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Effect of Subprime Crisis on U.S. Stock Market Return and Volatility

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The U.S. Subprime credit crisis began with massive defaults by Subprime borrowers in mortgage markets. The crisis created certain degree of impact on financial markets as shown by Longstaff (2010) on the contagion across financial markets from the credit crisis. Hence, this paper attempted to study about the behavior of U.S. stock market in term of stock return and volatility along with the Subprime crisis. Daily data of S&P 100 stock indexes for the period of May 2006 to December 2009 are studied using basic GARCH model. The data were then divided into three different sub-periods to allow the behavior of stock market in different sub-periods to be investigated. The following sub-periods are identified: early stage of Subprime crisis, recession of U.S. and period after the bankruptcy of Lehman Brothers. This paper revealed that the bankruptcy of Lehman Brothers following the Subprime crisis turned out to have bigger impact on stock market volatility but not on the stock returns in general, though the impact is transitory.

JEL Codes: G01, G10 and G15

1. Introduction

Basically, the U.S. Subprime credit crisis started with huge defaults by Subprime borrowers in the mortgage markets. The credit crisis led to massive losses or even bankruptcy among financial institutions and companies which hold large portfolio with mortgage-backed securities. This is consistent with the evidence provided by Longstaff (2010) of the contagion across markets from the credit crisis. Therefore, researchers gain interest to study about the U.S. Subprime credit crisis in their stock market analysis. Besides, various researches were conducted to study on stock market with large shocks due to global event or crisis such as the crash of 1987 (Choudhry 1996, Law 2006), the Asian crisis (Chakrabarti & Roll 2002, Holden et al 2005, Law 2006, Leeves 2007 and Karunanayake et al 2010), the September 11th terrorist attacks (Charles & Darne 2006 and Nikkinen et al 2008). From that respect, this article intends to study about the behavior of stock market in term of the stock return and volatility with the onset of Subprime crisis.

Initial sign of the Subprime credit crisis was detected on the real estate market when a drop of 3.3 percent on median price of U.S. home from the fourth quarter of 2005 and the real estate gains came to an abrupt halt in the first quarter of 2006 as reported by Christie via CNNMoney.com dated May 16, 2006. However, the credit crunch had slow contagion effects across other financial markets since the official recession was reported by The National Bureau of Economic Research (NBER) after 2 years time at

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December 2007 (Isidore 2008). Hence, we can further study the impact of Subprime crisis on stock market behavior during recession. In addition, the bankruptcy of Lehman Brothers, the fourth largest U.S. investment bank at September 15, 2008 turned out to be another big crash caused by the mortgage crisis leading a deep fall on stock market price (refer Figure 1).

Thus, it would be interesting to know the extent to which the Subprime crisis has shape the stock market behavior in term of returns and volatility in different stages. As a result, this paper firstly would like to study whether there is volatility clustering detected in different stages of Subprime crisis in U.S. stock markets. Next, the persistence of shocks to the volatility of returns is investigated if any. Last but not least, comparison on the behavior of U.S. stock market in terms of return and volatility is carried out across different stages of Subprime crisis or sub-periods.

In this context, this paper is organized as follows. Section 2 summarized some previous research outcomes done by the scholars relating stock market analysis with stock market crashes or global events. Next, the data examined and statistical analysis for answering the research questions in this study are described in section 3. The following section explained the results and findings for the study. Lastly, the paper ends with some conclusion remarks and limitation of study.

2. Literature Review

2.1 Stock Market Analysis and Market Crash or Crisis

Choudhry (1996) had developed a research on stock market volatility with the crash of 1987. Six emerging markets were studied using a GARCH-M model to investigate about the volatility, presence of time-varying risk premium and the persistence of shocks to the volatility before and after the crash of 1987. Overall, significant volatility clustering was found in stock returns but the shocks were not explosive. Some markets like Argentina, Greece and India demonstrated an increase of ARCH (Autoregressive Conditional Heteroskedasticity) effects after the crash while the rest of the emerging markets indicated significant change in ARCH effects (has/has no) before and after crash. Indeed, the findings only managed to find some evidence of changes in persistence of shocks to volatility for some emerging markets before and after the crash. On the other hand, the results mostly failed to prove any significant influence of volatility on returns (risk premia) except some significant inverse relationship was found for Argentina and India in post-crash.

Besides, Asian crisis also generated great interest for the researcher to study about the performance of stock market. Chakrabarti and Roll (2002) did a comparison between the East Asian stock markets (treated as diseased patient of the 1997 Asian crisis) and European markets (treated as healthy patient). Their results reported an increase of return volatility and co-movement for both regions with the onset of the crisis. Not surprisingly, the magnitude of increases in both measurements is 4 times larger in East Asia. In addition, diversification potential or investment opportunities were found to decline greatly at East Asia during the crisis. Holden et al (2005) on the other hand studied the calendar effects due to the day-of-week, month-of-year, days before or after holidays and within month effects on daily stock market returns of Thailand. Particular attention of these effects was

given prior to, during and after the Asian crisis. The results indicated many of tested calendar effects were small and not significant but these effects can significantly improve the forecast performance. The behavior of stock returns in terms of the ARCH effects, serial correlation problem and functional form turned out to be different before, during and after Asian crisis. Law (2006) also documented a prolonged impact on stock market volatility in Malaysia due to the 1997 Asian financial crisis. Stock return volatility was found decreasing but not yet calmed down to the level before the crisis by March 2003. He also pointed out that the Asian financial crisis has the great persistence effect on volatility.

Furthermore, a study on volatility of stock returns generated from Jakarta Stock Exchange Index during the Asian crisis was carried out by Leeves (2007). The findings indentified asymmetry impacts from conditional volatility shocks indicating negative shocks led to greater volatility compare to positive shocks during crisis. The asymmetric response started to rise at the end of 1997 and then declined during 1999. Though, the Indonesian stock market turned to behave more symmetrically to shocks towards the end of 1999. At the same time, the long run persistence effects declined. Karunanayake et al (2010) in addition disclosed that both 1997 Asian financial crisis and 2008 financial crisis had no impact on mean stock returns for U.S. but positive influence was detected on stock return volatility due to the crises. Besides, U.S. stock returns demonstrated high volatility persistence effect.

Apart from the above, Kapopoulos and Siokis (2005) found evidence that new generation of crashes (crashes of late ’90s and early ’00) exhibited stronger overreaction-overcorrecting pattern compared to old generation of crashes (crashes of late ’80s and early ’90s). In other word, the stock market need longer turbulent period for a convergence to a new equilibrium steady state after old crashes.

2.2 Stock Market Analysis and Global Event

Despite of stock market crash, studies of stock market had been done within the period covering major event especially the September 11th 2001 terrorist attack. Charles and Darne (2006) validated that the terrorist attacks at U.S. to be a permanent and temporary negative shocks for most of the international stock markets. Interestingly, the impact was more severe on other world stock markets instead of the U.S. stock markets even though the attacks were targeted directly at U.S. Besides, they also showed that macroeconomics news announcement from U.S. can generate large shocks to U.S. and European stock markets.

On top of that, Nikkinen et al (2008) compared the behavior of stock market returns and volatility in 6 different regions before and after the terrorist attacks at September 11th, 2001. They concluded that there was significant increase in volatility across regions after the attacks while the stock returns declined shortly after the attacks but rebounded over longer periods in 3 to 6 months time.

2.3 Subprime Credit Crisis and its Contagion Effects

A research done by Dooley and Hutchison (2009) explained that there was a long gentle decline in U.S. equities at the start of Subprime crisis in mid of 2007 through September 2008. The stock market indices in both U.S. market and emerging

markets exhibited a dramatic decline in September with extreme volatility after that. The reason given was that the news announcements such as Lehman bankruptcy led to a massive impact on the equities markets and transmission of such impact to emerging markets was discovered. This finding is consistent with the results by Celikkol et al (2010) regarding the increase of volatility of Turkey price index (ISE-100) after the bankruptcy of Lehman Brothers. Besides, similar examination was employed by Longstaff (2010) exposed that there was financial contagion spillover across to other financial markets as the Subprime crisis developed.

Another recent study was found by Ramlall (2010) regarding the influence of Subprime crisis on volatility clustering and leverage effects in major international stock markets. Evidences revealed that volatility clustering had increase after the Subprime crisis. The report also supported findings by Dooley and Hutchison (2009) that there was transmission of Subprime crisis to other emerging stock markets. At the same time, the leverage effect in post crisis was higher compare to pre crisis period in most of the international stock markets studied. The volatility due to negative shocks was found to be more pronounced in post crisis than pre crisis while the volatility due to positive shocks showed reverse pattern.

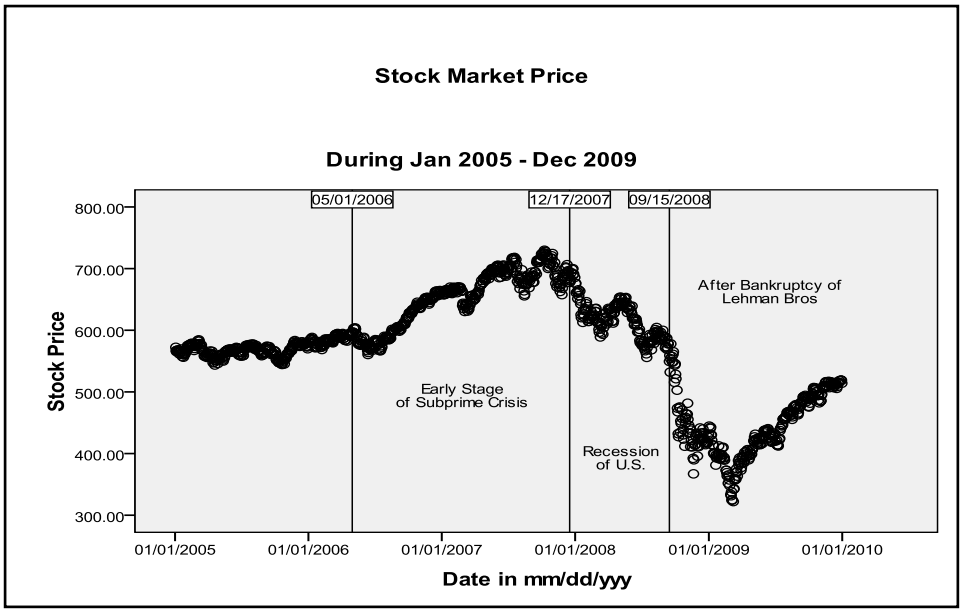
On top of the literatures, Engle and Ng (1993) suggested that negative shocks led to greater impact on volatility compared to positive shocks when they measured the effects of news on volatility estimation using Japanese stock returns from 1980 to 1988.

In that sense, this paper is motivated to extend the studies by investigating the impact of Subprime credit crisis on stock market returns and volatility. To my knowledge, there are yet few studies done to relate these two issues compared to the number of researches done on other stock market crashes.

3. The Methodology and Model

As the main objective of this paper is to study the impact of Subprime crisis on U.S. stock market return and volatility, hence daily data of S&P 100 stock indexes for the period of May 2006 to December 2009 were studied. Investigation on S&P 100 stock indexes that includes 100 leading U.S. stocks allows this paper to generate a better understanding based on largest and most established companies in U.S. The full period of study is then divided into 3 different stages to allow behavior of stock market returns and volatility to be investigated in each stage or sub-period of Subprime crisis. Referring to the facts and figures provided by Christie (2006), Isidore (2008), Dooley and Hutchison (2009), the following sub-periods are developed: Early stage of the Subprime crisis (May 2006 to mid-Dec 2007), Recession of U.S. (Mid-Dec 2007 to mid-Sept 2008) and Period after the Bankruptcy of Lehman Brothers (mid-Sept 2008 to Dec 2009).

Figure 1: Stock Market Price during Jan 2005 to December 2009



3.1 Model Specification

Two main latent variables for this study are the stock market return and volatility. The stock market returns for each sub-period are calculated as follows:

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

where R_t is the daily return of S&P 100 indexes at day *t***,** P_t is the closing price at day *t* and P_{t-1} as the closing price at day *t* – 1.

On the other hand, volatility is an unobservable variable. Hence, it is common practice in literatures (example see Perron and Qu 2008) to make use of square returns or absolute returns as proxy for volatility. However, Andersen and Bollerslev (1998) commented that squared returns are poor estimators of day-by-day movements in volatility and it is also an extremely noisy estimator. In that sense, the proxy for volatility adopted in this paper follows the step by Nikkinen et al (2008) which is the estimated volatility from the observed return series.

As a preliminary analysis, unit root test was employed on the observed return series for each sub-period using Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test by including the drift and constant terms. It was found that all 4 series of returns are stationary. In other words, the return series have no unit roots. Hence, the level form of returns will be used for further estimation throughout the analysis.

Next, model specification of ARMA process through correlogram for the mean equation was carried out. All 4 series of returns were found to fit AR(1) process well with the minimum AIC value compared to other ARMA process. Diagnostic check through various tests like invertibility test, autocorrelation test (referring to Q-statistics for the correlogram of residuals) and normality test (Jarque-Bera test) were applied to verify the required assumptions. The results demonstrated that

AR(1) process for all series do not violate any of the invertibility and non-autocorrelation assumption, however the normality assumption is not satisfied.

Hence, all the series of return were modelled using first-order autoregressive process with the following mean equation:

$$R_t = \theta_1 + \theta_2 R_{t-1} + \varepsilon_t \qquad \ldots\ldots\ (1)$$

Nevertheless, GARCH model will be applicable only if ARCH effects are found. Once ARCH effects discovered, the basic GARCH (1,1) model is adopted for estimating the conditional variance in this paper supported by most of the researches conducted for volatility study (example see Holden et al 2005, Charles & Darne 2006, Nikkinen et al 2008, Ramlall 2010). Therefore, the variance equation will be presented as:

$$h_t = \lambda + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \qquad \ldots\ldots\ (2)$$

where h_t is the conditional variance with the conditions of $\varepsilon_t \mid I_{t-1} \sim G.E.D\left(0, h_t\right)$ and all parameters of GARCH (1,1) process are restricted to be non-negative meaning to say $\lambda \geq 0$, $\alpha \geq 0$ and $\beta \geq 0$ to ensure that the conditional variance (h_t) is positive.

3.2 Hypothesis Testing

Firstly, this paper aimed to check whether there is any volatility clustering detected in different time periods. The signal of volatility clustering can be tested on the ARCH coefficient in the conditional variance equation (Eq. 2) which is captured by α with the following null hypothesis statement:

H_0: $\alpha_i = 0$ where *i* represent the period/sub-periods of study

On the other hand, this paper attempted to investigate the persistence effects of shocks on the volatility of U.S. stock returns whether to be permanent or only transitory. This objective can be done by testing if the persistence measure $\left(\alpha + \beta\right)$ is different from unity, i.e.

H_0: $(\alpha + \beta)_i = 1$ indicating permanent effects

where *i* represent the period/sub-periods of study

In what follows, hypothesis testing on mean will be carried out to examine whether there is any significant change on the stock return and volatility across the sub-periods. Non-parametric test on mean via Mann-Whitney test will be performed for both series if violation of normality assumption is found. The null hypothesis is presented as:

H_0: $\mu_i = \mu_j$ where *i* and *j* represent the period/sub-periods of study

4. The Findings

Volatility clustering in stock returns implies that large (small) changes in prices are followed by large (small) changes of either sign. The value of α for the full period (0.086) presented in Table 1 showed significant volatility clustering in whole. Interestingly, the ARCH effect turned to be significant only in Sub-period III (0.0382) when we study on 3 different sub-periods. Hence, there was only evidence of volatility clustering in stock returns after the bankruptcy of Lehman Brothers. However, the ARCH parameter in full period or Sub-period III is less than unity thus the shocks were not explosive.

Moreover, the persistence measure $(\alpha + \beta)$ in Table 1 provided information about the impact of shocks on volatility. It was found that all the periods are insignificantly different from unity except for Sub-period III. Therefore, evidence shows the persistence of shocks (Subprime crisis) to volatility is permanent for both Sub-period I and II implying that the conditional variances are non-stationary. In contrast, the shock of bankruptcy of Lehman Brothers due to Subprime crisis had only transitory impact on the volatility. In other words, we perceived that the persistence of shocks to volatility decay after the bankruptcy of Lehman Brothers at a slow rate as the persistence measure is very close to unity.

At the mean time, third research question to be answered in this article is about the behavior of U.S. stock market return and volatility across the period of study at different stages or sub-periods. Table 2.1 and 2.2 presented the summary statistics for both return and volatility series for each stages.

On average, U.S. stock market facing negative returns with the onset of Subprime crisis throughout the whole period of study referring to Table 2.1. The mean returns declined from the early stage of Subprime crisis (Sub-period I) towards the recession period (Sub-period II) but a small rebound was detected after the bankruptcy of Lehman Brothers. However, validation of the changes on mean return was examined and the result was disclosed in Table 3. The outcome indicated that the changes in mean returns were not significant. In contrary, the volatility of U.S. stock returns rise with the occurrence of Subprime crisis and continuous increment across sub-periods was discovered (refer the mean values in Table 2.2). Results from Table 3 in advance confirmed significant increase on volatility while the magnitude of increase in volatility seems to be higher after the bankruptcy of Lehman Brothers.

Table 1: AR(1)-GARCH(1,1) Results

	Mean Equation		Variance Equation			Persistence Value
Period	θ_1	θ_2	λ	α	β	$\alpha+\beta$
Full	0.0009*	-0.0872*	7.86E-07**	0.086*	0.915*	1.001
	(3.643)	(-2.759)	(1.753)	(4.111)	(49.102)	(0.013)
I	0.0009*	-0.1072	1.08E-06	0.0802	0.9109*	0.9911
	(3.682)	(-2.457)	(1.275)	(2.381)	(25.570)	(0.212)
II	-0.0006	-0.1149	2.27E-05	0.0199	0.8549*	0.8748
	(-0.629)	(-1.439)	(0.572)	(0.334)	(3.474)	(0.322)
III	0.0013	-0.0887	5.56E-07	0.0382*	0.9504*	0.9886***
	(1.950)	(-1.568)	(0.524)	(2.023)	(51.155)	(2.923)

Note:
* and ** denote significance at 5% and 10% level respectively with z-statistics in the parentheses.
*** implies significantly different from unity at 10% level with Chi-Square statistics from Wald coefficient test in the parenthesis.

Table 2.1: Descriptive Statistics of Returns

	Full	Sub-period I	Sub-period II	Sub-period III
Mean	-0.00016	0.00035	-0.00093	-0.00036
Median	0.00073	0.00055	0.00025	0.00126
Std. Dev.	0.01670	0.00857	0.01345	0.02435
Skewness	-0.15203	-0.49611	0.13649	-0.09372
Kurtosis	10.85243	5.51425	3.38301	6.51527
Jarque-Bera Statistics	2382.639*	125.114*	1.724	169.361*

Note: * implies significantly deviated from Normality assumption at 5% level for JB test

Table 2.2: Descriptive Statistics of Volatility

	Full	Sub-period I	Sub-period II	Sub-period III
Mean	0.00029	7.38E-05	0.00018	0.00053
Median	0.00013	5.87E-05	0.00018	0.00030
Std. Dev.	0.00047	5.29E-05	1.90E-05	0.00052
Skewness	3.13834	1.33511	-2.11562	1.09102
Kurtosis	12.79659	3.89137	11.49438	2.85170
Jarque-Bera Statistics	5217.376*	135.379*	697.949*	65.172*

Note: * implies significantly deviated from Normality assumption at 5% level for JB test

Table 3: Comparison of Returns and Volatility between Sub-periods

	Comparison in	
	Return	Volatility
a. Mean Change Between Sub-period I and II (II) – (I)	-1.277E-03	1.029E-04*
b. Mean Change Between Sub-period II and III (III) – (II)	5.738E-04	3.484E-04*

Note: Mann-Whitney Test (Non-parametric test) was conducted in order to test for the significant changes in the mean values of returns and volatility of U.S. market across sub-periods.
* denote significance at 5% level

5. Summary and Conclusions

As global events and stock market crash or crisis are an important element that can have great impact on the stock market, hence it is worthwhile for an extend analysis of stock markets during Subprime credit crisis. This paper is motivated to carry out similar study by Dooley & Hutchison (2009) and Ramlall (2010) to further investigate the behavior of U.S. stock market returns and volatility since the Subprime crisis.

Initially, this paper found that the volatility tends to cluster for the whole period of study which is consistent with the results by Ramlall (2010) of volatility clustering after Subprime crisis. However, this paper only detected significant ARCH effects after the bankruptcy of Lehman Brothers in contrast with the early stage of Subprime crisis and recession period. Though, the persistence of shocks (Subprime crisis) on volatility in the study before the bankruptcy was permanent while the opposite is appeared at its aftermath. Therefore, we can perceive that the shock caused by the bankruptcy has only transitory impact on the volatility of stock market returns and it decay in time with a very slow rate.

Besides, U.S. stock market revealed significant increases in volatility throughout the time periods but not on stock returns. This is supported by the previous literatures like Chakrabarti & Roll (2002), Law (2006), Leeves (2007) and Karunanayake et al (2010) due to crisis in general while on the other hand consistent with the findings of Dooley & Hutchison (2009) and Celikkol et al (2010) in particular due to the bankruptcy of Lehman Brothers.

In conclusion, the news about bankruptcy of Lehman Brothers following the Subprime crisis turned out to have exacerbated impact on stock market volatility but not on the stock returns in general.

Anyhow, this article is limited with volatility modelling assuming symmetric effect. Hence, future research may further the study by incorporating with asymmetric effect on volatility estimation due to stock market crash.

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