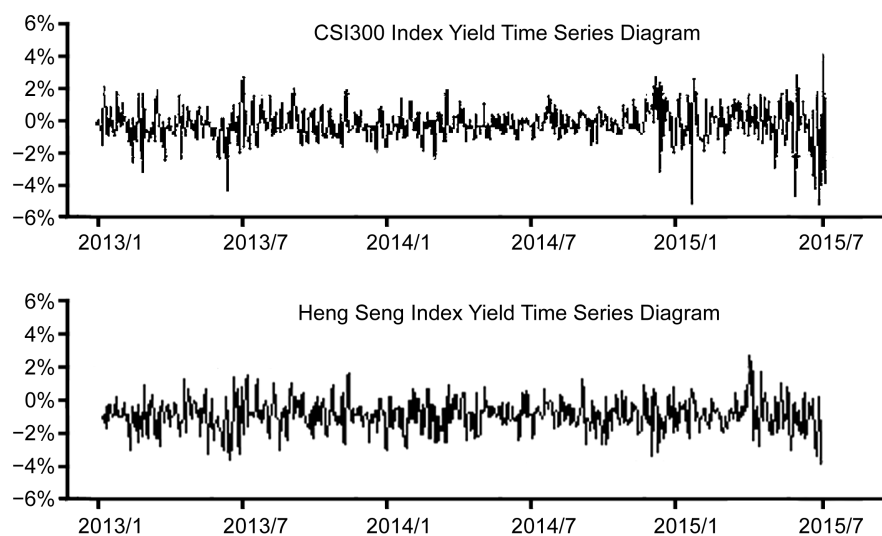


Figure 1. The CSI 300 Index and the Hang Seng index in Hong Kong yield time series diagram.

what's get in the observation on the chart, the yield on the CSI 300 Index is greater than the Hong Kong ones. The minimum and maximum returns of the CSI 300 stock index yield are almost 2 times of Hong Kong's Hang Seng index. Compared with the median return on Hang Seng index, CSI 300 stock index returns the median is far greater than zero. In terms of variance, the CSI 300 stock index is bigger than Hong Kong's.

Figure 2 for the two-index frequency histogram and normal QQ map. In the histogram, the solid line is the density curve of the index yield, and the dotted line is the density curve of the standard normal distribution. Observation of the histogram, we can find that both the CSI 300 index, and the Hong Kong Hang Seng Index, the distribution of the yield and the standard normal distribution are not the same, there are spikes behind the phenomenon. Observing the normal QQ figure, when a scatter all fall on the diagonal line, distribution is normal, but obviously on both sides of the diagonal, take away the feeling, the scatter in

Table 1. Comparison of commonly used statistics.

Basic statistics	y_hs	y_hk
Minimum	-7.8680	-3.1760
Median	0.0549	0.0021
Maximum	6.7150	3.8030
Mean	0.0800	0.0151
Standard deviation	1.5676	0.9522
Variance	2.4574	0.9067
kurtosis	3.9465	0.8539
Skewness ^a	-0.5390	0.0091

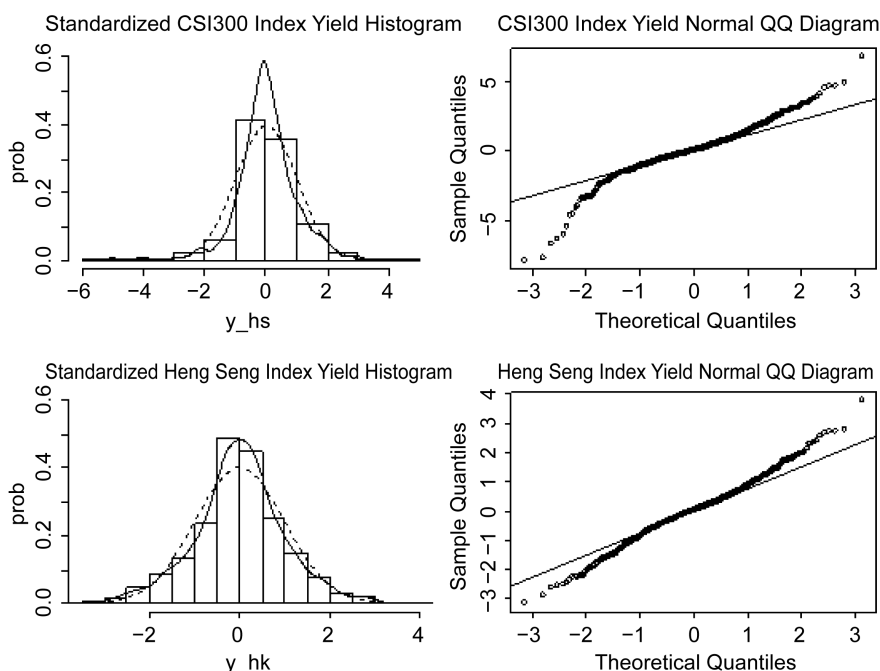


Figure 2. CSI 300 Index and the Hang Seng Index returns histogram, normal QQ diagram.

either the CSI 300 index, or Hong Kong's Hang Seng index, while the distribution of the yield is not a normal distribution. Besides, according to **Table 2** Shapiro-Wilk normality test, for the Shanghai and Shenzhen 300 index yield, W statistic of 0.94175, with the probability of p-value of $2.11\text{E}-14 < 0.05$, rejected the original hypothesis that the CSI 300 Index yield Disobedient to normal distribution. Similarly, the Hong Kong Hang Seng Index yield does not obey the normal distribution.

In conclusion, we can draw the following conclusions:

- The CSI 300 Index is more volatile and more volatile than the Hong Kong Hang Seng Index, indicating that China's stock market is more unstable.
- CSI 300 Index and Hong Kong Hang Seng are obviously fluctuation phenomenon of agglomeration, the yield distribution do not obey the normal distribution, there are the characteristics of peak tailing.

3.3. Analysis on SVL Model

3.3.1. Stationarity Test

As shown in **Table 3** above for the CSI 300 Index and the Hong Kong Hang Seng Index yield ADF test results. The original hypothesis is the existence of unit roots, the sequence is non-stationary. For the CSI 300 index yield y_{hs} , Dickey-Fuller = -6.1977 , corresponding to p-value = $0.01 < 0.05$, suggesting that is under the significance level of 0.05, rejects the original hypothesis that the CSI 300 index yield sequence is stable. Similarly, at the 0.05 significance level, the Hong Kong Hang Seng Index yield sequence is also a stationary series.

3.3.2. ARCH Effect Test

As shown in **Table 4** above for the CSI 300 Index and Hong Kong Hang Seng Index yield test results of the ARCH effect. The original assumption is that there is no ARCH effect. For the CSI 300 index yield y_{hs} , the ARCH effect of the LM

Table 2. Shapiro-Wilk normal inspection.

Variables	W	p-value
y_{hs}	0.9419	$2.11(*10^{-14})$
y_{hk}	0.9898	0.0003712

Table 3. ADF test.

Variables	Dickey-Fuller	Lag order	p-value
y_{hs}	-6.1976	8	0.01
y_{hk}	-7.0423	8	0.01

Table 4. LM test.

Variables	Chi-squared	df	p-value
y_{hs}	105.3	12	$2.19(*10^{-16})$
y_{hk}	31.27	12	0.001799

test of the chi-square statistic $\text{Chi-squared} = 105$, the degree of freedom $df = 12$, corresponding to $p\text{-value} = 2.20\text{E}-16 < 0.05$, indicating a significant level of 0.05, reject the original hypothesis, after that the CSI 300 index yield sequence exists ARCH effect. Similarly, at the 0.05 significance level, the Hong Kong Hang Seng Index yield sequence also exists in ARCH effect.

3.3.3. SVL Model Parameter Estimation and Analysis

Through the MCMC method, the parameters of the SVL model are estimated, and the iterations are 20000 times, and the previous 10000 times are removed and the parameters are estimated by the iteration value of 10000 times. With reference to the setting of the prior distribution of [10], the prior distribution of the parameters to be evaluated is as follows:

$$\mu \sim N(0, 100). \quad (6)$$

$$\varphi = 2 * \varphi^* - 1, \varphi^* \sim \text{beta}(20, 1.5). \quad (7)$$

$$\tau = \frac{1}{\sqrt{\tau^*}}, \tau^* \sim \text{Ga}(2.5, 0.025). \quad (8)$$

$$\rho \sim U(-1, 1). \quad (9)$$

Such as **Table 5** for the sequence of yield of the two index y_{hs} and y_{hk} parameter estimation results, output variables respectively μ , φ , τ , ρ posterior mean, a posteriori standard deviations, posterior 2.5% quantile, posterior 97.5%, and the statistic Rhat for judging convergence.

Rhat is the statistic for the MCMC convergence diagnosis based on the normal approximation proposed by [11]. The idea is to start multiple MCMC estimates of multiple strands from a large number of different initial values. The variance and intra-group variance were calculated from the estimated sequence generated at each initial value. If the construction of the model is effective and the convergence of the Markov chain is better, even if the initial value of the parameter is very different, it will converge quickly to the nearest value and fluctuate in the same value. Variance and the variance between the groups will be smaller. Specifically, the Rhat statistic is

$$\sqrt{\hat{R}} = \sqrt{\left(\frac{n-1}{n} + \frac{m+1}{mn} * \frac{B}{W} \right) \frac{df}{df-2}}. \quad (10)$$

Table 5. Result of model parameter estimates.

Series	Variable	Mean	sd	2.50%	97.50%	Rhat
y_{hk}	μ	-0.1962	0.1495	-0.5155	0.0795	1.0350
	φ	0.9460	0.0284	0.8795	0.9892	1.1280
	τ	0.1521	0.0442	0.0890	0.2524	1.1450
	ρ	-0.1828	0.1359	-0.3432	-0.0894	1.0430
y_{hs}	μ	0.7150	0.3224	0.0880	1.3950	1.0010
	φ	0.9764	0.0156	0.9374	0.9964	1.1160
	τ	0.1782	0.0402	0.1159	0.2725	1.1400
	ρ	-0.3598	0.1598	-0.6795	-0.0570	1.0320

where m is the number of initial values, $2n$ represents the total number of iterations, the first half of the n iteration values are removed, the n th iteration values are used for the second half, B is the variance between groups, W is the intra-group variance, df is the approximate T the degree of freedom of distribution. Conclusion in [11] suggested that when the Rhat is less than 1.2, the resulting Markov chain is convergent. With reference to this criterion, it can be seen from Table 5 that the estimates of the parameters μ , ϕ , τ and ρ of the model are convergent both in terms of the yield of the CSI300, y_{hs} , or the Hong Kong Hang Seng Index yield.

According to the characteristics of Table 5 and SVL model, we can see: μ represents the long-term effect of volatility logarithm. The CSI 300 index yield model has an estimate of 0.7150 and a 95% confidence interval of [0.08820, 1.3950]. The estimate of the Hong Kong Hang Seng Index yield model is -0.1962 and the confidence interval is 95%. [-0.5155, 0.0795]. Obviously, the CSI300 index yield model is estimated to be larger than the Hong Kong Hang Seng Index yield, and the interval between the CSI 300 Index yield model is entirely on the right side of the range estimate of the Hong Kong Hang Seng Index yield model. The As the logarithmic transformation is monotonous, so that the overall long-term fluctuations in Shanghai and Shenzhen stock market is far greater than the overall long-term fluctuations in the Hong Kong stock market. This is basically the same as our previous exploratory analysis. Compared with the Shanghai and Shenzhen stock markets, the Hong Kong stock market is more mature market, the long term, the volatility is relatively small. Shanghai and Shenzhen stock market volatility is relatively large, vulnerable to other external events.

ϕ stands for the return nature of logarithmic fluctuations, indicating that the current volatility will have a long-term impact on future volatility. The point estimate of the CSI 300 index yield model is 0.9764 and the confidence interval is 95%. [0.9374, 0.9964]. The Hong Kong Hang Seng Index yield rate is estimated at 0.9460 and the confidence interval of 95% is estimated to be [0.8795, 0.9892]. The point estimation ϕ of the y_{hs} model is slightly larger than that of the y_{hk} model, which is close to 1, and the interval estimates of the two are overlapped with a large part. Therefore, the Shanghai and Shenzhen stock markets and the Hong Kong stock market have almost the same degree of fluctuation. The nature of the return, which shows that the phenomenon of fluctuations in income agglomeration is obvious. The agglomeration of volatility is the persistence of risk, which reflects the long-term impact of current risks on future risks, which investors, especially long-term investors, do not want to see. For investors, both in Shanghai and Shenzhen stock markets or Hong Kong stock market, we must consider the sustainability of market risk.

ρ represents the degree of leverage on the rate of return on volatility. The point estimate of the CSI300 index yield model is what the interval of 95% confidence is estimated to be [-0.6795, -0.0570]. The estimation of the Hong Kong Hang Seng Index yield model is -0.1828 and the confidence interval of 95% is

estimated to be $[-0.3432, -0.0894]$. Whether the CSI300 Index yield or the Hong Kong Hang Seng Index yield, the 95% confidence interval does not include 0, and the points are estimated to be less than 0, indicating that the Shanghai and Shenzhen stock markets and the Hong Kong stock market there are obvious leverage effect. The absolute value of the point estimation ρ of the CSI300 index yield model is significantly larger than the absolute value of the Hong Kong Hang Seng Index yield model, indicating that the leverage effect of the Shanghai and Shenzhen stock markets is stronger than that of the Hong Kong stock market. In other words, when the market shows negative returns, the volatility impact in the Shanghai and Shenzhen stock markets is greater than which caused by the Hong Kong stock market. Negative correlation not only shows that stock market participants are often risk hobby, but also implies that the stock market speculation exists, which also evidence from a side of the mainland stock market is emerging stock market.

To sum up, we can draw the following conclusions:

- stock market volatility exist in both Shanghai and Shenzhen stock market and the Hong Kong concentration, the current market fluctuations, greatly affecting the market fluctuations would in the next issue, the instability yields..
- The volatility of the Shanghai and Shenzhen stock markets is larger than that of the Hong Kong stock market, partly because of the long-term characteristics of different markets and partly because the market leverage is not the same. The leverage effect of Shanghai and Shenzhen stock markets is greater, and the current volatility is affected by the previous period. It is obvious that the impact of the negative income in the previous period is greater than that of the positive income.

4. Conclusion and Prospect

This paper constructs the stochastic volatility model with leverage effect on the yield of Shanghai and Shenzhen 300 Index and the Hong Kong Hang Seng Index yield respectively, and compares the characteristics of Shanghai and Shenzhen stock market and Hong Kong stock market. Empirical results show that the mainland stock market long-term fluctuations in the larger leverage more. This shows that China's stock market is immature, and the market speculators occupy a large part. The market, some tiny events or news, is enough to make the market a strong volatility. In addition, China's stock market system and Hong Kong or Europe and the United States stock market system there are differences. In the transaction mode, the mainland market stock trading is taken by $T + 1$ trading, and Hong Kong stock market trading is taken by the $T + 0$ trading; in the trading varieties, the mainland market only stocks and funds, Hong Kong stock market, including Stocks, Hang Seng futures, options and other complex varieties of transactions. The Hong Kong stock market is more similar to the European and American stock markets. Therefore, some Hong Kong or Europe and the United States market mechanism does not necessarily apply to China's stock market. Not long ago short-lived fuse system, just four days, there have been two

closed. Each down to 5% of the suspension of trading points, after the resumption of trading, immediately fell to 7% of the day to stop trading points. This shows that the proportion of speculators in China's stock market is very large, a considerable number of people follow suit "investment". When you see the stock fell, a considerable part of the investors did not rational analysis, have to sell, resulting in further stock price drop. Therefore, the improvement of China's financial system, deepening the financial system reform, is still long way to go.

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