Dependence Structure of Equity and Foreign Exchange Markets: Evidence from Industrialized Asian Economies

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Abstract **- The world economy has experienced a number of financial crises over the past 15 years. They placed significant impacts on various countries. This paper attempts to explain the reasons causing the co-movement of foreign exchange market with the stock market in the industrialized Asian economies, including Japan, Korea, and Singapore. We find that the relationship is stronger during the crisis period. Johansen cointegration test result also supports the strong linkage in trading activities between industrialized Asian economies and U.S..**

Keywords - *co-movement, dependence structure, cointegration, stock market, foreign exchange market.*

1. Introduction

Exchange rate is defined as a price of one currency in terms of another. It is one of the most important elements which can impact other financial markets. The fluctuation of foreign exchange rate may be caused by the uncertainty of the world financial economy. Therefore, it leads to the need of examining exchange rate movements, in relationship with the other variables such as stock returns.

The reasons that can affect the co-movement between foreign exchange (FX) and stock markets include financial crisis and the introduction of new financial policy. The financial crises occurred world-wide during the past two decades have significant impacts on different economies directly or indirectly. There are signals of crisis in world economies which affected exchange rates, and followed by the fluctuation in stock market of some countries, such as October Crash in 1987, Asian Financial Crisis in 1997, and Global Financial Crisis from 2007 to 2008. There are many previous researches which studied the relationship between FX and stock markets across countries. Different countries are affected in a different way as their historical, cultural, political and financial backgrounds are not identical. Previous researches also find various results on this relationship by using a large number of models.

This paper aims to investigate the dependence structures between stock and FX markets in three Asian countries, Japan, Korea, and Singapore, over the period of 1994 to 2009. This paper follows the model of Phylatik and Ravazzolo (2005) closely to investigate the relationship between FX and stock markets in these three countries, and compare the results in two crisis periods, Asian Financial Crisis in 1997 and Global Financial Crisis in 2007-2008. Two scenarios as "flow" and "stock", defined in Phylatik and Ravazzolo (2005)'s paper will be considered in the present study. The reason to choose Japan and two newly industrial countries, South Korea and Singapore, is that they have most similar background, in terms of history, cultural, politics, and financial system.

Section 2 is the literature review. It explains the reasons cause co-movement of FX and stock markets and review the existing studies on this issue. It can be divided into Asian Pacific or South East Asian countries and industrial countries. The methodology and empirical tests results are also reviewed to compare whether the results are consistent when using the different tests. The dependence structures between the stock and FX markets are considered to examine the causality to see if the change in stock market leads to the changes in FX market or vice versa. Section 3 introduces the methodology and hypotheses and presents the descriptive statistics of data. It includes a model, which is proposed by Phylaktis and Ravazzolo (2005), and tests of causality and co-integration between variables. Section 4 shows the results from empirical research

and show the trend movement during the past period. The different implications of the government policies across these countries will be reviewed base on the empirical results in section 5. Section 6 concludes the paper and presents the limitation of the present study.

2. Literature Review

2.1 Reasons that lead to co-movement between stock and FX markets

The reasons lead to the co-movement between stock markets and FX markets include financial crisis, changes in monetary and financial policy, change in capital market structure and even a trend of development in world economy. There were some certain crises which affected the world financial economies during last two decades, which destroyed many national economies and caused a deep depression in many countries. These crises can be listed such as October Crash 1987 in the US, Recession in Japan 1992, Financial Crisis 1997 in Asia, etc

First of all, since Black Monday was occurred in October 1987 in US, so-called October Crash 1987, the international independence of stock prices was taken into much attention, which was improved by Eun and Shim (1989), Jeon and Chiang (1996), Lai *et al* (1993), Kurihara and Nezu (2006). Mallaris and Urrutia (1992) studies the correlation among the major stock markets in the world before and after October 1987 crash. They argue that there was no significant correlation before the crisis, whereas significant correlation was found during the crisis and decrease sharply after that.

Since the early of 1990s, Japan has experienced stagnation; even Japan is one of countries has strong influence to the others. During the economic down turn in years of 1990s, the share which used in investment in GDP decreased by 5 percent (Hilpert, 2003). Besides this problem, there were many issues which raised by Japanese crisis during 1990s, such as corporate governance, nearly absence of the productivity growth, etc.

Thirdly, the Asian Financial Crisis in 1997 had a strong impact on some Asian countries during that time. Jang and Sul (2002) conduct a research on the co-movement of Asian stock markets which were affected by Financial Crisis 1997 for 7 countries in Asian. They state that there was no co-movement between stock markets of these 7 countries until Financial Crisis was triggered. This crisis happened by the collapse in the value of Thai baht in July 1997, accompanies with the collapse of stock market following that. It became an Asia Crisis quickly when it spread to all other countries in the region and need to be supported from IMF bailout package. In contrary to effects of decline in stock market and devaluation in foreign exchange rate in Asia countries, they also stated that the stock and foreign currency markets in US and Europe at the same time still had strong performance. Then a question was raised is if all over the world economies has been experienced and affected same as each other from a certain crisis?

Choi *et al* (1998) agree that exchange rate is one of important factors to influence the stock markets. The appearance of newly emerging capital markets all over the world, especially in Asian countries, was received much attention. These emerging markets implement policies and regulations in recent years to facilitate the portfolio investment. Furthermore, capital flows into this area has increased dramatically for recent years, but the current problem is still mentioned about the exchange rate's uncertainty (Carrieri and Majerbi, 2006). The emerging market's financial crises of the 1990s also led to push the stock market booms in Latin American East Asia and Russia (Edwards, 2007). Doong *et al* (2005) examine the dynamic relationship between stock and exchange rate for six Asian emerging financial markets including Indonesia, Malaysia, Thailand, Korea, Philippines and Taiwan. They state that there is a rapid growth in these Asian economies in national income and expansion in capital market. They find a positive relationship between currency and stock markets.

Beside the appearance of new capital market in the emerging economies, the flexible exchange rate regimes in these economies also give a chance to increase the volatility of foreign exchange market and the risk associated with such investment (Phylaktis and Ravazzolo, 2005). Due to the lessons learned in the financial crisis, the choice of currency denomination currency is an important dimension to cover all portfolio decision. Once it changed, it might impact the stock market to secure all positions at that time.

2.2 Relationship between stock market and foreign exchange rate.

2.2.1 General issues

There are familiar results in some cases, which are relevant to time that the crises triggered. Mallaris and Urrutia (1992) find that a decline in relationship

between stock Asian stock markets after the October crash. Najand (1996) took into account the integration of international stock markets during October crash 1987, especially for Asian markets where Japan has much influence on the others. The results indicate that the return of Japan depends on the US performance. In his paper, Najand also argues that Japan is the major stock market which plays a significant role among the other Asian markets not only during but also after the October crash 1987. This result is in contrast with Mallaris and Urrutia (1992), who indicate a decrease in correlation after crisis. On the other hands, Jang and Sul (2002) examine the co-movement of Asian stock markets before, during and after Asian Financial Crisis in 1997 by using data from 1996 until 2000. They selected 7 Asian countries and specified them as direct crisis countries, which are affected by Crisis directly (as Thailand, Indonesia, Korea) and neighboring countries (as Japan, Hong Kong, Singapore and Taiwan). Their results show that there is almost no co-movement in stock markets between 7 Asian countries before crisis, but it increased during financial crisis. However, the strongest co-movement is found in some cases after the crisis (Jang and Sul, 2002). An instability of stock market which caused by Asia Financial crisis is nearly same with the results that October crash 1987 studied by Mallaris and Urrutia (1992), Jang and Sul (2002).

It is widely believed that exchange rate is an important variable to investigate the relationship among stock and FX markets (Choi *et al*., 1998, Homma *et al*., 2005). In the relationship between foreign exchange rates and domestic stock prices, the US stock market is always taken into account to examine its impact on domestic stock prices (Kurihara, 2006). For example, Phylaktis and Ravazzolo (2005) consider the US stock price, which represents the world capital market as an independent variable that can affect the domestic stock prices. It means that US market is one of weighted and influence markets all over the world. Most of local stock markets may change once the US stock market changes. This result is proved by many researches on financial crises (Kurihara, 2006; Phylaktis and Ravazzolo, 2005).

Phylatik and Ravazzolo (2005) show that stock prices are positively correlated with FX markets. Similarly, the current exchange rate and the emerging stock price changes display a highly positive relationship by evidence from India (Mishra *et al.,* 2007). The positive relationship is also found in Japan by Kurihara (2006). He explains this phenomenon by giving evidence that Japan is an exporte oriented-country. That means, an appreciated domestic currency will lead to the increase in foreign exchange rate (Yen/ USD for instance) and followed by the increase in the domestic stock market. In the emerging market, however, the relationship between stock and FX market needs to be reviewed with other macroeconomic variables and it depends on the economic situation (Carrieri and Majerbi, 2006).

2.2.2 Asian countries

A number of studies investigate the short-run and long-run relation between stock and FX markets. Jang and Sul (2002) prove that the relationship between stock markets is not strong enough in long-run because they find that there is a decrease in effects after a crisis. Doong *et al.* (2005) examines relation and pricing between stick and exchange rate for six Asian emerging countries including Indonesia, Malaysia, Philippines, Korea, Thailand, and Taiwan and find that there is no long-run relationship between the stock prices and exchange rates. Similar result is found in Malaysia using a bivariate model (Ibrahim, 2000). Phylaktis and Ravazzolo (2005) also illustrate a temporary effect on the long-rum co-movement of stock and FX markets.

Most of previous researches use Granger test (1969) to examine the causality of linkage between stock and FX markets. Doong et al. (2005) argue that there are no significant casual relations in Philippines and Taiwan. But the bi-directional causality is found in Indonesia, Korea, Malaysia and Thailand. Another study uses data from 7 Asian countries including Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan and Thailand to present a significant causality from exchange rate to stock price in Hong Kong, Japan, Malaysia and Thailand before the Asia crisis 1997 (Pan *et al.,* 2007). Pan et al. (2007)'s empirical tests also confirm the same results for all above 7 countries except Malaysia during the Asian Financial Crisis. However, no country expresses causality from reverse direction during that time (Pan et al., 2007).

Phylaktis and Ravazzolo (2005) introduce "flow scenario" and "stock scenario" with regarding to the sign of coefficient between domestic stock price and foreign exchange rates. They also test the influence of the financial crisis in 1997 on relationship between stock and FX markets and find that the increase in parameters during the period of Asian Crisis was short-lived.

2.2.3 Industrialized countries

Choi et al. (1998) state that foreign exchange rate is an important variable that affects international competitiveness performance of Japanese firms. They try to examine whether exchange rate risk is realized and priced in the Japanese stock market by using unconditional and conditional multi-factor asset pricing models. They find the different results using these two models. The unconditional model result shows that the exchange rate risk is not priced in Japanese stock market and even in US stock market and the pricing result depends on the choice of sub-period, suggesting the time-varying nature to price of the exchange rate risk. However, using conditional models, they find that in major world stock and currency markets, exchange rate risk is priced regardless of exchange rate measured used. It suggests the price of exchange rate risk in Japan is time-varying. Kurihara (2006) analyses the relationship between Japanese stock prices and foreign exchange rate, by adding other macroeconomic factors, as interest rate, into his model. US stock prices are also added into this model to test if it is a significant determinant of Japanese stock prices. Unit root test and the ADF test are applied to check the co-integration between variables and he find that interest rate does not affect much on Japanese stock prices, whereas the impact of exchange rate is positive and significant. Kukihara (2006) also argues that because Japan is an export oriented-country, the domestic currency depreciation is expected to be negatively related to the stock market movement. This finding is in line with Ma and Kao (1990), and Doong et al. (2005). Kurihara and Nezu (2006) include more variables, such as Euro/ Japanese yen's interest rate and the Euro/US dollar interest rate, in their model. The results remain unchanged.

Hyde (2007) seeks to investigate the sensitivity of stock returns at the industry level to market, exchange rate and interest rate shocks in the four major European economies: France, Germany, Italy and the UK by using the methodology of Campbell and Mei (1993). He finds the significant levels of exposure to exchange rate risk in industries in all four markets. Kolari, Moorman and Sorescu (2008) examine the cross-relationship of US stock returns and foreign exchange rate during period from 1973 to 2002. They demonstrate that firms with extreme absolute sensitivity to foreign exchange rate have lower required rates of return than other stocks. Their results suggest that the relationship between expected returns and foreign exchange exposure is non-linear (and inverse U-shaped).

2.3 Methodology used in the existing literature

2.3.1 Co-integration test

Many tests can be used to examine the co-integration between two variables. Unit root test and the methods of the Dickey_Fuller (DF) or Augmented Dickey_Fuller (ADF) are employed to investigate the co-integration and stationary between stock prices and exchange rates in numerous studies (Abdalla and Murinde, 1997; Doong et al., 2005; Homma et al., 2005; Kurihara, 2006; Kurihara and Nezu, 2006). Doong et al. (2005) uses this approach to test the stationary of levels and 1st differences of the stock index and exchange rate; and indicated that all the series of the stock prices and exchange rate are stationary at 1% level for the 1st differences of stock prices and exchange rate (Doong et al., 2005). Moreover, a positive relationship of co-movement between stock and exchange rate market was proved by Kurihara (2006).

Beside ADF test, Johansen trace test (1988) was also employed by Phylaktis and Ravazzolo (2005). In their paper, they introduce the concept of "flow scenario" and "stock scenario" with regarding to the sign of coefficient between domestic stock price and foreign exchange rates. According to the flow scenario, a correlation between domestic stock price and foreign exchange is positive due to its effect on economic activities. On the other hand, the stock scenario indicated that this correlation can be either negative or positive just because exchange rate will have different impacts on the various competing events.

2.3.2 Granger causality test

Many researchers use Granger causality test to check whether the stock returns lead the change in the exchange rate or vice versa (Abdalla and Murinde, 1997; Ibrahim, 2000; Doong *et al.,* 2005; Phylaktis and Ravazzolo, 2005; Pan et al., 2007). Abdalla and Murinde (1997) use the data within the period of 1985 to 1997 on Korea, India, Pakistan and Philippines. They report that the change in foreign exchange rate can make stock price change in Korea, Pakistan, India and the causality from the stock price to exchange rate was found for all sample countries, except Philippines (Abdalla and Murinde, 1997). The results for Philippines and Korea are consistent with those reported in Doong et al. (2005). Ibrahim (2000) indicates that there is uni-directional causality from

stock price to exchange rate in Malaysia and challenges that the causality between those two variables only in the nominal exchange rate, not the real one. However, Pan *et al*., (2007) argues that causality from stock price to exchange rate during the crisis was found for all sample countries, except Malaysia. Wald test is employed by Phylaktis and Ravazzolo (2005) in exploring the causality issues. They test various hypotheses bases on the flow and stock scenarios which have been mentioned above.

2.3.3 Other tests

The univariate GARCH-M and bivariate GARCH-M model for stock returns and exchange rate detect similar results in Doong et al. (2005). They find that the stock returns exhibit significant relation with the changes in exchange rate, except Thailand (Doong et al., 2005). Moreover, all correlations followed by this method are negative. It means that an appreciation in domestic currency leads to an increase in stock prices. Unconditional and conditional multi-factor asset pricing models were used to examine the situation in Japan (Choi et al., 1998). Using stock prices from TOPIC (Tokyo Stock Foreign Exchange), Homma et al. (2005) investigates the relationship between the FX and Japanese stock price by using Arbitrage Pricing Theory (APT). One of their main findings is that stock investors correctly evaluate firms' foreign asset position and appropriately respond to the change of the exchange rate after recession 1992.

In general, the relationship of co-movement between stock and FX markets is different in various countries. Reasons lead to the linkage between those two major variables (stock price and exchange rate) can be listed as crisis, capital flows into emerging markets (countries) and exchange rate regimes. Basically, using different methodology leads to various results. Most of them found the positive relationship between these variables. US stock price is recognised as a significant variable, which is needed to be considered as an influence on domestic stock price; whereas other macro-economic variables such as money supply, interest rate, government policy need to be reviewed (Ibrahim, 2000; Kurihara, 2006; Kurihara and Nezu, 2006).

3. Methodology and Hypotheses

3.1 Methodological issues

3.1.1 General model

This model aims to examine the relationship between domestic and foreign stock and FX markets, which is in line with the model proposed by Phylaktis and Ravazzolo (2005). It is presented as follows:

$$P_t^{domestic} = a_0 + a_1 S_t + a_2 P_t^{US} + \varepsilon_t \quad (1)$$

where

- $P_t^{domestic}$ is the domestic stock price at time t.
- P_t^{US} is US stock price at time t; both express in real term.
- S_t is the real exchange rate, defined as Domestic prices (CPI) relative to foreign prices multiplied by the nominal exchange. Both nominal exchange rate and real exchange rate are expressed in domestic currency against one unit of foreign currency (in this case is the US dollars). ε_t is a disturbance term.

Following the previous studies, all data are transformed by natural logarithms (Phylaktis and Ravazzolo, 2005, Febrian and Herwany, 2007). The exchange rate used in this model is in real term, in order to express a better competitive position of an economy (Chow et al., 1997; Phylaktis and Ravazzolo, 2005). The real exchange rate is computed from nominal exchange rate and consumer price index. The US stock market is usually taken as a leader and preventative of the world economy, who affects the rest of the world's economy fully or partially. In additional, the Japan, South Korea and Singapore markets are assumed to have mid-term to long-term relationship with the US market, so the US stock return is also added in addition to foreign exchange rate.

We will test the relationship between domestic stock prices with foreign exchange rates and US stock prices from 1994 until 2009 using Ordinary Least Square. OLS regression will give some general ideas of whether domestic stock markets have positive or negative relationship with foreign exchange rate. This method has been widely used by previous researches. In the case of Japanese and Singapore, the coefficient of exchange rates changes should be positive (Phylaktis and Ravazzolo, 2005; Kurihara, 2006). When changes in exchange rates (Yen/ USD) increase, it leads to depreciation in Japanese yen and following by promoting exports in Japan. Furthermore, Japan is also well-known as an exported-oriented country; hence an increase in foreign exchange rate causes a rise in domestic stock index. Some previous studies regarding the crisis 1997 argue that the reason that Korea was suffered is

relevant to Japan during the crisis (Khan, 2004, Hayashi, 2006). Therefore, it is most likely to forecast the positive coefficient α_1 as in the case of Japan.

The alpha of US stock return is expected to be positive due to the strong relationship and economics activities between Japan and US (Kurihara, 2006). The current global financial crisis 2007 and 2008, started in the US also affects to the rest of the world, including South Korea. A depress in the US stock markets cause a fall in Korean stock exchange (Kim and Rhee, 2009; Park and Lee, 2009).

3.1.2 Cointegration

On the basic of economy theory, two scenarios, which are relevant to the relationship between the foreign exchange with the domestic stock price index (coefficient α_1), are introduced in Phylaktis and Ravazzolo (2005).

"Flow" scenario is measured on the relationship between the exchange rate and economic activities. Following the explanation in Phylaktis and Ravazzolo (2005), a change in exchange rate impacts on economic activities such as future cash flows, aggregate demand and output, result in the firms' performance, which is relevant to the stock markets. They forecast there is a positive relationship between foreign exchange rate and domestic stock markets. This issue occurs when all information is conveyed to make an increase in the relationship between the US and these three countries, leading to an appreciation in real exchange rate and hence, cause a rise in domestic stock market.

Phylaktis and Ravazollo (2005) give another forecast according to the "stock" scenario. This approach forecast that the relationship between stock markets and exchange rate can be either positive or negative, depends on the relative strength and wealth among their economic activities.

In order to investigate the cointegration between variables, this paper follows the likelihood ratio test in Johansen (1988). Let Y_t is a vector of *P*, *S*, and P_{US} and n is a number of variable in the model (here n = 3). It is said that if Y_t is co-integration, it can be generated as follows:

$$\Delta Y_t = \mu + \sum_{i=1}^{k-1} a_i \Delta Y_{t-1} + a_k Y_{t-1} + \varepsilon_t \quad (2)$$

where:

- μ is a 3 x 1 vector of drift,
- *a* are 3 x 3 matrices of parameters,
- ε is a 3 x 1 noise vector.

The Johansen test statistic, the (n-r) common stochastic trends (trace statistic) is

$$Trace = -T \sum_{i=\gamma+1}^{n} \ln(1-\lambda_i) \quad (3)$$

where:

- λ_i are the (n-r) smallest squared canonical correlations of Y_{t-1} with respect to ΔY_t corrected for lagged and
- *T* is actual sample size (actual number of estimated observations)
- r is co-integration relationship (vector) in model ($0 \le r \le n$).

Then, this paper tests the null hypothesis:

H_{01}: *no integration between variables (r=0), alternative hypothesis will be there is 1 or more co-integration vector (r>0). We calculate* $\lambda_{trace}(0)$*, and*

H_{02}: *there is 1 or less than 1 co-integration vector (* $0 \le r \le 1$*), against the alternative of 2 or 3 co-integration vectors.*

If $\lambda_{trace}(0)$ is exceed the critical value (at significant 5%) of λ_{trace}, meaning that there is no co-integration between variables.

3.1.3 Multivariate Granger causality tests

We will check whether stock price leads to the changes in foreign exchanges or foreign exchange rate leads to the changes in stock prices by using the Granger Causality Test. This paper follows the method used in study of Phylaktis and Ravazzolo (2005), which includes two following steps. First of all, the Wald test is applied to find the lag term of the VAR (k) against VAR (k+1), then applied it on the first k VAR coefficient matrix

$$Y_t = \mu + A_1 Y_{t-1} + \cdots + A_p Y_{t-k} + \varepsilon_t \quad (4)$$

There are three variables in the system, the generated models for Japan, South Korea and Singapore as follows:

$$\begin{bmatrix} P \\ S \\ P^{US} \end{bmatrix} = \begin{bmatrix} A_{10} \\ A_{20} \\ A_{30} \end{bmatrix} + \begin{bmatrix} A_{11}(L)A_{12}(L)A_{13}(L) \\ A_{21}(L)A_{22}(L)A_{23}(L) \\ A_{31}(L)A_{32}(L)A_{33}(L) \end{bmatrix} \begin{bmatrix} P_{t-1} \\ S_{t-1} \\ P_{t-1}^{US} \end{bmatrix} + \begin{bmatrix} \varepsilon_P \\ \varepsilon_S \\ \varepsilon_{US} \end{bmatrix} \quad (5)$$

where:

- A_{io} are the parameters representing intercept terms
- A_{ij} are polynomials in the lag operator L
- P is domestic stock price index for Japan, South Korea and Singapore

At this stage, we can examine the above matrices by using OLS to test the coefficient and a significance of three equations for each country individually, depends on sub-period. As mentioned in Phylaktis and Ravazzolo (2005), the "flow" and "stock" approach regarding to the link between stock and foreign exchange markets is testing through these hypotheses

H1: *"Flow" channel:* $A_{12}(L) \neq 0$, $A_{13}(L) \neq 0$, *and* $A_{23}(L) \neq 0$;

H2: *"Stock" channel:* $A_{13}(L) \neq 0$, $A_{21}(L) \neq 0$, *and* $A_{23}(L) \neq 0$; *and*

H3: *"Flow" and "Stock" channels:* $A_{12}(L) \neq 0$, $A_{13}(L) \neq 0$, $A_{21}(L) \neq 0$, *and* $A_{23}(L) \neq 0$

Hypotheses

The following null hypotheses will be tested to examine the cointegration between FX markets and stock markets

H01: *no integration between variables (r=0), alternative hypothesis will be there is 1 or more co-integration vector (r>0). We calculate* λ_{trace} *(0), and*

H02: *there is 1 or less than 1 co-integration vector (*$0 \leq r \leq 1$*), against the alternative of 2 co-integration vectors.*

H03: *there are 2 or less than 2 co-integration vectors (*$1 \leq r \leq 2$*), against the alternative of 3 more than 3 co-integration vectors.*

The following three hypotheses will be also tested for the multivariate Granger causality:

H01: *"Flow" channel:* $A_{12}(L) = 0$, $A_{13}(L) = 0$, *and* $A_{23}(L) = 0$;

H02: *"Stock" channel:* $A_{13}(L) = 0$, $A_{21}(L) = 0$, *and* $A_{23}(L) = 0$; *and*

H03: *"Flow" and "Stock" channels:* $A_{12}(L) = 0$, $A_{13}(L) = 0$, $A_{21}(L) = 0$, *and* $A_{23}(L) = 0$

3.2 Data

Three Asian countries taken into empirical test along with the US are Japan, South Korea and Singapore. All the observations in this test are obtained from the International Financial Statistics database on International Monetary Fund (IMF) database website. The sample period of time is selected from January 1994 until February 2009 (except South Korea until March 2009) for all these countries. The data consists of monthly stock market index prices expressed in local currency; local bilateral spot exchange rates expressed as domestic currency per U.S dollar, and consumer price index (CPI). The real exchange rate is defined as

$$S_t = e_t \frac{CPI_t^{US}}{CPI_t} \quad (6)$$

where:

- CPI_t is the consumer price index for the Japan, South Korea and Singapore (domestic country).
- CPI_t^{US} is the consumer price index for the US.
- e_t is the nominal exchange rate (domestic currency/ US dollar).

This paper aims to investigate the dependence structure between stock exchange markets and foreign exchange markets during the financial crisis which affects Japan, Korea and Singapore fully or partially. Therefore, the sample period is aimed to divide into 4 different period of time, which includes:

Period 1-Before Asian Financial Crisis 1997 (January 1994 – June1997); Period 2-During Asian Financial Crisis (July 1997 – July 1999); Period 3-After Asian Financial Crisis and before Global Financial Crisis (August 1999 – June 2007); Period 4-During Global Financial Crisis (July 2007 – February 2009, except South Korea until March 2009).

4. Empirical Results

4.1 OLS regression result

Table 1 reports the OLS regression result. There are positive relationship between foreign exchange and stock markets for Japan, South Korea and Singapore. The results also show that the US stock price index does affect the domestic stock prices.

Table 1. Coefficient of $P_t^{domestic} = a_0 + a_1 S_t + a_2 P_t^{US} + \varepsilon_t$

	α_0	α_1	α_2	R-square	Adjusted R-square	P-value (F-statistic)
Japan	6.591 (13.302*)	0.620 (4.516*)	0.189 (3.023*)	0.103	0.093	0.000
Korea	15.639 (18.006*)	1.901 (13.873*)	0.557 (8.657*)	0.527	0.522	0.000
Singapore	2.802 (11.811*)	1.093 (5.619*)	0.542 (7.815*)	0.255	0.246	0.000

Figures in parentheses are t-statistic, * denotes significant at 5% level

We then test the null hypothesis to see if there is any relationship between change in FX rate or the US stock price and domestic stock price basing on the significant level at 5% by using t-statistic.

H_0: $\alpha_1 = 0$, $\alpha_2 = 0$; H_1: $\alpha_1 \neq 0$; $\alpha_2 \neq 0$

The results are also interesting. In all cases, the results suggest that we must reject the null hypothesis which is said that the US stock price does not affect these countries' stock price. Hence, it is said that the coefficient of the US stock market is significant in the case of Japan, Singapore, and South Korea. On the other hand, the foreign exchange rate also significant influence on domestic stock price in Japan and Singapore, and South Korea.

From the result summary, the unadjusted and adjusted coefficients of determination (R^2 and adjusted R^2) are high for South Korea, whereas they are lower in Japan and Singapore. They suggest that about 53% (South Korea) of the total variation in domestic stock prices can be explained by the variations in percentage changes in foreign exchange and the US stock price. On the other hand, there is just 10% and 25% of movement of variables can explain the change in Japanese and Singapore stock price, respectively. The results show that there is a high chance that South Korea stock market is explained by the other explanatory variable such as South Korea FX market and US stock market.

The P value in summarized table indicates for significant F statistic. This paper is going to test the null hypothesis of R-square is equal to zero, which means

H_0: $R^2 = 0$; H_1: $R^2 \neq 0$

In three case of Japan, South Korea and Singapore, the Significance F (is equal to the P value in table 1) are very low, which are less than 5% (i.e less than 0.05), then we can reject the null hypothesis of $R^2 = 0$ and accept the alternative hypothesis of R^2 # 0. It means that R^2 is significantly different from zero at the 5% level of significant. Then, we can conclude in light of this finding that the independent variables of FX market and US stock market do have explanatory power to the domestic stock market.

Table 2 reports the OLS regression results for four sub-periodsThe regression results presented that US stock price and FX rate are significant in most of the case during the period 1, which is before the Asian Financial Crisis 1997. There is only the FX rate in case of Singapore expresses as non-significant to the domestic stock market. This implies that we

need to accept the null hypothesis that $\alpha_1 = 0$, keeping the other variables constant, leads to a conclusion that the FX rate did not affect the Singapore stock price during this period. Different from the results of Japan and South Korea, there is also a positive relationship between US stock markets and Singapore stock markets before the Asian Financial Crisis 1997. It can be said that any improvement in US equity markets, i.e stock markets can lead to a positive change in Singapore stock markets. Once the Asian Financial Crisis occurs in 1997, Singapore is one of the economies who is impacted much from this crisis because of a negative changes of US stock markets.

Table 2. Testing coefficient of $P_t^{domestic} = a_0 + a_1 S_t + a_2 P_t^{US} + \varepsilon_t$ by using OLS regression for different 4 periods of Japan, South Korea and Singapore

	α_0	α_1	α_2
JAPAN			
Before Crisis 1997	2.828	-0.664	-0.344
01/1994 – 06/1997	(5.718 *)	(-4.253 *)	(-3.905 *)
During Crisis 1997	6.366	0.326	-0.099
07/1997 – 07/1999	(3.622*)	(0.997)	(-0.634)
Between two Crises	-4.210	-0.577	1.332
08/1999 – 06/2007	(-7.302 *)	(-6.134 *)	(23.788 *)
During Crisis 2007	-4.585	-0.195	1.009
07/2007 – 02/2009	(-4.308 *)	(-2.823 *)	(7.216 *)
SOUTH KOREA			
Before Crisis 1997	14.259	1.168	-0.433
01/1994 – 06/1997	(8.186 *)	(4.424 *)	(-8.672 *)
During Crisis 1997	9.909	1.267	0.778
07/1997 – 07/1999	(3.333 *)	(3.586 *)	(2.067 *)
Between two Crises	19.634	2.294	0.271
08/1999 – 06/2007	(16.875 *)	(16.599 *)	(2.841 *)
During Crisis 2007	4.624	0.388	0.772
07/2007 – 03/2009	(2.627 *)	(2.285 *)	(5.646 *)
SINGAPORE			
Before Crisis 1997	3.898	-0.424	0.137
01/1994 – 06/1997	(18.819*)	(-1.476)	(3.135 *)
During Crisis 1997	-1.124	4.473	1.729
07/1997 – 07/1999	(-0.865)	(5.008 *)	(4.748 *)
Between two Crises	-0.167	-0.083	1.073

08/1999 – 06/2007	(-0.173 *)	(-0.118)	(7.476 *)
During Crisis 2007	-2.404	-0.528	1.580
07/2007 – 02/2009	(-6.670 *)	(-1.563)	(23.235 *)

Note: Figures in parentheses are t-statistic, * denotes significant at 5% level

During the 1997 Asian Financial Crisis, the empirical results show that the US stock market and FX market are not significant in case of Japan, but they do affect the South Korea and Singapore stock markets. During this time, South Korea and Singapore are considered as NICs (Newly Industrialized Country) in Asia. They have close economic relationship with US. Besides, Singapore is one of the countries which is affected directly from Asian Financial Crisis 1997, after Thailand, so the results indicated that a change of Singapore stock index (α_2=1.729) is more than the other two countries (-0.099 and 0.778 for Japan and South Korea, respectively) due to one unit change in the US stock price, keeping the other variables constant. As mentioned in section of selected country, the Asian Financial Crisis 1997 start with the depreciation of Thailand currency (Baht Thai) and has strong impact in most of the South East Asia countries during this period, including Singapore. So this is the reason why Singapore stock markets fluctuated more than the other two countries when there are any changes in US stock markets, keeping FX rate unchanged.

After being affected from the Asian Financial Crisis 1997, these three countries executed reforms to strengthen their economies. However, the FX market and US stock markets still affect the domestic stock market in most cases at the level of significant of 5%. There are positive relationship between the US stock prices and domestic stock prices in all three cases of Japan, South Korea and Singapore. This implies that once there are any increases in the US stock markets, it can lead to the change in domestic stock markets toward the same direction. As mentioned above, the global financial crisis occurred since mid 2007, and peak of 2008, which initially started in the US, has impacted the rest of the world. Hence, the results show that the domestic stock price depends much on the US stock index during this period of global financial crisis.

4.2 Cointegration results

We test the cointegration between variables across three countries during four sub-periods between 1994 and 2009. The Johansen test is applied for this section to investigate how many cointegrating vectors which is expressed in *Equation 2*.

Firstly, this paper tests the unit roots test by using Augmented Dickey – Fuller (ADF) tests for stationary in the level of the series and the first difference of the series (P, S, and P_{US}). The hypothesis that the level of this series has a unit root can be accepted (cannot be rejected) in all cases and the hypothesis that the first difference of the series has a unit root can be rejected. So the results show that the time series are an I(1) variables (this results are presented in Table 3, can be available by using eViews).

After testing the unit root of the series, the cointegration is investigated by using the Johansen tests. This test investigates the null hypothesis of cointegration vectors r in *Equation 3* to see if there is any co-integration vector in this model. The following null hypotheses are tested and the results are shown in Table 4

H_{01}: *there is no integration between variables (r=0),*

H_{02}: *there is 1 or less than 1 co-integration vector (*$r \leq 1$*),*

H_{03}: *there is 2 or less than 2 co-integration vector (*$r \leq 2$*),*

The results of cointegration relationship between variables are shown in Table 4. The null hypothesis H_{01} which states that there is no cointegration vector cannot be rejected in the second and third sub-period across three countries.

Table 3. ADF Unit Root Tests

Augmented Dickey – Fuller (ADF) Unit Roots Tests				
Variables	***Period 1***	***Period 2***	***Period 3***	***Period 4***
P_Japan	-2.06	-1.91	-0.81	-0.33
P_Korea	-1.12	-1.36	-0.30	-0.69
P_Sing	-2.97	-0.99	-0.23	-0.59
P_US	1.53	-0.25	-0.91	0.54
Real_fx_japan	-0.72	-1.98	-0.76	-1.60
Real_fx_korea	-0.39	-2.16	-0.33	-0.59
Real_fx_sing	-3.27	-2.59	-2.65	-2.31
First difference				
rP_Japan	-4.58***	-3.13**	-7.34***	-3.99***
rP_Korea	-5.04***	-2.80*	-7.44***	-3.26**
rP_Sing	-7.21***	-4.34***	-9.53***	-3.36**
rP_US	-5.57***	-3.78***	-8.22***	-3.33**
rReal_fx_japan	-5.11***	-5.11***	-9.01***	-2.93*
rReal_fx_korea	-5.77***	-4.52***	-8.78***	-5.61***
rReal_fx_sing	-4.47***	-5.01***	-9.74***	-4.03***

*, **, and *** denote significant level of 10%, 5% and 1%, respectively

Table 4. Cointegration tests of $P_t^{domestic} = a_0 + a_1 S_t + a_2 P_t^{US} + \varepsilon_t$ Johansen tests statistics

	H_0: r = 0	**H_0: $r \leq 1$**	**H_0: $r \leq 2$**
JAPAN			
Jan 1994 – Jun 1997	20.74	7.36	0.46
Jul 1997 – Jul 1999	22.52	9.03	2.17
Aug 1999 – Jun 2007	19.62	3.25	0.03
Jul 2007 – Feb 2009	34.71**	9.41	0.32
SOUTH KOREA			
Jan 1994 – Jun 1997	33.98**	11.60	0.03
Jul 1997 – Jul 1999	16.25	5.95	0.04
Aug 1999 – Jun 2007	25.68	10.74	1.10
Jul 2007 – Mar 2009	36.43**	11.26	1.88

SINGAPORE			
Jan 1994 – Jun 1997	27.98*	9.45	0.01
Jul 1997 – Jul 1999	16.48	4.19	0.01
Aug 1999 – Jun 2007	24.97	7.02	0.03
Jul 2007 – Feb 2009	27.92*	9.72	0.50

Note: Figures are trace statistics, the r denotes the number of significant vectors, and the Johansen trace statistics test the hypothesis of at most two, one and zero cointegration vectors, respectively. ***, ** and * denote significance at 1%, 5% and 10% level, respectively. The period 1 (pre-Asian financial crisis 1997) indicates from Jan 1994 to Jun 1997, period 2 (during Asian financial crisis 1997) is from Jul 1997 to Jul 1999, period 3 is from Aug 1999 to Jun 2007, the last period (during current global crisis) indicates from Jul 2007 to Feb 2009 (except South Korea is to Mar 2009)

The null hypothesis is also accepted in the first sub-period, which is period of pre-Asian crisis 1997 in Japan. In South Korea and Singapore, we can reject the null hypothesis that there is zero cointegration vector between domestic stock price, the US stock price and FX rate during the pre-Asian crisis (except Japan) and the current global crisis 2007 at a 5% and 10% significance level.

In addition, the second and the third null hypothesis, H_{02} and H_{03}, respectively in the model cannot be rejected for all cases in the time series. This means that there is at least one cointegration vector which can show the links or the integrated relationship between stock markets and FX markets, especially during the global current crisis in all three countries. The current global financial crisis as mentioned in section *4.1* has impacted on Japan, South Korea and Singapore; hence these results can be evidences to show that there are some links between these markets due to cointegration vectors.

Cases of South Korea and Singapore are same when there are rejections of the first null hypotheses for same two periods, whenever we accepted both second and third null hypotheses during four periods of time. So, since South Korea and Singapore are New Industrialized Countries (NICs), it's necessary if their markets including stock markets and FX markets are connected to the US markets, to strengthen their economies. This also implies the linkage between the stock markets and FX markets, especially the relationship between the US and these countries. The trading issues in terms of exports and imports can be a measurement for the level of integration of a country. The results in this section can confirm the fact there is bilateral relationship between the US and domestic markets.

4.3 Multivariate Granger Causality Tests

In this section, we test the hypothesis regarding to two channels, "stock" and "flow" suggested by Phylaktis and Ravazzolo (2005). These hypotheses are investigated by testing the coefficient restrictions which are mentioned in section 3. According to that, this paper examine the null hypothesis of

H_{01}: *"Flow" channel:* $A_{12}(L)=0$, $A_{13}(L)=0$, *and* $A_{23}(L)=0$;

H_{02}: *"Stock" channel:* $A_{13}(L)=0$, $A_{21}(L)=0$, *and* $A_{23}(L)=0$; *and*

H_{03}: *"Flow" and "Stock" channels:* $A_{12}(L)=0$, $A_{13}(L)=0$, $A_{21}(L)=0$, *and* $A_{23}(L)=0$

by using Wald test. Moreover, the coefficient between the US stock index and Asian Stock Index is also examined by testing $A_{31}(L)=0$.

The first step of this methodology is finding the appropriate lag structure by using Wald test. This paper testing the VAR(k) against a VAR(k+1) and applied Wald tests on the VAR(k) coefficient matrix. Phylaktis and Ravazzolo (2005) suggested in their paper using Wald tests with standard Chi-square distribution (χ^2) with (n-1) degree of freedom.

Table 5 presents the order of lag length chosen by AIC and SC criterion. The order of lag length selected based on Schwarz criterion is k=1 for all four periods of time across three countries. However, the order of lag length from Akaike criterion is various across three countries through four periods of time. Then this paper will examine the Granger causality using Wald test for both criteria.

Table 5. Order of lag length, chosen by AIC and SC criterion

VAR Lag Order Criteria	Period 1 01/1994 – 06/1997	Period 2 07/1997 – 07/1999	Period 3 08/1999 – 06/2007	Period 4 07/2007 – 03/2009
JAPAN				
AIC	Lag 1	Lag 2	Lag 2	Lag 2
SC	Lag 1	Lag 1	Lag 1	Lag 1
SOUTH KOREA				
AIC	Lag 2	Lag 2	Lag 3	Lag 1
SC	Lag 1	Lag 1	Lag 1	Lag 1
SINGPAORE				
AIC	Lag 1	Lag 1	Lag 2	Lag 1
SC	Lag 1	Lag 1	Lag 1	Lag 1

Note: AIC is Akaike information criterion. SC is Schwarz information criterion.

After deal with the data and coefficient matrices, the VAR(1) for Japan, South Korea and Singapore in 4 periods are examined.

Table 6. Multivariate Granger Causality test with VAR(1) – Schwarz Information Criterion

		$A_{12}(L)=0$	$A_{13}(L)=0$	$A_{21}(L)=0$	$A_{23}(L)=0$	$A_{31}(L)=0$
JAPAN						
Jan 1994 – Jun 1997	χ^2	0.36	0.09	3.39*	12.90***	1.91
P value	(0.55)	(0.76)	(0.07)	(0.00)	(0.18)	
Jul 1997 – Jul 1999	χ^2	3.32*	4.83**	0.12	0.12	4.96**
P value	(0.08)	(0.04)	(0.73)	(0.73)		(0.03)
Aug 1999 – Jun 2007	χ^2	3.01*	1.71	0.56	1.30	2.71
P value	(0.09)	(0.19)	(0.45)	(0.25)		(0.10)
Jul 2007 – Feb 2009	χ^2	2.45	0.01	2.27	0.04	3.95*
P value	(0.13)	(0.91)	(0.15)	(0.85)		(0.06)
SOUTH KOREA						
Jan 1994 – Jun 1997	χ^2	0.35	3.41*	0.46	5.87**	1.37
P value	(0.56)	(0.07)	(0.50)	(0.02)	(0.25)	

Jul 1997 – Jul 1999	χ^2	1.27	2.71	0.24	0.22	2.16
P value	(0.27)	(0.11)	(0.62)	(0.64)	(0.16)	
Aug 1999 – Jun 2007	χ^2	0.02	2.36	16.61***	4.93**	0.00
P value	(0.89)	(0.13)	(0.00)	(0.03)	(0.98)	
Jul 2007 – Mar 2009	χ^2	6.60**	2.35	2.29	0.74	0.27
P value	(0.02)	(0.14)	(0.15)	(0.40)	(0.61)	
SINGAPORE						
Jan 1994 – Jun 1997	χ^2	0.02	1.95	1.74	2.03	0.93
P value	(0.87)	(0.17)	(0.19)	(0.16)	(0.34)	
Jul 1997 – Jul 1999	χ^2	1.81	0.39	1.08	4.79**	0.63
P value	(0.19)	(0.54)	(0.31)	(0.04)	(0.47)	
Aug 1999 – Jun 2007	χ^2	1.10	0.07	1.41	0.23	4.14**
P value	(0.29)	(0.79)	(0.24)	(0.63)	(0.04)	
Jul 2007 – Feb 2009	χ^2	2.47	0.76	0.03	0.00	36.99***
P value	(0.11)	(0.38)	(0.86)	(0.96)	(0.00)	

Note: Performing Multivariate Granger Tests by using Wald tests to examine the coefficient restrictions with chi-square distribution (χ^2). Figures in parentheses are P value; ***, ** and * denote significance at level of 1%, 5% and 10% respectively. The period 1 (pre-Asian financial crisis 1997) indicates from Jan 1994 to Jun 1997, period 2 (during Asian financial crisis 1997) is from Jul 1997 to Jul 1999, period 3 is from Aug 1999 to Jun 2007, the last period (during current global crisis) indicates from Jul 2007 to Feb 2009 (except South Korea is to Mar 2009).

This paper investigates the Granger causality test through the flow and stock channel by testing the restrictions which is followed by Wald test. The "flow" channel is examined with the restrictions of A_{12}, A_{13}, and A_{23}. The restrictions of A_{13}, A_{21}, and A_{23} are used for testing the 'stock' channel. Moreover, the restriction of A_{31} is referred as the impact or causality of domestic stock markets across Japan, South Korea and Singapore to the US stock markets. The results which are generated by eViews are presented in Table 6.

Firstly, this paper analyses the relationship between restrictions of A_{13} and A_{31}. As the results in Table 6, at the significant level of 5% and 10%, the restriction of A_{13} is rejected in some periods of Japan and South Korea, whereas the restriction of A_{31} is accepted in all of four periods in South Korea and first two periods of Singapore. If the significant level of 25% is counted in this analysis, the number of periods in which the restriction of A_{13} is rejected increase. It includes period 2 and 3 in Japan, all four periods in South Korea, and the first period in Singapore. Generally, that the restriction A_{13} is rejected and A_{31} is accepted at the same time occurs during four periods of time since 1994 until first quarter of 2009 in South Korea (at up to 25% of significant level) and before the Asian financial Crisis 1997 in Singapore. This relationship implies that the US stock markets do impact and cause the change in domestic stock markets in South Korea and Singapore. This result proves the strong link between the US economy and these Asian economies, especially in South Korea since 1994 until now during the Asian financial Crisis 1997 and the current global financial crisis 2007, 2008.

Secondly, the flow scenario which is introduced in section 3.1.2 is presented in this section by looking at the restrictions of A_{12}, A_{13} and A_{23}. According to Granger causality ideas, this scenario shows the relationship of the FX markets and stock markets (of the US as well as domestic ones). There is no case that shows the flow channel since those restrictions cannot be rejected at the same time in all cases across these three countries. There are some cases that imply

the link between the domestic stock markets - the FX markets, and the domestic ones with the US stock markets. These issues occur during the period of crisis 1997 in Japan and current global crisis 2008 in South Korea since the restrictions of $A_{12}=0$ and $A_{21}=0$ are rejected. However, the stock channel is adopted by South Korea and Singapore since the restrictions $A_{13}=0$, $A_{21}=0$ and $A_{23}=0$ are all rejected for the time pre-global crisis and during global crisis 2007, 2008 (South Korea) and pre-Asian financial crisis 1997 (in Singapore). Hence, since the years after Asian Financial Crisis, South Korea markets started to connect through stock channel, while the Singapore markets have connected since the early of 1990s, before the Asian crisis. This channel also proves the evidence that there is a strong link from the FX markets, which depend much on the relative strength of the various in pre-crisis. Whatever changes in stock markets at that time will cause the fluctuation in the FX rates and can be a reason leads to the crisis then.

The order of lag structure is chosen by Akaike Information Criterion is various between four periods of time across three countries. Table 7 presents the results of Granger causality which is investigate by using Wald test.

Table 7. Multivariate Granger Causality test with VAR(k) – Akaike information criterion

		$A_{12}(L)=0$	$A_{13}(L)=0$	$A_{21}(L)=0$	$A_{23}(L)=0$	$A_{31}(L)=0$
JAPAN						
Jan 1994 – Jun 1997	χ^2	0.36	0.09	3.39*	12.90***	1.91
P value		(0.55)	(0.76)	(0.07)	(0.00)	(0.18)
Jul 1997 – Jul 1999	χ^2	5.51*	3.97	0.85	1.64	3.89
P value		(0.06)	(0.14)	(0.65)	(0.44)	(0.14)
Aug 1999 – Jun 2007	χ^2	3.20	1.63	1.48	1.81	5.41*
P value		(0.20)	(0.44)	(0.48)	(0.40)	(0.07)
Jul 2007 – Feb 2009	χ^2	4.87*	1.77	8.85**	2.00	10.88***
P value		(0.08)	(0.41)	(0.01)	(0.37)	(0.00)
SOUTH KOREA						
Jan 1994 – Jun 1997	χ^2	3.92	9.3**	0.75	4.60	2.60
P value		(0.14)	(0.01)	(0.69)	(0.10)	(0.27)
Jul 1997 – Jul 1999	χ^2	6.23**	1.92	0.26	0.77	290.61***
P value		(0.04)	(0.38)	(0.88)	(0.68)	(0.00)
Aug 1999 – Jun 2007	χ^2	16.01***	4.50	14.86***	6.42*	0.74
P value		(0.00)	(0.21)	(0.00)	(0.09)	(0.86)
Jul 2007 – Mar 2009	χ^2	6.60**	2.35	2.29	0.74	0.27
P value		(0.02)	(0.14)	(0.15)	(0.40)	(0.61)
SINGAPORE						
Jan 1994 – Jun 1997	χ^2	0.02	1.95	1.74	2.03	0.93

P value		(0.87)	(0.17)	(0.19)	(0.16)	(0.34)
Jul 1997 – Jul 1999	χ^2	1.81	0.39	1.08	4.79**	0.63
P value		(0.19)	(0.54)	(0.31)	(0.04)	(0.47)
Aug 1999 – Jun 2007	χ^2	8.74**	5.99*	0.99	1.36	6.37**
P value		(0.01)	(0.05)	(0.61)	(0.51)	(0.04)
Jul 2007 – Feb 2009	χ^2	2.47	0.76	0.03	0.00	36.99***
P value		(0.11)	(0.38)	(0.86)	(0.96)	(0.00)

Note: Performing Multivariate Granger Tests by using Wald tests to examine the coefficient restrictions with chi-square distribution (χ^2). Figures in parentheses are P value; ***, ** and * denote significance at level of 1%, 5% and 10% respectively. The period 1 (pre-Asian financial crisis 1997) indicates from Jan 1994 to Jun 1997, period 2 (during Asian financial crisis 1997) is from Jul 1997 to Jul 1999, period 3 is from Aug 1999 to Jun 2007, the last period (during current global crisis) indicates from Jul 2007 to Feb 2009 (except South Korea is to Mar 2009)

The results based on Akaike Information Criterion are significantly different from the one follows to the Schwarz criterion due to the different VAR lag order. The results in Table 6 show that the South Korea markets did connected through flow channel during sub period 1 and 3, which are pre-crises period in 1997 and 2007 since the null hypothesis H_{01}: $A_{12}=0$, $A_{13}=0$ *and* $A_{23}=0$ is rejected. Besides, the results also show that Japan and Singapore markets did not connected through flow channel.

The results also further show the link of the stock channel within markets of each country. The result also shows that the null hypothesis H_{02}: $A_{13}=0$, $A_{21}=0$ *and* $A_{23}=0$ is rejected in some cases. In Singapore, the markets seem to be connected through stock channel in the pre-Asian crisis 1997, since January 1994 until the Asian financial crisis 1997. The South Korea markets also connected through stock channel in the pre-global crisis. These results are same with the one in the sub-section *5.3.1*. The only different issue from the previous sub-section is that the South Korea markets did connect through both flow and stock channel since all the restrictions A_{12}, A_{13}, A_{21} and A_{23} are statistically different from zero. The exchange rate play an important role in making balance the domestic demand and supply of the assets in economy, which helps to improve the strength of the economy as well as improve the domestic stock price. On the other hands, a balance and development in domestic demand and supply leads to the demand for foreign security and follows by the appreciation in exchange rate.

5. Policy Implications

The empirical results in *section 4* show that impacts on Japan during two crises in 1990s and 2000s. Following the fluctuation in domestic stock markets after the Asian financial crisis 1997 and the recession in Japan in 1990s, the Japanese government started to design and execute a new monetary policy which can bring benefits to its economies at that time. The quantitative monetary easing was implemented by Bank of Japan since March 2001 and is one of policies of recovering Japanese economies after recession and crisis. The main issue of quantitative easing policy is that the interest rate is close to zero. This leads to the changes in stock prices and the impacts of the FX rate on stock prices due to the application of this policy. One of the purposes of implementing this policy is recovering the Japanese economies. On the other hand, this policy also influenced stock markets, i.e the stock prices increased after crisis (Kurihara, 2006). Besides, the policy also keeps exchange rate and US stock price as a main target which impact on the domestic stock markets. Kurihara (2006) also has conclusions of the effectiveness from the Japanese quantitative easing policy. He concludes that easing policy since March, 2001 is applied effectively in impacting the domestic stock prices. In addition, the VAR (vector autoregression) models from this expansion policy have a positive effect on Japanese stock prices, investment as well as production (Kirchner, 2006; Zammit, 2006). Kirchner also finds that there are reliable supports for an effect from quantitative easing measures on bond yields as well as domestic stock prices in Japan. In brief, the Japanese quantitative monetary easing is one of implications of

Japan government in case of promoting the recovery its economy, including stock and FX markets.

Similar to Japan, South Korea government also published policies to rescue the economy after crisis. Kim and Rhee (2009) show that main reasons for the current global financial crisis are the boom of the real estate markets bubble and a fall down of financial system in South Korea. So it is necessary for the central bank in South Korea to monitor the real estate, stock and derivative markets. Moreover, it provides the liquidity for financial structure but reorganises to respond to the crisis effectively. After all impacts that South Korea is suffered, the government has to follow some restructure in the purpose of saving the economy out of the crisis. As the results of that, the financial restructure and corporate restructure need to be done at the same time to strengthen the financial systems in South Korea. If the Japanese government uses the quantitative monetary easing to recover its economy, hence it's not the case in South Korea. The monetary easing policy is not work properly and effectively in case of South Korea. Instead of that, the fiscal policy was implemented to seek for a balance between banking sectors and capital markets (Park and Lee, 2009).

The policies and strategies in Singapore also need to be mentioned as an implication of the Singapore's government after the crises. Because during the period of crisis, most entrepreneurs in Singapore have to face with uncertainty hardship and depression, results in an economic downturn in Singapore's economy. Hence, it is significant for the government to look at its economy and execute the appropriate policies to strengthen the financial markets. Due to experience in previous financial crisis, the Monetary Authority of Singapore has been maintaining the strong financial system to ensure well functioning markets. In addition, the confidence of investor needs to be kept by any incentive strategies from the government. As a result of that, Singapore government has implemented the current monetary policy which can support price stability through Singapore exchange markets (Keat, 2009). Besides, Singapore also sets stringent criteria for equity markets, i.e stock markets in order to create more transparency in financial markets after crises.

6. Conclusion

In this paper, we examine the dependence structure between equity and foreign exchange markets in three industrial Asian countries including Japan, South Korea and Singapore. The empirical results provide some insights on the relationship between equity and FX markets. First, between 1994 and 2009, the general investigation on coefficients of the model presents the positive relationship of between domestic stock price and foreign exchange rate, as well as the US stock price index in all cases across countries. The regression on four sub-periods also implies the positive relationship between stock markets and FX markets for some cases. In Singapore, the impact of the FX markets and the US stock markets is stronger during the Asian financial crisis 1997, in comparison to the other periods due to high coefficient α_1 and α_2 **(**in absolute value). This regression shows that the US stock market is an important independent variable, along with the FX market; both of them also have a strong link with the domestic stock markets.

Second, the cointegration investigation by using Johansen trace test also shows the connection between markets across these three countries. Although there are some rejections of the null hypotheses before the Asian Financial Crisis 1997 and during the current Global Financial Crisis 2007 - 2008, the other cases are all accepted even for both the hypotheses at most two or one cointegration vectors. The results from this test can confirm the relationship between the US and each domestic market through the existence of cointegration vectors.

Third, the multivariate Granger causality tests also further presented the link between FX and domestic stock markets. Under Schwarz Information Criterion, the results show the causality between the US stock markets and the domestic ones in some cases of South Korea and Singapore. There are connections between markets in South Korea and Singapore through stock channel during the global current crisis, but no case implies the flow connection under this criterion. However, it is not the case under the Akaike Information Criterion when South Korea markets did connect through flow channel. Moreover, South Korea markets are also linked together through both "flow" and "stock" channel during the global current crisis in 2007 - 2008 under this criterion. The results indicated that the exchange rate determinant dose not only depend on economic activities but also the strength and wealth of those activities. The exchange rate plays an important role in making balance the domestic demand and supply of the assets in economy, which helps to improve the strength of the economy as well as the domestic stock price. On

the other hand, a balance and development in domestic demand and supply leads to the demand for foreign security and follows by the appreciation in exchange rate.

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