

# Dynamic Interrelationship among the Stock Markets of India, Pakistan and United States

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**Abstract**—The interrelationship between international stock markets has been a key study area among the financial market researchers for international portfolio management and risk measurement. The characteristics of security returns and their dynamics play a vital role in the financial market theory. This study is an attempt to find out the dynamic linkages among the equity market of USA and emerging markets of Pakistan and India using daily data covering the period of January 2003–December 2009. The study utilizes Johansen (*Journal of Economic Dynamics and Control*, 12, 1988) and Johansen and Juselius (*Oxford Bulletin of Economics and Statistics*, 52, 1990) cointegration procedure for long run relationship and Granger-causality tests based on Toda and Yamamoto (*Journal of Econometrics*, 66, 1995) methodology. No cointegration was found among stock markets of USA, Pakistan and India, while Granger-causality test showed the evidence of unidirectional causality running from New York stock exchange to Bombay and Karachi stock exchanges.

**Keywords**—Causality, Cointegration, India, Pakistan, Stock Markets, US.

## I. INTRODUCTION

THE financial crises in the world have stimulated great interest for financial market researchers to examine the extent of interrelationship among the equity markets of world. The policy makers, portfolio managers, investors and researchers have been tried to get an apposite model for investment activities that can expose linkages across financial markets, particularly among bordering regions. The appropriate financial market models improve the view of the markets' commotion and allow the investors to aptly price underlying assets and their derivatives, as well as to hedge the allied portfolio risks. The studies found that the US stock market influences most of the European and Asian stock markets, on the other hand, these stock markets have no or little impact on the US stock market.

The financial market researchers and academicians have utilized two empirical approaches for testing the interdependence of national and international stock markets. In the first approach, studies have examined the spreading and impulsive behavior of world equity markets by using ARCH/GARCH models and their extensions. In the second approach, studies have used Vector Autoregressive (VAR) techniques for short and long run dynamic relationships among the equity markets. According to latter approach, if stock market variables are found to be cointegrated then this

involves that stock markets are interdependent. Since the present study is employing cointegration to test long run interdependence among US, Pakistan and Indian stock exchanges, therefore, literature review is limited to only those studies that have taken this approach.

The seminal work vis-à-vis cointegration analysis on time series variables has done by Granger [1], Engle and Granger [2], and Granger and Hallman [3]. The analysis considers the I(1)–I(0) type of cointegration in which linear permutations of two or more I(1) variables are I(0) [4]. Granger & Hallman [3] demonstrated that investment assessments merely-based on short-term asset returns are inadequate, as the long-term relationship of asset prices is not considered. Lucas [5] and Alexander [6] have established that Index tracking and portfolio optimization is based on cointegration rather than correlation alone may result in higher asset returns while using applications of cointegration analysis to portfolio asset allocation and trading strategies.

Taylor and Tonks [7] utilized a bivariate cointegration analysis proposed by Engle and Granger [2] to investigate whether the stock market of UK is integrated with the stock markets of US, Germany, Netherlands and Japan by using monthly data on stock price indices of these countries for the sub-periods, April 1973–September 1979 and October 1979–June 1986 and found that there is a long run interdependence among these equity markets. Kasa [8] found a single common stochastic trend in the stock markets of the US, UK, Japan, Germany and Canada using monthly and quarterly data from 1974 to 1990. Kanas [9] investigated the association among the US, UK, Germany, France, Switzerland, Italy and Netherlands. Kanas [9] utilized daily data from 3<sup>rd</sup> January, 1983 to 29<sup>th</sup> October, 1996 and employed different methodologies to test for cointegration such as the multivariate trace statistic, the Johansen method and the Bierens [10] non parametric approach. Kanas [9] in his empirical investigation explored that the US stock market has no long run relationship with any of the six European equity markets. He further recommended that the possible long-run benefits can be reaped by diversifying in US and in any of the above six European equity markets.

Darrat *et al.* [11] examined the cointegration (Johansen-Juselius test) between US and Middle East (Egypt, Jordan and Morocco) emerging stock markets. Their empirical results suggested that the Middle East equity markets are segmented internationally. However, these equity markets are highly integrated within the regional. Moreover, the Granger causality test indicated that the Egyptian equity market was a leading force driving other markets in the region. The obvious segmentation of the Middle East equity markets from the global market implies that these emerging markets offer potential diversification gains to international investors.

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Haung *et al.* [12] investigated the causality and cointegration among the equity markets of the United States, Japan and the South China Growth Triangle (SCGT) region over the sample period (October 2, 1992 to June 30, 1997) and found that there is no long run relationship among these markets except between Shanghai and Shenzhen stock markets. The empirical results of Haung *et al.* [12] study also suggested that price changes on the Hong Kong stock market lead the Taiwan market by 1 day and the stock returns of the US and Hong Kong markets are found to be contemporaneous. Moreover, there is feedback causality between the Shanghai and the Shenzhen Stock Exchanges.

Bessler and Yang [13] investigated the cointegration among Australia, Japan, Hong Kong, UK, Germany, France, Switzerland, US and Canada and explored one cointegrating vector. They suggested that the US has a consistent long-run impact on the other markets.

Narayan *et al.* [14] examined the dynamic linkages between the equity markets of Bangladesh, India, Pakistan and Sri Lanka in a multivariate cointegration framework using daily data for the period 2<sup>nd</sup> January 1995 to 23<sup>rd</sup> November 2001. They explored that in the long-run, stock prices in Bangladesh, India and Sri Lanka Granger cause stock prices in Pakistan. However, in the short-run there is unidirectional causality running from stock prices in Pakistan to India, stock prices in Sri Lanka to India and from stock prices in Pakistan to Sri Lanka.

Dunis and Shannon [15] found long run relationship among emerging markets from south-east Asia (Indonesia, Malaysia, and the Philippines) and central Asia (Korea, Taiwan, China, and India) with the three established markets, the US, UK, and Japan over the period 31<sup>st</sup> August, 1999–29<sup>th</sup> August, 2003. Vo and Daly [16] analyzed 10 year daily return data for the period 1994 to 2003 of Asian equity market indices and selected advanced nation's equity market indices and employed correlation, cointegration and the Granger causality test. Their empirical results suggested that there was a weak causal relationship among Asian equity markets and between Asian equity markets and developed countries' equity markets.

Syriopoulos and Roumpis [17] investigated relationship between several South Eastern Europe's equity markets and two established equity markets (the US and Germany). Syriopoulos and Roumpis [17] explored the existence of a long-run relationship while in the short-run, investors may reap the benefits in diversifying their portfolio investment in the South East Europe. Gupta and Donleavy [18] argued that the growing integration among equity markets steadily shrinks benefits resulting from international diversification. The pragmatic research pertaining to cointegration and causality of incorporating capital markets has been vigorous.

Many studies addressed the issue of capital markets in emerging economies [19]-[21]. The earlier studies have explored the relationships among different stock exchange markets but the markets in Pacific-Basin region, Europe and North America, South Asia have received comparatively little research interest [22]. A large number of financial market researchers have paid their attention on the subject of

international financial integration and investment diversification [7], [21] and [23]-[31].

Earlier studies such as [19], [32] and [33] have found that the US equity market is most dominant equity market in the world. Cheung and Mak [34] and Masih and Masih [35]- [37] found that the US is a global factor affecting both the developed and developing markets. As quoted by Chan [38] "The financial market in United States has long been seen as the leader of global financial market."

The present study is aimed to investigate the interdependence among equity markets of US (established market) and emerging markets of India and Pakistan (emerging markets). There very few studies which have examined this issue between US and emerging markets. Moosa and Al-Loughani [39], Saatcioglu and Starks [40] Basci *et al.* [41], Gündüz and Hatemi-J [42] have analyzed the interdependence among emerging markets by focusing on weekly or monthly data. However, this study is utilizing daily data for the period January 2003–December 2009. The rationale for selecting one established and two emerging stock markets is as under:

- India and Pakistan are one of the biggest south Asian economies and sharing the borders. The main purpose is to check out the interdependence of these two cross border countries.
- As proven by literature that US is the most influential market [34]-[37]. So to check whether US is also impacting the biggest markets of these two big countries of South Asia or not?

The foremost contribution of this paper is twofold. First, the study employs some econometric technique based on VAR analysis to study the dynamic causal association among the stock markets. We utilized the multivariate cointegration technique based on the work of Johansen [43] and Johansen and Juselius [44] to determine the number of stochastic trends among the stock indices, Toda-Yamamoto [45] based Granger causality to identify the causal relationships among the stock markets. Second, we study if there are linkages among the emerging Asian stock markets (India and Pakistan) and examine their nature of linkage with respect to the established market of US. In this manner, we expect to harmonize the existing literature on global financial integration since empirical work on these emerging markets is still lacking.

The rest of the study is organized as follows. Section II describes the data used. Section III explains methodological issues. Section IV discusses the time series properties of 100 indices of Bombay, Karachi and New York stock exchanges followed by the discussion of Variance Decomposition Analysis. Section V concludes.

## II. DATA

In this study, the empirical analysis is conducted by using daily data for the period from January 2003 to December 2009. Daily 100 indices of Karachi Stock Exchange of Pakistan (KSE), National Stock Exchange of India (CNX) and New York Stock Exchange of US (NYSE) are obtained from their respective websites.

The NYSE-100 index companies have a combined float-adjusted market capitalization of nearly \$7.3 trillion, covering 36% of the available market capitalization of all NYSE listed stocks. CNX-100 is a diversified 100 stock index accounting for 35 sectors of the Indian economy. CNX-100 represents about 73.3% of the free float market capitalization as on September 30, 2009. The KSE-100 is a capital weighted index and represents about 90 percent of market capitalization of the stock exchange.

### III. METHODOLOGY

The cointegration test is used to investigate long-run relationships among non-stationary time series [46]-[48]. Most of the financial and macroeconomic time series variables are non-stationary and the regression analysis performed in a usual approach generates spurious results [2], [49]. It is, therefore, prerequisite to perform the unit root tests before empirical analysis.

#### A. Unit Root Tests

There are several tests in the literature to check the unit root in time series variables and each test has its own advantages and disadvantages. This study uses two unit root tests namely Augmented Dickey Fuller (ADF) [50] and Ng-Perron [51] to avoid the criticism on individual test.

The study uses following two types of ADF regressions (with intercept and intercept and trend):

$$(1-L)X_t = \alpha_0 + \beta X_{t-1} + \sum_{j=1}^p \gamma_j (1-L)X_{t-j} + \varepsilon_{1t}; \quad (1)$$

$$(1-L)X_t = \alpha_0 + \alpha_1 t + \beta X_{t-1} + \sum_{j=1}^p \gamma_j (1-L)X_{t-j} + \varepsilon_{2t}; \quad (2)$$

where

$t$  is time period

$X_t$  is any time series variable

$L$  is lag operator

$(1-L)X_t = X_t - X_{t-1}$

$p$  = Number of lags in the dependent variable.

$\varepsilon_{1t}$  and  $\varepsilon_{2t}$  are stochastic error terms.

The stationarity of the variable can be tested by using the following hypothesis:

$H_0: \beta=0; (X_t \text{ is Non-Stationary})$

$H_a: \beta<0; (X_t \text{ is Stationary})$

The null hypothesis is rejected if the t-statistic of  $\beta$  is less than the critical value. The optimum lag length in the ADF regression insures the residuals do not violate the assumption of serially correlated and imitate a white noise process.

Ng-Perron [51] proposed four unit root test statistics that are calculated using generalized least squares (GLS) de-trended data for a time series variable. Ng-Perron unit root test statistics have good power and size properties as compare to the widely used DF/ADF and Phillips-Perron [52] unit root tests. The first unit root test statistic namely  $MP_T^d$  developed by Ng and Perron calculates the Elliot, Rothenberg, and Stock (ERS) point optimal statistic for GLS de-trended time series data as under:

$$MP_T^d = \begin{cases} (\bar{c}_k^2 - \bar{c}T^{-1}(y_T^d)^2) / f_0 & \text{if } x_t = \{1\} \\ (\bar{c}_k^2 + (1-\bar{c})T^{-1}(y_T^d)^2) / f_0 & \text{if } x_t = \{1, t\} \end{cases} \quad (3)$$

where  $k = \sum_{t=2}^T (y_{t-1}^d)^2 / T^2, \bar{c} = -7$  if  $x_t = \{1\}, \bar{c} = -13.5$  if  $x_t$

$= \{1, t\}$ ,  $f_0$  is the zero frequency spectrum term, and  $y_T^d$  is the GLS de-trended value of a time series variable. The other three statistics developed by Ng-Perron [51] namely  $MZ_\alpha^d$ ,  $MZ_t^d$  and  $MSB^d$  are the further improvements of the Phillips-Peron (PP) test statistics. These statistics correct for size distortions when residuals are negatively correlated.  $MZ_\alpha^d$ ,  $MZ_t^d$  and  $MSB^d$  are estimated using the following equations:

$$MZ_\alpha^d = (T^{-1}(y_T^d)^2 - f_0) / 2k \quad (4)$$

$$MZ_t^d = MZ_\alpha^d \times MSB^d \quad (5)$$

$$MSB^d = (k / f_0)^{1/2} \quad (6)$$

The above Ng-Perron test statistics are based on a specification for  $x_t$  and a process for estimating  $f_0$ , the zero frequency spectrum term. The specification for  $x_t$  can take a constant or a constant and a linear trend. The consistent estimate of the residual spectrum at frequency zero is obtained on the basis of autoregressive (AR) spectral regression (GLS-detrended).

#### B. Cointegration

Having tested the stationarity of each time series, and confirmed that each series have the same order of homogeneity ( $d$ ), the next step is to seek cointegration. In this step, the study has investigated whether there is a long run relationship between the  $CNX_t$ ,  $KSE_t$  and  $NYSE_t$ . For this purpose, Johansen [43] and Johansen and Juselius [44] cointegration tests have been utilized.

Johansen [43] and Johansen and Juselius [44] have developed a maximum likelihood testing method on the number of cointegrating vectors, which also includes testing procedures for linear restrictions on the cointegrating parameters, for any set of variables. This cointegration is applied by using vector autoregressive (VAR) model, a general unrestricted VAR model with  $k$  lags can be represented as under:

$$Z_t = \mu + A_1 Z_{t-1} + \dots + A_k Z_{t-k} + \xi_t; \quad (7)$$

$t = 1, 2, 3, \dots$

where  $Z_t$  is ( $n \times 1$ ) vector,  $\mu$  is ( $n \times 1$ ) vector of constant terms,  $A_1 \dots A_k$  are ( $n \times n$ ) matrices of parameters and  $\xi_{1t}$  is ( $n \times 1$ ) vector of usual error term and it is independent from all independent variables.

The Johanson's cointegration proposed two test statistics through VAR model that are used to identify the number of cointegrating vectors, namely the trace test statistic and the maximum eigen-value test statistic. The trace statistic tests the null hypothesis that the number of distinct cointegrating relationships is less than or equal to ' $r$ ' against the alternative hypothesis of more than ' $r$ ' cointegrating relationships, and is defined as:

$$\lambda_{trace}(r) = -T \sum_{j=r+1}^p \ln(1 - \hat{\lambda}_j); \quad (8)$$

where

$\lambda_j$  = The eigen-values

$T$  = Total number of observations

The maximum likelihood ratio or put another way, the maximum eigen-value statistic, for testing the null hypothesis of at most ‘ $r$ ’ cointegrating vectors against the alternative hypothesis of ‘ $r+1$ ’ cointegrating vectors, is given by:

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (9)$$

Johansen [43] argues that,  $\lambda_{\text{trace}}$  and  $\lambda_{\max}$  statistics have non-standard distributions under the null hypothesis, and provides approximate critical values for the statistic, generated by Monte Carlo methods.

*C. Granger Causality Based on Toda-Yamamoto Procedure*

This study exploits Toda-Yamamoto [45] based Granger causality test to find out the direction of causality between  $CNX_t$ ,  $KSE_t$  and  $NYSE_t$  which is based on augmented level VAR with integrated and cointegrated processes. Toda-Yamamoto showed that usual causality tests are cumbersome and sensitive to the values of the nuisance parameters in finite samples and therefore their results are unreliable. The advantage of using this procedure is that it is not necessary to pretest the variables for the integration and cointegration properties and therefore avoids the possible pretest biases.

Toda-Yamamoto procedure uses a Modified Wald (MWALD) test for restrictions on the parameters of the VAR( $k$ ) model and estimates a VAR[ $k+d_{\max}$ ], where  $k$  is the lag order of VAR and  $d_{\max}$  is the maximal order of integration for the series in the system).

Two steps are carried out to executing the procedure. The first step involves determination of the lag length ( $k$ ) of VAR model and the maximum order of integration ( $d$ ) of the time series variables in the system. After the selection of optimum lag length VAR ( $k$ ) and the order of integration  $d_{\max}$ , a level VAR is estimated with a total of  $k+d_{\max}$  lags. The second step involves carrying out standard Wald tests to the first  $k$  VAR coefficient matrix to make Granger causal inference.

In order to test for Toda-Yamamoto based Granger causality among  $CNX_t$ ,  $KSE_t$  and  $NYSE_t$ , the study estimates the following VAR ( $k+d_{\max}$ ):

$$\begin{bmatrix} CNX_t \\ KSE_t \\ NYSE_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} + \sum_{i=1}^{k+d_{\max}} \begin{bmatrix} \beta_{1i} & \delta_{1i} & \phi_{1i} \\ \beta_{2i} & \delta_{2i} & \phi_{2i} \\ \beta_{3i} & \delta_{3i} & \phi_{3i} \end{bmatrix} \begin{bmatrix} CNX_{t-i} \\ KSE_{t-i} \\ NYSE_{t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix}; \quad (10)$$

where  $t$  is the time subscript,  $\alpha$ 's are the intercepts.  $\beta$ 's,  $\delta$ 's and  $\phi$ 's are the coefficients of  $CNX_t$ ,  $KSE_t$  and  $NYSE_t$  respectively.  $\varepsilon_{3t}$ ,  $\varepsilon_{4t}$  and  $\varepsilon_{5t}$  are error terms that are assumed to be white noise. Standard Wald tests are applied to the first  $k$  coefficient matrices using the usual  $\chi^2$ -statistic. The hypothesis for Granger causality can be drawn as  $CNX_t$  “Granger-causes”  $KSE_t$  if  $\delta_{1i} \neq 0$  and  $NYSE_t$  if  $\phi_{1i} \neq 0$ . Similarly, other hypothesis can be drawn for unidirectional and bidirectional causality among rest of the under investigating variables.

IV. EMPIRICAL RESULTS

*A. Level of Integration*

Before testing for long run equilibrium among the stock market indices of India ( $CNX_t$ ), Pakistan ( $KSE_t$ ) and US

( $NYSE_t$ ), the ADF and Ng-Perron unit root tests are applied to see the integrated properties of time series variables. The results of the ADF test at level and first difference are reported in Table I. The results indicate that the t-statistics for all series from ADF test are statistically insignificant and the null hypothesis of non-stationary at level can not be rejected. Therefore, these variables have a unit root problem or they share common stochastic movements. When the ADF test is conducted at first difference of each variable, the null hypothesis of non-stationary is rejected as shown in Table I. The Ng-Perron unit root test is also showing the similar results in Table II that all variables are non-stationary at level and share the common stochastic movements at first difference. This is consistent with some previous studies<sup>1</sup> which demonstrated that most of the macroeconomics and financial series are expected to contain unit root and thus integrated of order one I(1). Therefore, all variables have same level of integration at I(1) and a higher order of differencing is not required further to perform the unit root test. Since the variables are integrated of same order I(1), so, multivariate cointegration test for long run analysis could be conducted.

TABLE I  
ADF UNIT ROOT TEST

at Level		
Variables	Without Trend (k)	Trend & Intercept (k)
$CNX_t$	-0.9868 (1)	-1.9426 (1)
$KSE_t$	-1.6854 (1)	-1.1347 (1)
$NYSE_t$	-1.3111 (2)	-1.2910 (2)
at 1 <sup>st</sup> Difference		
Variables	Without Trend (k)	Trend & Intercept (k)
$CNX_t$	-39.2329 <sup>a</sup> (0)	-39.2223 <sup>a</sup> (0)
$KSE_t$	-36.8262 <sup>a</sup> (0)	-36.8544 <sup>a</sup> (0)
$NYSE_t$	-36.1277 <sup>a</sup> (1)	-36.1559 <sup>a</sup> (1)

Note: <sup>a</sup> Indicates the rejection of the null hypothesis of non-stationary at 1% significance level. The rejection of null hypothesis for ADF test is based on the MacKinnon critical values and numbers in parentheses indicate number of lags (k) based on Schwarz Information Criterion

TABLE II  
NG-PERRON UNIT ROOT TEST

At Level (Without Trend)					
Variables	MZa	MZt	MSB	MPT	Lag Length
$CNX_t$	0.7612	0.62656	0.8231	47.4106	1
$KSE_t$	-0.0258	-0.02543	0.9859	54.2708	1
$NYSE_t$	-2.3271	-1.07216	0.4607	10.4853	2
At Level (Trend & Intercept)					
$CNX_t$	-7.5934	-1.94637	0.2563	12.0060	1
$KSE_t$	-2.1409	-0.91404	0.4269	36.4009	1
$NYSE_t$	-2.4338	-1.0369	0.4260	34.7665	2
At 1 <sup>st</sup> Difference (Without Trend)					
$CNX_t$	-904.7 <sup>a</sup>	-21.268 <sup>a</sup>	0.0235 <sup>a</sup>	0.0275 <sup>a</sup>	0
$KSE_t$	-584.2 <sup>a</sup>	-17.082 <sup>a</sup>	0.0292 <sup>a</sup>	0.0499 <sup>a</sup>	2
$NYSE_t$	-10.999 <sup>b</sup>	-2.3031 <sup>b</sup>	0.2094 <sup>b</sup>	2.3969 <sup>b</sup>	1
At 1 <sup>st</sup> Difference (Trend & Intercept)					
$CNX_t$	-905.3 <sup>a</sup>	-21.28 <sup>a</sup>	0.0235 <sup>a</sup>	0.1018 <sup>a</sup>	0
$KSE_t$	-888.27 <sup>a</sup>	-21.072 <sup>a</sup>	0.0237 <sup>a</sup>	0.1055 <sup>a</sup>	0
$NYSE_t$	-42.068 <sup>a</sup>	-4.5638 <sup>a</sup>	0.1085 <sup>a</sup>	2.2862 <sup>a</sup>	1

Note: <sup>a</sup> and <sup>b</sup> indicate the rejection of the null hypothesis of non-stationary at 1% and 5% significance level. The rejection of null hypothesis for Ng-Perron unit root test is based on the Ng-Perron [51], table 1, and the selection of lag length (k) is based on Schwarz Information Criterion (SIC).

<sup>1</sup> See for example [53] and [54]

*B. Johanson Cointegration*

The long run relationship among daily 100 indices of the Karachi Stock Exchange of Pakistan, the National Stock Exchange of India and the New York Stock Exchange of US is investigated through the Johansen’s cointegration. The results of the Johansen’s cointegration tests of both  $\lambda_{max}$  and  $\lambda_{trace}$  statistic are given in Table III. In both cases the null hypotheses of no cointegration can not be rejected at 5% and 10% level of significance. This suggests that these three equity markets are not cointegrated in the long-run.

*C. Granger Causality Based on Toda and Yamamoto Procedure*

The three under investigating stock exchange markets have no long run equilibrium relationship. Therefore, short-run analysis can not be determined. However, the benefit of Toda-Yamamoto based Granger causality test is that it can be applied even in the absence of long-run equilibrium relationship. The results of Granger causality test based on Toda-Yamamoto among  $CNX_t$ ,  $KSE_t$  and  $NYSE_t$  are reported in Table IV. The optimum lag length of VAR is  $k = 4$  based on AIC and FPE criteria. However, all variables are stationary at first difference, therefore  $d_{max} = 1$ . We estimate a system of VAR at levels with a total of  $k + d_{max} = 4 + 1 = 5$  lags.

The results in Table IV suggest that there is unidirectional causality running from  $NYSE_t$  to  $CNX_t$  and  $KSE_t$ . This suggests that a developed stock exchange of US market is causing emerging stock exchanges of India and Pakistan. These results are contradictory with some earlier studies. The results are dissimilar due to the application of different Granger-causality test which has advantage over traditional causality tests. Toda-Yamamoto demonstrated that in this procedure it is not necessary to pretest the variables for the integration and cointegration properties and therefore avoids the possible pretest biases.

*D. Variance Decomposition Analysis (VDA)*

The VDA provides the complementary information on the dynamic behavior of the variables in the system. The forecast variance can be decomposed into the contributions by each of the different shocks. The VDA shows the proportion of the forecast error variance for each variable that is attributed to its own innovation and to innovation in the other endogenous variables. Variance decomposition is also used to better understand the direction of which effects are greater? [55] and [56]. The results of variance decomposition are given in Table V. The variance decomposition of  $KSE_t$  suggest that in twenty days, about 96.47% of the variation of  $KSE_t$  is accounted by its own past 100 indices, 0.58% and 2.95% is accounted by the past 100 indices of  $CNX_t$  and  $NYSE_t$ . The variance decomposition of  $CNX_t$  suggests that in twenty days, about 88.44% of the variation of  $CNX_t$  is accounted by its own past 100 indices, while 1.69% and 9.87% variation is accounted by the past 100 indices of  $KSE_t$  and  $NYSE_t$  respectively. On the other hand, about 94.06% of the variation of  $NYSE_t$  is explained by its own past values, however, about 0.79% and 5.13% is explained by past 100 indices of  $KSE_t$  and  $NYSE_t$  respectively.

TABLE III:  
JOHANSEN COINTEGRATION TEST

Unrestricted Cointegration Rank Test (Trace)				
Hypotheses		Trace Statistic	Critical Values at 5%	Critical Values at 10%
H <sub>0</sub>	H <sub>a</sub>			
$r = 0$	$r \geq 1$	21.33410	29.79707	27.06695
$r \leq 1$	$r \geq 2$	3.358978	15.49471	13.42878
$r \leq 2$	$r \geq 3$	0.010089	3.841466	2.705545
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypotheses		Max-Eigen Statistic	Critical Values at 5%	Critical Values at 10%
H <sub>0</sub>	H <sub>a</sub>			
$r = 0$	$r = 1$	17.97512	21.13162	18.89282
$r \leq 1$	$r = 2$	3.348888	14.26460	12.29652
$r \leq 2$	$r = 3$	0.010089	3.841466	2.705545

V. CONCLUSION

This study attempts to investigate whether one developed stock exchange of US and two emerging stock exchanges of India and Pakistan are interlinked by utilizing Johanson cointegration and Toda-Yamamoto based Granger-causality. The daily data for 100 indices of Bombay, Karachi and New York stock exchanges ranges from January 2003 to December 2009. The empirical results indicate that the 100 indices of three stock exchanges are non-stationary at level and become

TABLE V:  
VARIANCE DECOMPOSITION ANALYSIS

Variance Decomposition of $KSE_t$ :				
Period	S.E.	$KSE_t$	$CNX_t$	$NYSE_t$
1	133.2805	100.0000	0.0000	0.0000
5	342.4330	99.0200	0.0191	0.9609
10	491.7545	98.3158	0.1108	1.5734
15	597.1032	97.4729	0.3031	2.2239
20	680.4792	96.4701	0.5832	2.9467
Variance Decomposition of $CNX_t$ :				
Period	S.E.	$KSE_t$	$CNX_t$	$NYSE_t$
1	58.9960	0.576545	99.423	0.000000
5	142.7889	0.966663	91.0404	7.992908
10	200.3442	1.2014	89.2974	9.501266
15	243.0797	1.4426	88.7352	9.822139
20	278.0565	1.6904	88.4433	9.866327
Variance Decomposition of $NYSE_t$ :				
Period	S.E.	$KSE_t$	$CNX_t$	$NYSE_t$
1	65.2548	0.3370	7.3574	92.30560
5	125.9180	0.3026	7.1408	92.55652
10	171.4714	0.4323	6.2290	93.33875
15	205.7288	0.5994	5.6218	93.77876
20	233.8169	0.7885	5.1256	94.08590
Cholesky Ordering: $KSE, CNX, NYSE$				

stationary at first difference, as a consequent the cointegration can be applied for long run relationship. The results of Johanson cointegration indicate that the three equity markets have no long-run equilibrium relationship. This fact suggests that the diversification of portfolio in Bombay and Karachi stock exchanges is beneficial in long-run.

In the present study, the outcomes of Toda-Yamamoto based Granger-causality test exhibit contradictory evidence with some earlier studies due to the use of different Granger-causality test which has advantage over traditional approaches. The results of this application show that unidirectional causality exists from New York stock exchange to Bombay and Karachi stock exchanges. However, Bombay and Karachi stock exchanges do not cause New York stock exchange. This phenomenon might be the result of the trade relations of India and Pakistan with US.

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