

Examining volatility spillover between Asian stock markets

Khalil Jebran, Amjad Iqbal*

This study examined the volatility spillover effects between Asian stock markets, i.e., Pakistan, India, Sri Lanka, China Mainland, Japan and China Hong Kong. The daily data was considered from the period 4th January, 1999 to 1st January, 2014, consisting 5 trading days from Monday to Friday. The volatility spillover between stock markets was captured by using GARCH (generalized auto regressive conditional heteroskedasticity) model. The empirical analyses show evidence of significant bidirectional spillover of return and volatility between China Mainland and Japan. The results also show significant bidirectional volatility transmission between the following equity markets; China Hong Kong and Sri Lanka, China Mainland and Sri Lanka. The significant unidirectional transmissions of stock market volatility are found to be flowing from; India to China Mainland, Sri Lanka to Japan, Pakistan to Sri Lanka, China Hong Kong to India and Japan. These results are important for economic policy makers in order to safeguard the financial sector from international financial shocks. The investors can use this information for making efficient portfolio which will reduce their risk and enhance their returns.

Keywords: volatility spillover, Asian stock markets, GARCH model, time series analyses

1. Background

Liberalization opened different set of opportunities to investors, which provided investors an opportunity to select and manage different portfolios around the globe. The internationalization of equity markets gained considerable attentions of investor all over the world. Investors began to invest in different equity markets wherever they can earn more benefits. The removal of investment barriers to equity markets although enhanced the returns of investors, however also became the cause of integration of different equity markets. The flow of financial crises between different markets is one of the foremost cause of integrations of markets. The knowledge about spillover of financial information from one market to other gained a considerable attention over the last few decades. The main focus of the researchers is to provide the information about integration about markets, because two integrated market will not provide the benefits of portfolio diversification (Jebran 2014).

Numerous studies examined the spillover effects of volatility between different

* Khalil Jebran (Corresponding Author, email: khaliljebranuom@gmail.com) Visiting Lecturer, Department of Management Studies, University of Malakand, Pakistan; Amjad Iqbal (email: amjadiqbal1987@yahoo.com), Doctoral Student at School of Accounting, Dongbei University of Finance and Economics, China.

equity markets. Most of the researchers have studied developed equity markets for volatility spillover effects, however, there are also studies which examined developing as well as emerging equity markets. The various studies carried out for developed equity markets include studies like for example (Hu et al., 1997; Chou et al., 1999; Ng, 2000; Baele, 2002; Wagner and Szimayer, 2004; Harris and Pisedtasalasai, 2006; Diebold and Yilmaz, 2009; Xiao and Dhesi, 2010). The studies on developing equity markets include studies like see for example (Mukherjee and Mishra, 2010; Joshi, 2011; Choo et al., 2011; Sakthivel and Kamaiah, 2011). There are also studies that examined emerging equity markets integrations, see for example (Wang et al., 2005; Worthington and Higgs, 2004; Li and Majerowska, 2008; Beirne et al., 2009). These studies provide valuable insights about integration between equity markets and provide investors effective investments opportunities regarding portfolios.

Markowitz (1952) laid the foundation of portfolio theory. He provided the concept of portfolio diversification. According to him, investments should be made on the basis of risk and return relationship. People should prefer those investments which provide maximum benefit at given level of risk or should prefer low risk at given level of return. According to portfolio theory, investment should be made in non-correlated assets. This reveals that, if there is no correlation between variables, the shock arising in one asset may not transmit to other asset and vice versa. In this aspect, the risk of investment is minimized and return is maximized. So careful selection of assets should be made in this regard to minimize the risk and maximize the return of portfolios.

The foundation of portfolio theory gained considerable attention of investors to know about the integration between different equity markets around the globe. This motivated many investors and researchers to explore the integration of different equity markets. The knowledge of integration would provide investors to prevent themselves from markets imperfections. If the markets are integrated in terms of spillover of volatility; so one market crises will be transferred to other market (Baele, 2002; Choo et al., 2011). The other aspect regarding integration of markets is that, it also plays a key role for determining the price of different securities. The investor is willing to pay a high price for non integrated securities rather than correlated assets (Glezakos et al., 2007).

The importance of unveiling the association of equity markets has motivated this study to know about the relationship between different equity markets. This study has been undertaken to analyze the volatility spillover effects between Asian countries and regions. The aim behind using Asian countries and regions is to provide insights to investors regarding their geographical equity markets. The Asian countries and regions included in this study are taken from South and East Asia. This study considered 3 countries from South Asia and 2 from East Asia. The countries taken from South Asian are Sri Lanka, India and Pakistan. The countries considered from East Asia are Japan and China. Karachi Stock Exchange (KSE) is the major market Pakistan and is considered for this study. The Bombay Stock Exchange (BSE) has been selected from India. The Colombo Stock Exchange (CSE) is selected from Sri Lanka. The Shanghai Stock Exchange (SSE) is selected from China Mainland. The Hang Seng Stock Exchange (HSSE) is selected from China Hong Kong. The Nikkei 225 (Nikkei) is considered from Japan in this study. This novelty of the paper is that, it is using daily

data which is considered to give more spurious results than weekly and monthly data. Furthermore, this study considers 15 years period for purpose of long term analyses. This study will add to the literature of Asian countries and regions. This study also constitutes a sample of diverse mix countries and regions and will also add to the literature of diverse mix Asian countries and regions. This study will provide benefits to investors, as the information of this study will provide them knowledge about the integration of markets which will help them in making portfolios decision.

The rest of the paper is organized as follows. The second part discusses the literature review. The third part shows methods and data description. The fourth section discusses empirical results. The fifth part is about conclusion and policy implication.

2. Literature Review

The finance literature provides numerous studies which provide information about volatility spillover effects between different stock markets. The knowledge of how information is transmitted from one market to other is the prime focus of many domestic and foreign investors for the investment decision making in different markets. Most of the studies have been carried out to study developed equity markets; however there are also studies analyzing developing and emerging markets. The literature can be divided into studies that have been undertaken to study developed, developing and emerging equity markets. The studies on developed equity markets include studies like see for example (Hu et al., 1997; Chou et al., 1999; Ng, 2000; Baele, 2002; Wagner and Szimayer, 2004; Harris and Pisedtasalasai, 2006; Diebold and Yilmaz, 2009; Xiao and Dhesi, 2010). Hu et al. (1997) studied four emerging markets, namely, Shenzhen, Shanghai, Hong Kong and Taiwan with the developed equity market of US and Japan. Their analyses were based on daily data from period October 5th, 1992 to February 15th, 1996. By applying the causality in variance test, they found evidence of transmission of volatility among China Hong Kong and US market. Chou et al. (1999) provided evidence of spillover effect of volatility between US and China Taiwan markets. The analyses were made on Engle and Kroner M-GARCH model. They used various types of data for examining volatility; closed to open and open to closed data rather than simply using daily data. Their analyses indicate the transmission of both return and variance between China Taiwan and US. Ng (2000) examined the transmission of volatility from Japan and US equity market to six pacific basin stock markets (Thailand, Korea, China Hong Kong, Malaysia, Singapore and China Taiwan). By taking the weekly data of stock returns, he analyzed by using ARCH family framework. The empirical analyses of the study provide evidence of spillover of volatility from Japan and US to many equity markets of Pacific Basin. Baele (2002) extended the literature of flow of volatility of US and European Union markets with selected 13 markets of Europe. He has taken weekly data of stock returns and analyzed by using GARCH and BEKK model. He found increasing tendency of shocks for many markets during 1990. The results further provide evidence of shock transmission from US market to Switzerland, United Kingdom and Sweden. Wagner and Szimayer (2004) studied the established equity market of Germany and US for examining volatility transmission.

They have considered daily data from 1992 to 2002. Their analyses reveal statistically significant spillover effects of equity markets but the tendency was mostly related to country specific. They concluded that the shock spillover shows robustness in the crises period. Harris and Pisedtasalasai (2006) empirically studied mean and volatility transmission for the small and large stocks in United Kingdom. The daily data taken from January 1986 to December 2002 is converted into continuous compounded return for the indices of FTSE small caps, FTSE 250 and FTSE 100. The empirical analyses are undertaken by using GARCH model. By applying the model, they found statistically significant transmission of volatility for both the small caps as well large caps of UK. They finally concluded that the shocks are mostly flowing from larger caps to smaller caps of UK market. Diebold and Yilmaz (2009) extended the literature for seven developed equity markets (France, Germany, Japan, US, China Hong Kong and UK) with twelve emerging markets (South Korea, Chile, Argentina, China Taiwan, Singapore, Philippines, Thailand, Brazil, South Korea, Argentina, Mexico and Malaysia). They have done a novel work for examining volatility transmission by taking data of both before and after Asian financial crises period. The VAR model is applied in examining volatility transmission. Their results reveal no current trend in return spillover but show robustness with time. However, they found clear robustness of volatility transmission with time. They concluded integration of many markets. Xiao and Dhesi (2010) examined transmission of volatility for four indices of (FTSE 100, S & P 500, DAX and CAC) from the period 5th January, 2004 to 1st October, 2009. They used two different Multivariate model, BEKK and DCC model, and found evidence of statistically significant volatility transmission between European and US market. Their results show evidence of spillover of shock from US to all other selected equity markets.

The studies on developing equity markets include studies like see for example (Mukherjee and Mishra, 2010; Joshi, 2011; Choo et al., 2011; Sakthivel and Kamaiah, 2011). Mukherjee and Mishra (2010) empirically examined volatility transmission of equity market of India with twelve selected equity markets (China Mainland, Malaysia, Sri Lanka, Thailand, Indonesia, Pakistan, Malaysia, Korea, China Hong Kong, Sri Lanka, China Taiwan and Japan). Their observations consist of intraday stock price from July 1998 to April 2008. By applying GARCH model, they found evidence of bidirectional return spillover between India and all selected markets except Sri Lanka. Joshi (2011) empirically examined the spillover of return and volatility between Asian countries and regions (Korea, China Mainland, India, Indonesia, China Hong Kong and Japan). By applying BEKK-GARCH model, he found bidirectional return spillover in following markets; Indonesia and China Mainland, Korea and Japan, India and China Hong Kong, China Hong Kong and Korea. Choo et al. (2011) examined volatility transmission between larger and smaller stocks of Malaysian equity market. By using daily data from April 1992 to September 2005, they employed GJR-GARCH model for examining volatility transmission. Their analyses show evidence of bidirectional spillover of return for larger and smaller stocks. Sakthivel and Kamaiah (2011) examined co-movement and transmission of volatility between markets of India, Australia, US, UK and Japan. By using GARCH model they found bidirectional spillover of volatility of India and US equity market. They also found unidirectional

transmission of shocks from UK and Japan to India.

The studies on emerging equity markets include studies like see for example (Wang et al., 2005; Worthington and Higgs, 2004; Li and Majerowska, 2008; Beirne et al., 2009). Wang et al. (2005) used EGARCH model for examining the volatility transmission from established equity markets of Japan and US to newly emerged capital markets of Asia. Their empirical analyses show evidence of both return and shock transmission from established markets to emerging capital markets of Asia. Worthington and Higgs (2004) studied the emerging market of Asia for cross border transmission of volatility. They used GARCH model for investigating spillover effects. They found statistically significant spillover of volatility from Japan capital market to newly emerged markets of Indonesia, Korea and China Hong Kong. Li and Majerowska (2008) empirically investigated emerging market of Budapest stock exchange and Warsaw stock exchange in comparison with US and Frankfurt. The daily data is examined through BEKK-GARCH model. Their analyses reveal clear evidence of transmission of volatility US and DAX capital markets to Budapest and Warsaw equity market. Beirne et al. (2009) examined newly emerged markets with established markets for flow of shocks from one market to other. The data ranges from 1990 to 2008 for 41 newly emerged markets. By applying Tri-variate GARCH model, they found clear evidence of flow of shocks from established markets to emerging markets.

Based on the discussed literature, we develop the following hypothesis for this study.

H0: There is no volatility spillover between Asian stock markets.

H1a: There is bidirectional volatility spillover between Asian stock markets.

H1b: There is unidirectional volatility spillover between Asian stock markets.

3. Methods

This study is using time series data for the period January 4th, 1999 to January 1st, 2014. The period of study is of 15 years aiming for comprehensive analyses. The data for the selected Asian equity markets is obtained from Yahoo finance.com. The observations consist of stock price indices which consist of daily closing stock indices. The closing stock price indices consist of 5 working days from Monday to Friday. As this study considered daily data, so there were missing observations in many stock markets data. The missing values have been calculated by using interpolation method. This is done in order to capture daily volatility spillover. The data for stock indices has been matched with each other in terms of dates in order to have daily analyses. This study considered Asian stock markets. This study has taken 3 countries from south Asia and 2 from East Asia. The countries selected from South Asia are India, Sri Lanka and Pakistan. The countries taken from East Asia are Japan and China. Karachi Stock Exchange (KSE) is the major market of Pakistan and is considered in this study. The Bombay Stock Exchange (BSE) has been selected from India. The Colombo Stock Exchange (CSE) is selected from Sri Lanka. The Shanghai Stock Exchange (SSE) is selected for China Mainland. The Hang Seng Stock Exchange (HSSE) is selected from

China Hong Kong. The Nikkei 225 (Nikkei) is considered from Japan in this study.

As this study considered time series data, so it is necessary to analyze the stationarity of the underlying variables. The most widely methods used to check stationarity are Dickey and Fuller (1979) (ADF) and Phillips and Perron (1988) (PP) test. Dickey and Fuller (1979) test is using given below regression model.

$$\Delta Y_t = \beta_0 + \delta Y_{t-1} + a_i \sum_{i=1}^m Y_{t-i} + \mu_t \quad (1)$$

Where Δ shows differences, α , β and δ are coefficients and Y is variable to be estimated. Phillips and Perron (1988) test is based on first order auto regressive model on following equation.

$$\Delta Y_t = \alpha_0 + \beta Y_{t-1} + \mu_t \quad (2)$$

Where α is coefficients, represents differences, β is slope and Y is variable to be estimated.

The volatility spillover between the Asian stock markets is examined by using GARCH (generalized auto regressive conditional heteroskedasticity). The GARCH analyses can be carried out on the data which has autocorrelation and heteroskedasticity issues. Before estimating the GARCH model, the ARCH effect has been analyzed in data in order to know about the presence of heteroskedasticity and autocorrelation data in variables. Table 3 shows the results of ARCH effect in the underlying variables of the study. The probability of Chi-square is checked for analyzing the ARCH effect which shows significant ARCH effect in all stock market indices. The GARCH model of this study has been represented in equation (3) and (4). The equation (3) shows the mean equation and the equation (4) shows the variance equation. The equation (4) is the volatility spillover equation to be carried out. First, we have estimated a separate model of GARCH for each series and then generated volatility residual series from that specific model for each stock market. We have used squared volatility residuals in our analyses because in GARCH model, volatility is assumed to be positive. The generated volatility residual series has been used as a proxy for shock to each stock market indices which has been used in equation (4).

$$Y_t = c + \gamma Y_{t-1} + \omega_{t-1} \varepsilon_t \quad (3)$$

$$h_t = \alpha_0 + \beta_1 \varepsilon_{t-1}^2 + \alpha_1 h_{t-1} + \delta (\text{squared residual}_{\text{stock indices}}) \quad (4)$$

The equation (3) is the mean equation which examines the return spillover from one market to other market, while the equation (4) is the volatility spillover equation that measures the volatility spillover from one market to other. In equation (3), Y_t represent the return of stock indices, the parameter γ measures the effect of lagged return on the stock indices, the parameter ω measure the effect of lagged return on the underlying stock market. In simple words, it measures the return spillover from the underlying market. In equation (4), $\alpha_1 \geq 0$, $\beta_1 \geq 0$, $\alpha_0 > 0$ represents conditional variance of equity markets, that is a mean function; α_0 volatility news of previous period is

examined as 1st difference of residual square from mean equation (Σ_{t-1}^2); h_{t-1} is previous period's estimated variance. In equation (4), the parameter δ measures the volatility spillover from the stock market. In equation (4), (squared residual_{stock indices}) represents the generated squared volatility residuals, which has been generated from a separate GARCH model for each stock market.

4. Empirical results

In the preliminary step, the behavior of the data has been analyzed by using descriptive statistics. Table 1 shows the analyses of descriptive statistics for the selected stock markets. The analyses show evidence that the highest mean daily return between the selected equity markets is given by stock market of Pakistan that is 0.08%, while the minimum mean daily return for the period of study is showed by Japan stock exchange that is 0.0049%. Furthermore, the descriptive statistics shows that maximum mean standard deviation is represented by stock market of India that is 1.56%, while the minimum mean standard deviation of 1.2% is represented by equity market of Sri Lanka. Furthermore, the analyses show that all the stock market indices are negatively skewed. The Jarque-Bera statistics is significant in all stock market indices. The descriptive statistics shows that all the stock indices data are not normally distributed.

Table 1
Summary statistics

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
India	0.000489	0.159943	-0.11809	0.015626	-0.11385	9.713559	7355.167
Sri Lanka	0.000592	0.116124	-0.13906	0.011217	-0.34435	23.37271	67730.02
China Hong Kong	0.000221	0.134068	-0.13582	0.015336	-0.07551	10.93031	10254.75
Pakistan	0.000844	0.082547	-0.07741	0.013991	-0.34711	6.099103	1644.079
Japan	4.92E-05	0.094941	-0.12111	0.01473	-0.66144	8.868493	5898.844
China Mainland	0.00016	0.094008	-0.09256	0.015489	-0.02587	7.578448	3417.272

Source: Authors Formation.

The Figure 1 represents the time plot of all the selected Asian stock market indices of The graph illustrates that the most of the stock market indices are showing common trends. The stock indices are showing declining trend after 2007 which was due to global financial crises. The Figure 2 represents the graphical representation of the stock indices returns data for the selected period. The figure elaborates that all stock indices are more volatile in the selected period. The volatility clustering in all indices is found more after the 2007 crises period.

The second step is to analyze the stationarity of all the selected stock markets indices of the study. The stationarity of the data is analyzed by employing unit root analyses. The Dickey and Fuller (1979) (ADF) and Phillips and Perron (1988) (PP) tests were employed to examine the order of stationarity of the data. Table 2 shows the empirical results of unit root analyses that has been carried out on the natural logarithms of stock prices index of all markets. The analyses show clears evidence of

non stationarity of all underlying variable on level while stationarity on the first lag of all variables. The ADF and PP test represents similar results of stationarity.

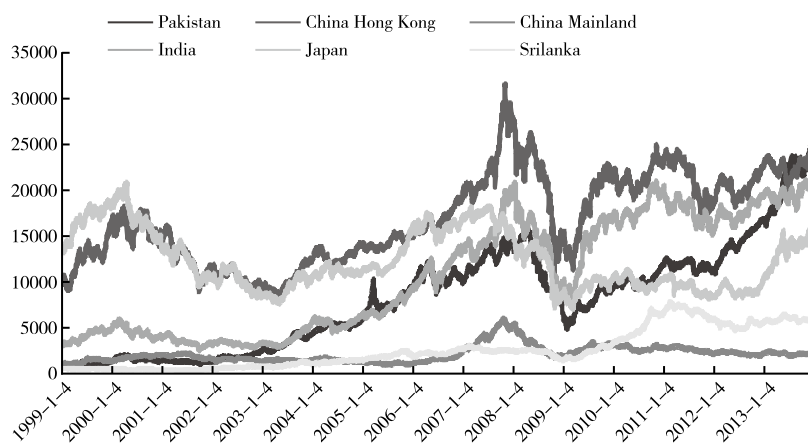


Figure 1. Stock Market Index

Source: Authors Formation.

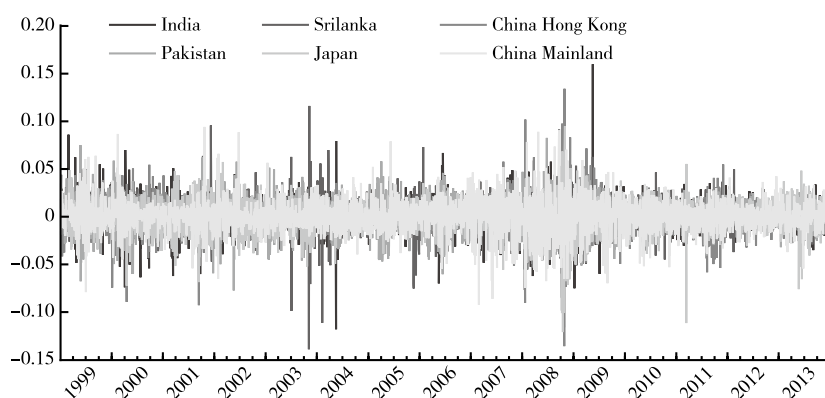


Figure 2. Stock Indices Returns

Source: Authors Formation.

The transmission of volatility spillover is aimed to be examined by employing GARCH model. The observations of the study are converted into continuously compounding returns for the purpose of capturing conditional variance of stochastic components of the returns. The GARCH model is related to ARCH family framework. The assumption of the ARCH family is that there must be heteroskedasticity and autocorrelation problem in data set. In other words, ARCH effect should exist in data set. In this aspect, ARCH effect is examined by employing autoregressive model. The variable is converted to 1st lag and then ARCH test is applied to examine ARCH effect by checking probability of chi-square. The results of autoregressive model are shown in Table 3. The result shows the presence of ARCH effect in all stock markets. This confirms that GARCH model can be applied; as there exists problem of both heteroskedasticity and autocorrelation in all the underlying data sets.

Table 2
Unit root results

Variables	ADF		PP	
	Level	1 st Diff.	Level	1 st Diff.
India	-0.934554	-57.84548**	-0.926896	-57.72980**
Sri Lanka	-0.393679	-40.83287**	-0.446672	-50.11421**
China Hong Kong	-1.836501	-62.70618**	-1.836588	-62.70621**
Pakistan	-1.154962	-55.91908**	-1.117635	-57.72733**
Japan	-1.662088	-62.97833**	-1.585209	-63.04025**
China Mainland	-1.782500	-62.37812**	-1.814469	-62.41755**
Critical Values				
1%	-3.431837			
5%	-2.862082			
10%	-2.567102			

Note: * and ** indicates $p < 5\%$ and 1% respectively. ADF is (Dickey and Fuller, 1979) test of stationarity. PP is (Phillips and Perron, 1988) test of stationarity.

Source: Authors Formation.

Table 3
ARCH test

variables	Constant	AR(1)	ARCH Test
Pakistan	0.075523 (0.00)	0.111300 (0.00)	384.3693 (0.00)
China Mainland	0.016119 (0.51)	0.002308 (0.88)	87.42359 (0.00)
India	0.044887 (0.07)	0.077620 (0.00)	148.1162 (0.00)
Japan	0.005308 (0.82)	-0.007162 (0.65)	255.4044 (0.00)
China Hong Kong	0.021946 (0.37)	-0.002907 (0.85)	461.4526 (0.00)
Sri Lanka	0.046225 (0.00)	0.223677 (0.00)	354.0241 (0.00)

Note: Probabilities are shown in parenthesis. AR(1) is the first difference of the computed variables. Arch test is carried out to know about Arch effect.

Source: Authors Formation.

The analyses of the mean equation are represented in Table 4. The mean equation show the results of return spillover between the selected stock indices. The analyses show statistically significant first lag own return spillover for equity market of India, Sri Lanka, Pakistan, Japan; which imply that they are dependent on their own first lag. The own lag return effect of Stock market of China Hong Kong and China Mainland is insignificant, which points to the evidence that these markets return doesn't depend on their own lag return. The bidirectional return spillover has been found between the stock markets of China Mainland and Japan. The bidirectional spillover between China Mainland and Japan represents that the returns of these markets are dependent

on each other. Furthermore, the results show that China Mainland and Japan equity markets negatively affect the returns of each other. The results show no evidence of any other bidirectional return transmission between other selected equity markets. The results reveal unidirectional returns spillover from Sri Lanka to Indian stock market. The results reveal that Sri Lankan equity market enhances the returns of Indian equity market. Furthermore, the results show that there is unidirectional return spillover from equity market of China Mainland to China Hong Kong and Pakistan equity markets respectively. The results reveal that stock market of China Mainland adversely affect the returns of China Hong Kong while positively affect the returns of Pakistan equity market. Furthermore, the results imply that stock market of India positively affect the returns of China Hong Kong and Japan equity markets. The results show that China Hong Kong stock market adversely affects the returns of Pakistan stock market. Overall the magnitude of returns spillover was found greater in case of India to Japan (0.1365) equity market while lowest (0.0147) in case of Sri Lanka to Indian stock market.

Table 4
Mean Equation results

DV→	India	Sri Lanka	China Hong Kong	Pakistan	Japan	China Mainland
C	0.0009** (3.83E-05)	0.0002 (0.0003)	0.0001 (0.0004)	0.0012** (0.0003)	0.0001 (0.0004)	-0.0002 (0.0004)
India (-1)	0.0942** (0.0052)	0.0462 (0.0261)	0.1234** (0.0276)	0.0154 (0.0199)	0.1365** (0.0271)	-0.0270 (0.0291)
Sri Lanka (-1)	0.0147** (0.0035)	0.2259** (0.0285)	0.0048 (0.0161)	0.0289 (0.0281)	0.0173 (0.0232)	0.0112 (0.0098)
China Hong Kong (-1)	-0.0019 (0.0045)	-0.0068 (0.0279)	-0.0068 (0.0395)	-0.0508* (0.0254)	0.0488 (0.0364)	0.0330 (0.0306)
Pakistan (-1)	0.0060 (0.0033)	0.0018 (0.0186)	0.0209 (0.0280)	0.1295** (0.0196)	0.0137 (0.0281)	-0.0164 (0.0273)
Japan (-1)	0.0072 (0.0037)	0.0089 (0.0261)	-0.0301 (0.0352)	-0.0101 (0.0261)	-0.0770* (0.0371)	-0.0374* (0.0153)
China Mainland (-1)	-0.0035 (0.0029)	-0.0137 (0.0255)	-0.0717* (0.0284)	0.0509* (0.0200)	-0.0663* (0.0260)	-0.0241 (0.0307)

Note: * and ** indicates $p < 5\%$ and 1% respectively. The figures in parenthesis are standard errors. India (-1) represents returns spillover from stock market of India. Sri Lanka (-1) represents returns spillover from stock market of Sri Lanka. China Hong Kong (-1) represents returns spillover from stock market of China Hong Kong. Pakistan (-1) represents returns spillover from stock market of Pakistan. Japan (-1) represents returns spillover from stock market of Japan. China Mainland (-1) represents returns spillover from stock market of China Mainland.

Source: Authors Formation.

The analyses of volatility spillover are represented in Table 5. The analyses has been estimated separately for each market taking as dependent variable and all the other stock market volatility has been allowed to examined shock spillover. The volatility series has been created for each market and has been used as a proxy for shock spillover to other market. The analyses show evidence of own market volatility transmission in all selected stock indices. The magnitude of own market spillover of volatility is found to be highest in case of stock market of India (0.46) while lowest for

stock market of Sri Lanka (0.012).

H0: No volatility spillover between Asian stock markets.

The results reveal that stock market of India show no evidence of volatility spillover to stock market of Sri Lanka, China Hong Kong, Pakistan and Japan respectively. Furthermore, the results reveal no volatility spillover from stock market of Sri Lanka to Pakistan and India. The results also show that stock market of China Hong Kong show no evidence of volatility transmission to stock market of Pakistan, Japan and China Mainland. The results reveal no volatility spillover from Pakistan stock market to equity market of India and China Mainland. Furthermore, the results show no volatility spillover from Japan to stock market of India, Sri Lanka, China Hong Kong and Pakistan. Moreover, the results show no evidence of volatility spillover from stock market of China Mainland to India, Pakistan and China Hong Kong. The analyses also point to the evidence that the selected Asian equity markets have no volatility spillover to stock market of Pakistan. The results point to the evidence that equity market of remains independent to shocks of their respective regional geographical equity markets. The absence of volatility spillover between the stock markets serves an important role in portfolio diversification. The no volatility spillover between the markets represents that these markets offer diversification opportunities to investors. The institutional and individual investors can invest in these non correlated markets and can minimize their risk and enhance their portfolio returns.

H1a: Bidirectional volatility spillover between Asian stock markets.

The results show significant bidirectional volatility between China Hong Kong and Sri Lanka equity markets, but the persistence of volatility spillover is found larger in case of Sri Lanka. Furthermore, the results show that Sri Lanka and China Mainland equity markets have bidirectional volatility spillover. Moreover, there are bidirectional linkages between China Mainland and Japan. The significant bidirectional spillovers of volatility imply that the shock in one market is responsible to bring changes in the other market volatility and vice versa. The bidirectional volatility spillover between equity markets represents that these markets are integrated. Furthermore, the integration of these markets also points to the evidence that there are less diversification benefits for investors in these markets. The economic integration between the selected markets might be due to geographical location which allows investors to allocate their assets in the selected market which decreases their transaction cost. The low restrictions on capital inflows and the economic activities such as trade and investment among the countries and regions also increase integrations in equity markets.

H1b: Unidirectional Volatility spillover between Asian stock markets.

The unidirectional linkages in terms of volatility are observed to be flowing in the following markets; from stock market of India to China Mainland, from stock market of Sri Lanka to Japan, from stock market of China Hong Kong to India, from stock market of Pakistan to Sri Lanka, from stock market of Pakistan to China Hong Kong and from stock market of Pakistan to Japan. The unidirectional shock spillover provides the knowledge about the shock that is produced in one market and is transmitted to other market while the shock receiving market doesn't respond to the shock sending market. The magnitude of highest cross market shock spillover has been found from stock market of Pakistan to China Hong Kong (-0.041) while the lowest has been found from

stock market of China Hong Kong to Sri Lanka (-0.006). The stock market of Sri Lanka and Pakistan has been found to have volatility spillover to most of the selected equity markets. The results of the study are consistent with Joshi (2011).

Table 5
Variance equation results

DV→	India	Sri Lanka	China Hong Kong	Pakistan	Japan	China Mainland
	-7.77E-08 (9.35E-08)	0.0001** (1.35E-05)	0.0001** (3.73E-05)	0.0001** (5.08E-05)	0.0001** (1.68E-05)	0.0001** (1.51E-05)
	-0.1831** (0.0293)	0.1443** (0.0211)	0.1112** (0.0312)	0.0509 (0.0754)	0.1180** (0.0319)	0.0972** (0.0254)
	0.4162** (0.0617)	0.5485** (0.0570)	0.5234** (0.0994)	-0.0536 (0.3326)	0.5295** (0.0527)	0.4699** (0.0219)
RSD_India	0.4640** 0.185	-0.0001 (0.0019)	-0.0036 (0.0136)	-0.0052 (0.0031)	-0.0079 (0.0046)	-0.0104** (0.0008)
RSD_Sri Lanka	0.0003 (0.0005)	0.0127** (0.0022)	-0.0200** (0.0029)	0.0067 (0.0013)	-0.0172** (0.0024)	-0.0209** (0.0011)
RSD_China Hong Kong	0.0051** (0.0017)	-0.0061* (0.0028)	0.0235* (0.0091)	-0.0004 (0.0049)	0.0029 (0.0082)	0.0039 (0.0084)
RSD_Pakistan	0.0003 (0.0006)	-0.0244** (0.0029)	-0.0411** (0.0036)	0.2073** (0.0195)	-0.0398** (0.0061)	-0.0219 (0.0154)
RSD_Japan	-7.93E-05 (0.0002)	-0.0055 (0.0040)	0.0021 (0.0132)	-0.0047 (0.0055)	0.0193* (0.0087)	-0.0098** (0.0104)
RSD_China Mainland	9.71E-06 (0.0004)	-0.0159** (0.0024)	-0.0119 (0.0086)	-0.0037 (0.0085)	-0.0229** (0.0082)	0.0489** (0.0070)

Note: * and ** indicates $p < 5\%$ and 1% respectively. The figures in parenthesis are standard errors. DV is the dependent variable used when the model is estimated. RSD_Pakistan represents volatility spillover from stock market of Pakistan. RSD_Sri Lanka represents volatility spillover from stock market of Sri Lanka. RSD_China Hong Kong represents volatility spillover from stock market of China Hong Kong. RSD_India represents volatility spillover from stock market of India. RSD_Japan represents volatility spillover from stock market of Japan. RSD_China Mainland represents volatility spillover from stock market of China Mainland. From top to down is the estimated model for a single market.

Source: Authors formation.

5. Conclusions and implications

This study was an attempt to examine the volatility spillover dynamics between the selected Asian stock markets for the period 4th January, 1999 to 1st January, 2014. The analyses was based on daily data because of examining the daily shock spillover between the financial markets. The Asian countries and regions considered for analyses are; Pakistan, India, Sri Lanka, China Mainland, Japan and China Hong Kong. The sample also constitutes a mixture of diverse mix countries and regions. The stationarity of the variables is examined by using unit root analyses. The volatility transmission has been explored by using GARCH (generalized auto regressive conditional heteroskedasticity) model. The empirical results reveal significant return and volatility spillover between Asian stock markets. The analyses reveal bidirectional return

spillover between stock market of China Mainland and Japan only. The unidirectional transmission of return is observed to be flowing from Sri Lanka to India, China Mainland to China Hong Kong, China Hong Kong and China Mainland to Pakistan, India to Japan and China Hong Kong. The empirical evidence on bidirectional flow of volatility is found in the following countries: China Hong Kong and Sri Lanka, China Mainland and Sri Lanka, China Mainland and Japan. The unidirectional transmission of volatility from one stock market to other stock market is found to be flowing from India to China Mainland, Sri Lanka to Japan, China Hong Kong to India, Pakistan to Sri Lanka, China Hong Kong to Japan. The analyses are evident of bidirectional transmission of return and volatility between China Mainland and Japan. Furthermore, the analyses show that non of the selected stock markets have volatility spillover to stock market of Pakistan.

The results of the study have important implications for economic policy makers and investors. For economic policy makers, the information about volatility spillover between financial markets would be of greater interest for them for economic stability because financial markets integrations imply financial sector integration, so the policy makers need to design such policies which would safeguard the financial sector from the international financial shocks. They would be able to predict any future crises, if they have some historical information about financial markets integrations. Furthermore, they may be able to implement successful policies by having information about behavior of financial markets. The results of this study are also important for investors, who want to make efficient portfolios and make capital budgeting decisions in the selected markets. The institutional and individual investors can benefit from portfolio diversification by investing in non correlated markets which will reduce their risk and enhance their returns. They may be able to prevent themselves from the financial crises of markets by investing in non integrated markets.

References

- Baele, L. (2002). Volatility spillover effects in European equity markets: evidence from a regime switching model. Ghent University, *Working Paper*, 1-62.
- Beirne, J., Caporale, G. M., Schulze-Ghattas, M., & Spagnolo, N. (2009). Volatility spillovers and contagion from mature to emerging stock markets. *Working Paper series*, 1113, 1-48.
- Choo, W.C., Loo, S. C., Ling, L. B., & Ung, S. N. (2011). Return and volatility spillover between large and small stocks in Bursa Malaysia. *International Journal of Business and Social Science*, 2(1), 76-185.
- Chou, R. Y., Lin, J. L., & Wu, C. S. (1999). Modeling the Taiwan stock market and international linkages. *Pacific Economic Review*, 4(3), 305-320.
- Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association*, 74(366a), 427-431.

- Diebold, F. X., & Yilmaz, K. (2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. *The Economic Journal*, 119(534), 158-171.
- Glezakos, M., Merika, A., & Kaligosfiris, H. (2007). Interdependence of major world stock exchanges: How is the Athens stock exchange affected. *International Research Journal of Finance and Economics*, 7(1), 24-39.
- Harris, R. D., & Pisedtasalasai, A. (2006). Return and volatility spillovers between large and small stocks in the UK. *Journal of Business Finance & Accounting*, 33(9-10), 1556-1571.
- Hu, J. W. S., Chen, M. Y., Fok, R. C., & Huang, B. N. (1997). Causality in volatility and volatility spillover effects between US, Japan and four equity markets in the South China growth triangular. *Journal of International Financial Markets, Institutions and Money*, 7(4), 351-367.
- Jebran, K. (2014). Dynamic linkages between Asian countries stock markets: evidence from Karachi Stock Exchange. *Research Journal of Mangement Sciences*, 3(5), 6-13.
- Joshi, P. (2011). Return and volatility spillovers among Asian stock markets. *SAGE Open*, 1(1), 1-9.
- Li, H., & Majerowska, E. (2008). Testing stock market linkages for Poland and Hungary: a multivariate GARCH approach. *Research in international Business and Finance*, 22 (3), 247-266.
- Markowitz, H. (1952). Portfolio selection. *The Journal of Finance*, 7(1), 77-91.
- Mukherjee, K. N., & Mishra, R. K. (2010). Stock market integration and volatility spillover: India and its major Asian counterparts. *Research in international Business and Finance*, 24(2), 235-251.
- Ng, A. (2000). Volatility spillover effects from Japan and the US to the Pacific-Basin. *Journal of international money and finance*, 19(2), 207-233.
- Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, 75(2), 335-346.
- Sakthivel, P., & Kamaiah, B. (2011). Correlation and volatility transmission across international stock markets: a bivariate garch analysis. *Journal of Applied Research in Finance Bi-Annually*, 3(2), 270-278.
- Wagner, N., & Szimayer, A. (2004). Local and spillover shocks in implied market volatility: evidence for the US and Germany. *Research in international Business and Finance*, 18(3), 237-251.
- Wang, Y., Gunasekarage, A., & Power, D.M. (2005). Return and volatility spillovers from developed to emerging capital markets: the case of South Asia. *Contemporary Studies in Economic and Financial Analysis*, 86, 139-166.
- Worthington, A., & Higgs, H. (2004). Transmission of equity returns and volatility in Asian developed and emerging markets: a multivariate GARCH analysis. *International Journal of Finance & Economics*, 9(1), 71-80.
- Xiao, L., & Dhesi, G. (2010). Volatility spillover and time varying conditional correlation between the European and US stock markets. *Global Economy and Finance Journal*, 3(2), 148-164.