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Article

Global Financial Crisis in Effecting Asymmetrical Co-integration between Exchange Rate and Stock Indexes of South Asian Region: Application of Panel Data NARDL and ARDL Modelling Approach with Asymmetrical Granger Causality

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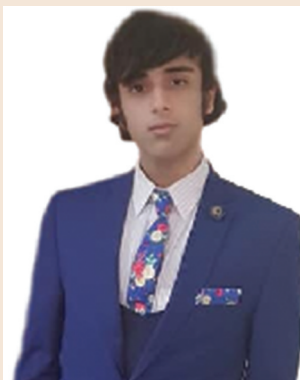
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BANKING & FINANCE | RESEARCH ARTICLE

Global Financial Crisis in Effecting Asymmetrical Co-integration between Exchange Rate and Stock Indexes of South Asian Region: Application of Panel Data NARDL and ARDL Modelling Approach with Asymmetrical Granger Causality

Umaid A Sheikh^{1*}, Mosab I. Tabash² and Muzaffar Asad³

Abstract: This research examines the impact of positive and negative shocks of exchange rate on South Asian Stock indexes by employing a Non-linear Panel autoregressive distributive lag model along with a Panel Asymmetric granger casualty test. For the Panel-NARDL model, the Pre-crisis regime comprises of 289 observations from 1st January 2000 to 1st January 2008, the post-crisis regime consists of 547 observations from 1st January 2009 to May 2020 and the whole sample is constituted upon 960 observations from 1st January 2000 to May 2020.



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Umaid A Sheikh has completed several academic degrees including BBA-Hons and Master of Business Administration from Comsats University, Islamabad. He has also completed his M.Phil. in Accounting and Finance with A grade in thesis and 87% overall aggregate average. His research works appear in other scientific journals indexed by Scopus, WOS, and ABDC.

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PUBLIC INTEREST STATEMENT

This research article has examined the symmetrical and asymmetrical linkages between exchange rate fluctuations and stock indexes of Pakistan, India, Bangladesh and Sri-Lanka by utilizing linear panel ARDL and NARDL modelling and asymmetrical granger causality analysis. Data period is divided into three different types of time frames such as before the global financial crisis, after the crisis, and when the whole sample period is selected. Results have shown that symmetrical panel-based ARDL models failed to establish a long-term linear co-integrating association between exchange rate fluctuations and stock indexes when the whole sample period is selected and for regime before the crisis. However, the asymmetrical panel-based NARDL model established asymmetrical co-integration between positive and negative shocks to exchange rate fluctuations and stock indexes.

Pesaran's 2007 cross-sectional augmented IPS unit root test is also applied after estimating Pesaran's 2004 CD test. Findings indicated that the linear panel-based ARDL model failed to establish long-term cointegration between exchange rate fluctuation and stock indexes before the global financial crisis and when the overall sample period is selected. However, the asymmetrical panel-based ARDL model established a non-linear long-term association between exchange rate fluctuation and stock indexes in three regimes. Moreover in long run, when the whole sample is selected, investors reacted to only positive shocks to exchange rate and did not react to negative shocks. However, in the short run investors reacted equally to both positive and negative shocks to exchange rates. In pre-crisis and post-crisis regimes, stock indexes are only inversely related to positive shocks to exchange rate fluctuations and investors did not react to negative fluctuations in the exchange rate. However, in the short run and before the global financial crisis, investors reacted to only positive shocks to exchange rate but in the short run and after the crisis, investors did not react to positive shocks. The significance of this research is two-fold: Firstly, we have examined the reaction of investors to both positive and negative shocks to exchange rate fluctuations under three different regimes. Secondly, we have shown that non-linear panel-based modelling is more effectual in estimating asymmetrical linkages between exchange rate fluctuation and stock indexes.

Subjects: Statistics for Business, Finance & Economics; Economics and Development; Economics; Macroeconomics; Monetary Economics; International Economics; Development Economics

Keywords: non-linear panel ARDL; cross-sectional augmented IPS unit root; South Asian stock indexes; global financial crisis; asymmetric granger causality analysis; exchange rate and stock prices

1. Introduction

The 2008 Financial downturn in the South Asian economies mostly impacted Indian and Sri-Lankan economic development (Asad & Farooq, 2009; Carrasco et al., 2010). In 2010, a working paper series published by the Asian development bank stated that within these economies, capital markets have begun to streamline and a portion of the money supply has returned. However, the magnitude of the regeneration arising from reserve bank interventions can not be calculated. Although by 2010, South Asia's economic growth is well below average, the production gap is lower for India and Sri-Lanka as compared to other economies of the South Asian region (Carrasco et al., 2010). The economic crunch of 2008 has recently created serious economic disruptions for South Asian economic development (Raj, 2014) and contributed significant inflationary pressures on the economy of the whole region (Filardo, 2011). With the disastrous impact of governmental employees' payroll disruptions on the services industry and declining agricultural growth of India as a consequence of water shortages, economic development in India in the last three months of 2009 depreciated to 6%. The global financial crisis has not only stimulated disruptions in Asian economies (Keat, 2010; Raj, 2014; World Bank feature Story, 2010) but also affected the South Asian economy (Athukorala & Chongvilaivan, 2010) and this has motivated us to study the asymmetrical impact of exchange rate fluctuations on stock indexes of selected economies of the South Asian region by utilizing non-linear Panel ARDL modelling.

Figure 1. Exchange rate and stock indexes of Pakistan, Bangladesh, India and Sri-Lanka.

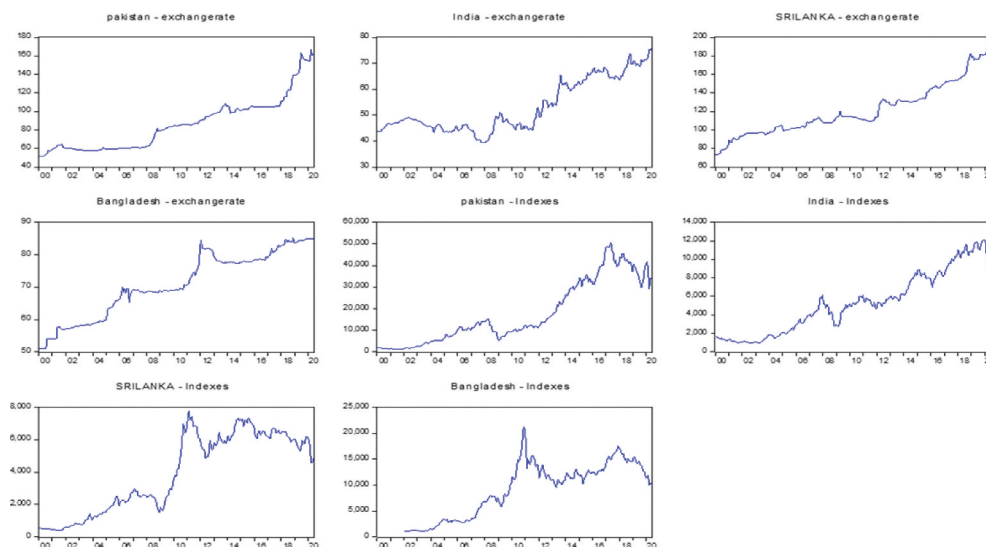


Figure 2. Scatter-plot diagram for correlations between exchange rate and stock indexes.

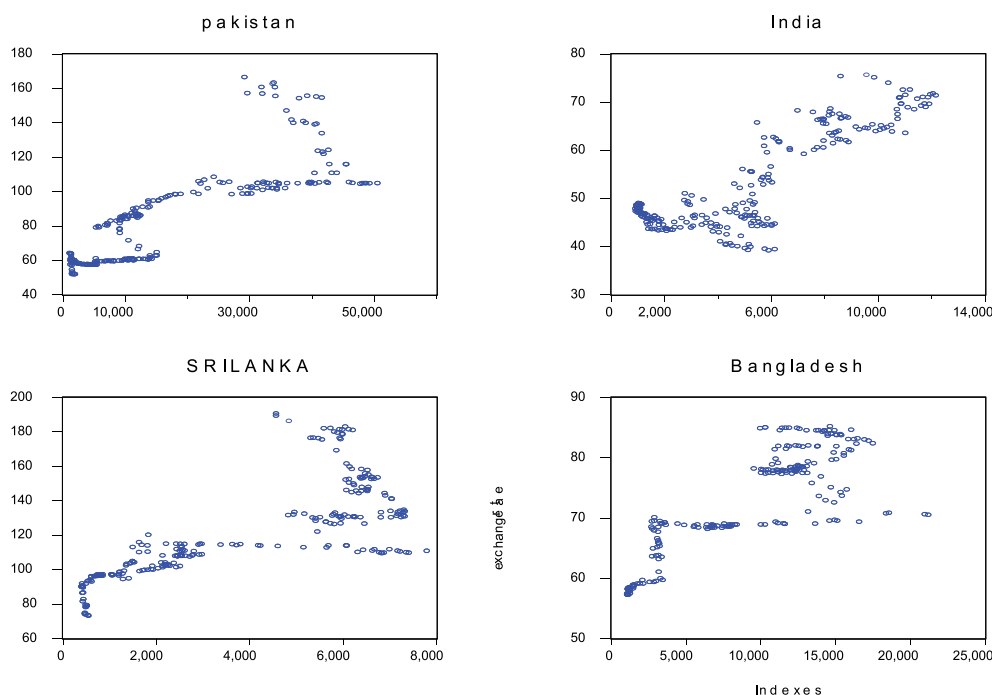


Figure 1 shows that the global financial crisis has affected stock indexes of Pakistan, India, Sri Lanka and Bangladesh. Figure 2 confirms that the relationship between fluctuations in currency values and stock indexes is non-linear or asymmetrical in nature.

Figure 1 shows that the global economic crunch has stimulated depreciating trend in the stock indexes of Pakistan, Bangladesh, Sri Lanka and India and the indexes of corresponding economies moved in a downward direction during the economic crisis of 2008. However, the exchange rate moved in opposite (upwards) direction during 2008. This furthermore motivates the researchers to investigate the asymmetrical influence of fluctuations in currency values on stock indexes for three different time frames such as pre-economic crisis regime, post-crisis and when the whole sample period is selected.

The purpose of this research article is to examine asymmetrical linkages between exchange rate fluctuations on stock indexes of selected four South Asian economies such as Pakistan, India, Bangladesh, and Sri Lanka. Panel NARDL model is utilized to investigate the asymmetries between exchange rate fluctuations and stock indexes for four selected economies because Panel NARDL model is having the capacity to disintegrate exchange rate into positive and negative shocks for examining the nonlinear impact of exchange rate fluctuations on stock indexes of selected four countries: India, Pakistan, Bangladesh and Sri-Lanka. Panel NARDL model is useful for exploring the asymmetries between exchange rate and stock indexes for selected South Asian economies as a whole. This research article fills the following important research gaps that remain uncharted in existing researches.

Firstly, most of the research article on the exchange rate-stock index nexus have explored symmetrical linkages between both underlying variables (Adjasi et al., 2011; Akbar et al., 2019; Delgado, & Saucedo, 2018; Hussain, 2019; Keswani & Wadhwa, 2018; Mosab et al., 2020; Muhammad & Gang, 2015; Tripathi & Seth, 2014; Roubaud & Arouri, 2018; Sheikh et al., 2020; Shiva & Sethi, 2015; Simbolon & Purwanto, 2018; Singhal et al., 2019; Sultana & Reddy, 2017; You et al., 2017) and limited efforts have been made to investigate the influence of +ve and -ve shocks to exchange rate fluctuations on stock indexes.

Secondly and importantly, most research articles have either utilized symmetrical or linear econometric modelling or asymmetrical econometric modelling by utilizing time-series data (Areli Bermudez Delgado et al., 2018; Chkir et al., 2020; Corbet et al., 2018; Jung et al., 2020; Sikhosana & Aye, 2018; Akbar et al., 2019; Anisak & Mohamad, 2019; Andriansyah & Messinis, 2019; Choi et al., 2019; Hung, 2019; Hussain, 2019; Kassouri & Altıntaş, 2020; Keswani & Wadhwa, 2018; Kumar, 2019; Liang et al., 2020; Mathur, 2018; Noura et al., 2019; Rexford, 2019; Roubaud & Arouri, 2018; Salvatore, 2019; Shakil et al., 2018; Singhal et al., 2019; Simbolon & Purwanto, 2018; Wei et al., 2019; Xie et al., 2020; Mosab et al., 2020; Sheikh, et al., 2020; Asad et al., 2019). However, to the best of our knowledge, no efforts have been made to utilize the Panel NARDL modelling approach for investigating asymmetrical linkages between exchange rate fluctuations and stock indexes. As this is the first research article which has explored asymmetrical linkages between exchange rate fluctuations and stock indexes by utilizing Panel NARDL modelling approach for three multiple regimes: pre-economic recessionary regime, post-economic recessionary and over the entire sample period).

2. Literature review

This literature review section explains the general impact of the exchange rate on stock indexes and also reported previous research findings on the asymmetrical relationship between exchange rate and stock indexes.

2.1. Exchange rate and stock prices relationship

In the existing literature on the nexus between exchange rate-stock indexes, some researchers have analyzed the asymmetrical impact of exchange rate on the stock index (Sheikh et al., 2020), but others have found that stock index variabilities symmetrically impacted exchange rate fluctuations (Asad & Farooq, 2009; Muhammad & Gang, 2015; Sheikh, et al. 2020). Muhammad and Gang (2015) found that stock indexes are an important contributing factor for exchange rate volatility by utilizing restricted vector autoregressive modelling, for example, RMB is appreciated when Chinese stock indexes moved in an upward direction. Moreover, country risk has not been found as an important factor for increasing volatility in the exchange rate; however, the RMB plays a deterministic role in influencing the country's risk of China. The specific purpose of another research article is to determine that whether macroeconomic fluctuations (including the cost of borrowing, inflationary factors, exchange rate fluctuations, and economic development within a country) affect stock prices positively and the magnitude of impact on stock indexes. Lentina and Purwanto (2018) found that variations in selected macroeconomic variables with the exception of economic development significantly contributed to the volatility of real estate firms listed

on the Indonesian stock exchange. Sheikh et al. (2020) have also found that the global financial crisis impacted asymmetrical co-integrating linkages between stock indexes and exchange rates. Mosab et al. (2020) have also utilised time series-based non-linear estimation techniques such as NARDL modelling framework and found a non-linear impact of currency values on Pakistan's stock indexes.

Kumar (2019) investigated the asymmetric causality between macroeconomic variations such as changes in Indian currency values, oil prices, and Indian stock indexes by employing asymmetric granger causation analysis and time-series NARDL modelling technique. Results reported two-way causation between fluctuations in currency values and oil prices. Furthermore, one-way causation is also identified running from currency fluctuation to stock indexes. When oil prices are exposed to +ve and -ve shocks, there is a positive impact on stock indexes for +ve shocks associated with 1 period lag of oil prices and there exists an indirect association with stock indexes for -ve shocks to 1 period lag of oil prices. Chkir et al. (2020) were interested in investigating the hedging properties of oil prices against currency fluctuations and found that oil price fluctuations serve as a weak hedge against fluctuation in currency values. Furthermore, authors have also estimated the dynamic association between currency valuation, stock indexes, and oil prices of different economies categorized by oil-producing and non-oil-producing countries through employing the VINE copulas method. Results have shown that there is negative but significant dependence between currency fluctuations and oil prices. Mexico is famous for the exploration of oil and gold and is also importing petroleum goods (Singhal et al., 2019). Singhal et al. (2019) investigated the dynamism between selected macroeconomic fluctuations and stock indexes through the utilization of symmetrical co-integrating techniques covering the time span from 2006 to 2018. Findings suggested a direct symmetrical influence of gold prices on stock indexes. Stock indexes are also affected by sentiments of investors and according to the arbitrage pricing theory, there must be a symmetrical or linear linkage between macroeconomic and stock index fluctuations (Akbar et al., 2019). Akbar et al. (2019) investigated the complex dynamism between selected macroeconomic factors and stock indexes by utilizing unrestricted VAR and Bayesian VAR modelling using data from 2001 to 2014. After testing the seasonality effect within data, followed by certain symmetrical co-integration approaches, authors have found a direct dynamic association between exchange rate fluctuation and stock indexes. Furthermore, stock indexes and exchange rate variability are having a depreciating trend during inflationary pressures.

Delgado et al. (2018) examined the dynamic inter-relationship between macroeconomic fluctuation and stock indexes in the Mexican context through utilizing restricted VAR covering the period from 1992 to 2017. Findings suggested contributing impact of exchange rate on stock indexes. Yang (2017) was interested in exploring the dynamic association between stock indexes and the exchange rate and the role of monetary policy interventions on the variables. Findings have shown that exchange rate fluctuations symmetrically and instantly impact stock indexes by employing restricted structural vector autoregression using time-series data from 1999 to 2016. In another relevant research article, Roubaud and Arouri (2018) investigated the dynamic interrelationship between currency fluctuation and stock indexes by utilizing multiple switching VAR models. Authors have found significant dynamic association across all variables, the existence of a dynamic but asymmetrical association between variables and variant relational associations between macroeconomic variables-stock indexes are identified for different regimes (Roubaud & Arouri, 2018). Adjasi et al. (2011) investigated the symmetrical associations between stock prices and exchange rate variability in selected African economies. Park and Shin (2020) observed that limited research articles in existing literature emphasize on the relationship between exchange rate variations and stock indexes in wake of the global economic crisis 2008. Building upon this significant research gap, the authors have found asymmetrical associations between exchange rate volatility and stock indexes for individual member countries of the MENA region by utilizing VECH-GARCH modelling and VECM approach. However, Park and Shin (2020) have not utilized the nonlinear panel autoregressive distributive lag modelling technique (NPARDL) in order to find out the asymmetrical association between exchange rate fluctuation and South Asian stock indexes

but only found strong perseverance in the unpredictability of currency values during the crisis and before crisis period. Sheikh, Chaudhry and Mukhtar (2018) confirmed that panel data modelling is more efficient in examining the association between financial and non-financial variables and Asian automotive stock indexes.

Financial derivatives were mostly incorporated in conformity with the appropriate assurance of risk mitigation and, consequently, the fluctuation of the underlying spot market. The same is predicted for derivatives of interest rates since these instruments are believed to provide long-term stability in the rate of interests and therefore stock indexes (Nandy & Chattopadhyay, 2014). Volatility in stock indexes is not generated just because of certain macroeconomic determinants but these variabilities are also arising due to firms' micro-level financial determinants such as financial ratios of firms. Sultana and Reddy (2017) determined the role of financial and non-financial determinants of Indian firms in causing stock index volatility and found that macroeconomic factors such as exchange rate, interest rate, etc. and non-macroeconomic variables contributed to stock returns volatility for Indian firms. Macroeconomic variables played an important role in contributing to a nation's economy regardless of whether the nations are underdeveloped, developed, or emerging. Keswani and Wadhwa (2018) investigated that changes in selected macroeconomic variables including fluctuations in currency, cost of borrowing, inflationary pressures can influence the stock price volatility of the Indian economy through employing advanced cointegration techniques and utilizing time-series data from 2006 to 2016. Hung (2019) investigated the stock indexes and exchange rate volatility transmission between selected countries of the European region through utilizing time-series data from 2000 to 2017 and employed DCC and CCC (GARCH) modelling. Authors have furthermore segregated the data into multiple periods such as regime before the global economic crunch of 2008 and after the global economic crisis regime. Results have indicated that there is 2-way volatility transmission between exchange rates and stock indexes for three economies of Europe: Hungary, Czech Republic, and Croatia. However, results also indicated that there is only one-way volatility transmission between both financial markets for Hungary after the global financial crisis regime and for Romania before the crisis regime.

3. Data collection and selection of variables

The purpose of this research is to explore asymmetries between exchange rate fluctuation and stock indexes of four selected South Asian economies such as Pakistan, India, Bangladesh, and Sri Lanka. In order to explore asymmetrical linkages between exchange rate fluctuations and stock indexes of four selected economies as a whole, non-linear Panel data modelling is utilized. The pre-crisis regime for cross-sectional time-series data consist of 289 observations covering the period from January 2000 to January 2008, the post-crisis regime is constituted upon 547 observations from January 2009 to January 2020 and the whole sample period is comprised upon 960 observations as a whole for all four countries covering the period from January 2000 to May 2020. The purpose of Panel NARDL modelling is to estimate the non-linear co-integrating association between positive and negative shocks to exchange rate and stock indexes for shorter and longer horizons. Data on exchange rate fluctuations have been collected from the CIEC data repository, investing.com, and tradingeconomics.com covering the time span from January 2000 to May 2020. Stock indexes of India, Pakistan, Bangladesh, and Sri Lanka has been collected from stock exchange websites of selected countries such as Pakistan stock exchange (KSE-100 indexes), Indian stock exchange (NIFTY-50), Bangladesh stock exchange (Chittagong Stock indexes top 30), and Sri-Lankan stock exchange (CSE-All shares). The sample period is divided into three-time frames such as pre-crisis regime for the period before the global financial crisis, the post-crisis regime is for the period after the crisis and the whole sample period is selected to find out the impact of positive and negative shocks to exchange rate fluctuations on stock indexes of four countries as a whole.

4. Research methodology

This section explains the econometric procedure of estimating non-linear Panel A.R.D.L modelling for the asymmetrical impact of exchange rate fluctuations on stock indexes of selected South Asian economies as a whole.

4.1. Panel non-linear ARDL modelling

Panel non-linear and linear ARDL model can be estimated if none of the variables is becoming stationary at 2nd differencing; therefore, for estimation of Panel NARDL model, it is important that variables should be integrated at same order, e.g. regressors and regressand are displaying seasonality trends at level but converted into stationary after taking first differencing (Pesaran et al., 2001; Shin et al., 2014). It is still possible to estimate Panel-based NARDL model when certain variables are displaying non-stationarity trends at level but others are stationary at level. This means that some of variables are non-stationary at level but others are stationary, e.g. assortment of I (0) and I (1) (Shin et al., 2014). First step towards the estimation of Panel NARDL model is to find out the cross-sectional dependence in data, in case of cross-sectional dependence, first-generation unit root test will are no longer reliable (e.g. LLC by (Levin et al., 2002), Fisher Type Pane unit root test by (Choi, 2001) and Hadri Langrage Multiplier (LM) panel unit root test by (Hadri, 2000) and it has become important to estimate seasonality trends through cross-sectional augmented IPS Panel unit root test developed by Pesaran in 2007 also known as 2nd-generation Panel unit root testing approach (Pesaran, 2007).

Cross-sectional augmented IPS Panel unit root formula can be written in following manners,

$$CIPS(N, T) = N^{-1} \sum_{i=1}^N t_i(N, T),$$

Cross-sectional dependence test is estimated through the CD test of (Pesaran, 2004)¹

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^N \rho_{ij} \right)^{\wedge}$$

N = No. of South Asian economies within Panel data set, T = Number of observations with respect to the variable under observation, = pairwise correlation of residuals. Table 1 contains estimations from the CD test of (Pesaran, 2004). As stated above, the Panel NARDL model can be estimated when none of either regressor or regressand is I (2). Pesaran's CD test and Cross-sectional augmented IPS Panel unit root test confirms cross-sectional dependency and seasonality effects within the data sets respectfully.

Table 1. Pesaran's 2004 Cross-sectional dependency test

Variables	Test	Statistics	Probability
Whole sample period (January 2000 to May 2020)			
Stock indexes	Pesaran CD test	18.98***	0.0000076
Exchange rate	Pesaran CD test	17.54***	0.000041
Pre-crisis regime (January 2000 to January 2008)			
Stock indexes	Pesaran CD test	21.54***	0.000004
Exchange rate	Pesaran CD test	25.87***	0.0000001
Post-crisis regime (January 2009 to May 2020)			
Stock indexes	Pesaran CD test	15.41***	0.00000054
Exchange rate	Pesaran CD test	24.07***	0.000023

Values of Pesaran's 2004 CD test

Next step is to estimate the Panel ARDL model and Panel NARDL model in order to reconnoiter that either the connotation between currency values fluctuation and South Asian stock indexes is actually linearly related or non-linearly related. Error correction term of Panel ARDL model can be written in subsequent manner,

$$\Delta indexes_{it} = \alpha_{0i} + \pi_{1i}\xi_{it-1} + \sum_{j=1}^p \gamma_{ij}\Delta indexes_{it-j} + \sum_{j=0}^q \delta_{ij}\Delta exchangerate_{it-j} + u_i + \varepsilon_{it} \quad (1a)$$

Equation 1b shows Panel ARDL model specification,

$$\Delta indexes_{it} = \alpha_{0i} + \alpha_{1i}indexes_{it-1} + \beta_{1j}exchangerate_{it-1} + \sum_{j=1}^p \gamma_{ij}\Delta indexes_{it-j} + \sum_{j=0}^q \delta_{ij}exchangerate_{it-j} + u_i + \varepsilon_{it} \quad (1b)$$

In equation 1a, stock indexes of South Asian selected economies are taken as dependent variable and fluctuation in the exchange rate is taken as a regressor in order to investigate asymmetrical linkages between both. ξ_{it-1} denotes long-run equilibrium in linear panel ARDL model. The particular lag length can be selected on basis of Akaike information criterion (AIC), Schwarz information criterion (SIC) and Bayesian information criterion (BIC). Moreover, p and q are lag orders of corresponding regressand and regressors respectively. Long-run coefficient for both regressand and regressors are represented by a and b , whereas short-run coefficients for stock indexes and exchange rate fluctuations are represented by γ and δ correspondingly.

According to equation 1a, If ECT value is negative and significant this means that there is long-run co-integrating association between fluctuations in stock indexes of selected economies of the South Asian region and exchange rate variability. Equation 1a and 1b estimated symmetrical panel ARDL model for investigating symmetrical linkages between exchange rate fluctuations and stock indexes, however, according to Figure 2, it is purposed that actual relationship between underlying variables is non-linear in nature. We also estimate both Panel NARDL and ARDL for exploring that either actual relationship between South Asian stock indexes is linear or non-linear in nature. Non-linear Panel NARDL model can be represented as,

$$\Delta indexes_{it} = \alpha_0 + \alpha_1 indexes_{it-1} + \alpha_2^+ exchangerate_{it-1}^+ + \alpha_2^- exchangerate_{it-1}^- + \sum_{k=1}^p \beta_k \Delta indexes_{it-k} + \sum_{k=0}^q (\delta_k^+ \Delta exchangerate_{it-k}^+ + \delta_k^- \Delta exchangerate_{it-k}^-) + u_i + \varepsilon_{it} \quad (2a)$$

Equation 2b represented non-linear Panel-based ECT model incorporated in this study,

$$\Delta indexes_{it} = \alpha_{0i} + \pi_{1i}^+ \xi_{it-1}^+ + \pi_{1i}^- \xi_{it-1}^- + \sum_{j=1}^p \gamma_{ij}^+ \Delta indexes_{it-j}^+ + \sum_{j=1}^p \gamma_{ij}^- \Delta indexes_{it-j}^- + \sum_{j=1}^p \delta_{ij}^+ \Delta exchangerate_{it-j}^+ + \sum_{j=1}^p \delta_{ij}^- \Delta exchangerate_{it-j}^- + u_i + \varepsilon_{it} \quad (2b)$$

Equation 2a and 2b shows that stock indexes and exchange rate fluctuations are decomposed into their respective positive and negative shocks according to method purposed by (Shin et al., 2014). Exchange rate fluctuations and stock indexes are disintegrated into positive and negative signs in the following ways:

$$exchangerate_{it}^+ = \sum_{k=1}^t \Delta x_{ik}^+ = \sum_{k=1}^t \max(\Delta x_{ik}, 0) \quad (3a)$$

$$\text{exchangerate}_{it}^{-} = \sum_{k=1}^t \Delta x_{ik}^{-} = \sum_{k=1}^t \min(\Delta x_{ik}, 0) \quad (3b)$$

$$\text{indexes}_{it}^{+} = \sum_{k=1}^t \Delta y_{ik}^{+} = \sum_{k=1}^t \max(\Delta y_{ik}, 0) \quad (3c)$$

$$\text{indexes}_{it}^{-} = \sum_{k=1}^t \Delta y_{ik}^{-} = \sum_{k=1}^t \min(\Delta y_{ik}, 0) \quad (3d)$$

According to equation 2a and 2b, stock indexes and exchange rate fluctuations are decomposed into positive and negative signs in order to investigate asymmetrical linkages between +ve and -ve shocks to currency value fluctuations ($\alpha_2^{+} \text{exchangerate}_{it-1}^{+}$ and $\alpha_2^{-} \text{exchangerate}_{it-1}^{-}$) and stock indexes of four selected economies of South Asian region as a whole. Non-linear ARDL model by (Shin et al., 2014) is extension of linear ARDL model purposed by (Pesaran et al., 1999). Asymmetrical linkages between positive and negative shocks to exchange rate and stock indexes is investigated through utilizing Wald test statistics, if $\alpha_2^{+} \text{exchangerate}_{it-1}^{+}$ and $\alpha_2^{-} \text{exchangerate}_{it-1}^{-}$ are not equal then we can conclude asymmetric impact of positive and negative shocks to exchange rate on stock indexes. However short run asymmetric impact is analyzed through utilizing Wald test statistics for δ_k^{+} and δ_k^{-} , there exist short run asymmetric impact of positive and negative shock to exchange if δ_k^{+} is not equal to δ_k^{-} . In case of Panel NARDL modelling approach, nonlinear long run relationship between positive and negative shock to exchange rate is determined on basis of significant and negative values of $\pi_{1i}^{+} \xi_{it-1}^{+}$, $\pi_{1i}^{-} \xi_{it-1}^{-}$, these values determine that there exist asymmetrical long run co-integrating impact of exchange rate fluctuations on the stock indexes.

4.2. Hatemi-J asymmetrical granger causality for panel data

Asymmetrical granger causality test by (Hatemi-J, 2012) is also utilized in order to investigate that whether positive and negative fluctuations in currency values are asymmetrically granger causing South Asian stock indexes in three regimes. Hatemi-J in 2012 developed asymmetrical granger causality test by extending the work of (Granger & Yoon, 2002) and furthermore stated that asymmetrical granger causality is different from symmetrical granger causation in such a way that positive and negative shocks to dependent and independent variables may have a different impact on each other. Let consider that we are interested in investigating panel-based granger causation between $x_{i1,t}$ and $x_{i2,t}$. In below equation 1 and 2, $e_{1i,t}$ and $e_{2i,t}$ are identified as white noise error terms,

$$x_{i1,t} = x_{i1,t-1} + e_{i1,t} = x_{i1,0} + \sum_{j=1}^t e_{i1,j} \quad (1)$$

$$x_{i2,t} = x_{i2,t-1} + e_{i2,t} = x_{i2,0} + \sum_{j=1}^t e_{i2,j} \quad (2)$$

Both positive and negative shocks to and can be classified as

$$e_{i1,t}^{+} = \max(e_{i1,t}, 0), e_{i1,t}^{-} = \min(e_{i1,t}, 0)$$

$$e_{i2,t}^{+} = \max(e_{i2,t}, 0), e_{i2,t}^{-} = \min(e_{i2,t}, 0)$$

and hence $e_{i1,t}$, can be written as $e_{i1,t}^{+} + e_{i1,t}^{-} = e_{i1,t}$, and $e_{i2,t}$, can be written as $e_{i2,t}^{+} + e_{i2,t}^{-} = e_{i2,t}$,

consequently equation 1 can be rewritten as $x_{i1,t} = x_{i1,t-1} + e_{i1,t} = x_{i1,0} + \sum_{j=1}^t e_{i1,j}^{+} + \sum_{j=1}^t e_{i1,j}^{-}$

and equation 2 can be redefined as $x_{i2,t} = x_{i2,t-1} + e_{i2,t} = x_{i2,0} + \sum_{j=1}^t e_{i2,j}^{+} + \sum_{j=1}^t e_{i2,j}^{-}$

According to (Hatemi-J, 2012) positive and negative shocks to $x_{1,t}$, and $x_{2,t}$, can be defined as

$$x_{1,t}^+ = x_{1,t}^+ + e_{1,t}^+ = x_{1,t}^+ + \sum_{j=1}^t e_{1j}^+$$

$$x_{1,t}^- = x_{1,t}^- + e_{1,t}^- = x_{1,t}^- + \sum_{j=1}^t e_{1j}^-$$

$$x_{2,t}^+ = x_{2,t}^+ + e_{2,t}^+ = x_{2,t}^+ + \sum_{j=1}^t e_{2j}^+$$

$$x_{2,t}^- = x_{2,t}^- + e_{2,t}^- = x_{2,t}^- + \sum_{j=1}^t e_{2j}^-$$

In this research article, our goal is to investigate the impact of positive and negative shocks to exchange rate fluctuations on stock indexes; therefore, by focusing only on positive shocks associated with a variable, we have x_{1t} and x_{2t} and both are equal to $x_{1,t}^+$ and $x_{2,t}^+$, granger causation can be implemented under particular VAR environment by utilizing VAR-SUR(k) model,

$$\begin{bmatrix} x_{1,t}^+ \\ x_{2,t}^+ \end{bmatrix} = \begin{bmatrix} \beta_{i,0} \\ \gamma_{i,0} \end{bmatrix} + \begin{bmatrix} \sum_{r=1}^k \beta_{i1,r} & \sum_{r=1}^k \beta_{i2,r} \\ \sum_{r=1}^k \gamma_{i1,r} & \sum_{r=1}^k \gamma_{i2,r} \end{bmatrix} \times \begin{bmatrix} x_{1,t-r}^+ \\ x_{2,t-r}^+ \end{bmatrix} + \begin{bmatrix} e_{1,t}^+ \\ e_{2,t}^+ \end{bmatrix} \quad (3a)$$

When both variables are disintegrated into negative shocks,

$$\begin{bmatrix} x_{1,t}^- \\ x_{2,t}^- \end{bmatrix} = \begin{bmatrix} \beta_{i,0} \\ \gamma_{i,0} \end{bmatrix} + \begin{bmatrix} \sum_{r=1}^k \beta_{i1,r} & \sum_{r=1}^k \beta_{i2,r} \\ \sum_{r=1}^k \gamma_{i1,r} & \sum_{r=1}^k \gamma_{i2,r} \end{bmatrix} \times \begin{bmatrix} x_{1,t-r}^- \\ x_{2,t-r}^- \end{bmatrix} + \begin{bmatrix} e_{1,t}^- \\ e_{2,t}^- \end{bmatrix} \quad (3b)$$

When one is positive and other is negative,

$$\begin{bmatrix} x_{1,t}^+ \\ x_{2,t}^- \end{bmatrix} = \begin{bmatrix} \beta_{i,0} \\ \gamma_{i,0} \end{bmatrix} + \begin{bmatrix} \sum_{r=1}^k \beta_{i1,r} & \sum_{r=1}^k \beta_{i2,r} \\ \sum_{r=1}^k \gamma_{i1,r} & \sum_{r=1}^k \gamma_{i2,r} \end{bmatrix} \times \begin{bmatrix} x_{1,t-r}^+ \\ x_{2,t-r}^- \end{bmatrix} + \begin{bmatrix} e_{1,t}^+ \\ e_{2,t}^- \end{bmatrix} \quad (3c)$$

When one is negative and other is positive,

$$\begin{bmatrix} x_{1,t}^- \\ x_{2,t}^+ \end{bmatrix} = \begin{bmatrix} \beta_{i,0} \\ \gamma_{i,0} \end{bmatrix} + \begin{bmatrix} \sum_{r=1}^k \beta_{i1,r} & \sum_{r=1}^k \beta_{i2,r} \\ \sum_{r=1}^k \gamma_{i1,r} & \sum_{r=1}^k \gamma_{i2,r} \end{bmatrix} \times \begin{bmatrix} x_{1,t-r}^- \\ x_{2,t-r}^+ \end{bmatrix} + \begin{bmatrix} e_{1,t}^- \\ e_{2,t}^+ \end{bmatrix} \quad (3d)$$

Equation 4a to 4d can be utilized to find out the asymmetrical causality between exchange rate and stock indexes; however, this research article utilized asymmetrical granger causality to find out that either positive and negative shocks to exchange rate are granger causing stock indexes or not in three different regimes such as pre-crisis, post-crisis and when the whole sample is selected.

5. Panel NARDL modelling results

Result section deals with non-linear Panel NARDL modelling approach for investigating the asymmetrical impact of exchange rate fluctuations on stock indexes of selected countries of South Asian region (Pakistan, India, Bangladesh and Sri-Lanka) as a whole.

Table 2. Descriptive Statistics for Panel data

Descriptive statistics	Indexes	Exchange rate	Indexes	Exchange rate	Indexes	Exchange rate
Whole sample period (January 2000 to May 2020)			Pre-crisis regime (January 2000 to January 2008)		Post-crisis regime (January 2009 to May 2020)	
Mean	9011.064	82.63198	3478.421	67.17014	13,221.83	95.48047
Median	6142.935	74.89250	2442.110	59.70000	10,013.31	84.49500
Maximum	50,591.57	190.5000	14,321.39	113.4400	50,591.57	190.5000
Minimum	403.6000	39.19500	562.2000	39.19500	1638.060	44.21000
Std. Dev.	9675.417	32.33660	3119.066	21.24711	10,697.89	34.13016
Skewness	2.184217	1.044623	1.840113	0.819826	1.764594	0.757028
Kurtosis	7.716501	3.628270	5.744535	2.299335	5.173255	2.823834
Jarque-Bera	1646.256	194.3532	253.7967	38.28517	391.5199	52.95420
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	8,614,577.	80,979.34	1,005,264.	19,412.17	7,232,340.	52,227.82
Sum Sq. Dev.	8.94E+10	1,023,697.	2.80E+09	130,014.6	6.25E+10	636,017.9
Observations	956	980	289	289	547	547

Note: This table shows the descriptive statistics of panel data for three different types of regimes such as pre-crisis, post-crisis and when the whole sample period is selected.

5.1. Panel NARDL estimation results

Table 2 explains the descriptive statistics of stock indexes and exchange rate fluctuations of selected economies of South Asian regions like Pakistan, India, Sri-Lanka and Bangladesh. The standard deviation of selected South Asian economy's stock indexes and exchange rate fluctuations is greater in the post-crisis regime as compared to the pre-crisis regime and when the whole sample period is selected. Moreover, skewness for exchange rate fluctuations and South Asian selected country's stock indexes are higher when the whole sample period is selected. However, skewness for stock indexes and the exchange rate is higher for the pre-crisis regime as compared to post-crisis regime. Higher positive skewness values depict the largest right tails and higher values for stock indexes and exchange rate fluctuations against US dollars (depreciation of local currency). This further strengthens our motivation to study asymmetries between the exchange rate and stock indexes of selected South Asian countries. Higher SD values of stock indexes in the post-crisis regime mean that higher incidence of volatility in stock indexes and observations more often deviate from their average mean values. Table 1 shows cross-sectional dependence for South Asian stock indexes and exchange rate in three different regimes.

Table 3. Coefficient of variation (COV)

Variables	Coefficient of variation (COV)
Before global financial crisis (2000–2009)	
Stock indexes	0.89
Exchange rate	0.31
After global financial crisis (2009–2020)	
Stock indexes	0.80
Exchange rate	0.35
When whole sample period is selected (2000–2020)	
Stock indexes	1.07
Exchange rate	0.39

Note: Coefficient of variation for exchange rate and stock indexes in three different regimes

Table 1 confirms cross-sectional dependency for stock indexes and an exchange rate of selected economies of South Asian countries, this confirms that cross-sectional augmented IPS unit root test developed by (Pesaran, 2007) is more appropriate for detecting seasonality in cross-sectional time-series data. Pesaran's 2004 cross-sectional dependence test confirms that panel data are cross-sectional dependent, this can be furthermore confirmed from the variance of coefficient (VOC) calculated from Table 2

Table 3 reports that the coefficient of variance for stock indexes is higher in the pre-crisis regime as compared to post-crisis regime which means the existence of heterogeneity within the panel data sets. However, the coefficient of variation for exchange rate fluctuations is higher in the pre-crisis regime than post-crisis regime. In the case of cross-sectional dependence within panel data sets, Pesaran's 2007 CIPS unit is more appropriate (Kouton, 2019). Vastly heterogeneity within panel data sets is generally because of invariant volatilities in exchange rate fluctuation and stock indexes of four selected economies of the South Asian region.

Table 4 reports that neither stock indexes of selected South Asian economies nor fluctuations in currency values against the US dollar became stationary at 2nd differencing. This shows that Panel NARDL and ARDL model is an appropriate choice for investigating the asymmetrical and symmetrical impact of exchange rate fluctuations on stock indexes of Pakistan, India, Bangladesh and Sri Lanka. Moreover, Table 4 shows that all variables are integrated in the same order, e.g. stock indexes and exchange rate are having a depiction of seasonality effects at level but after taking the first difference, all have become stationary or there remained no seasonality effects in exchange rates and stock indexes after differencing one time. Following the approach of (Kouton, 2019), results of Panel-based ARDL by (Pesaran et al., 1999) and NARDL by (Shin et al., 2014) for the symmetrical and asymmetrical association between exchange rate and stock indexes are reported in Tables 5 and 6. Table 5 is divided into three sections and each section explains the symmetrical and asymmetrical impact of exchange rate fluctuation on stock indexes for the whole sample period, before the crisis and after crisis regime for longer horizons. Table 6 is consisted of the symmetrical and asymmetrical association between stock indexes and exchange rates for shorter horizons during the pre-crisis regime, post-crisis regime and when the whole sample is selected.

5.1.1. Panel NARDL model estimated results when whole sample period is selected

Table 5 reports the long-term results of the symmetrical panel-based ARDL model and asymmetrical Panel ARDL model for three different types of regimes such as before the crisis, after the crisis, and when the whole sample is selected. The symmetrical Panel ARDL model fails to establish a long-term relationship between exchange rate fluctuation and stock indexes because the linear ECT term is insignificant and non-negative when the whole sample is selected. For the whole sample period, non-linear ECT established asymmetrical linkages between fluctuation in stock indexes and exchange rate for longer horizons. Panel-based NARDL model estimated that investors of selected South Asian economies reacted to only positive shocks to exchange rate fluctuations and did not consider negative shocks to exchange rate fluctuations for longer horizons. For example, an increase in positive shocks to US dollars against local currency value (devaluation in local currency), there is a decrease in stock indexes. This may be due to an increase in international dollar value, producer price appreciates, which may have a negative influence on the overall earnings of the firm and is reflected by stock indexes. This is known as a flow-oriented approach. For the whole sample period and shorter horizons, both symmetrical and asymmetrical panel-based NARDL models showed similar results. In the case of the Panel ARDL model, there is an indirect association between stock indexes and exchange rate fluctuations and the Panel NARDL model showed that investors reacted equally but inversely to +ve and -ve shocks to exchange rate fluctuations, and there existed indirect association for shorter horizons between exchange rate fluctuation and stock indexes. However, the magnitude of investor's reactions to negative shocks of exchange rate fluctuations is greater as compared to positive shocks to the exchange rate. Negative reactions of investors to positive and negative shocks to exchange rate fluctuations in

Table 4. Pesaran's 2007 cross-sectional Augmented IPS unit root analysis

Variables	CIPS1	CIPS2	CIPS3	Critical value (5%)	CIPS1	CIPS2	CIPS3	Critical value	Order of variables
Whole sample period is selected									
At level At first differencing									
Stock indexes	-0.91	-1.40	-1.75	-1.90	-2.95	-4.10	-4.50	-4.90	I(1)
Exchange rate	-1.50	-1.90	-2.10	-2.30	-3.50	-3.80	-4.10	-4.90	I(1)
Before crisis									
At level At first differencing									
Stock indexes	-1.145	-1.440	-1.660	-1.90	-3.05	-4.20	-4.80	-5.20	I(1)
Exchange rate	-1.430	-1.720	-1.826	-2.01	-4.10	-4.80	-5.10	-6.20	I(1)
After crisis									
At level At first differencing									
Stock indexes	-1.19	-1.4	-1.8	-2.1	-4.50	-4.90	-5.20	-5.60	I(1)
Exchange rate	-0.80	-1.20	-1.60	-1.90	-3.50	-3.95	-4.80	-5.50	I(1)

Note: This table is divided into three parts. First parts show the Pesaran's 2007 panel unit root test for whole sample period, 2nd and 3rd parts show the panel-based CIPS unit root result for pre-crisis and post-crisis regime.

Table 5. Panel ARDL and Panel NARDL model estimated results for pre-crisis regime, post-crisis regime and when the whole sample is selected for longer horizons

		Panel symmetrical ARDL results				Panel asymmetrical ARDL results			
		When whole sample period is selected		When whole sample period is selected		When whole sample period is selected		When whole sample period is selected	
Variables	coefficient	Standard errors	t-values	coefficient	Standard error	t-values	p-values		
Exchange rate	1.706237	17.90100	0.095315						
Exchange rate+				-0.031114	0.008247	-3.772872	0.0002		
Exchange rate-				-0.033140	0.022668	-1.461974	0.1441		
Non-linear ECT				-0.03958*	0.015639	-2.527563	0.0117		
Linear ECT	0.000292	0.000234	1.248048						
Wald test for long-run asymmetries				-3.65***					
Hausman test indicates that PMG is more appropriate than MG	1.21 (0.87)								
Before global financial crisis b		Before global financial crisis							
Exchange rate	0.022474	0.058086	0.386915						
Exchange rate+				-0.0576**	0.021359	-2.6973	0.00054		
Exchange rate-				-0.047185*	0.025502	-1.850246	0.065		
Non-Linear ECT				-0.1525***	0.012293	-12.41299	0.00087		
Linear ECT	-0.008442	0.011619	-0.726581						
Wald test for long-run asymmetries				-0.65					
Hausman test indicates that PMG is more appropriate than MG	0.98 (0.17)								
After global financial crisis a		After global financial crisis							
Exchange rate	-0.012***	0.004754	-2.704953						

(Continued)

Table 5. (Continued)

Panel symmetrical ARDL results		Panel asymmetrical ARDL results				
Exchange rate+			-0.013**	0.004433	-2.941902	0.0032
Exchange rate-			-0.022*	0.011804	-1.887317	0.055
Non-linear ECT			-0.1034***	0.022388	-4.625832	0.00014
Linear ECT	-0.087***	0.017847				
Wald test for Exchange rate long-run asymmetries			-4.902760			
Hausman test indicates that PMG is more appropriate than MG	0.46 (0.10)		-1.89			

Note: This table presents long-run Symmetrical and Asymmetrical impact of exchange rate fluctuations on stock indexes.

Table 6. Panel ARDL and Panel NARDL model estimated results for pre-crisis regime, post-crisis regime and when the whole sample is selected for shorter horizons

Symmetrical ARDL results							
When whole sample period is selected			When whole sample period is selected				
Variables	coefficient	Standard errors	t values	coefficient	Standard error	t values	p values
ΔExchange rate	-0.0171***	0.005520	-2.548981				
ΔExchange rate+				-0.013077	0.005390	-2.426198	0.0155
ΔExchange rate-				-0.014611	0.005555	-2.630287	0.0087
Wald test for short run asymmetries				-1.12			
Before global financial crisis before global financial crisis							
ΔExchange rate	-0.021***	0.007197	-2.948975				
ΔExchange rate+				-0.041140	0.018167	-2.264476	0.0244
ΔExchange rate-				0.025509	0.022475	1.134978	0.2575
Wald test for short run asymmetries				-7.21***			
After global financial crisis after global financial crisis							
ΔExchange rate	-0.0107***	0.0004	-2.51				
ΔExchange rate+				-0.008755*	0.005182	-1.689339	0.0918
ΔExchange rate-				-0.0138***	0.003620	-3.814558	0.0002
Wald test for exchange rate short run asymmetries				-1.54			

Note: This table presents short-run symmetrical and asymmetrical exchange rate fluctuations on stock prices.

short term can be explained by a flow-oriented approach. The appreciation of local exchange rates because of depreciating US dollar decreases exporter's profitability and expenses associated with imported goods, while domestic currency declination against US dollars raises profitability associated with exported goods but expenses allied with imported goods upsurges (Andriansyah & Messinis, 2019; Chkir et al., 2020; Hung, 2019; Xie et al., 2020). Further, currency value adjustments also had various implications on the performance of an enterprise's trade, including potential foreign currency receivables and payable (Bahmani-Oskooee & Saha, 2016). Therefore, an increase in local currency valuation against US dollars adversely impacts the export-dominated economy's stock indexes but such an appreciation is favourable for stock indexes of economies relying on imported goods. For the whole South Asian region in long run and when the whole sample period is selected, only positive shocks to exchange rates negatively impact stock indexes because of the import-oriented economy. However, in the short run and when the whole sample period is selected, investors reacted equally to both appreciation and depreciation in currency values but the magnitude of the impact of currency appreciation on stock indexes is greater as compared to currency depreciation impact. This means that positive and negative fluctuations in appreciation and depreciation of local currency brought different results for South Asian stock indexes, but in the long run, appreciation in local exchange rates is having no impact on stock indexes. In the short run and when the whole sample period is selected, local currency depreciation impact may be harmful to importers but beneficial for exporters but at the same time appreciation in local currency (negative shocks to US\$) proved to be equally harmful to exporters. This is why stock indexes reacted negatively (positively) to both positive (negative) shocks to the exchange rate. These findings are inconsistent with (Aravind, 2017; Arif et al., 2014; Chiang Leong & Hui, 2014; Hussain, 2019; Keswani & Wadhwa, 2018; Mazuruse, 2014) because they have only utilized symmetrical models in examining linkages between exchange rate fluctuation and stock indexes.

5.1.2. Panel NARDL results before global financial crisis

In long run and before the global financial crisis, the symmetrical panel-based ARDL model fails to establish the long-run non-linear co-integrating association between exchange rate fluctuation and stock indexes. Non-linear Panel ARDL model established a non-linear association between exchange rate fluctuation and stock indexes and the value of non-linear ECT term is -0.1525 and significant which means that system is getting towards its long-run equilibrium at a particular speed of 15 percent per month. According to the results of the nonlinear panel-based ARDL model, only positive shocks to exchange rate fluctuations are having an indirect effect on stock indexes and negative shocks to exchange rate fluctuation remain statistically insignificant. This means that investors have only reacted to currency depreciation rather than appreciation, e.g. with the increase in the exchange rate, stock indexes decrease in long run and before crisis regime. This means that currency depreciation is having an inverse impact on stock indexes because of import-dominated regime. According to a flow-oriented approach, depreciation in local currency increases the producer prices of many goods and in this way, the profitability of firms relying on imported goods is decreased. Similarly, in the short run and before the global financial crisis, stock indexes reacted to only positive fluctuations in exchange rates, and negative shocks to exchange rate fluctuations remain statistically insignificant. However, Wald test statistics indicated an asymmetrical association between exchange rate fluctuation and stock indexes for shorter horizons and before the global financial crisis. There are wide differences in the results of the two regimes: before the global financial crisis and when the whole sample period is selected. In short term and when the whole sample period is selected, investors reacted inversely to both positive and negative shocks to exchange rate fluctuations, which means that currency appreciations and depreciation have significant impacts on stock indexes of four selected economies. The detrimental impact may be because of import-oriented and export-oriented dynamics of the region. Appreciations in local currency are more profitable for organizations relying on imported goods, whereas depreciation in local currency is more profit-oriented for organizations associated with export businesses. However, investors reacted negatively to both positive and negative shocks to exchange rate fluctuations because import-oriented and export-oriented region cancel the potential benefit associated with either appreciation or

depreciation in local currency rates against US dollars. For example, in case of depreciation of the local currency, importers are the loss bearer and exporters may increase their profitability (Andriansyah & Messinis, 2019; Ingalhalli et al., 2016; Noura et al., 2019). However, at the same time, appreciation in the local currency against US dollars decreases the profitability of exporters, which is again reflected by composite stock indexes. But in the period before the crisis regime, only positive shocks to exchange rate causes stock indexes to decrease, and negative shocks to exchange rate did not significantly cause the stock index to decrease for both longer and shorter horizons. This shows that the South Asian region before the crisis is heavily relying on imports rather than exports as only positive shocks to exchange rate is significantly decreasing the stock indexes and investors did not react to negative shocks to exchange rate in the pre-crisis regime for shorter and longer horizons.

5.1.3. Panel NARDL results after global financial crisis

After the global financial crisis both symmetrical and Asymmetrical panel-based NARDL model established long-term co-integrating association between fluctuations in the exchange rate and stock indexes. The symmetrical panel ARDL model formulates the indirect relationship between exchange rate and stock indexes; however, the reaction of investors to both positive and negative fluctuations in stock indexes cannot be possible in the symmetrical panel-based ARDL model.

According to the Panel NARDL model, investors reacted negatively to currency depreciation. Results reported that only positive shock to exchange rate fluctuations are having an inverse

Table 7. Panel Asymmetric granger causality test

Null hypothesis:	Obs	F-Statistic	Prob.
When whole sample period is selected			
INDEXES_POS does not Granger Cause EXCHANGERATE_POS	936	3.07527	0.0157
EXCHANGERATE_POS does not Granger Cause INDEXES_POS		4.18169	0.0023
INDEXES_NEG does not Granger Cause EXCHANGERATE_POS	936	1.09139	0.3595
EXCHANGERATE_POS does not Granger Cause INDEXES_NEG		2.08204	0.0812
INDEXES_POS does not Granger Cause EXCHANGERATE_NEG	936	1.67973	0.1525
EXCHANGERATE_NEG does not Granger Cause INDEXES_POS		2.39230	0.0491
INDEXES_NEG does not Granger Cause EXCHANGERATE_NEG	936	6.91657	2.E-05
EXCHANGERATE_NEG does not Granger Cause INDEXES_NEG		1.10473	0.3530
Before global financial crisis			
INDEXES_POS does not Granger Cause EXCHANGERATE_POS	289	0.40537	0.6671
EXCHANGERATE_POS does not Granger Cause INDEXES_POS		0.76521	0.4662
INDEXES_NEG does not Granger Cause EXCHANGERATE_POS	289	0.15284	0.8583

(Continued)

Null hypothesis:	Obs	F-Statistic	Prob.
EXCHANGERATE_POS does not Granger Cause INDEXES_NEG		0.73513	0.4804
INDEXES_POS does not Granger Cause EXCHANGERATE_NEG	289	1.22024	0.2968
EXCHANGERATE_NEG does not Granger Cause INDEXES_POS		0.02023	0.9800
INDEXES_NEG does not Granger Cause EXCHANGERATE_NEG	289	0.81081	0.4456
EXCHANGERATE_NEG does not Granger Cause INDEXES_NEG		0.84940	0.4288
After Global financial crisis			
INDEXES_POS does not Granger Cause EXCHANGERATE_POS	547	2.07449	0.1504
EXCHANGERATE_POS does not Granger Cause INDEXES_POS		5.49361	0.0195
INDEXES_NEG does not Granger Cause EXCHANGERATE_POS	547	0.80667	0.3695
EXCHANGERATE_POS does not Granger Cause INDEXES_NEG		0.27825	0.5981
INDEXES_POS does not Granger Cause EXCHANGERATE_NEG	547	0.00037	0.9847
EXCHANGERATE_NEG does not Granger Cause INDEXES_POS		12.7824	0.0004
INDEXES_NEG does not Granger Cause EXCHANGERATE_NEG	547	0.19014	0.6630
EXCHANGERATE_NEG does not Granger Cause INDEXES_NEG		0.95142	0.3298
INDEXES_NEG does not Granger Cause INDEXES_POS	547	18.2823	2.E-05
INDEXES_POS does not Granger Cause INDEXES_NEG		37.1173	2.E-09

relationship with stock indexes and negative shocks to exchange rate are insignificant. This means that currency depreciation is having an inverse impact on stock indexes as this shows that selected countries of the South Asian region are relying on imported goods. These results are inconsistent with (Areli Bermudez Delgado et al., 2018; Bagchi, 2017; Dimitropoulos & Asteriou, 2009; González et al., 2018; Ingalhalli et al., 2016; Muhammad & Gang, 2015) because these studies have relied only on symmetrical modelling approach and other have utilized only time-series NARDL model (Awodumi & Adewuyi, 2020; Baz et al., 2019; Charfeddine & Barkat, 2020; Jung et al., 2020; Kumar, 2019; Liang et al., 2020; Mathur, 2018; Rajesh, 2019). This is the first research that has examined non-linearity between exchange rate fluctuation and stock indexes for Pakistan, India, Bangladesh, and Sri-lanka. Table 7 reports the results for asymmetrical granger causality analysis.

Table 7 reports that when the whole sample period is selected, there is a unidirectional causality running from positive shocks of currency values towards negative shocks of stock indexes and negative shocks to exchange rates fluctuation are granger causing positive shocks to stock indexes. However, before the global financial crisis, there is no asymmetric Granger causality

running from positive and negative shocks of exchange rate towards positive and negative shocks to stock indexes. After the global financial crisis, there is a unidirectional causality running from positive shocks and negative shocks to the exchange rate towards positive shocks to stock indexes. According to the flow-oriented approach, positive fluctuations in US dollars against local currency depreciates the local currency and this depreciation may have a negative impact on import-oriented economy of the South Asian region. Depreciation in local currency is harmful to companies relying on imported goods (Chkir et al., 2020) and services for manufacturing products within Pakistan, India, Sri Lanka, and Bangladesh, which is again reflected by stock indexes of selected economies of the South Asian region (Al-hajj et al., 2018; Andriansyah & Messinis, 2019; Chkir et al., 2020; Kassouri & Altıntaş, 2020; Keswani & Wadhwa, 2018; Nouira et al., 2019; Rexford, 2019; Xie et al., 2020).

6. Conclusion and policy recommendations

This research article has examined the symmetrical and asymmetrical linkages between exchange rate fluctuations and stock indexes of Pakistan, India, Bangladesh, and Sri-lanka by utilizing linear panel ARDL and NARDL modelling and asymmetrical granger causality analysis. Data period is divided into three different types of time frames such as before the global financial crisis, after the crisis, and when the whole sample period is selected. Results have shown that symmetrical panel-based ARDL models failed to establish a long-term linear co-integrating association between exchange rate fluctuations and stock indexes when the whole sample period is selected and for regime before the crisis. However, the asymmetrical panel-based NARDL model established asymmetrical co-integration between positive and negative shocks to exchange rate fluctuations and stock indexes. In the existing literature, symmetrical models have been utilized for investigating the linkages between exchange rate fluctuation and stock indexes, and only a few research articles utilized the time-series NARDL model, but these studies have been carried out for the developed economies and context outside the region of South Asia. For the long term, findings have shown that positive shocks to exchange rate fluctuations formulated an indirect association with stock indexes during the pre-crisis regime and when the whole sample period is selected. According to a flow-oriented approach, this may be because currency depreciation is having a harmful impact on organisations relying on the imported product for finished goods and other import centric businesses. Currency depreciation against US dollars increases the producer prices and also minimizes the profitability of import-dominated businesses.

This research article contributes to the existing literature in the following three ways and also provides practical insights for investors, government, and academicians. Firstly, this research contributes to the existing literature by investigating asymmetrical linkages between exchange rate and stock indexes as symmetrical ECT failed to establish a long-term relationship between exchange rate and stock indexes. Secondly, on a long-term basis, the global financial crisis cannot be able to impact asymmetrical linkages between exchange rate fluctuations and stock indexes during pre-crisis, post-crisis and when the whole sample is selected. However, for shorter horizons, the global financial crisis has changed the asymmetrical relationship between the exchange rate fluctuation and stock indexes.

This shows that short-term investors should consider both positive and negative shocks to exchange rate fluctuation before investing in stock indexes of Pakistan, Bangladesh, India and Sri-Lanka. During three regimes and in long term, only positive fluctuations in the exchange rate are having a negative impact on stock indexes, this means that appreciation of US dollars against local currency is having a detrimental impact on stock indexes. This is mostly because selected countries are dependent on import-oriented goods rather than exporting goods to other countries. The stock investors of the South Asian region needs to consider these positive fluctuations in US dollars against local currency or local currency depreciation as this research classified the detrimental impact of local currency depreciation on stock indexes in long term. Thirdly, in existing literature, most of the researchers utilized either symmetrical panel-based model or asymmetrical time-series modelling for investigating symmetrical or asymmetrical linkages

between exchange rate fluctuation and stock indexes. Those studies were either limited to a single economy or have utilized symmetrical or asymmetrical time-series econometric modelling for exploring exchange rate – stock index nexus. This is the first research article which has utilized both symmetrical and asymmetrical panel-based NARDL modelling approach for exploring the asymmetrical nexuses between exchange rate and stock indexes.

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Note

1. "Pesaran, M. H. 2004. General diagnostic tests for cross section dependence in panels. University of Cambridge, Faculty of Economics, Cambridge Working Papers in Economics No. 0435"

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