DOI: http://doi.org/10.4038/sljer.v5i1.59

Sri Lanka Journal of
Economic Research
Volume 5(1) November 2017
SLJER.05.01.B:
pp.79-94
Sri Lanka Forum of
University Economists

VOLATILITY SPILLOVERS BETWEEN SOUTH ASIAN STOCK MARKETS: EVIDENCE FROM SRI LANKA, INDIA AND PAKISTAN

Yeshan Withanage

Prabhath Jayasinghe

Abstract

This study examines the existence, magnitude and direction of volatility spillovers between the Sri Lankan stock market and two other major stock markets in the South Asian region: India and Pakistan. Main stock indices of Sri Lanka, India, and Pakistan are employed as proxies to represent stock markets of each country. Daily data over the period 2nd January 2004 to 23rd September 2014 is used for estimations. Volatility spillovers are modeled through a trivariate BEKK – GARCH (1, 1) model to capture the cross-market effects. There exist bilateral intraday volatility spillovers between Sri Lanka and both markets. It is evident that the intraday effect from Pakistan to Sri Lanka is stronger than the same effect from India to Sri Lanka. However, with respect to overnight volatility spillovers, there is only a unilateral spillover effect from Sri Lanka to India. Evidence for the presence of volatility spillovers between these three South Asian economies makes the tasks of monetary policy makers, investors and fund managers more complicated than they would otherwise have been.

Key Words – *Volatility spillovers, South Asian stock markets, Multivariate GARCH models, BEKK models*

Yeshan Withanage
Department of Finance, University of Colombo, Colombo 03, Sri Lanka
yeshanwithanage@gmail.com

Prabhath Jayasinghe
Department of Business Economics, University of Colombo, Colombo 03, Sri Lanka
prabhath@dbe.cmb.ac.lk

INTRODUCTION

"Volatility appears to be a meteor shower ['which rains down on the earth as it turns'] rather than a heat wave"

- Engle, Ito and Lin (1990)

The increasing globalisation and regionalisation of economic activities and financial liberalisation of nations have resulted in the integration of economies and equity markets around the globe (Mukherjee and Mishra, 2010). The integration of stock markets makes trading counterparts highly interdependent on each other's trading activities, thus giving rise to volatility linkages. However, evidence on market interactions and information transmissions in South Asian capital markets is hard to find (Wang, Gunasekarage and Power, 2005). In such a context, it is a sensible and timely attempt to examine whether Sri Lanka as a small emerging market is sensitive to the innovations originating from other markets in the region and/or whether innovations in the Sri Lankan market have any impact on other markets in the region. Hence, the primary focus of this study is on volatility linkages, one of the significant aspects of international financial relations, between Sri Lanka and two other major markets in the South Asian region: namely India and Pakistan. The reason for the selection of these three markets is their prominence in the South Asian region. More specifically, the objective of this study is to uncover whether there are volatility spillovers among the three countries and to find the directions and magnitudes of such spillovers in case of their being present.

Understanding and exploring the nature of volatility transmission between Sri Lanka and other regional markets will be helpful to policy makers in addressing financial stability issues. From the investors' point of view, it will also provide important insights on implications for market efficiency, profitable investment opportunities and risk diversification.

The rest of this study can be outlined as follows. Section 2 will provide the theoretical background for volatility transmissions between markets. Section 3 contains a brief survey of relevant literature. Information on the data and the sample are described in Section 4. Section 5 outlines the proposed econometric model employed to explore the presence, magnitude and direction of volatility spillovers. In section 6, empirical results are reported and discussed. Section 7 contains concluding remarks.

THEORETICAL BACKGROUND

Factors underlying contagion such as herding, trade linkages, financial linkages and the wake-up call hypothesis are the best candidates for a theoretical explanation of the existence of volatility spillovers, their magnitudes and directions.

Blasco, Corredor and Ferreruela (2012) states that *herding* is present in a certain market 'when investors opt to imitate the trading decisions of those who they believe to be better informed, rather than acting upon their own beliefs and information'. When investors merely mimic the trading actions of others in this manner, the information content of prices may decrease drastically, making market prices informationally inefficient. Thus, herding behavior makes markets more volatile than if investors would have acted independently (Froot, Scharfstein and Stein, 1992; Choe, Kho and Stulz, 1999; Alper and Yilmaz, 2004; Avramov, Chordia and Goyal, 2006). When markets tend to be informationally inefficient and excessively volatile, foreign as well as local investors are likely to engage in a situation of mass departure of capital from the relevant market. This behavior of market participants may lead to transmission of volatility between asset markets (Van Rijckeghem and Weder, 2001; Pritsker, 2001).

Trade linkages refer to the real association between countries as established by trading physical goods and services. Corsetti et al. (2000) explains how trade linkages, mainly based on competitive devaluation, implicitly contribute to volatility spillovers among trading partners depending on their market conditions. They conclude that competitive devaluation targeted at achieving economic growth through exports can induce sharper currency depreciation than that required by any initial deterioration in fundamentals. Moreover as cited in Kaminsky, Reinhart and Vegh (2003), Nurkese's classic story of competitive devaluations further explain how asset prices in the market of each trading partner get affected by currency devaluations in one country. Thus, if market participants expect a game of competitive devaluation, they are more likely to sell their holdings of securities and to curtail or refuse to extend their lending to those countries.

With financial globalisation, financial institutions have gained access to international financial market transactions. Through these *financial linkages*, the banking system gets updated about the occurrences of shocks or news events. In addition, the effect of these events may get amplified by the international and the domestic interbank markets through volatility spillover effects between countries. Moreover, according to a model developed in Kodres and Pritsker (2002), volatility transmission can occur when 'informed' investors begin to respond to private information on a certain country-specific factor by optimally rebalancing the exposure of their portfolios to the shared macroeconomic risk factors in markets of other countries. When there is asymmetric information in the countries where rebalancing occurs, 'uninformed' investors are not able to fully identify the source of the change in asset demand and they respond to it as if the rebalancing is relevant to information on their country. As a result, an idiosyncratic shock may generate excess volatility across asset markets of countries (as cited in Kaminsky et al., 2003).

Wake-up call hypothesis also provides a theoretical explanation to volatility spillovers. Kaminsky et al. (2003) defines a 'wake-up call' as a situation in which investors 'wake-up' to the weaknesses that have been revealed in a crisis country and proceed to avoid and move out of countries that share similar characteristics with the crisis country.

A BRIEF SURVEY OF LITERATURE

Volatility of returns provides valuable insights into the flow of information between markets (Ross, 1989; Tanizaki and Hamori, 2009), and the extent to which markets are interlinked will govern the level of volatility spillovers between/among markets (Gonzalo and Olmo, 2005). Hamao, Masulis and Ng (1990), Lin and Ito (1994), Koutmos and Booth (1995), and Karolyi (1995) are among many others who pioneered scholarly work in analysing the presence of volatility spillovers across markets. Both Hamao et al. (1990) and Koutmos and Booth (1995) studied the Tokyo, London, and New York markets using daily data around the 1987 crisis and report contradictory findings with regard to the spillover effect between London and Tokyo. Karolyi (1995) empirically illustrates the possibility of having such contradictory findings due to different conditional variance specifications, and without loss of generality one can also argue that it could be due to different sample periods. More interestingly, Ng (2000) brought empirical evidence to show that volatility spillovers are driven by currency fluctuations, market liberalisation and the size of trades. Kaminsky et al. (2003) later provided theoretical explanations to this in the form of channels of information transmission or contagion. Continuing along the same lines, Connolly, Stivers and Sun, (2005) and Rua and Nunes (2009) examine the co-movements of return and volatility. Tanizaki and Hamori (2009) examines the return and volatility spillovers in the presence of the holiday, asymmetry and day-of-the-week effects as well. Jung & Maderitsch (2014) looks into structural breaks in volatility spillovers between international financial markets and does not find evidence of contagion. Beirne, Caporale, Schulze-Ghattas & Spagnolo (2013) cite evidence for volatility spillovers from mature to emerging stock markets. Alotaibi & Mishra (2015) report significant return spillover effects from global and regional stock markets to Gulf Cooperation Council (GCC) stock markets.

In addition, Wei, Liu, Yang and Chaung (1995), Miyakoshi (2003), Worthington and Higgs (2004) and Li and Giles (2015) study the volatility and return spillovers from developed markets to Asian emerging markets. Cha and Oh (2000) reports that the links between developed markets and Asian emerging markets began to increase after the stock market crash in October 1987 and significantly intensified since the outbreak of the Asian financial crisis in July 1997. Wang et al. (2005) report that evidence on market interactions together with information transmissions in South Asian capital markets is hard to find, despite the increased economic activities and the interest of local and foreign investors in these markets due to recent economic reforms and the liberalisation of capital markets.

There are only a few studies that inquire into the linkages of the Colombo Stock Exchange (CSE) with other markets in the region. Elyasiani, Perera and Puri (1998) examines the interdependence and dynamic linkages between Sri Lanka and the markets of its major trading partners from 1989 to 1994. The study finds no significant interdependence between the Sri Lankan market and other equity markets due to many reasons such as small capitalisation, lack of liquidity, high concentration in blue chips and unilateral investment barriers on Sri Lankan investors at that time. Given that this study was carried out even before the 1997 East Asian Financial Crisis, it can be argued that those findings have little relevance to the present day links between the same markets. Wang et al. (2005) examine the return and volatility spillovers from USA and Japan to India, Pakistan and Sri Lanka during the period 1993 to 2003 and find a significant effect of volatility spillovers from USA to India and Sri Lanka. In addition, Mukherjee and Mishra (2010) also investigate the return and volatility spillovers between Indian stock market and 12 other developed and emerging Asian countries over a period from 1997 to 2008 and report that there is a significant and contemporaneous intraday volatility spillover effect from India to Sri Lanka.

DATA AND SUMMARY STATISTICS

The sample includes three stock markets in the South Asian region: the CSE, the Bombay Stock Exchange (BSE) and the Karachi Stock Exchange (KSE). Each country is assumed to be represented by its main market index. Accordingly, volatility of returns on ASPI of Sri Lanka, S&P BSE 500 of India and KSE ASPI of Pakistan have been used to trace the spillovers among these markets. The study uses daily data over the sample period 2nd January 2004 to 23rd September 2014, which results in 2,429 observations. The preference for daily data over weekly or monthly data is due to the fact that the interactions between markets associated with volatility spillovers are better captured by daily data.

Since trading sessions in the three markets are asynchronous on a given day as indicated in Figure 1, following Lin and Ito (1994) and Mukherjee and Mishra (2010), the scope of the analysis is divided into two sessions, namely intraday session and overnight session. Intraday and overnight return series have been calculated by using the daily index prices for each country in the following manner:

Intraday return for country i on day t is calculated by taking the difference of natural logarithm of closed and open prices and is denoted as $o\_c\_i_t$ where *i* = *sl* (Sri Lanka), *ind* (India), *pak* (Pakistan).

$$o\_c\_i_t = \ln\left(P_{i,t}^{Close}\right) - \ln\left(P_{i,t}^{Open}\right) \quad (1)$$

Overnight return for country i on day t is calculated by taking the difference of natural logarithm of open price of day t and closed price of day $t-1$ and is denoted as $c\_o\_i_t$ where *i* = *sl* (Sri Lanka), *ind* (India), *pak* (Pakistan).

$$c\_o\_i_t = \ln\left(P_{i,t}^{Open}\right) - \ln\left(P_{i,t-1}^{Close}\right) \quad (2)$$

Figure 1: Trading Periods for Each Exchange With Respect to IST Zone

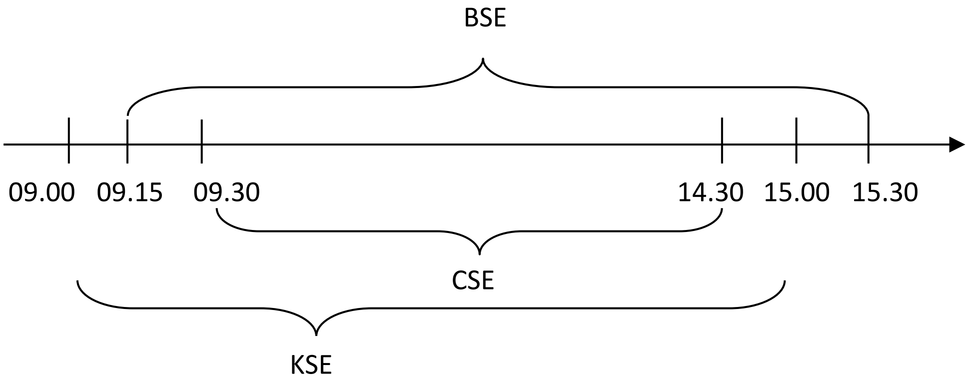

Table 1: Summary Statistics for Intraday Returns

	o_c_sl	o_c_ind	o_c_pak
Mean	0.000636	-0.000954	-0.000287
Standard Deviation	0.010585	0.013380	0.012376
Skewness	-0.701674	-0.967982	-0.389645
Kurtosis	13.26801	10.22201	5.716829
Jarque-Bera statistic	0.000000	0.000000	0.000000

As indicated in Table 1, Sri Lanka is the only country with a positive mean intraday return within the sample, though none of these mean returns is significantly different from zero. Sri Lankan market shows the least unconditional volatility (0.010585), while the Indian market shows the highest (0.01338). All three return series are negatively skewed, indicating that negative returns are more common than positive returns. Moreover, in terms of kurtosis, all indices have higher peaks. This indicates that all three return series have asymmetric and leptokurtic distributions. The p values of the Jarque-Bera (JB) test statistic also suggest that the return series are not normal.

In two respects, descriptive statistics of overnight returns indicated in Table 3 are different from those of intraday returns. First, both India and Pakistan display positive returns. Again, none of these mean returns is significantly different from zero. The second notable difference is that the Sri Lankan return series is highly negatively skewed, thus indicating that negative returns are more common than positive returns. As compared with the Sri Lankan return series, the Indian return series displays a low positively-skewed distribution while the Pakistan return series displays a low negatively-skewed distribution.

Table 2: Summary Statistics for Overnight Returns

	c_o_sl	c_o_ind	c_o_pak
Mean	0.000155	0.001558	0.001072
Standard Deviation	0.003351	0.007571	0.005125
Skewness	-9.877364	0.541039	-0.884568
Kurtosis	407.5299	22.00797	17.17097
Jarque-Bera statistic	0.000000	0.000000	0.000000

MODEL SPECIFICATIONS

It is widely accepted that autoregressive conditional heteroskedasticity models are much capable of handling volatility. Consider a vector stochastic process $\{R_t\}$ of order 3×1. After conditioning to the past information which has been generated up to and including time t-1 ($\mathcal{F}_{t-1}$), the conditional mean equation system with respect to a finite vector of parameters (θ) is constructed for each session (intraday and overnight) as follows.

$$R_t = \mu_t(\theta) + \xi_t \tag{3}$$

where $\mu_t(\theta)$ is the conditional mean vector and

$$\xi_t = H_t^{1/2}(\theta) z_t \tag{4}$$

where $H_t^{1/2}(\theta)$ is a 3×3 positive definite matrix. Additionally, we assume 3×1 random vector z_t to have the following properties:

$$E(z_t) = 0 \; and \; Var\,(z_t) = I_3 \tag{5}$$

where I_3 is the identity matrix of order 3.

Thus, the conditional variance of matrix of R_t can be defined as follows:

$$\begin{aligned} Var(R_t|\mathcal{F}_{t-1}) = Var_{t-1}(R_t) &= Var_{t-1}(\xi_t) \\ &= H_t^{\frac{1}{2}} Var_{t-1}(z_t)(H_t^{\frac{1}{2}})' \\ &= H_t \end{aligned} \tag{6}$$

and, $R_t|\mathcal{F}_{t-1} \sim N(0, H_t)$

The variance-covariance matrix (H_t) has been parameterised as a trivariate BEKK GARCH process. For parsimony and computational ease, a restricted version of full BEKK model - more specifically, BEKK GARCH (1, 1) with lower triangular parameter matrices - is used. Bollerslev et al. (1992) state that the GARCH (1, 1) model is sufficient enough for modeling the variance dynamics over very long sample periods. The proposed specification is given by equation (7).

$$H_t = \Omega\, \Omega' + \mathrm{A}\, \xi_{t-1}\, \xi'_{t-1}\, \mathrm{A}' + \mathrm{B}\, H_{t-1}\, \mathrm{B}' \tag{7}$$

Ω in equation (7) is a 3×3 lower triangular matrix of constants. A and B are 3×3 lower triangular parameter matrices. Matrix A, elements of which measure the effects of shocks or short-run impact on the conditional variances, shows how the conditional variances are correlated with past squared errors. Matrix B shows how persistent the conditional variances among the markets are and its elements measure the lagged own GARCH effect on a certain market as well as such effects from other markets. As such, a more elaborative form of the model represented by equation (7) is as follows:

$$\begin{aligned} H_t = &\begin{bmatrix} \omega_{11} & 0 & 0 \\ \omega_{21} & \omega_{22} & 0 \\ \omega_{31} & \omega_{32} & \omega_{33} \end{bmatrix} \times \begin{bmatrix} \omega_{11} & \omega_{21} & \omega_{31} \\ 0 & \omega_{22} & \omega_{32} \\ 0 & 0 & \omega_{33} \end{bmatrix} \\ &+ \begin{bmatrix} \alpha_{11} & 0 & 0 \\ \alpha_{21} & \alpha_{22} & 0 \\ \alpha_{31} & \alpha_{32} & \alpha_{33} \end{bmatrix} \times \begin{bmatrix} \varepsilon_{1,t-1} \\ \varepsilon_{2,t-1} \\ \varepsilon_{3,t-1} \end{bmatrix} \times \begin{bmatrix} \varepsilon_{1,t-1} & \varepsilon_{2,t-1} & \varepsilon_{3,t-1} \end{bmatrix} \times \begin{bmatrix} \alpha_{11} & \alpha_{21} & \alpha_{31} \\ 0 & \alpha_{22} & \alpha_{32} \\ 0 & 0 & \alpha_{33} \end{bmatrix} \\ &+ \begin{bmatrix} \beta_{11} & 0 & 0 \\ \beta_{21} & \beta_{22} & 0 \\ \beta_{31} & \beta_{32} & \beta_{33} \end{bmatrix} \times \begin{bmatrix} h_{11,t-1} & h_{12,t-1} & h_{13,t-1} \\ h_{21,t-1} & h_{22,t-1} & h_{23,t-1} \\ h_{31,t-1} & h_{32,t-1} & h_{33,t-1} \end{bmatrix} \times \begin{bmatrix} \beta_{11} & \beta_{21} & \beta_{31} \\ 0 & \beta_{22} & \beta_{32} \\ 0 & 0 & \beta_{33} \end{bmatrix} \end{aligned} \tag{8}$$

where $H_t = \begin{bmatrix} h_{11,t} & h_{12,t} & h_{13,t} \\ h_{21,t} & h_{22,t} & h_{23,t} \\ h_{31,t} & h_{32,t} & h_{33,t} \end{bmatrix}$ is a symmetric matrix.

$(i.e. \;\; h_{12,t} = h_{21,t} \;,\; h_{13,t} = h_{31,t} \;, and \;\; h_{23,t} = h_{32,t} \,)$

The diagonal parameters of matrices A and B measure the effects of own past shocks or 'news' and own past volatility respectively. The off diagonal elements of matrix A (i.e. α_{21}, α_{31} and α_{32}) measure the cross-market impact of lagged squared innovations while the off diagonal elements of B (i.e. β_{21}, β_{31} and β_{32}) measure the impact of cross-market lagged volatility on conditional variance (or volatility spillovers). With the proposed restricted version of BEKK model, the results of volatility spillovers 'from other markets to Sri Lanka' and 'from Sri Lanka to other markets' are obtained separately[3]. However, the results are synthesised in Tables 3 and 4 [4].

The specified model can be estimated efficiently and consistently by using the full information maximum likelihood method (Engle and Kroner, 1995; Kroner and Ng, 1998) under the auxiliary assumption of an iid. normal distribution for the standardised innovations. Given a sample of T observations of the returns vector, R_t, the parameters of the trivariate system are estimated by optimising the following conditional log-likelihood function with respect to θ:

$$L = \sum_{t=1}^{T} L_t\,(\theta)$$

$$L_t(\theta) = -\frac{3}{2}\ln(2\pi) - \frac{1}{2}\ln|H_t| - \frac{1}{2}(\varepsilon_t' H_t^{-1}\varepsilon_t) \qquad (9)$$

where θ represents the parameter vector to be estimated. Marquardt optimisation algorithm has been employed to obtain the estimate for parameters.

EMPIRICAL RESULTS AND DISCUSSION

The intraday session involves only contemporaneous volatility spillovers under the assumption that information generated in one market during a day is fully transmitted to the other market on the same day. The results of intraday spillovers reported in the left panel of Table 3 confirm the presence of significant volatility spillover effects from both India and Pakistan towards Sri Lanka. With respect to overall shock spillovers, the estimated results indicate that the shock in Indian market will be significantly transmitted to the Sri Lankan market while the overall shock spillovers from Pakistan to Sri Lanka are marginally significant at 10% level. As indicated in the right panel of Table 3, volatility spillovers from Sri Lanka to India are more significant than spillovers to Pakistan. With respect to the overall shock spillovers, estimated results conclude that the

[3] For the data in the given time frame, we could not run the full BEKK model due to the problem of near singular matrix in inverse calculation.

[4] Detailed results can be produced upon request.

transmission of shocks from Sri Lanka to India is not significant whereas their transmission to Pakistan is highly significant.

According to the left panel of Table 4, there is no evidence to claim that overnight volatility spillovers exist from both India and Pakistan towards Sri Lanka. However, with respect to overall shock spillovers, the estimated results indicate that the transmission of shocks from India is highly significant though there is no evidence to say that overall shocks get spilled over from Pakistan to Sri Lanka.

Table 3: Empirical Results of Intraday Spillovers

From other markets (j) towards Sri Lanka			From Sri Lanka towards other markets (i)		
j	Volatility Spillover effect	Overall shock Spillover effect	i	Volatility Spillover effect	Overall shock spillover effect
India	- 0.012681*** (0.0001)	0.040988*** (0.0000)	India	0.015985*** (0.0095)	- 0.024069 (0.1557)
Pakistan	- 0.016191*** (0.0006)	0.016696* (0.0981)	Pakistan	0.014301** (0.0410)	- 0.029915** (0.0347)

Note. *** Significant at 1%; ** Significant at 5%; * Significant at 10% ; Figures appearing underneath each parameter estimate within parenthesis are probabilities

Table 4: Empirical Results of Overnight Spillovers

From other markets (j) towards Sri Lanka			From Sri Lanka towards other markets (i)		
j	Volatility Spillover effect	Overall shock Spillover effect	i	Volatility Spillover effect	Overall shock spillover effect
India	- 0.000935 (0.1835)	0.005677*** (0.0059)	India	0.022309*** (0.0000)	- 0.126511*** (0.0000)
Pakistan	0.000554 (0.7807)	- 0.006805 (0.1574)	Pakistan	- 0.005608 (0.2684)	0.044244*** (0.0000)

Note. *** Significant at 1%; ** Significant at 5%; * Significant at 10%; Figures appearing underneath each parameter estimate within parenthesis are probabilities

The figures in the right panel of Table 4 suggest that the volatility spillovers from Sri Lanka to India are highly significant. However, there is no evidence to claim that volatility spillovers do exist towards Pakistan. With respect to overall shock spillovers, the estimated results conclude that there are significant spillover effects from Sri Lanka to both India and Pakistan.

The Ljung-Box Q statistic for residuals and squared residuals are used to test for the presence of unfiltered linear and non-linear dependencies in residuals, ξ_t, of the estimated BEKK model. Results are reported in Table 5, which indicates that Ljung-Box Q statistic is not statistically significant for lags 14 and 20 in both regressions intraday and overnight except in one case, where the statistic is marginally significant at 10% level. This confirms that the proposed model to estimate volatility spillover effects among the three markets has been correctly specified.

Table 5: Results of Diagnostic Tests

	Sri Lanka		India		Pakistan	
	Intraday	Overnight	Intraday	Overnight	Intraday	Overnight
LB – Q (14)	23.573*	16.394	17.591	18.582	18.340	16.299
LB – Q (20)	25.738	20.640	20.293	24.127	26.469	24.183
LB – Q^2 (14)	17.927	5.016	15.333	12.924	10.680	2.503
LB – Q^2 (20)	23.069	5.682	24.284	16.802	11.915	3.465

Note. *** Significant at 1%; ** Significant at 5%; * Significant at 10%; LB – Q (14) and (20) and LB – Q^2 (14) and (20) denote the Ljung-Box Q statistics for residuals for 14 lags and 20 lags and squared residuals for 14 and 20 lags, respectively.

In this context, based on the model of cross-border daily equity returns by Griffin, Nadari and Stulz (2004), a few reasons can be pointed out to explain why capital has been pushed towards Sri Lanka from India. First, CSE was able to make huge gains for investors even during the 2008/09 post global financial crisis period and was not subject to many major drops in prices as the other larger markets. Second, CSE was the sixth best performing equity market within the region by 2013 while outperforming BSE. In fact, to counter the negative fallout of the global meltdown on the Indian and Pakistan equity markets, the governments of both countries implemented some macroeconomic and policy level measures. For instance, the Indian central bank took a number of monetary easing and liquidity enhancing measures to facilitate flow of funds (Bajpai, 2011). Pakistani authorities declared an unusual amnesty in January 2012 to facilitate stock market growth by allowing investors to buy shares with no questions raised about where their money had come from. With the introduction of this remission, the daily volume traded on KSE has doubled; which lasted until June 2014. Based on the same model, it can be argued that capital might have been pulled from Sri Lanka to Pakistan because of it being top performer within the region, ahead of Sri Lanka and India. In addition, Sri Lanka's status of being the relatively smallest market with less liquidity, more predictability and higher returns (Padhi and Lagesh, 2012), might have had an impact on pushing capital from other markets towards it.

Moreover, most of the emerging markets have thin trading, lack of transparency coupled with informational inefficiency and speculative trading by few market makers which make those markets vulnerable to financial bubbles followed by a market crash (Chan, Lee and Woo, 2003). Because of these shared characteristics among the three markets, the behavior of market participants around the crisis period and resulting transmission of capital flows across the markets can be explained by the wake-up call hypothesis (Kaminsky et al., 2003) as well as the flight to quality argument (Baur and Lucey, 2009; Johansson, 2010).

CONCLUDING REMARKS

This study set out to explore the existence, size and the direction of volatility spillovers between Sri Lankan stock market and two major South Asian regional equity markets, viz., India and Pakistan. The empirical literature in this area, especially in the context of Sri Lanka, is inconclusive and not common compared to studies on the equity markets in other countries. Findings show the existence of bilateral intraday volatility spillovers between Sri Lanka and India as well as Sri Lanka and Pakistan. It has been evident that, with respect to the intraday session, the effect from Pakistan to Sri Lanka is stronger than the effect from India to Sri Lanka. However, with respect to the overnight session, we found only a unilateral spillover effect from Sri Lanka to India.

In terms of the cross-market lagged squared innovations, estimated results indicate highly significant spillovers from Sri Lanka to Pakistan and from India to Sri Lanka in both intraday and overnight sessions. In addition, there are significant spillovers from Sri Lanka to India only in the overnight session.

The exploration and close examination of the nature of volatility spillovers between Sri Lanka and other markets have important implications for policy makers in addressing financial stability issues especially with regard to monetary policy. Monetary policy can simply rely on controlling market fundamentals only if there is no adverse impact from existing volatility spillovers. Furthermore, as Giannellis, Kanas, & Papadopoulos (2010) point out, monetary authorities have to be cautious about volatility in asset markets if it is caused by non-fundamental factors such as irrational investing behavior in such markets. The existence of volatility spillovers from other South Asian markets to the local market also implies that policy makers have to be watchful during turbulent times such as financial crises. Moreover, investors and other fund managers benefit from the new research insights on shock and volatility spillover effects between Sri Lanka and other markets in the region. The findings also provide important insights on implications for market efficiency, profitable investment opportunities and risk diversification. Nevertheless, findings based on past data may be of limited use in investments in stock markets where returns depend largely on current events and news.

REFERENCES

Alotaibia, A. R., & Mishra, A. V. (2015). Global and Regional Volatility Spillovers to GCC Stock Markets. *Economic Modelling*, *45*, 38-49.

Alper, C. E., & Yilmaz, K. (2004). Volatility and Contagion: Evidence from the Istanbul stock exchange. *Economic Systems*, *28*(4), 353-367.

Avramov, D., Chordia, T., & Goyal, A. (2006). Liquidity and Autocorrelations in Individual Stock Returns. *The Journal of Finance*, *61*(5), 2365-2394.

Bajpai, N. (2011). Global Financial Crisis, Its Impact on India and the Policy Response. *Working paper* No 5, Colombia Global Centers, South Asia, Columbia University.

Baur, D. G., & Lucey, B. M. (2009). Flights and Contagion - An Empirical Analysis of Stock – bond Correlations. *Journal of Financial Stability*, *5*(4), 339-352.

Beirne, J., Caporale, G. M., Schulze-Ghattas, M & Spagnolo, N. (2013). Volatility Spillovers and Contagion from Mature to Emerging Stock markets. *Review of International Economics*, *21*(5), 1060-1075.

Blasco, N., Corredor, P. & Ferreruela, S. (2012). Does Herding Affect Volatility? Implications for the Spanish stock market, *Quantitative Finance*, *12*(2), 311-327.

Bollerslev, T., Chou, R. Y., & Kroner, K. F. (1992). ARCH modeling in finance: A Review of the Theory and Empirical Evidence. *Journal of Econometrics*, *52*(1), 5-59.

Cha, B. & Oh, S. (2000). The Relationship between Developed Equity Markets and the Pacific Basin's Emerging Equity Markets. *International Review of Economics & Finance*, *9*(4), 299-322.

Chan, H. L., Lee, S. K., & Woo, K. Y. (2003). An Empirical Investigation of Price and Exchange Rate Bubbles during the Interwar European hyperinflations. *International Review of Economics & Finance*, *12*(3), 327-344.

Choe, H., Kho, B. C., & Stulz, R. M. (1999). Do Foreign Investors Destabilize Stock Markets? Korean experience in 1997. *Journal of Financial Economics*, *54*(2), 227-264.

Connolly, R., Stivers, C., & Sun, L. (2005). Stock Market Uncertainty and the Stock-Bond

Return Relation, *Journal of Financial and Quantitative Analysis, 40*(1), 161-194.

Corsetti, G., Pesenti, P., Roubini, N., & Tille, C. (2000). Competitive Devaluations: toward a Welfare-based Approach. *Journal of International Economics*, *51*(1), 217-241.

Elyasiani, E., Perera, P., & Puri, T. N. (1998). Interdependence and Dynamic Linkages between Stock Markets of Sri Lanka and Its Trading Partners. *Journal of Multinational Financial Management*, *8*(1), 89-101.

Engle, R., Takatoshi I., & W. Lin (1990). Meteor Showers or Heat Waves? Heteroskedastic Intra-daily Volatility in the Foreign Exchange Market, *Econometrica*, 58(3), 525-42.

Engle, R. F., & Kroner, K. F. (1995). Multivariate Simultaneous Generalized ARCH. *Econometric theory*, *11*(01), 122-150.

Froot, K. A., Scharfstein, D. S., & Stein, J. C. (1992). Herd on the Street: Informational Inefficiencies in a Market with Short-term Speculation. *The Journal of Finance*, *47*(4), 1461-1484.

Giannellis, N., Kanas, A. & Papadopoulos, A. P. (2010). Asymmetric Volatility Spillovers between Stock Market and Real Activity: Evidence from the UK and the US, *Panoeconomicus*, *4*, 429-445.

Gonzalo, J., & Olmo, J. (2005). *Contagion versus Flight to Quality in Financial markets.* UC3M Working Paper Series. Retrieved September 04, 2014 from http://hdl.handle.net/10016/339

Griffin, J. M., Nadari, F., & Stulz, R. M. (2004). Are Daily Cross-border Equity Flows Pushed or Pulled?. *Review of Economics and Statistics*, *86*(3), 641-657.

Hamao, Y., Masulis, R. W., & Ng, V. (1990). Correlations in Price Changes and Volatility across International Stock Markets. *Review of Financial Studies*, *3*(2), 281-307.

Johansson, A. C. (2010). *Stock and Bond Relationships in Asia.* CERC Working Paper 14. Retrieved June 16, 2014 from http://swopec.hhs.se/hacerc/papers/hacerc2010-014.pdf.

Jung, R. C. & Maderitsch, R. (2014). Structural Breaks in Volatility Spillovers between International Financial Markets: Contagion or mere Interdependence? *Journal of Banking & Finance*, *47*, 331-342.

Karolyi, G. A. (1995). A Multivariate GARCH Model of International Transmissions of Stock Returns and Volatility: The Case of the United States and Canada. *Journal of Business & Economic Statistics*, *13*(1), 11-25.

Kaminsky, G. L., Reinhart, C. M., & Vegh, C. A. (2003). The Unholy Trinity of Financial Contagion. *Journal of Economic Perspectives, 17*(4), 51-74.

Kodres, L. E., & Pritsker, M. (2002). A Rational Expectations Model of Financial Contagion. *The Journal of Finance*, *57*(2), 769-799.

Koutmos, G. & Booth, G.G. (1995). Asymmetric Volatility Transmission in International Stock markets. *Journal of International Money and Finance*, *14*(6), 747–762.

Kroner, K. E., & Ng, V. K. (1998). Modeling Asymmetric Co-movements of Asset Returns. *Review of Financial Studies*, *11*(4), 817-844.

Li, Y. & Giles, D. E. (2015) Modeling Volatility Spillover Effects between Developed Stock Markets and Asian Emerging Stock Markets. *International Journal of Finance & Economics*, *20*(2), 155-177.

Lin, W. L., & Ito, T. (1994). Price Volatility and Volume Spillovers between the Tokyo and New York Stock Markets. In *The Internationalization of Equity Markets*. University of Chicago Press, 309-343.

Miyakoshi, T. (2003). Spillovers of Stock Return Volatility to Asian Equity Markets from Japan and the US. *Journal of International Financial Markets, Institutions and Money*, *13*(4), 383-399.

Mukherjee, K. & 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.

Padhi, P. & Lagesh, M. A. (2012). Volatility Spillover and Time-varying Correlation among the Indian, Asian and US Stock Markets. *Journal of Quantitative Economics, 10*(2), 78-90.

Pritsker, M. (2001). The Channels for Financial Contagion. In *International Financial Contagion.* US: Springer, 67-95.

Ross, S. A. (1989). Information and Volatility: The No-arbitrage Martingale Approach to Timing and Resolution Irrelevancy. *The Journal of Finance*, *44*(1), 1-17.

Rua, A., & Nunes, L. C. (2009). International Movement of Stock Market Returns: A Wavelet Analysis. *Journal of Empirical Finance*, *16*(4), 632-639.

Tanizaki, H., & Hamori, S. (2009). Volatility Transmission between Japan, UK and USA in Daily Stock Returns. *Empirical Economics*, *36*(1), 27-54.

Van Rijckeghem, C., & Weder, B. (2001). Sources of Contagion: Is it Finance or Trade? *Journal of International Economics*, *54*(2), 293-308.

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.

Wei, J., K. C., Liu, Y. J., Yang, C. C., & Chaung, G. S. (1995). Volatility and Price Change Spillover Effects across the Developed and Emerging Markets. *Pacific-Basin Finance Journal*, *3*(1), 113-136.

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.