SPILLOVER EFFECTS OF THE SUB-PRIME MORTGAGE CRISIS TO THE ASIAN STOCK MARKETS

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Abstract

This paper aims to analyze the effects of the sub-prime mortgage crisis on several Asian stock markets. An Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) model is employed to provide an empirical evidence of the direct spillover. The indirect effect is measured through the spillover effects from the increased volatility in the U.S. stock markets to the Asian stock markets. The results showed that the market integration occurs within Asian stock markets. Meanwhile the asymmetric effects are evident for all the Asian countries stock markets, indicating that financial markets in Asia are suffered more from negative news (shocks) lead to more volatilities compared to positive news.

Keywords: Stock market, sub-prime mortgage crisis, volatility, spillover effect
JEL classification numbers: C22, F36, G15

Abstrak

Paper ini bertujuan untuk menganalisis pengaruh krisis sub-prime mortgage pada beberapa pasar saham Asia. Model Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) digunakan untuk mendapatkan bukti empiris dari kenaikan volatilitas dalam pasar saham Amerika pada pasar-pasar saham Asia. Hasil analisis memperlihatkan bahwa integrasi pasar terjadi di dalam pasar saham Asia. Sementara itu, pengaruh asimetris terbukti terjadi di pasar-pasar saham Asia, mengindikasikan bahwa pasar-pasar keuangan di Asia menderita lebih parah sebagai akibat dari kejutan negatif dibandingkan dengan dampak dari kejutan positif.

Kata kunci: Pasar saham, krisis sub-prime mortgage, volatilitas, pengaruh spillover
JEL classification numbers: C22, F36, G15

INTRODUCTION

The U.S. sub-prime mortgage crisis has created widespread financial market turmoil around the world. Several foremost financial institutions and major banks around the world have reported massive losses. Some big financial companies had even had to file for bankruptcy. The crisis had also spread to Asian financial markets. Stocks markets in many Asian countries declined significantly following the fall in the U.S. stock market.

To some extent, the sub-prime crisis can be seen as a repetition of the late 1990s Asian crisis, which saw the property bubble bursting and setting off a full blown financial crisis in the region. This time, however, the bubble burst was outside the Asian region.

The sudden and persistent drop in the housing market in the U.S. had caused increase risk of default and foreclosure of several U.S. major companies. These troubled companies had to reduce their expected earnings significantly. Investors' confidence falls as risk increases. The crisis has not only adversely affected business investment but also reduced consumer's spending due to negative wealth effects.

This in turn results in downward pressure on economic growth in the U.S.

The risks created by the sub-prime crisis, which lead to the financial market crisis in the U.S. easily transferred to Asian financial markets. The reason is that the global financial markets are rapidly integrating into a single market. This can be observed from the growing co-movement between the U.S. markets and the Asian markets. For instance, when the stock market return in the U.S. is affected by certain news, one may observe reaction in Asian stock market through the movement of the market indices.

The reasons underlie the spillover effect of the sub-prime mortgage crisis to the Asian market can be divided into two possible explanations. One is that investors may shift their portfolio from the U.S. stock market to Asian stock market. This is in line with diversification of risk for their assets holdings. This will increase the Asian stock market index.

Another explanation is that the sub-prime crisis may lead to higher volatilities and subsequently giving stress for the Asian economy. This may cause investors to shift their portfolio from the stock market and move to other asset holdings, e.g. commodity such as oil and gold. This will decrease the Asian stock market index.

Moreover, the slowdown in the U.S. economy is likely to cause slower economic growth in Asia. This in turn may cause a fall in the Asian stock markets due to downward adjustment in the expected cash flow in the stock markets. This effect is becoming more important as the Asian economies are dependent on export market to the U.S.

This paper aims to analyze how the effect of sub-prime crisis spills over to several Asian stock markets, i.e. China, Hong Kong, Indonesia, Malaysia, Singapore, and South Korea. In particular, we want to analyze how the transmission mechanism of the sub-prime crisis to the Asian stock markets and how fast the effect of the sub-prime crisis spillover to the Asian stock markets.

We use stock market return volatility in order to capture the dynamic of country stock markets. We hypothesize that the sub-prime crisis could affect the Asian stock market either directly or indirectly. The crisis may directly affect the Asian's companies, financial institutions and banks, which have ventured in the sub-prime-related investments. This can be measured by the effect of increased volatility in the ten most affected U.S. financial institutions and investment banks into the Asian stock markets. Moreover, the indirect effect is measured through the spillover effects from the increased volatility in the U.S. stock market to the Asian stock markets.

We employ extension of an Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) model of Engle and Ng (1993) namely EGARCH in Mean (EGARCH-M) in order to examine the spillover effects of the sub-prime mortgage markets to the selected Asian stock markets. The EGARCH models are widely used in the literature because of their ability to capture the co-movement of not just the returns but also the volatility and evaluate the causal relationship in return and volatility.

The sub-prime crisis was started by the U.S. housing boom during 2006 to 2007 before the lending standard started to deteriorate along with the increase of lending portion by people with poor credit credentials. The housing boom especially triggered by dramatic portion of the sub-prime mortgage in which it evolved from a small part of the mortgage market classified into lowest-rates borrowers comprising about 14 percent of the U.S. mortgage together with the other risk category Alternative-A (Alt-A) about 10 percent. All together are categorized into low-document loans (see Oliver 2007; Demyanyk and Hemert, 2008).

The housing boom was creating bubbles indicated by the rise of property price which in turn increase borrowers' confidence to borrow at a sub-prime (less than the lowest) rate with the expectation that the housing price would rise at a variable rates. The bubble in the housing price started to burst in late 2005 when housing prices decline along with higher interest rates and resulted to lending default.

Some studies have indicated thatthe crisis should have been predicted long time before. Demyanyk and Hemert (2008) argue that the bad performance covers all the segments in mortgage markets not only from sub-prime but also in other forms like fixed-rate, hybrid, purchase-money, cash-out refinancing, low-documentation, and full-documentation loans. All of them have indicated substantially higher delinquency rates than loans made the prior five years. Therefore, this contradicts common believe that the sub-prime mortgage crisis came from low-documentation mortgages.

Demyanyk and Hemert (2008) explain how the dramatic growth of sub-prime mortgage market and quality market deteriorated dramatically. Since the last seven years, there exist increasing adjusted delinquency rates steadily. In principal, the spread of sub-prime mortgage did not take into account the default risk of the loans. Moreover, when the overall riskiness of the sub-prime loans increase, this should be followed by an increase in the sub-prime mark-up. In fact, this adjustment is not accommodated for different borrowers.

However, the sub-prime crisis is argued by some analysts as a common phenomenon, following the pattern of boom-bust scenario of financial markets. Rapid market growth is followed by loosening underwriting standards, deteriorating loan performance, and decreasing risk premiums. Cases of Argentina in 1980, Chile in 1982, Sweden, Norway, and Finland in 1992, Mexico in 1994, Thailand, Indonesia, and Korea in 1997 all experienced the culmination of a boom-bust scenario in different economic settings (see Demyanyk and Hemert 2008). The Asian crisis in 1997-1998 in fact gave lessons for Asian to be aware of the crisis indicated by the holding huge foreign reserves which help them when any run on their currencies and limit the kind of Asian contagion occurs.

Dell'Ariccia et al. (2008) find the period of rapid credit growth tend to be followed by loosening lending standards. They studied 50 million individual loan applications and find that delinquency rates increase sharply in areas that experienced larger increases in the number and volume of originated loans. This relationship is related to falls of lending standards and a decline in denial rates not explained by improvement in the underlying fundamentals. Furthermore, they argue that decrease in lending standards is caused by the following four factors. First, when credit boom become larger, standards are likely to decline. Second, along with the faster rate of house price appreciation, the associated standards become lower. This is consistent with the notion that to some extend lenders are gambling on a continuing housing boom since they let the fact that borrowers in default could always liquidate the collateral and repay the loan. Third, there are changes in market structure in which lending standards declined more in regions where large (and aggressive) previously absent institutions entered the market. Fourth, banks privileges through increase remedy to loan sales and asset securitization seems to affect lender behavior with lending standards. This is experiencing greater declines in areas where lenders sold a larger proportion of originated loans.

The factors show why boom in housing markets was ended badly since along with the price appreciation, bad practices of control and monitoring of the markets are ignored and this allow speculators and poor credit credential investors to join the market and run it recklessly.

Beside that, monetary policy is argued to contribute to the cycle. Dell'Ariccia et al. (2008) argue that easy monetary policy plays the role for the boom. Consequently, when the crisis occurs the Fed is in difficult position, since cutting the rates would not help to overcome the problem. By cutting the rates, the Fed would encourage moral hazard for the financial system and this only help the speculators to have possibility to gambling more. Subsequently, the policy would worsen exchange rates and rise commodity prices (see Steidtmann, 2007) This is evident when the Fed cut the interest rates in August 2007 from 5.02 to 1.98 in April 2008, before it increases again afterwards.

The spillover effect of the sub-prime crisis was studied by Tong and Wei (2008). They divide the channel of spillover effects into two, namely changes in firm's sensitivity to consumer demand based on response to the 9/11 shock in 2001 and tightening liquidity constraint on non-financial firms. They found that both channels apply but a tightened liquidity squeeze is economically more important than a reduced consumer spending in explaining cross firm differences in stock price declines. When the sub-prime crisis occurs, many non-financial firms have experienced a dramatic decline in stock prices. If the crisis represents a tightening of liquidity beyond financial institutions, the effect tend to be more damaging for firms which facing more liquidity constrained. By exploring this variation across firms, Tong and Wei calculate the extent to which the sub-prime trouble is affecting the real economy. However, they admit that a tightening of liquidity does not need be the only channel through which the sub-prime crisis could damage the real sector. Demand for firm's output could be compressed through a loss of consumer confidence, and hence a reduction in current and future consumer spending.

Studies on stock markets spillover effect in ASEAN countries were preceded by the examination of the stock markets integration. The spillover effects tend to increase when markets are already integrated that the interdependence among markets is built and this is the concern of investors to be able to forecast the volatility of the markets across the region.

The topic of financial markets integration in ASEAN had been increasingly studied by economists. This is triggered by the Asian financial liberalization in 1990s, even though it is becoming more significant since the end of the crisis. Ng (2002) said that the reasons for the rapid growth of ASEAN markets are; 1) growing liberalization of the economy, 2) restructuring of the private sector, 3) gradual opening of the stock market to foreign investors, 4) strong economic growth, and 5) privatization of state enterprises.

Ng (2002) analyzed the co-movement among stock markets in the South-East Asia following the opening of the ASEAN stock markets in the 1990s. Ng employed cointegration and time-varying parameter models to examine the ASEAN-4 stock markets, namely Indonesia, the Philippines, Singapore and Thailand from December 1987 to November 1997. He found that co-movement within the region had increased since the liberalization through an opening up of the financial markets. The result shows that the ASEAN-4 countries stock markets became more closely linked shown by greater co movement in the returns. Furthermore, the stock markets returns of Indonesia, the Philippines, and Thailand are more closely linked with that of Singapore.

After the crisis, the linkage among countries in ASEAN is getting stronger. ASEAN countries recently tend to decrease their dependency on loans from banking and switch to bonds and stock as the source of capital especially outside the region. Click and Plummer (2005) examine the de-

gree of correlation across financial markets in the ASEAN-5, Indonesia, Malaysia, Singapore, the Philippines and Thailand. They use simple correlation as a way to assess the feasibility of policy initiatives to enhance ASEAN market integration and the implication for portfolio investors. Specifically, their paper considers whether the stock markets of the ASEAN-5 are integrated or otherwise segmented by applying cointegration technique to extract long run relation (see Click and Plummer 2005). The result shows that the ASEAN-5 stock markets are integrated up to some degrees and are not segmented completely by national borders. From the perspective of policy makers, an initiative to have further integration is feasible and desirable. Form the perspective of portfolio investor, the benefits of diversifying international portfolio within the countries will decline but not eliminate.

Both studies strengthen the premise that stock markets in ASEAN are more integrated to the world stock markets and bring more capital into the countries from abroad. Theoretically, an integrated market is more efficient compared to a segmented market (see Click and Plummer 2005). Even though from the perspective of investors a more integrated markets means less benefits from the portfolio diversification across countries since there is no difference to allocate the capital, yet an integrated market allows investors to allocate the capital within the region where it is the most productive. With more capital flow across countries, additional trading in individual securities will improve the liquidity of the stock markets. This in turn would decrease the cost of capital for the firms which find for capital and also for investors which have lower transaction cost. Therefore, there is more efficient allocation of capital within the region (see Click and Plummer 2005; Ng 2002).

However, Ng (2002) argues analysis of cointegration test is not sufficient to show whether the markets are integrated. This is because cointegration assumes time-invariance of the cointegrating relationship. In fact, financial data are characterized by time-varying data. Therefore, application of conventional time series and econometric models such as linear regression work only when the variance is constant and the application would produce bias results. Models of unconditional volatilities are proposed for time variation in second- or higher-order moments, such as financial data. Autoregressive Conditional Heteroscedasticity (ARCH) model is firstly proposed by Engle (1982) to examine this kind of data. Since then, the extension of the model have varied and been examined by researchers especially for the purpose of forecasting stock market volatility. Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model of Bollerslev (1986) is the ARCH extension which is most vastly adopted in many studies.

METHODS

Financial data such as stock market return are widely known to have a non-normal distribution, characterized by some common distinctions. First, the kurtosis of the stock market returns is larger than kurtosis of the normal distribution in which it is leptokurtic. Second, the distribution of the stock market returns is skewed, either to the right (positive skewness) or to the left (negative skewness). Finally, the variance of the stock markets returns is not constant over time or the volatility is clustering. Volatility clustering by some analysts is regarded as the persistency of the stock market volatility..

Cotter and Stevenson (2004) suggest that the use of daily data provides a deeper analysis of volatility transmissions and are able to overcome problems caused by monthly structural breaks. Daily stock market return can be calculated as the difference of natural logarithmic of the price index, as follows:

$$r_{i,t} = \log(P_{i,t} / P_{i,t-1}), \quad (1)$$

where $r_{i,t}$ is the actual return of stock market index for country i at time t, while $P_{i,t}$ and $P_{i,t-1}$ are the closing prices of stock of country i at days t and $t-1$, respectively. Meanwhile the volatilities of the stock market returns are calculated as follows

$$Vol_{r,i,t} = [r_{i,t} - E(r_{i,t})]^2, \quad (2)$$

where $Vol_{r,i,t}$ is the volatility of returns in country i at day t, and $r_{i,t}$ denotes the actual return in country i at day t. $E(r_{i,t})$ represents the expected price at time t.

In this paper, we use daily stock price index (closing price) of six Asian countries, namely Jakarta composite index (JCI) Indonesia, Kuala Lumpur composite index (KLSE) Malaysia, Korea composite index (KOSPI), Hong Kong index (HKEx), Singapore Strait Times index (SGX) and Shanghai composite index (SSE) China. Meanwhile, the U.S. stock market is represented by the Standard & Poor index (S&P).

Moreover, since we hypothesize that the spillover originated from the collapse of major companies and banking affected by the sub-prime crises, therefore we choose five major financial institutions and five major investment banks, i.e. Bear Sterns, Goldman Sachs, JP Morgan, Lehman Brothers, Merrill Lynch, Morgan Stanley, Wachovia, Wells Fargo, Bank of America, and Citigroup. We use the average return indices of these ten financial institutions and banks as proxy for sub-prime market. All data are obtained from the Yahoo finance online covering the period 1/03/05 to 4/30/08. Figure 1 shows the logarithmic of the price volatilities for all the observed countries.

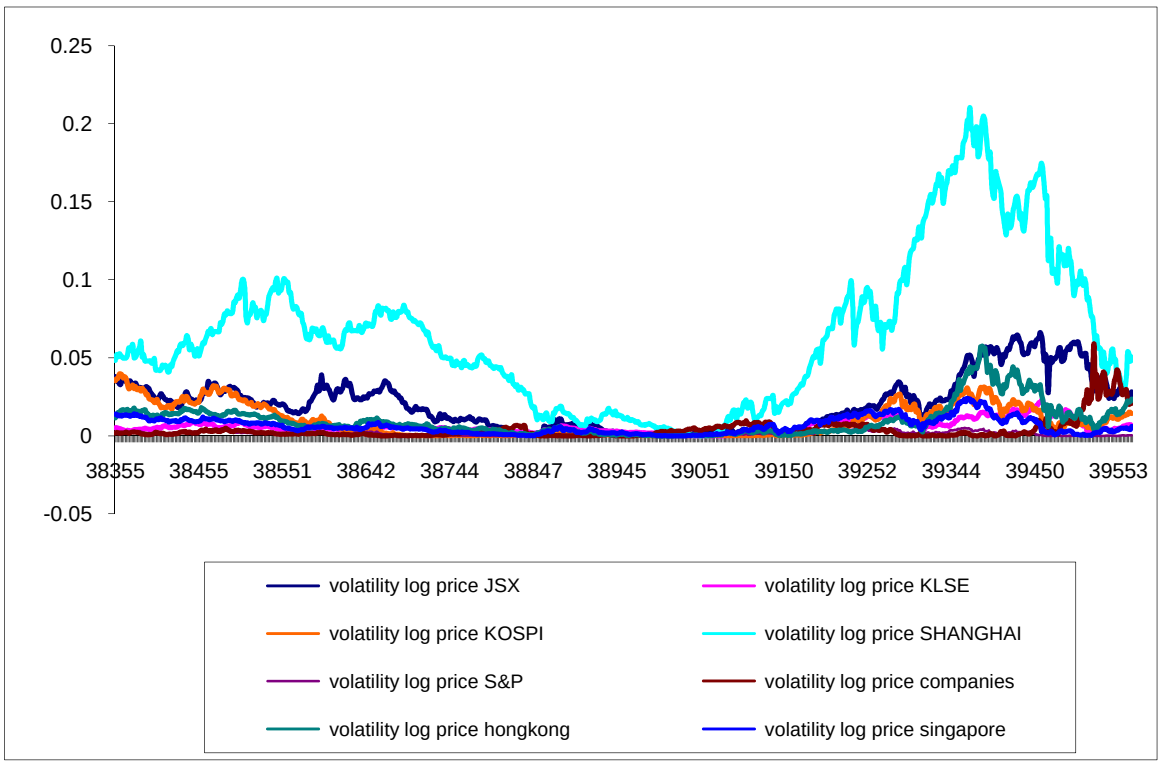

Figure 1: Volatility Log Price for the Asian and the U.S. Stock Market

Tabel 1: Statistic Descriptive for Daily Stock Market Returns in Several Asian Stock Markets and The U.S. Stock Markets

	JSX	KLSE	KOSPI	SSE	SGX	HKEx	SP	COMP
Mean	0.00048	0.00020	0.00041	0.00062	0.00026	0.00034	0.00008	-0.00014
Median	0.00100	0.00036	0.00081	0.00078	0.00052	0.00053	0.00035	0.00001
Maximum	0.0401	0.0127	0.0253	0.0386	0.0258	0.0342	0.0180	0.0634
Minimum	-0.0561	-0.0433	-0.0327	-0.0554	-0.0400	-0.0638	-0.0153	-0.0479
Std. Dev.	0.0068	0.0040	0.0059	0.0086	0.0051	0.0065	0.0040	0.0082
Skewness	-1.0832	-2.5153	-0.6185	-0.7924	-0.8500	-1.2985	0.0005	0.2530
Kurtosis	12.7942	25.3087	6.2405	8.6716	10.1602	17.7703	5.6203	13.2379
Jarque-Bera	3165.334	16452.26	378.4821	1090.941	1703.722	7075.191	215.9952	3305.338
Observation	755	755	755	755	755	755	755	755

Figure 1 shows the fluctuations of log price indexes for all the selected countries. Shanghai stock market presents the highest volatility especially during the period of mid 2005 to early 2006 and the period of mid 2007 to early 2008. The volatility peaked in mid of 2007 before it declined. The Indonesian stock market volatility is relatively higher than the other Asian stock markets and below Shanghai market. Most of the Asian stock market follows a similar pattern of volatilities. The U.S. S&P stock market records very low volatilities as well as the 10 most affected stock price indexes. The average 10 companies stock price index started to fluctuate during the early 2008 indicate that the companies' stock price dropped dramatically as the impact of the crisis.

Since the purpose of this paper is to model the returns and their associated volatilities for the stock markets, Table 1 summarizes the descriptive statistics for the return series. Stock market returns for Indonesia and China are relatively higher on average compared to the other returns. In contrast, the average 10 companies in the U.S. provide the lowest average return during the period. Indonesia and China provide the highest average return since they present the highest return. The 10 companies originally present the highest return, yet it also provides the lowest. Therefore, the average return is one of the smallest compared to the Asian markets return. The value of standard deviations supports the facts presented in Figure 1, in which Shanghai market has the highest volatility followed by the JSX. Interestingly, the average companies show a high number of volatility especially during the period of early 2008. Furthermore, the average return of 10 companies is negative, indicating the decreasing tendency of stock prices returns during the period. In addition, measure of skewness and kurtosis indicate the left-skewed and leptokurtic of the return distribution (the Jarque-Bera statistics significantly reject the normality hypothesis of stock market returns).

Models that are commonly used to analyze these kinds of data are ARCH and GARCH models. These models are able to examine time varying data which is characterized by heteroscedastic variance. GARCH model improve ARCH model by effectively removes the excess kurtosis in return series.

Another weakness of ARCH model and its extension GARCH model is they do not take into account the different impact of positive and negative shocks on the conditional volatility (or risk). Volatility is likely to decline when price increase and tend to increase when price falls or known as leverage effects. In asset prices movements, bad news seems to have a greater impact on volatility than positive shocks of a similar magnitude (McAleer, 2005) therefore, EGARCH model of (Nelson, 1991; Engle and Ng, 1993) is applied since it is able to order good news (positive return shocks)

and bad news (negative return shocks) to have a different impact on volatility). The model is able to capture asymmetric effects that focus on the impact of conditional variance of the conditional return.

The other model is also estimated namely the GARCH-M model of Fang et al. 2008). The model allows the returns to be partly determined by their associated risks. This model was developed based on the premise that higher risk may bring about higher returns. Thereby, the model is useful to guide investors in diversifying assets between the real estate and other assets based on the level of risks.

By combining the models of EGARCH and GARCH-M models, the model applied for the study is EGARCH (1,1)-M model. The model takes into account the impact of conditional variance and asymmetric effect along with the tradeoff between risk and return. The impact of the sub-prime crisis to Asian stock markets is tested using several different models. The first model represents a direct effect of the sub-prime crisis to the U.S. stock markets. The second model represents the direct impact of the sub-prime crisis to the Asian stock markets. The third model represents indirect impact of the sub-prime crisis to the Asian stock market pass through the U.S. stock markets. Finally, the last model represents both the direct and indirect impacts of the sub-prime crisis and the downturn of the U.S. stock market to the Asian stock market.

Consider the mean equations:

Model 1:

$$r_{S\&P} = \alpha + \beta_1 r_{comp} + \vartheta\sigma_t^2 + \varepsilon_t, \varepsilon_t \sim N(0, \sigma_t^2) \quad (3)$$

Model 2:

$$r_{i,t} = \alpha + \beta_1 r_{comp,t} + \sum_{j=2}^{n} \beta_j r_{j,t} + \vartheta\sigma_t^2 + \varepsilon_t, \varepsilon_t \sim N(0, \sigma_t^2) \quad (4)$$

Model 3:

$$r_{i,t} = \alpha + \beta_1 r_{S\&P,t} + \sum_{j=2}^{n} \beta_j r_{j,t} + \vartheta\sigma_t^2 + \varepsilon_t, \varepsilon_t \sim N(0, \sigma_t^2) \quad (5)$$

Model 4:

$$r_{i,t} = \alpha + \beta_1 r_{comp} + \beta_2 r_{S\&P,t} + \sum_{j=2}^{n} \beta_j r_{j,t} + \vartheta\sigma_t^2 + \varepsilon_t, \varepsilon_t \sim N(0, \sigma_t^2) \quad (6)$$

All the above models share similar variance equation as follows:

$$Log(\sigma_t^2) = \omega + \delta \log(\sigma_{t-1}^2) + \zeta \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \gamma \left| \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} \right| \quad (7)$$

where $r_{i,t} = \log(P_{I_t} / P_{I_{t-1}})$ represents the stock return in country i at period t and $r_n = \log(P_{I\,nt} / P_{I\,nt-1})$ where $r_{j,t}$ is the stock market returns in country j at time t. σ_t^2 is the conditional variable (the unsystematic hetero-risk) at period t. α, β, ϑ are the parameters of the mean equation while ω, δ, ζ are the parameters of the variance equation. Parameter ϑ denotes the effects of a particular conditional variance on stock market return. A significantly positive value of ϑ means that the effect of risk on returns is positive and *vice versa*. In the variance equation, when $\zeta \neq 0$ demonstrates the existence of asymmetry and $\zeta < 0$ demonstrates the existence of the leverage effect. Moreover, EGARCH-M model also allows for asymmetric which is caused by the changeable standard residual of the level term and the unstable ζ value. If ζ **=0** then a positive return shock has the same effect on volatility as the negative return shock of the same amount. If ζ **<0,** positive return shocks actually reduce volatility and if ζ **>0** then a positive return shocks increases volatility. Commonly the coefficient is negative therefore positive return shocks generate less volatility than negative return shocks. Maximum likelihood method is employed to estimate EGARCH-M model.

The diagnostic tests to test the independences of the return series are *Q*-statistic and the Lagrange Multiplier (LM). *Q*-statistic is employed to test the presence of non-linear effects (GARCH effects) in residuals. *Q*-statistic is calculated from the squared residuals and it can be used to identify the order of the GARCH process.

RESULTS

Table 2 presents the correlation coefficients among the stock markets under study. The correlation coefficients of the stock market return range from a highest of 0.78 (S&P and U.S. companies) to the lowest of nil (China-U.S. companies in U.S.). The correlation is relatively low between the Asian stock markets and the U.S. stock market, while the correlations among the Asian stock markets are relatively high. The U.S. stock market is relatively highly correlated with the stock markets of Korea (0.15) and Singapore (0.12), while the average return of the ten financial institutions and investment banks in the U.S. are highly correlated with the S&P return and is weakly correlated with the Asian stock return. In general, within the Asian stock markets, JSX is relatively correlated with some of the Asian markets such as Malaysia, Korea and Hong Kong, as indicated by its highest correlation coefficient. These results are preliminary indication of the degree on integration across Asian stock markets.

Table 2: Correlation Matrix for Daily Stock Markets Returns

	JSX	KLSE	KOSPI	SSE	SGX	HKEx	SP	COMP
JSX	1	0.55	0.55	0.22	0.43	0.54	0.10	0.06
KLSE		1	0.48	0.25	0.43	0.47	0.10	0.06
KOSPI			1	0.20	0.47	0.52	0.15	0.06
SHANG				1	0.12	0.32	0.02	0.00
SINGAPORE					1	0.40	0.12	0.01
HONG KONG						1	0.08	0.05
SP							1	0.78
COMP								1

Table 3: Estimation Results of EGARCH (1,1)

Parameter	Model 1
	S&P
α	-7.59E-05
ϑ	38.198
β_{COMP}	**0.401**
$\beta_{S\&P}$	
β_{JSX}	
β_{KLSE}	
β_{KOSPI}	
β_{SSE}	
β_{HKEx}	
β_{SGX}	
ϖ	**-5.476**
δ	**0.576**
ζ	**-0.040**
γ	**0.500**
Diagnostic Test	
Q(12)	19.69
LM(12)	3.29

Notes: Entries in bold indicate significant at 5% level. Entries in italic indicate significant at 10% level.

Table 4: Estimation Results of EGARCH (1,1)

Parameter	Model 2					
	JSX	KLSE	KOSPI	SSE	HKEx	SGX
α	0.000278	-6.60E-05	5.80E-05	0.000572	-0.000165	**-0.000328**
ϑ	-2.045	6.264	7.136	-2.127	5.003	22.057
β_{COMP}	-0.011	*-0.018*	0.006	0.032761	**0.049**	0.002
$\beta_{S\&P}$						
β_{JSX}		**0.110**	**0.188**	0.000	**0.189**	**0.128**
β_{KLSE}	**0.378**		**0.187**	**0.429**	**0.221**	**0.365**
β_{KOSPI}	**0.230**	0.032		0.014	**0.158**	**0.169**
β_{SSE}	-0.002	**0.031**	-0.013		**0.067**	0.008
β_{HKEx}	**0.228**	**0.092**	**0.246**	**0.033**		**0.175**
β_{SGX}	**0.076**	**0.149**	**0.195**	0.058	**0.260**	
ϖ	**-3.081**	**-0.538**	*-0.860*	**-0.586**	**-0.935**	**-0.558**
δ	**0.735**	**0.970**	**0.931**	**0.962**	**0.944**	**0.968**
ζ	**-0.228**	**-0.047**	*-0.078*	**-0.043**	-0.006	**-0.128**
γ	**0.305**	**0.255**	**0.144**	**0.285**	**0.421**	**0.248**
Diagnostic Test						
Q(12)	18.26	16.10	8.27	13.72	20.6*	15.76
LM(12)	12.96	5.25	9.40	11.88	8.0	17.60

Notes: Entries in bold indicate significant at 5% level. Entries in italic indicate significant at 10% level

Table 5: Estimation Results of EGARCH (1,1)

Parameter	Model 3				
	JSX	KLSE	KOSPI	SSE	HKEx
α	0.000283	-0.000127	-0.000141	0.000563	-0.000138
ϑ	-1.284	17.892	15.584	-1.585	4.230
β_{COMP}					
$\beta_{S\&P}$	-0.060	**-0.045**	**0.086**	-0.036	0.041
β_{JSX}		**0.107**	**0.193**	0.003	**0.180**
β_{KLSE}	**0.374**		**0.180**	**0.417**	**0.244**
β_{KOSPI}	**0.231**	*0.030*		0.021	**0.168**
β_{SSE}	-0.001	**0.033**	-0.014		**0.068**
β_{HKEx}	**0.228**	**0.095**	**0.245**	**0.257**	
β_{SGX}	*0.080*	**0.151**	**0.182**	0.061	**0.237**
ϖ	**-3.134**	**-0.530**	**-0.940**	-0.567	-0.954
δ	**0.731**	**0.971**	**0.923**	**0.963**	**0.942**
ζ	**-0.229**	**-0.040**	**-0.082**	**-0.040**	0.001
γ	**0.315**	**0.259**	**0.139**	**0.282**	**0.416**
Diagnostic Test					
Q(12)	18.56	18.52	8.27	13.92	16.87
LM(12)	13.78	6.37	9.02	11.79	8.77

Notes: Entries in bold indicate significant at 5% level. Entries in italic indicate significant at 10% level

Table 6: Estimation Results of EGARCH (1,1)

Parameter	Model 4					
	JSX	KLSE	KOSPI	SSE	HKEx	SGX
α	0.000299	-9.18E-05	-0.000151	0.000557	-0.000179	-0.000345
ϑ	0.000	12.125	15.844	-2.099	5.666	*22.684*
β_{COMP}	0.039	-0.001	-0.049	-0.042	0.038	-0.024
$\beta_{S\&P}$	-0.113	-0.044	**0.152**	0.024	0.029	*0.068*
β_{JSX}		**0.108**	**0.193**	0.002	**0.189**	**0.127**
β_{KLSE}	**0.370**		**0.186**	**0.431**	**0.224**	**0.369**
β_{KOSPI}	**0.238**	**0.031**		0.011	**0.155**	**0.163**
β_{SSE}	-0.003	**0.032**	0.011		**0.068**	0.010
β_{HKEx}	**0.226**	**0.094**	**0.242**	**0.260**		**0.174**
β_{SGX}	**0.079**	**0.151**	**0.185**	0.054	**0.260**	*0.068*
ϖ	**-3.143**	**-0.533**	**-0.939**	**-0.558**	**-0.933**	**-0.543**
δ	**0.730**	**0.971**	**0.924**	**0.964**	**0.944**	**0.968**
ζ	**-0.231**	-0.042	**-0.079**	**-0.041**	**-0.003**	**-0.128**
γ	**0.316**	**0.259**	**0.140**	**0.278**	**0.422**	**0.238**
Diagnostic Test						
Q(12)	19.3*	16.04	8.50	13.77	20.75*	12.25
LM(12)	12.52	5.46	9.17	11.93	7.97	20.26

Note: Entries in bold indicate significant at 5% level. Entries in italic indicate significant at 10% level

The estimation of the EGARCH (1,1)-M models for each equations in section three is exhibited in Table 3, 4, 5, and 6. As explained in the last section, the models are distinguished whether it includes the direct or/and indirect effects of the sub-prime crisis on the Asian stock markets.

Model 1 and Model 2 represents the direct impact of the sub-prime crisis on the U.S. stock markets and on the Asian stock market respectively. Model 3 assumes that the sub-prime crisis only affect the Asian stock market indirectly through its impact on the U.S. stock market. Finally, Model 4 combines both the direct and indirect effects of the sub-prime crisis for the Asian stock markets.

In Model 1 and Model 2, the independent variable is the average return of 10 most affected companies. In Model 3, the independent variable is the U.S. stock markets (S&P). Model 4 includes both of these independent variables.

Overall, the result shows interdependence among markets in a range of magnitude. Moreover, the effect of risk on return as represented in ϑ is not significant, indicating that the tradeoff between risk and return is not evident for all the markets. Meanwhile, the diagnostic tests for *Q*(12) and LM test show that before order of 12, the ARCH effects disappears.

Table 3 provides the β values of the mean equation. In Model 1, the average return of the ten U.S. companies significantly affects the U.S. stock market return. The sign is positive suggesting the likelihood of decrease in the U.S. stock market return as the average return of the ten U.S. companies falls. The impact of a decrease in the average companies' returns lead to a decrease in the U.S. stock returns by 0.4 points. Furthermore, the ϑ value is insignificant meaning that the effect of unsystematic risk σ_t^2, on the U.S. stock return is not evident. Moreover, the value of ζ of the variance equation is significantly negative, indicating the existence the leverage effect on conditional variance. Moreover, the asymmetric effect suggests that the nega-

tive news bring about larger volatility than positive news.

The direct effect of the sub-prime crises to the Asian stock market is expressed in Model 2 in Table 4. The direct spillover effects from the collapse of 10 companies in the U.S., however, only apply for Hong Kong stock market. This means that the channel of the sub-prime crisis does not directly come from the fall in the sub-prime mortgage returns. However, most the Asian stock markets (except Hong Kong and Korea) indicate the presence of asymmetric risk meaning that the effects of bad news have larger impact compared to positive news at the same magnitude as indicated by the significance of ζ values. Moreover, they also indicate the presence of the leverage effect on the conditional variance suggesting the existence of volatility clustering.

The impact of sub-prime crisis indirectly affect Malaysian and Korean stock markets through the fall of U.S. stock market return as expressed in Model 3 in Table 5. The impact for Malaysia is negative, in which the fall in the U.S. stock returns would increase the Malaysian stock return. In contrast, the fall in the U.S. stock market leads to decrease in Korean stock return. The impact of declining U.S. stock return is not significant for the remaining Asian stock markets returns. This may indicate that the investors use the Asian stock market to diversify their portfolio investment in order to compensate their loss in the sub-prime market. Furthermore, the asymmetric effect applies for Indonesia, Malaysia, Korea and China, indicating that bad news has greater impact than positive news. Consistent with Model 2, there is no leverage effect in Hong Kong stock markets.

Model 4 incorporates both the direct and indirect effect of the sub-prime crisis. Compared to Model 3, Model 4 implicitly confirms that the indirect effect applies more than direct effect. When the returns of most affected countries and the returns of S&P are estimated together to the return of the Asian markets, the impact of the fall in returns of companies do not have any affects to the Asian stock markets returns. Meanwhile, the fall in S&P returns directly affect the returns of JSX, SGX (even only in 10% confidence level) and KOSPI. The latter experienced the highest positive effect from the fall in S&P return. The impact of the fall in the U.S. stock market returns is negative for Indonesia, indicating that these two markets are seen as substitutes by the investors. Recalling the negative relationship between the U.S. stock markets and the Malaysian stock markets, it can be said that there is negative relationship between developed and developing countries' stock markets. This result suggests that the downturn of the U.S. stock market will contribute to lower returns for Korea (KOSPI) and Singapore (SGX). This also suggests that the relationships between developed countries' stock market is not substitute.

Moreover, Model 4 is able to capture the existence of the leverage effects for all the Asian stock markets except for Malaysia. The values of ζ are negatively significant, indicating the existence of the leverage effects and asymmetric effects in which the negative news have greater impact than positive news. Moreover, the effects of risk on return is evident for SGX (at 10 percent level of significance) indicating that higher risk yield higher return in stock markets Singapore.

The spillover effect of the sub-prime crisis is not significant in the Asian stock markets. However, the spillover e ffect of across countries stock market return is significant, indicating that the interdependence among the Asian stock markets. The stock return for JSX is mostly influenced by the return from KLSE (0.37), while the JSX return affects returns series of KOSPI, HKEx and SGX. This result is in line with the correlation matrix which shows that JSX is highly correlated with

KLSE, KOSPI and HKEx. Meanwhile, Singapore stock market return affects significantly the return in KLSE and HKEx while return from SSE influences KLSE and HKEx stock returns. This may arguably be interpreted that SSE market are more integrated to Kuala Lumpur and Hong Kong stock market.

The interdependence among countries' stock markets represents a more integrated financial market in Asia. The result in this paper is in line with the previous study, which suggests that the Asian countries are becoming closely linked together. Market integration is becoming more significant and intense. Eventually this integrated market requires efficiency in the region stock markets along with higher initiatives to switch the source of capital from banking to bond and stocks.

CONCLUSION

Using the U.S. stock market return and the average returns of the 10 most-affected banking and financial companies, we explore the effect of the sub-prime mortgage crisis. The paper attempts to analyze the spillover effects of the sub-prime crisis to six Asian stock markets, namely Jakarta composite index (JCI) Indonesia, Kuala Lumpur composite index (KLSE) Malaysia, Korea composite index (KOSPI), Hong Kong index (HKEx), Singapore Strait Times index (SGX) and Shanghai composite index (SSE) China.

An EGARCH model is employed to examine the direction of the spillover effects and the presence of the trade-off between the risk and return for each Asian stock market returns. We also test the significance of the asymmetric effects between positive and negative news. The results show that the sub-prime crisis indirectly affects the Asian stock markets return through the falls in the U.S. stock market return. However, the effect is not significant for Asian stock markets since the region interdependence across countries is stronger than its interdependence with the U.S. stock market. The result also indicates that the market integration occurs within Asian stock markets. Moreover, the trade-off between the risk and return is not evident except for Singapore.

Meanwhile the asymmetric effects are evident for all the Asian countries stock markets. In addition, we find evidence of the leverage effects in all the stock markets, which means negative news lead to higher volatility relative to the positive news. The interdependence among countries' stock markets represents a more integrated financial market in Asia. The result in this paper is in line with the previous study, which suggests that the Asian countries are becoming closely linked as market integration is becoming more significant and intense. Eventually this integrated market will require efficiencies in the region's stock markets.

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