Comparison of the Volatility of Stock Market Returns in Taiwan, USA and Europe

Hsiao-Fen Chang

***Abstract*—From the VIX, Taiwan's VIX is evidently higher than that of America's and Europe's before the sub-prime crisis. While after the sub-prime crisis, Taiwan's VIX is mostly lower than that of America's and Europe's. 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. Second, Negative information has a greater impact on the stock market in Europe and America. TWII does not seem to be affected by the negative information as severely.**

***Index Terms*—Global Financial Crisis, Stock Market Returns, Volatility, EGACH-M Model.**

I. 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 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.

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.

With the effects of the financial crisis in 2008 still remaining, the whole world has not recovered from the financial crisis, but subject to the debt crisis in Europe, this multi-blow to the global economy will inevitably lead to a substantial decline in economic status.

European sovereign debt crisis seems to be deteriorating. It will drag down global economic growth and create an even greater risk than the global financial crisis.

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.

II. Data Description

A. The Stock Market Prices and VIX

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 indices' daily closing prices as representation for stock prices and used the EVIEW 5.0 software for analysis.

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.

B. Data Resource

In this study, we analyze the closing price of stock indexes of Europe, America, and Taiwan, which are EURO STOXX 50 (SX5E), S&P500 and Taiwan weighted indices (TWII) respectively. The information source of Europe, America's stock indices and volatility of S&P500 are from Yahoo! and Google! Finance (http://finance.yahoo.com；http://www.google.com.) Dow Jones EURO STOXX 50 Volatility Index (VSTOXX) is downloaded from http://www.stoxx.com and the information source of Taiwan's stock index and 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 2007/1/2 to 2012/3/12.

From Fig 1, Fig 2 and Fig 3, the figures of America and Europe's stock market price and VIX are more similar, while Taiwan's is obviously more distinguishable. For the stock price, fluctuation margins of America and Europe

Manuscript received September 2, 2012; revised September 25, 2012.
Hsiao-Fen Chang is with Department of Accounting Information, Aletheia University, 32 Chen-Li St.Tamsui, Taipei County, Taiwan (e-mail: jessica0329au@yahoo.com.tw; au4237@mail.au.edu.tw).

DOI: 10.7763/IJEEEE.2012.V2.149

have obviously widened. America's widening of margin was especially dramatic, although recently the fluctuation margins have narrowed, America and Europe have not returned to their original price range of 2007. However, Taiwan's the stock price has almost returned to its price in 2007.This might be related to the price limits in Taiwan.

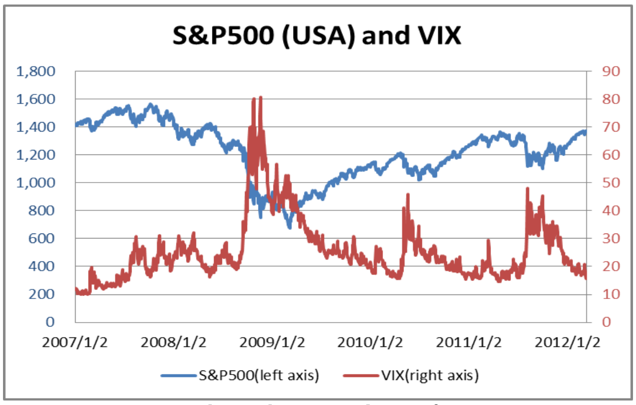

Fig. 1. The stock prices and VIX of America

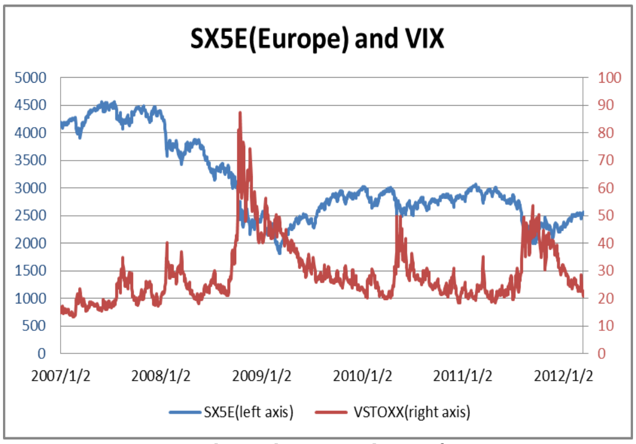

Fig. 2. The stock prices and VIX of Europe

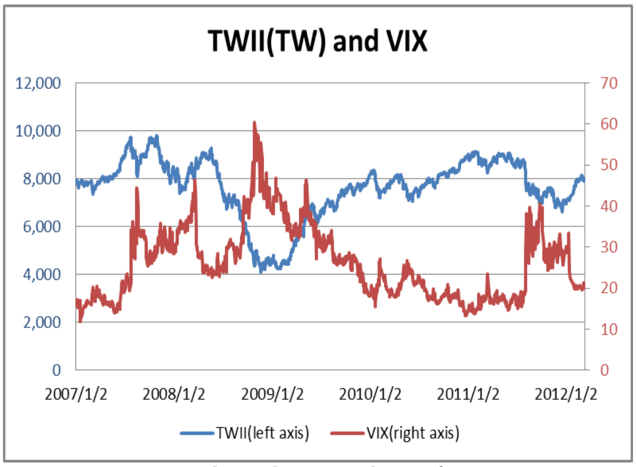

Fig. 3. The stock prices and VIX of Taiwan

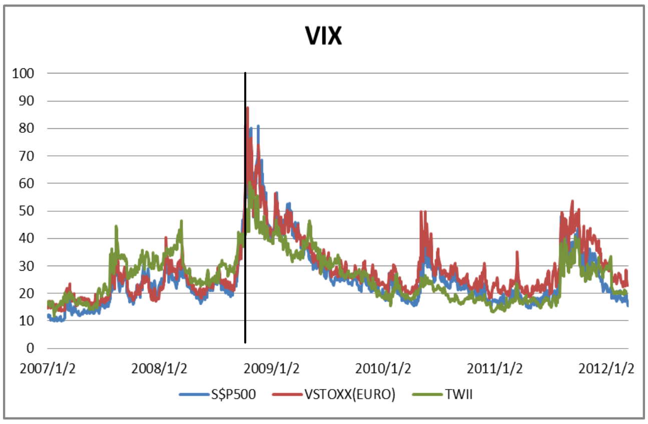

Fig. 4. The VIX of America, Europe and Taiwan.

From Fig.4, before the sub-prime crisis (shown on the left side of the vertical line), Taiwan's VIX is evidently higher than that of America's and Europe's. In contrast, after the vertical line, from sub-prime crisis leading to European sovereign debt crisis until the first few months 2012, Taiwan's VIX is mostly lower than that of America's and Europe's.

C. *Stock Market Returns*

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

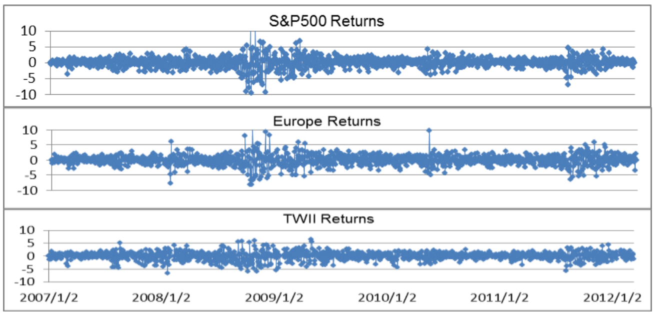

Fig. 5. The stock market returns of America, Europe and Taiwan

In Economics, a structural fracture means structural changes in the overall time series. Usually it means the changes in government policies, changes in regulations or the interference of economic variable, such as a sudden and serious international disaster (civil war), or the global financial crisis. In econometric model, if we fail to find out the structural fracture point, it will affect the testing and interpreting ability of the model, so it is necessary to identify the structural breaking point and separate the inter-partition segment to do model estimation

To make sure the accuracy of the split point date of the data, this paper uses the Quandt-Andrews unknown breakpoint test to find the most likely structural changes point in stock returns, then discard one month sample data neighboring the structure break points as trimming and uses the Chow's Breakpoint Test for testing.

TABLE I

Stock Market	date SBP (Structural Break Point)	p-value (Quandt-Andrews unknown Breakpoint Test)	p-value (Chow's Breakpoint Test)
TWII	2008/9/22	0.0246**	0.0015***
S&P500	2008/10/7	0.039**	0.000***
SX5E	2008/10/8	0.0001***	0.000***

Note: The symbol*** signifies significance at 1% level; the symbol** signifies significance at 5% level; the symbol* signifies significance at 10% level.

TABLE II: DESCRIPTIVE STATISTICS

Index	TWII(Taiwan)			S&P500(USA)			SX5E(Europe)		
	Entire period	Before SBP	After SBP	Entire period	Before SBP	After SBP	Entire period	Before SBP	After SBP
Mean	0.000006	-0.02943	0.05598	-0.0025	-0.0344	0.0494	-0.03835	-0.0579	-0.00125
Median	0.108163	0.0989	0.122	0.0907	0.0695	0.1128	-0.0296	-0.0232	-0.0256
Std.	1.5163	1.521	1.428	1.6544	1.1737	1.5904	1.7516	1.2805	1.7507
Skew.	-0.3334	-0.515	-0.284	-0.2582	-0.1844	-0.3621	0.07878	-0.3025	0.2129
Kurt.	5.18863	4.591	5.5094	9.7966	3.9517	7.3059	7.7878	7.1563	6.3986
Jarque-Bera	280.932	60.663	232.80	2530.17	18.4049	668.0996	1267.88	316.06	417.441
p-value	0.0000	0.0000	0.0000	0.0000	0.00010	0.0000	0.0000	0.0000	0.0000
ADF	-33.433	-20.142	-25.6276	-29.397	-24.194	-32.627	-37.276	-23.691	-29.139
p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sample size	1288	405	844	1307	424	841	1326	430	854

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 I reports the date of the structure break point for TWII, Breakpoint Test and Chow's Breakpoint Test. S&P500 and SX5E, Including the Quandt-Andrews Unknown

Table II reports descriptive statistics for these sample data. We can see that the European stock index was the most affected index. Its mean and median are negative, and it has the biggest fluctuation. The S&P500 and TWII of after SBP have positive means and medians, in other words, as the high risk rises, it attracts risk investors by chance. Compared with SX5E and S&P500, TWII might gain larger profits because its mean and median are bigger.

The kurtosis coefficient of all three indices for the entire period is greater than three, meaning that all the indices have Leptokurtosis characteristics. The kurtosis coefficient of the indices 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 SBP, After SBP). The null hypothesis of the unit root was rejected, which shows that the three stock market returns are stationary.

III. MODEL CONSTRUCTION AND PARAMETER ESTIMATION

A. Model Construction

The daily stock market return's distribution usually has two characteristics. The first is "volatility clustering" as mentioned by Mandelbrot [1] "..., 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 [2] and generalized by Bollerslev [3]; 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 [5] 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:

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

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 [6]. 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 SX5E, S&P500, and TWII. 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 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 IV.

TABLE III

Stock Market	The optimal model	
	Before SBP	*After SBP*
TWII	ARMA([3,13],[3,13,14]) EGARCH(1,1)	ARMA([1,13],[13]) EGARCH(1,1)
S&P500	MA([3])[a] EGARCH(1,1)	ARMA([5,11],[1,5,11]) EGARCH(1,1)
SX5E	ARMA(1,1) EGARCH(1,1)	ARMA(3,3)[b] EGARCH(1,1)

Note: The symbol a indicates that it is enough to find the fitted model without the AR (Autoregressive process) term to adjust the residuals.The symbol b indicates that ARMA(3,3) is equal to ARMA([1,2,3],[1,2,3]).

From Table III, in the ARMA process, we can see that in different nations the stock price returns are influenced by price information. Take SX5E for example; before SBP, SX5E is affected by the preceding day; after SBP, SX5E is affected by the previous three days. According to the market efficiency theory, in the weak-form efficient market, the present's price may reflect the price information, especially recent information. Therefore, S&P500 of before SBP is more effective comparing the others. However, regardless of before or after SBP, TWII is mainly influenced by the price information of the preceding day and the previous the 13th day.

TABLE IV

Stock Market	During time	$\hat{\lambda}$	$\hat{c}$	$\hat{\omega}$	$\hat{\alpha}$	$\hat{\gamma}$	$\hat{\beta}$
TWII	Before SBP			-0.115 ***	0.157 ***	0.086 ***	0.97 ***
	After SBP	0.02867 **		-0.063 ***	0.0923 ***	0.147 ***	1.006 ***
S&P500	Before SBP					-0.1858 ***	0.967 ***
	After SBP	0.0539 *		-0.0326 ***	0.0502 ***	-0.127 ***	0.978 ***
SX5E	Before SBP					-0.1858 ***	0.96 ***
	After SBP			-0.0369 **	0.0575 ***	-0.179 ***	0.992 ***

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.

B. Estimation and Empirical Result

From Table IV, we can see that the $\hat{c}$ value of three stock markets are blanks both before and after SBP, indicating that the non-risk repayment is insignificant at 10% level in regression, so it has been eliminated from the model.

Probably due to the global financial crisis, all three countries are taking the ease monetary policy, so the effect of the non-risk rate is unobvious. In the condition variation equation, the constant $\hat{\omega}$ has promulgated a long-term fluctuation fixed cost. In Table IV, regardless of before or after SBP, the TWII absolute value of $\hat{\omega}$ is higher than the other two indices. This indicates that 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 SBP) saw abnormal fluctuations.

Other than this, the result of the coefficients of $\hat{\gamma}$ shows that none of the indices' 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 SX5E and S&P500, negative $\hat{\gamma}$ values mean the greater influences that negative information has on the market prices. TWII 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.

IV. Conclusions

This article examines Taiwan, Europe and the U.S. stock market price fluctuations: From the VIX, Taiwan's VIX is evidently higher than America's and Europe's before the sub-prime crisis. While after the sub-prime 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 SBP. Second, Negative information has a greater impact on the stock market in Europe and America. TWII does not seem to be affected by the negative information as severely.

References

[1] B. Mandelbrot, "The Variation of Certain Speculative Prices," *Journal of Business*, vol. 36, pp. 394-419, 1963.

[2] R. F. Engle, "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of UK inflation," *Econometrica*, vol. 50, pp. 987-1008, 1982.

[3] T. Bollerslev, "Generalized autoregressive conditional heteroskedasticity," *Journal of Econometrics*,vol. 31, pp. 307-327, 1986.

[4] R. F. Engle, D. M. Lilien, and R. P. Robin, "Estimating Time Varying Risk Premia in the Term Structure: The ARCH-M Model," *Econometrica*, vol. 55, pp. 391-407, 1987.

[5] D. Nelson, "Conditional Heteroskedasticity In asset Returns: A New Approach," *Econometrica*, vol. 59, pp. 347-370, 1991.

[6] J. Y. Campbell and L. Hentschel, "No News is Good News: An Asymmetric Model of Changing Volatility in Stock Returns," J*ournal of Financial Economics*, vol. 31, pp. 281-331, 1992.

Hsiao-Fen Chang was born and raised in Taipei, Taiwan on March 29,1968. She got a BA degree majoring in international trade from Tunghai University in Taichung, Taiwan in 1990. From 1990 to 1994, she was a research assistant of Taiwan Institute of Economic Research in Taipei. She got a MS degree majoring in statistics from Tunghai University in Taichung, Taiwan in 1996. In 2003, she got her PhD degree from Tamkang University, Taipei, majoring in mathematical statistics.

From 2003 until now, she has been an assistant Professor of Aletheia University, Taipei. The previous publications was : Convergence theorems for the lengths of consecutive successes of Markov" in journal Applied Probability; and A one-stage procedure for testing homogeneity of means against an ordered alternative under unequal variance". In journal Communications in Statistics-Simulation and Computation.

Dr. Chang received the best paper of the oral session award on February 28, 2012 3rd International Conference on Financial Theory and Engineering in Singapore