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An international Comparison of Volatility in Stock Market Returns Prior and Post Global Financial Crisis

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Abstract. The aim of this study is to compare the volatility in stock market returns prior and post global financial crisis. From the VIX, before the crisis, Taiwan's VIX is evidently higher than that of America's and Europe's. While after the crisis, Taiwan's VIX is mostly lower than that of America's and Europe's. In this study, the EGACH model is chosen for analysis. From the EGACH model we can determine two points. First, the Taiwan stock market is mainly influenced by the price information of the preceding day and has a relatively long fluctuation time and is following the high fluctuation cost regardless of before or after the crisis. Second, EURO STOXX 50 and S&P 500 have greater influences before or after the crisis on the negative information of the market prices. TAIEX does not seem to impact the negative information severely.

Keywords: global financial crisis; stock market returns; volatility; EGACH-M model

1. Introduction

The global financial crisis really started to show its effect in the middle of 2007 and into 2008. It is believed to have begun with the credit crunch, the sub-prime crisis and housing bubble issues in America. The collapse of Lehman Brothers on September 14, 2008 marked the beginning of a new phase in the global financial crisis, while many financial institutions later faced serious liquidity issues. Twenty-one developed countries' share indexes had dropped by 21% - the biggest decline in range since 1971. The whole world lapsed into an unprecedented economic crisis. America's economic decline severely affected various countries' exports, leading some export-oriented countries to fall into decline as well. The financial tsunami swept over the globe, impacting almost every country.

Taiwan is a small open economy; therefore it has a high probability of being influenced by developed countries. The Taiwanese economy is heavily dependent on exports, and during the financial crisis, the destruction of wealth in North America led to reduced demand for imports, which had a severe impact on Taiwan's export performance. The global financial crisis made its presence felt in Taiwan as Taiwan's forecast economic growth rate for 2009 was 3.34 percent, a sharp decline from a forecast 5.5 percent in 2008. Taiwan's share index also fell by half from its high of 9,303 on May, 2008.

In addition, those economies in Europe whose financial sectors had been highly internationalized and that were closely linked to the US were also badly affected.

While a number of macroeconomic and financial variables like GDP, interest rate, exchange rate, unemployment rate, etc., influence the stock market, this paper places an emphasis on a comparative analysis of Taiwan's stock market and that of America's and Europe's. The purpose is to find the difference in these three market fluctuations, explain the reasons for fluctuation in Taiwan's stock market, and provide information that hopefully is helpful for policy-makers.

2. Data description

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2.1. Data resource

A stock index can represent the general standards and changes in many stock prices. This thesis uses the share price index to weigh the changes in general stock prices (in the whole stock market), which, to a certain extent, reflect the change and tendency of the stock market.

I chose three stock indexes' daily closing prices as representation for stock prices - (A) and (B) as before and after specimens for Taiwan, S&P 500 (USA), and Europe's stock market, and used the EVIEW 5.0 software for analysis.

2.2. Data description

In this study, we analyze the closing price of stock indexes of Europe, America, and Taiwan, which are EURO STOXX 50, S&P 500, and TAIEX respectively. The information source of Europe and America's stock index is Yahoo! Finance (http://finance.yahoo.com) and the information source of Taiwan's stock index is Taiwan Economic Journal Co., Ltd (http://www.tej.com.tw/twsite/)

The data used in this paper cover the daily stock index of the three countries from 2005/1/4 to 2011/7/25. We can categorize the data into three periods: the whole period (2005/1/4 to 2011/7/25), before the crisis (2005/1/4 to 2008/9/13), and after the crisis (2008/9/14 to 2011/7/25).

Stock market returns:

$$R_t^i = (\ln P_t^i - \ln P_{t-1}^i) * 100\%, \qquad i = 1, 2, 3 \tag{1}$$

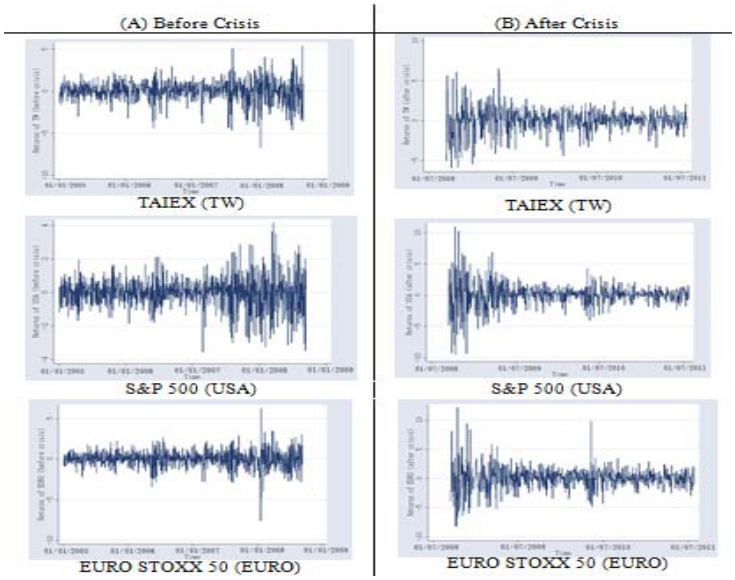

Fig. 1: The Stock Market Returns of America, Europe and Taiwan before and after Global Financial Crisis.

"Fig.1" is a comparison of stock price fluctuations in America, Europe and Taiwan. The fluctuation margins of America and Europe have obviously widened after the financial crisis (America's widening of margin was especially dramatic), but the financial crisis has not been continuous, and there are no severe impacts on Taiwan's fluctuation margin (Taiwan has price limits). Although recently the fluctuation margins of America, Europe and Taiwan have narrowed, they have not returned to their original fluctuation range of 2007.

Fig. 2: The graph above compares the volatility index between Taiwan, America and Europe.

2.3. VIX

After the global stock crisis in 1987, NYSE imported circuit breakers in 1990 to stabilize the stock market and protect its investors. These circuit breakers allowed us to observe dynamic fluctuations of the market. To measure the fluctuation rate of the market, the Chicago Board Options Exchange (CBOE) established VIX (Market Volatility Index) in 1993. The VIX represents one measure of the market's expectation of stock market volatility over the next 30-day period.

Before the crisis (shown to the left of the red vertical line on the graph), Taiwan's VIX is evidently higher than America's and Europe's.

After the crisis, (shown to the right of the red vertical line on the graph), Taiwan's VIX is mostly lower than America's and Europe's.

Table1. Descriptive Statistics

Index	TW			S&P 500			EURO		
	Entire period	Before crisis	After crisis	Entire period	Before crisis	After crisis	Entire period	Before crisis	After crisis
Mean	0.021	0.003	0.045	0.006	0.004	0.009	-0.005	0.010	-0.024
Median	0.081	0.051	0.118	0.083	0.079	0.100	0.011	0.023	-0.033
Std.	1.356	1.259	1.472	1.417	0.922	1.871	1.480	1.034	1.913
Skew.	-0.396	-0.528	-0.298	-0.260	-0.232	-0.226	0.207	-0.425	0.331
Kurt.	3.087	2.783	3.073	10.490	2.206	6.801	8.884	5.210	5.966
Jarque-Bera	683.08	332.66	285.73	7528.3	193.77	1368.5	5509.7	1092.6	1078.1
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ADF	-38.08	-30.50	-26.63	-34.04	-34.95	-22.99	-32.13	-33.8	-21.87
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sample size	1627	914	713	1651	929	722	1683	953	730

Note: The rows "Mean", "Std.", "Skew.", and "Kurt." stand for the sample mean, standard deviation, skewness coefficient, and kurtosis coefficient of the five indices.

"Table 1." reports descriptive statistics for these sample data. We can see that the European stock index was the most affected index after the crisis. Its mean and median are negative, and it has the biggest fluctuation. Taiwan's TAIEX was not nearly as affected. Its mean is five times that of the indexes of Europe and the USA.

The kurtosis coefficient of all three indexes for the entire period is greater than three, meaning that all the indexes have Leptokurtosis characteristics. The kurtosis coefficient of the indexes of both the USA and Europe is higher, which demonstrates its response from the impacts of the latest news. The p-value of the Jarque-Bera examination is far smaller than the significance level, so it doesn't conform to the normal distribution. The higher the Jarque-Bera value, the more obvious the character of Leptokurtosis, the further away it is from the normal distribution, and the greater the internal uncertainty.

ADF (Augmented Dickey-Fuller) is used to proceed with a unit root test on the data of the three-time series (Entire period, Before crisis, After crisis). The null hypothesis of the unit root was rejected, which shows that the three stock market returns are stationary.

3. Model construction and parameters estimation

3.1. Model construction

The daily stock market return's distribution usually has two characteristics. The first is "volatility clustering" as mentioned by Mandelbrot [5] (p. 418) "large changes tend to be followed by large changes-of

either sign- and small changes tend to be followed by small changes" This statement is observed in many financial applications. The second is a leptokurtic (with the sample kurtosis coefficient>3) and asymmetric distribution. This strongly rejects the Gaussian white noise hypothesis for the return sequence. What asymmetry refers to is that new information tends to cause volatility, and negative information generates a greater impact on volatility than positive information of the same magnitude.

A GARCH (generalized autoregressive conditional heteroskedasticity) model was proposed by Engle [3] and generalized by Bollerslev [1]; the GARCH-M model was introduced by Engle, Lilien and Robins [4]. Under the assumption of conditionally normal or t-distribution, the EGARCH-M model's coefficients are non-negative; therefore, the GARCH-M model cannot explain either the leptokurtic distribution or volatility clustering of the return series, especially not for the volatility asymmetry. To take the asymmetric volatility effect into account, some nonlinear mechanisms were introduced into the conditional variance specification of the GARCH model.

Nelson [6] developed the exponential GARCH (EGARCH) model and replaced the normality assumption of standardized innovations with the generalized error distributions assumption. We prefer the EGARCH-M model, which accommodated more precise estimations of the asymmetric relationship between stock price returns and volatility changes.

The EGARCH(1,1)-M model ：

Mean equation:

$$R_t^i = c + \lambda\sqrt{\sigma_t^2} + \sum_{i=1}^{p} a_i R_{t-1}^i + \sum_{i=1}^{q} b_i \frac{1}{i-j+1} \sum_{i=1}^{i} R_{t-1}^i + \varepsilon_t \quad , \quad \varepsilon_t = \sqrt{\sigma_t^2} Z_t \tag{2}$$

Variance equation:

$$\log(\sigma_t^2) = \omega + \alpha \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \beta \log(\sigma_{t-1}^2) \tag{3}$$

The mean equation takes the effects of various elements into account, such as risk premium and the course of ARMA(p,q). These elements' economic significance is as below: Most investors are risk averters. The bigger the stock fluctuation, the greater the return they expect from it; therefore, the more obvious the risk premium.

On how the i value was chosen; firstly, the software did a correlation analysis on the tacitly acknowledged lag 36 steps variables. And the value of p,q was chosen due to the ACF (Autocorrelation Function) and PACF (Partial Autocorrelation Function).

The σ_t^2 in equations (2) and (3) are conditional variance. The larger σ_t^2, the larger the range of stock price fluctuation. Generally speaking, σ_t^2 is a measurement for risk, and λ reflects the positive correlation between risk and return [2]. c and ω are both constants; they represent the non-risk returns of stock investment. ε_t is the error term series. Z_t is a process of standardization, its mean is zero, and variance is one.

Generally, we use the Lagrange Multiplier Test (LM Test) to test for the existence of the ARCH effect. This thesis uses the LM Test to examine the residual series of EURO STOXX 50, S&P 500, and TAIEX. If the p-value is less then significance level 0.05, this indicates that the outcome of the examination is significant, and that the residual series has an ARCH character. Using the maximum likelihood method and EVIEWS5.0 software to solve the equation set from above, we have the estimated value of maximum likelihood of all parameters from equation (2) to (3).

For results of the estimated value of each parameter, please refer to "Table 3".

Table2

location	The optimal model		
	Entire period	*Before crisis*	*After crisis*
TAIEX	AR(1)[a] EGARCH(1,1)	AR(1)[a] EGARCH(1,1)	AR(1)[a] EGARCH(1,1)
S&P 500	MA(1) EGARCH(1,1)	ARMA(2,1) EGARCH(1,1)	EGARCH(1,1)[b]
Euro 50	ARMA((2),(2)) EGARCH(1,1)	EGARCH(1,1)[b]	ARMA((1,4),(4,)) EGARCH(1,1)

Note: The symbol [a] indicates that it is enough to find the fitted model without the MA (Moving Average process) term to adjust the residuals. The symbol [b] indicates by the Q statistics and the graph of ACF, the PACF may judge the residuals are write noises，so we do not need to establish ARMA(p, q) to adjusts the residual item.

From "Table 2", in the ARMA process, we can see that in different nations the stock price returns are influenced by price information. Take TAIEX for example; regardless of before or after the crisis, it is mainly influenced by the price information of the preceding day. However, before the crisis, the S&P 500 index is affected by the previous two days; after the crisis, EURO STOXX 50 is affected by the preceding day and the previous four days. Yet the S&P 500 index of after the crisis and EURO STOXX 50 of before the crisis are simply not affected by the before price information. According to the market efficiency theory, in the weak-form efficient market, the present's price may reflect the beforehand price information, especially recent information. Therefore, the S&P 500 index of after the crisis and EURO STOXX 50 of before the crisis are more effective.

Table3

location	During time	$\hat{\lambda}$	$\hat{c}$	$\hat{\omega}$	$\hat{\alpha}$	$\hat{\gamma}$	$\hat{\beta}$
TAIEX	Entire period	-0.254**	0.35***	-0.105***	0.145***	0.108***	0.986***
	Before crisis	-0.229***	0.347***	-0.078***	0.111***	0.12***	0.99***
	After crisis	-0.574**	0.635***	-0.140***	0.18***	0.093**	0.939***
S&P 500	Entire period			-0.088***	0.117***	-0.108***	0.983***
	Before crisis			-0.051**	0.054*	-0.157***	0.971***
	After crisis			-0.061***	0.084***	-0.122***	0.986***
Euro 50	Entire period			-0.077***	0.108***	-0.17***	0.978***
	Before crisis					-0.220***	0.96***
	After crisis	0.048***	-0.0087***	-0.048*	0.08**	-0.17***	0.979***

Note: The symbol*** signifies significance at 1% level; the symbol** signifies significance at 5% level; the symbol* signifies significance at 10% level. Blanks indicate that the argument independent variable is insignificant at 10% level in regression, so it has been eliminated from the model.

3.2. Estimation and empirical result

From "Table 3", we can see that the $\hat{c}$ value of the European stock market is negative after the financial crisis, indicating that the non-risk repayment is negative in this market. Because the total returns ratio is equal to the non-risk rate of return plus the risk premium, and since all market average gross revenues are non-negative, therefore the high risk premium rises to make up for negative non-risk repayment, thus an investor might obtain an average return. In other words, as the high risk premium rises, it attracts risk investors by chance. In the condition variation equation, the constant $\hat{\omega}$ has promulgated a long-term fluctuation fixed cost. In table III, regardless of before or after the crisis, the TAIEX absolute value of $\hat{\omega}$ is higher than the other two indices. This indicates that the Taiwan stock market has a relatively long fluctuation time and is following the high fluctuation cost.

Another distinctive result is that the coefficient $\hat{\alpha}$ values of Taiwan are still the largest; this demonstrates that the Taiwan stock market has a very outstanding volatility clustering effect, and that the duration of its price fluctuation is longer. Once some kind of impact causes stock price returns to have an abnormal fluctuation, this kind of abnormal fluctuation is unable to eliminate itself in the short term (it may be because of the rise and decline percentage limit, which is why it was longer during times when Taiwan's stock market (both before and after the crisis) saw abnormal fluctuations.

Other than this, the result of the coefficients of $\hat{\gamma}$ shows that none of the indexes' coefficient is zero and all of the coefficients are significant, which means that the impact of information is not symmetrical; it is also an indication of the leverage effect mentioned elsewhere. From this, we can conclude that in EURO STOXX 50 and S&P 500, negative $\hat{\gamma}$ values mean the greater influences that negative information has on the market prices. TAIEX does not seem to have a severe impact on the negative information.

As can be seen by the empirical analysis above, compared with the other two stock markets, stock prices of Taiwan stock market volatility has shown a relatively long period. This is because of Taiwan has price limits, it is not possible to eliminate in the short term, it requires higher fluctuation cost to digest the risk which the fluctuation brings. In addition, due to the social stability and other reasons, it will usually carry on the guarantee to investor's investment loss explicitly or implicitly, such as, national security fund or postal funds into the stock market, so investors will relax their awareness of the risk and management, thereby affecting the volatility of asset prices, this action, whether really exists or only in concept, has affected investors in determining asset prices and volatility to a certain extent.

4. Conclusions

This article examines Taiwan, Europe and the U.S. stock market price fluctuations: From the VIX, before the crisis, Taiwan's VIX is evidently higher than America's and Europe's. While after the crisis, Taiwan's VIX is mostly lower than America's and Europe's. Obviously, investors in Taiwan are rather more opportunistic when investing in long-term investment holdings. From the EGACH model we can determine two points. First, the Taiwan stock market is mainly influenced by the price information of the preceding day and has a relatively long fluctuation time and is following the high fluctuation cost regardless of before or after the crisis. Second, EURO STOXX 50 and S&P 500 have greater influences before or after the crisis on the negative information of the market prices. TAIEX does not seem to impact the negative information severely.

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