Co-Movement of Pakistan Stock Exchange with India, SP 500 and Nikkei 225: A Time-frequency (Wavelets) Analysis

Shahzad, Syed Jawad Hussain and Zakaria, Muhammad and Rehman, Mobeen ur and Ahmed, Tanveer and Khalid, Saniya

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Syed Jawad Hussain Shahzad
Lecturer, COMSATS Institute of Information Technology
E-mail: jawad.kazmi5@gmail.com

Muhammad Zakaria
Assistant Professor, COMSATS Institute of Information Technology

Mobeen Ur Rehman
Lecturer, COMSATS Institute of Information Technology

Tanveer Ahmed
Lecturer, COMSATS Institute of Information Technology

Saniya Khaild
Lecturer, COMSATS Institute of Information Technology

Abstract

This study examines the co-movement between the Pakistan, Indian, S&P 500 and Nikkei 225 stock markets using weekly data from 1998 to 2013. The time-frequency relationship between the selected stock markets is conducted by using measures of continuous wavelet power spectrum, cross-wavelet transform and cross (squared) wavelet coherency. The empirical evidence suggests strong dependence between Pakistan and Indian stock markets. The co-movement of Pakistani index with U.S and Japanese, the developed markets, varies over time and frequency where the long-run relationship is dominant. The results of cross wavelet and wavelet coherence analysis indicate moderate covariance and correlation between stock indexes and the markets are in phase (i.e. cyclical in nature) over varying durations. Pakistan stock market was lagging during the entire period in relation to Indian stock market, corresponding to the 8~32 and then 64~256 weeks scale. Similar findings are evident for S&P 500 and Nikkei 225 indexes, however, the relationship occurs during the later period of study. All three wavelet indicators suggest strong evidence of higher co-movement during 2008-09 global financial crises. The empirical analysis reveals a strong evidence that the portfolio diversification benefits vary across frequencies and time. This analysis is unique and have several practical implications for regional and international investors while assigning the optimal weightage of different assets in portfolio formulation.

Keyword: Co-movement; Pakistan stock exchange; S&P 500; Nikkei 225; Wavelet Analysis

Introduction

The flow of capital from one country to another country is beneficial for both the source and host country and a rapid growth in international investment have recently been observed. The reason behind this could be the relaxation of controls on foreign exchange transaction and capital movements, decrease in cost of information and transaction due to improvement in technology, and because of expansion in the multinational operations of major companies (listing of firm on multiple stock exchanges). Contrary to that, restrictions will decrease these flows.

The risk of a portfolio can be decreased by diversifying the portfolio internationally in sock markets which are not perfectly correlated and where the correlation structure is stable. This diversification advantage has led finance researchers to investigate whether international stock markets are interdependent or not? Higher interdependence among stock exchanges would suggest less diversification advantage for investors. However, an investor from outside the region would find it easier and justifiable to invest in an integrated regional stock exchange. In addition to stock investors, managers would need to evaluate capital investment in different countries. If capital markets are segmented then investment projects with similar risks must be treated differently. In addition to the diversification and integration, Engle and Yoo (1987) and Clements and Hendry (1995) have further identified the importance of investigating cointegration among international equity markets i.e. if there exist a cointegration then it would mean predictability of at least one of the dependent variable in the set of cointegrated variables. The higher the cointegration between the set of variable implies that the dependent variable is highly predictable.

Previous studies have mainly focused on developed and European markets through different econometric techniques. These studies have used Johanson cointegration and Vector Error Correction (VECM) methods (Chen et al., 2000; Masih & Masih, 2001; Ratanapakorn & Sharma, 2002; Cerny, 2004; Aggarwal & Kyaw, 2005; Ciner, 2006; Egert & Kocenda, 2006; Hooi Lean & Ghosh, 2009; Huyghebaert & Wang, 2010), Vector Auto regressive (VAR) model (Cha & Oh; 2000; Dekker et al., 2001; Besslera & Yang, 2003; Yang et al., 2003; Click & Plummer, 2004; Diamandis; 2008), Generalize Auto-regression Heteroskedasticity (GARCH) model (Lahrech & Sylwester; 2011) and Pooled Mean Group (PMG) methodology (Boubaker & Jouini, 2014) among others. None of these studies have considered the developing markets like Pakistan besides that it was declared as the best market in the world based on its performance by Business Week, in 2002.

Given the divergent conclusions[1] of the researches in this field and emergence of Pakistan stock exchange, it is important to investigate the co-movement of KSE 100 index with regional and international developed markets. The features of emerging markets are different because of their lower correlation with the developed markets. Adding stocks from emerging markets to the portfolio of developed markets will be beneficial for the efficient diversification of portfolio (Ajayi & Mehdian, 1995; Bowman & Comer, 2000). It is important that increasing interest and investment of international investors in these under developed/developing markets may also cause fluctuations in regional and international equity markets may make these markets vulnerable to international shocks. Finally, an insight into relationship between local and global markets can be utilized by investors for potential benefits and by policy makers for regulatory framework keeping in view

[1]There are inconclusive empirical studies on the cointegration relationship between many emerging and developed markets. For details on the linkages between the stock markets see Colm Kearney & Brian M. Lucey (2004).

the linkage between South Asian, and developed markets. We used weekly closing values of stock market indices for Pakistan, India, US and Japan. Wavelet approach, recently used by Aloui et al, (2014) to investigate the co-movement between sharia stocks and sukuk in GCC markets, is used to uncover the potential linkages between these stock markets. In the next section of the paper the data, methodology and results are discussed. Concluding remarks are provided in the last section.

3. Data, Methodology and Findings

3.1. Stock Market Data

This study examines the co-movement of Karachi Stock Exchange (KSE-100) Index of Pakistan with S&P Bombay Stock Exchange Sensitive Index (BSE 30), the Standard & Poor's (S&P) 500 and Nikkei 225 Index. BSE 30, S&P 500 and Nikkei 225 indexes are considered the best representative benchmarks of Indian, US and Japanese equity markets. The data of weekly stock prices are taken from Econ Stats: The Economic Statistics and Indicators Database (Economy Watch) for a period 1 January 1998 to 31 December 2013 based on data availability. The period considered for empirical analysis is not only recent but is also sufficiently large to indicate long-run relationship between the variables and the impact of recent international events. We have used weekly price date instead of calculating the stock market returns as wavelet analysis has the advantage to decompose the time-series into its time and frequency components. Pre-filtering and stationarity is not required as the time series data is translated and scaled in the wavelet analysis. Floros (2005), Charles and Darne´ (2006), and Masih and Majid (2013) have also used price data instead of returns. The variables have been transformed to logarithmic form so the coefficients may be interpreted as the elasticity.

3.2. Time series properties

The plots of all time-level series is shown in Fig. 1 which captures the joint dynamics of the variables. All the series portray a similar time trends and hence indicate a potential long-run relation between the markets. There is also evidence of sharp decrease in values during 2001 and 2008 global financial crisis. This preliminary evidence motivates a detailed investigation on the short- and long-run linkages between market indexes to different economic conditions and shocks. Unsurprisingly, the Pakistani stock market index has increased significantly during the sample period and hence highlights that investment in Pakistani market can be beneficial for local, regional and international investors.

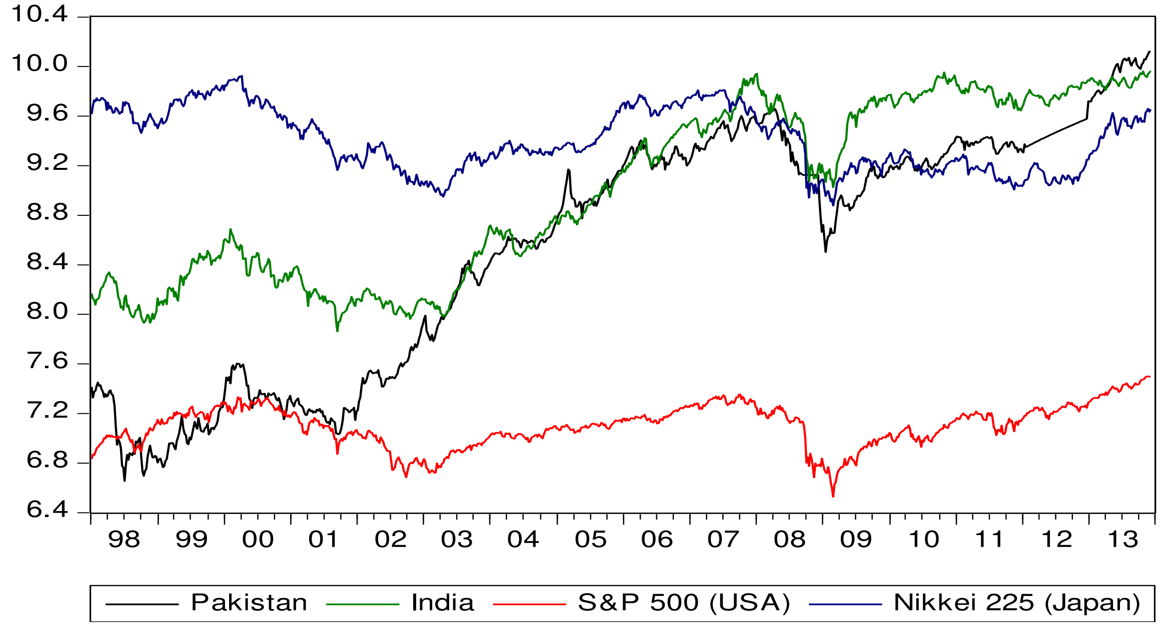


Fig 1: Evolution of stock markets over time.

Table 1 provides some descriptive statistics of the selected time series. Nikkei 225 has the highest average value, whereas, risk measured in term of standard deviation is highest for Pakistan. Similarly the difference between maximum (10.12) and minimum (6.655) values is also large for Pakistan. The value of Pakistan stock exchange has increased more than selected stock markets and hence display higher deviation from its mean. Further, in all indices, the skewness statistic is negative except for Japan. The reported statistics also show that the excess kurtosis statistic is higher for all indices, revealing the existence of leptokurtic distributions. The Jarque–Bera test with a p-value of zero strongly rejects the null hypothesis of normal distribution for all time series, indicating the non-normality. Pearson's correlation coefficients of pairs reveal that correlation coefficient between Pakistan and Indian stock markets is high (0.92) and positively signed which also statistically significant at the 1% level. There is low positive and statistically significant correlation (0.33) between Pakistan and S&P 500 index. Pakistan stock exchange has a week negative (-0.22) but significant correlation with Nikkei 225 index of Japan. These findings are not surprising because regional markets are usually impacted by similar events and economic conditions in the region. The nature of relationship between with more distant markets is usually low and that makes Pakistan a potential diversification investment for international investors.

Table 1: Descriptive Statistics (1998W1 - 2013W52).

	Pakistan	India	S&P 500 (USA)	Nikkei 225 (Japan)
Mean	8.552	9.006	7.101	9.407
Std. Dev.	0.981	0.702	0.169	0.250
Min.	6.655	7.863	6.527	8.878
Max.	10.121	9.964	7.498	9.924
Skewness	-0.425	-0.091	-0.363	0.109
Ex. Kurtosis	1.691	1.366	2.925	1.798
J-B Statistics	84.301^{a}	93.625^{a}	18.514^{a}	51.676^{a}

Pearson's Correlation Coefficients				
Pakistan	1			
India	0.921^{a}	1		
S&P 500 (USA)	0.331^{a}	0.436^{a}	1	
Nikkei 225 (Japan)	-0.222^{a}	-0.136^{a}	0.595^{a}	1

Sample period is from January 1, 1998 to December 31, 2013, with weekly frequency, and is totaling 832 weekly observations. J–B represents the Jarque–Bera normality test.
^{a} indicates 1% level of significance. All stock series are non-stationary and all correlation coefficients are significant at 1%.

The stationarity of the times series has been examined by applying ADF (Dickey and Fuller, 1979) and PP (Philips and Perron, 1988). The results of unit root tests for are given in Table 2. Table 2 shows that all the index time series have unit root behavior at level and become stationery when first differenced without intercept and trend.

Table 2: ADF and PP Unit Root Test Results.

	ADF Unit Root Test		PP Unit Root Test	
Variables	Level	1st difference	Level	1st difference
Pakistan	-1.680	-24.248^{a}	-1.841	-24.316^{a}
India	-1.948	-18.178^{a}	-2.086	-28.044^{a}
S&P 500 (USA)	-2.053	-30.872^{a}	-1.974	-30.857^{a}
Nikkei 225 (Japan)	-1.527	-29.428^{a}	-1.565	-29.419^{a}

ADF & PP present Augmented Dickey-Fuller and Phillips-Perron unit root tests, respectively. Lag order for all test is 14. Reported values are of t statistics, ^{a} indicates 1% level of significance. All series are *I* (I).

As a prolog to examine the dependencies between Pakistan, Indian, S&P 500 and Nikkei 225 indexes, Granger (1969) causality test is applied to assess the causality relationships. Results of the causality analysis are reported in Table 3. The results of weekly time series indicate presence of three causality relations at 1%, 5% and 10% level. There is a strong bidirectional causality between Pakistan and Indian stock markets. In a second relationship, causality runs from Nikkei 225 to Pakistan stock exchange that is significant at 10% level. However, there is no short run relationship between Pakistan and S&P 500 evident through Granger causality. The combined results of both Granger causality and Pearson's pairwise correlation show that in an investment perspective, the regional stock markets i.e. Pakistan and India exhibit a high level of interdependence.

Table 3: Results of Pairwise Granger Causality.

Null Hypothesis	F statistics	Probability
India does not Granger Cause Pakistan	10.398^{a}	0.000
Pakistan does not Granger Cause India	3.880^{b}	0.021
S&P 500 (USA) does not Granger Cause Pakistan	1.884	0.152
Pakistan does not Granger Cause S&P 500 (USA)	0.482	0.617
Nikkei 225 (Japan) does not Granger Cause Pakistan	2.424	0.089
Pakistan does not Granger Cause Nikkei 225 (Japan)	0.258	0.772

^{a} & ^{b} indicate 1% and 5% level of significance, respectively.

3.3. Zhou's (1996) long horizon regression

To expound the co-movement between Pakistan, India, S&P 500 and Nikkei 225 indexes for the short and long-time horizons, we have applied long-horizon regressions following Zhou (1996), Kim and In (2007) and a recent work of Aloui, et al (2014) on relationship between sharia stocks and sukuk in the GCC markets. Following specification is regressed to estimate the coefficients:

$$\Delta P_{t,t+N} = \beta_0 + \beta_1 \Delta I, SP, N_{t,t+N} + \mu_{t,t+N}$$

In the above equation, $\Delta P_{t,t+N}$ are the changes in the natural log of weekly Pakistan stock index from time (t) to (t + N), $\Delta I, SP, N_{t,t+N}$ are the changes in natural log of weekly India, S&P 500 and Nikkei 225 indexes from (t) to (t + N), respectively. $\mu_{t,t+N}$ indicates the stochastic innovation in the change of the Pakistan stock index. Results of the estimation over different time periods are reported in Table 4. Firstly, the relationship between Pakistan and other regional i.e. India as well as international developed markets i.e. S&P 500 and Nikkei 225 indicated through R^2 statistic increases as the time-horizon goes up in weeks. This finding implies that the predictive power of changes in the regional and developed indexes in explaining the Pakistan stock index increases with the time period. For example, R^2 increases from 1.5% for the 1 week-time horizon to 13.3% for the 12 weeks (quarter) time horizon in case of India. Second, the slope coefficients for all stock markets is positive and highly significant. Additionally, the slope coefficients increase, in terms of absolute values, with the increase of time-horizon. These findings suggest that the degree of co-movement of Pakistan stock market increases with India, S&P 500 and Nikkei 225 as the time period increases. Hence, we can infer that the long term relationship should be considered while performing co-movement analysis. The change in co-movement over time can be attributed as a shifts in investors' behavior with the passage of time. Newey and West (1987) method is used to insure asymptotically valid standard errors and a positive definite variance-covariance matrix.

Table 4: Results of Zhou's (1986) Regression Estimates.

	N (weeks)				
Variables		1 week	4 weeks	12 weeks	26 weeks
India	β_1	0.135^a (0.036)	0.332^a (0.085)	0.492^a (0.133)	0.236^a (0.145)
	R^2	0.0159	0.074	0.183	0.084
S&P 500 (USA)	β_1	0.136^a (0.049)	0.235^a (0.123)	0.617^a (0.196)	0.814^a (0.236)
	R^2	0.008	0.019	0.139	0.290
Nikkei 225 (Japan)	β_1	0.112^a (0.041)	0.198^a (0.106)	0.639^a (0.156)	0.507^a (0.164)
	R^2	0.009	0.018	0.215	0.247

Regressions are according to Eq. (1). Values in the parentheses are of Newey-west corrected standard errors. ^{a} indicates 1% level of significance.

3.4. Wavelet Analysis

Aguiar-Conraria et al. (2008) have pointed out the two very important features of the wavelets analysis. First, the (discrete) wavelet transform has often been applied in the in most of the economic applications as a low and high pass filter. The economist find it hard to believe that these methods can provide better understanding of the data in comparison to the traditional techniques i.e. band pass filtering technique. Secondly, it is difficulty to analyze two or more time series simultaneously. Most of the previous economic studies have either used this technique to examine individual time series or several time series individually. And the decomposition is then further studied by using the using the traditional time series methodologies e.g. correlation or Granger causality analysis (Aguiar-Conraria et al; 2008, p. 2865). The wavelet power spectrum deals with a single time series and helps to examine the variations in a time series at different frequencies and periods over different scales.

The inability of wavelet power spectrum to deal with two time series have been overcome by Hudgins et al. (1993) and Torrence and Compo (2013) by developing the cross wavelet power and cross (squared) wavelet coherency, and phase difference. These techniques can deal with two time series by accommodating the time frequency analysis. These methods shows the curbed covariance and correlation coefficient between different series in the time frequency space. The addition of phase term help to examine the occurrence of pseudo cycle over the time. This phase difference also provide information regarding the lead-lag relationship between fluctuations of the two time series (Aguiar-Conraria et al.; 2008, p. 2867)[2].

Figure 2 shows the continuous wavelet power spectrum of Pakistan, Indian, S&P 500 and Nikkei 225 indexes in sequence. These images indicate presence of some common islands in case of Indian, S&P 500 and Nikkei 225 Indexes. Specifically, these common trend in three wavelet power spectrums are occurring during 2008 to 2009 over different scales. These pattern reveal that global financial crises had a significant impact of Indian and developed stock markets. However, the Pakistan stock market is an exception. As mentioned previously, continuous wavelet power transform does not reveal a more precise picture on co-movement between the markets. Thus, we have further examined the cross relationship through cross wavelet transform.

[2] For detailed specification of wavelet approach used in this paper see Shahbaz et al., 2014)

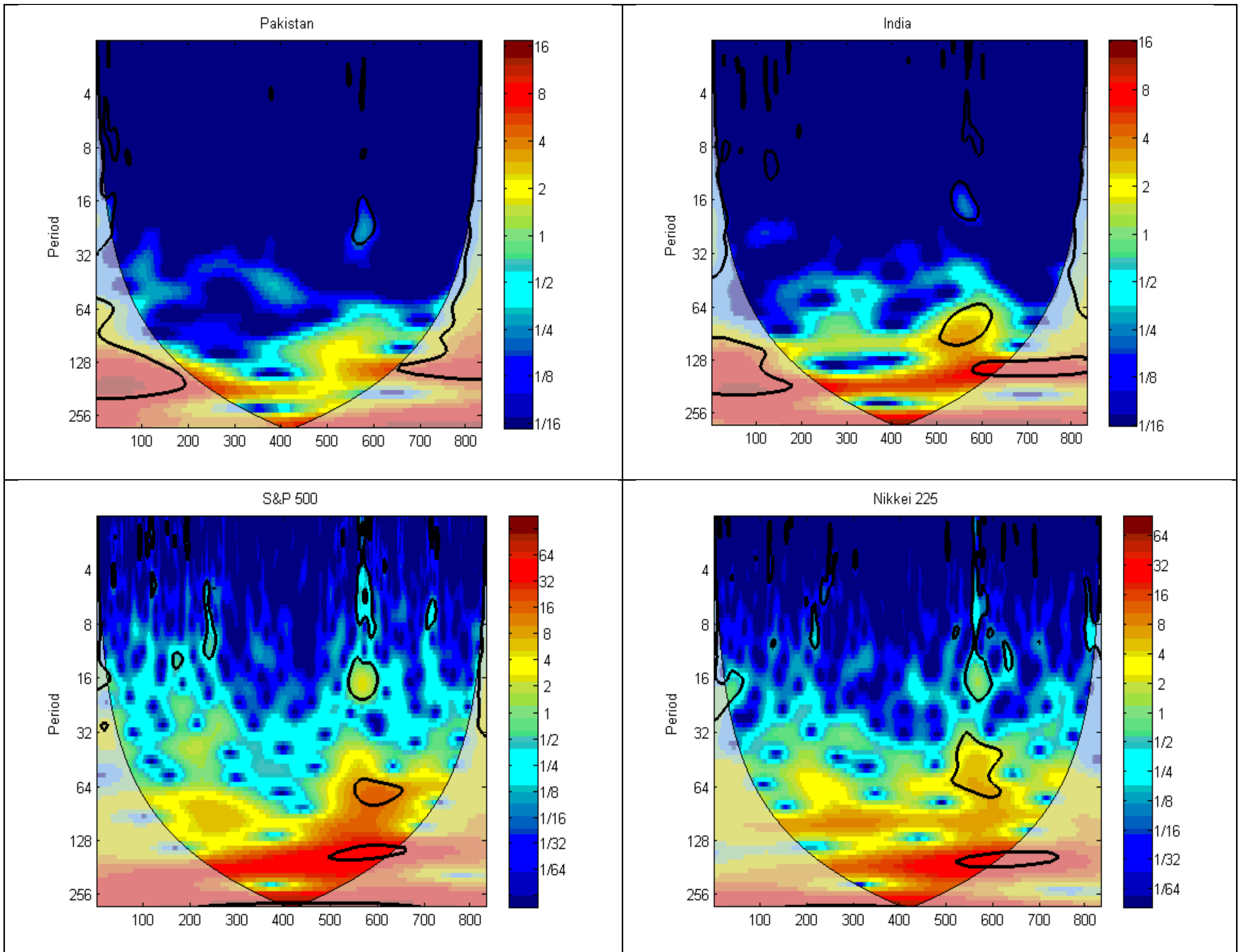
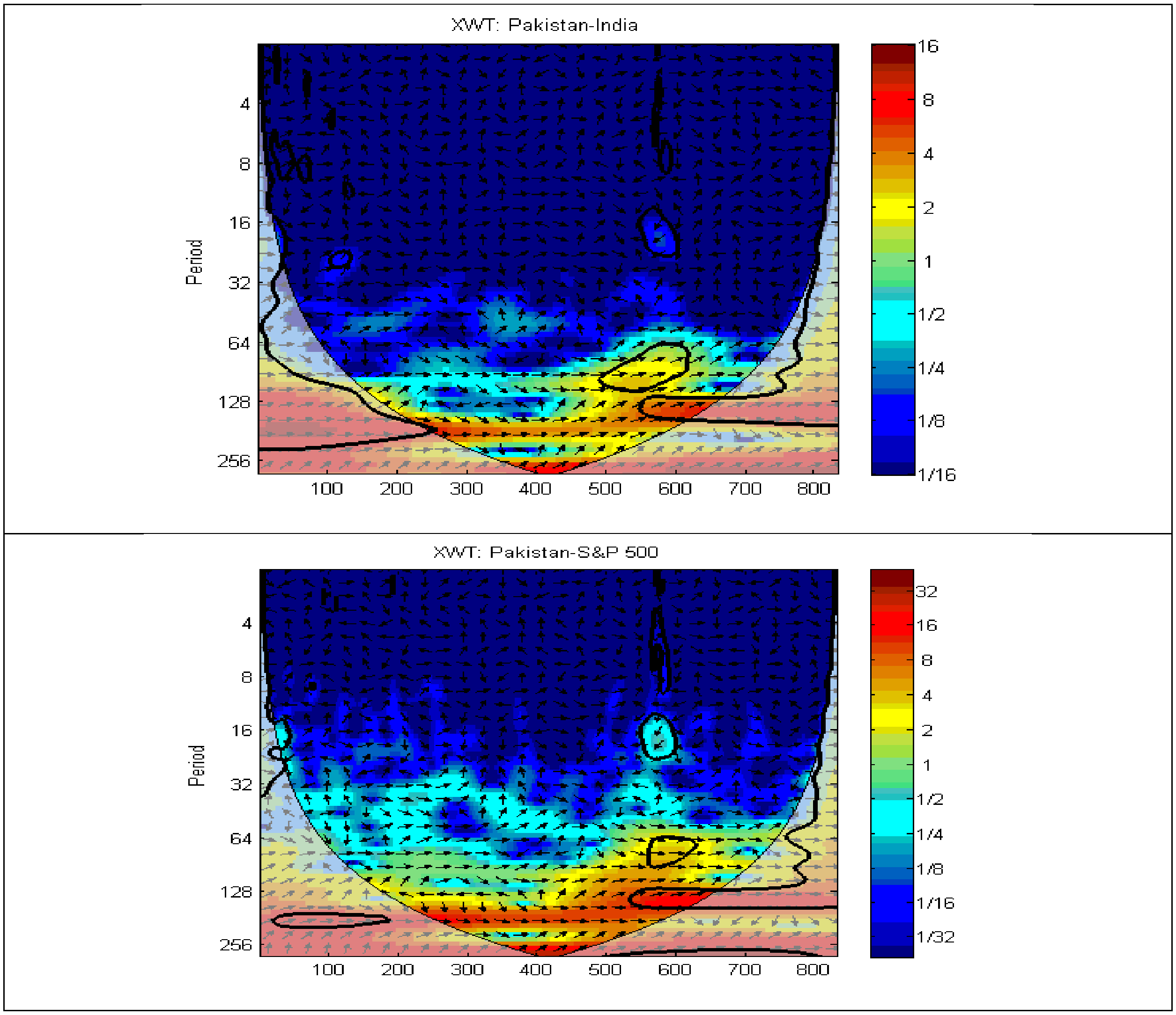


Fig. 2: The continuous wavelet power spectrum of Pakistan, India, S&P 500 and Nikkei 225 Indexes.

Note: The dense black outline indicates the 5% significance level against the red noise. The lighter shade cone shows the edge effect also named as cone of influence (COI). Color code is indicated to the right of each picture where blue indicates the low power and red shows high power. Y-axis measures the frequencies or scale and X-axis represent the time in weeks.

The results of cross wavelet power are presented in Figure 3. Interestingly, the direction of arrows for all three relations at different periods i.e. frequency bands is not same over the entire sample period. However, if we focus on the significant regions, the arrows are straight right and hence indicate the variables are in phase. Similarly, the variables are in phase in the high power regions. The important point to observe here is the direction of arrows in significant and high power regions. As the direction of arrows is not very clear therefore it is hard to make a conclusion on the lead lag relationship between the stock markets in different frequency bands and over time periods. Thus we can conclude that significant and power regions of cross wavelet analysis are unable to suggest a precise view on the lead-lag and cyclical-anticyclical nature of the stock markets. However, these findings are significant as traditional techniques would not have been able to reveal these results. We can still conclude that there is strong relationship between the markets during 2008-09.

The wavelet cross power spectrum simply multiplies the continuous wavelet power transform of two individual series and does not normalize these series to a single wavelet power spectrum. This limitation may produce misleading results. If a time series exhibits a strong peak and other have a local spectra the peaks in the cross spectrum may have resulted due to one time series and may have nothing to do with cross relationship between the two series. This limitation of cross wavelet transform motivates us to further our analysis through wavelet coherency known to provide conclusive results on cross relationship. However, wavelet cross-spectrum may still be used to examine the phase spectrum.



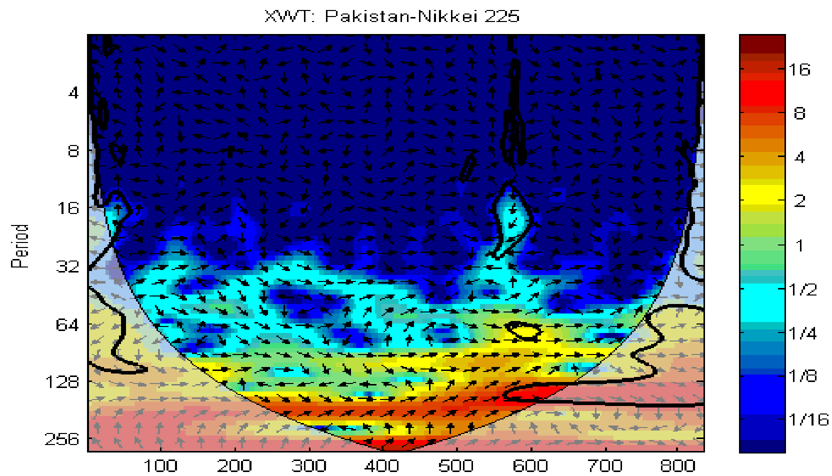
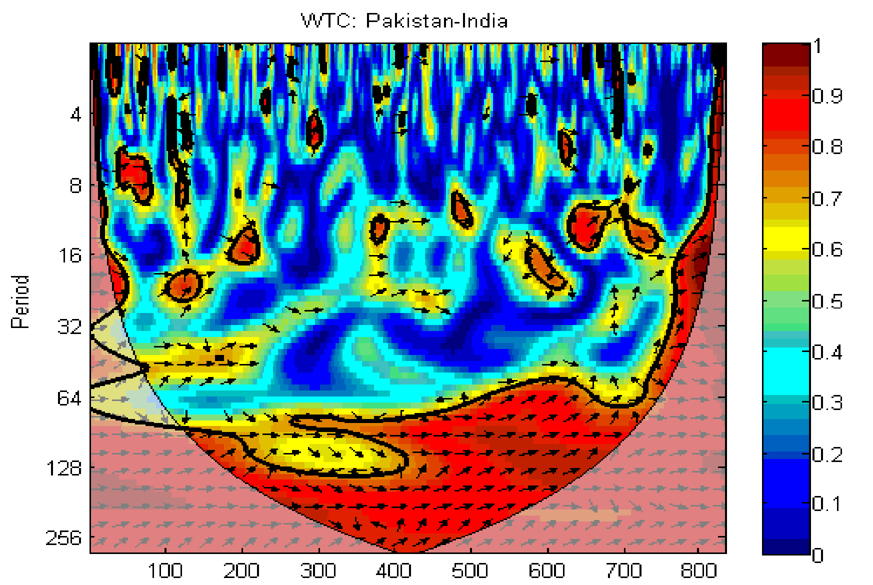


Fig. 3: Cross wavelet transform of the Pakistan, India, S&P 500 and Nikkei 225 time series.

The dense black outline indicates the 5% significance level against the red noise. The lighter shade cone shows the edge effect also named as cone of influence (COI). Color code is indicated to the right of each picture where blue indicates the low power and red shows high power. Y-axis measures the frequencies or scale and X-axis represent the time in weeks. Arrows indicate the phase difference between the two series. Interpretation of the direction is a follow:

(→) = variables are in phase (cyclical effect on each other); (↗) = Pakistan is lagging; (↘) = Pakistan is leading; (←) = variables are out of phase (anti-cyclical effect); (↖) = Pakistan is leading; (↙) Pakistan is lagging.

Finally, the results of cross-wavelet coherency are presented in Figure 4. The squared WTC of weekly price series of Pakistan with Indian, S&P 500 and Nikkei 225 stock markets are shown in Figure 4. In comparison to cross wavelet analysis, wavelet coherency provides a clear view of the lead-lag as well as in phase-out phase relationship between the indexes. The lead-lag relationship is not clear at short periods i.e. up to 32 weeks. However, the arrows are right or right up during the entire sample period to the 32~128 week scale for S&P 500 & Nikkei 225 and 64~256 weeks scale for India. The evidence suggests that all the markets are in phase with Pakistan stock market i.e. they have a cyclical effect on Pakistani market. The arrows are in upward direction in case of India so we can infer that Pakistan stock exchange is lagging. Similarly there are few upward arrows in the high dense and significant regions of S&P 500 and Nikkei 225 relation. These particular finding ware certainly not evident through our analysis with cross wavelet. The analysis through WTC provides very clear sign on lead-lag as well as show which market influences or is influenced by other market due to cyclical or anti-cyclical shocks. The findings of this paper could not have been possible through the traditional time series or fourier transformation analysis.


WTC: Pakistan-India
Period
4
8
16
32
64
128
256
100
200
300
400
500
600
700
800
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
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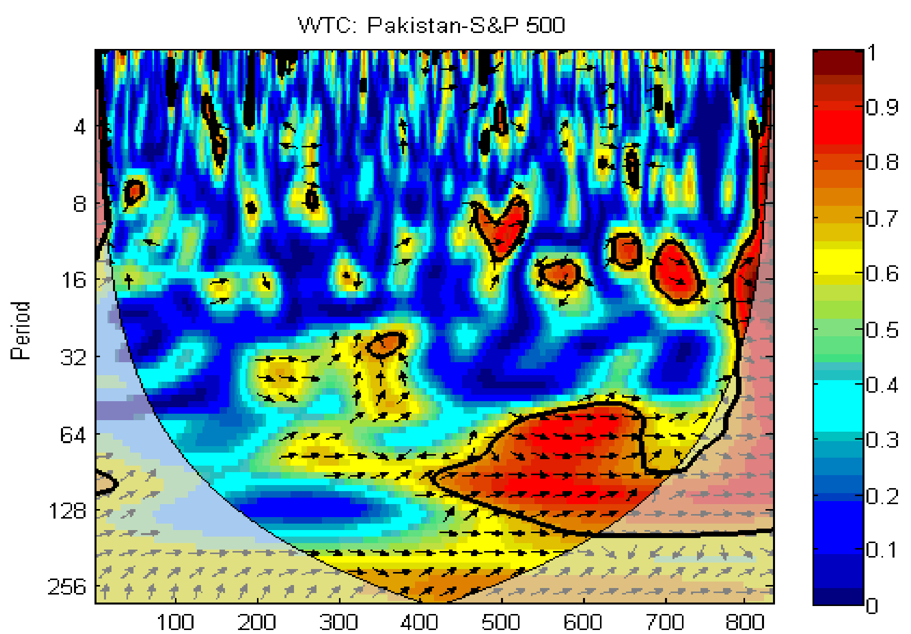
WTC: Pakistan-S&P 500
Period
4
8
16
32
64
128
256
100
200
300
400
500
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1
0.9
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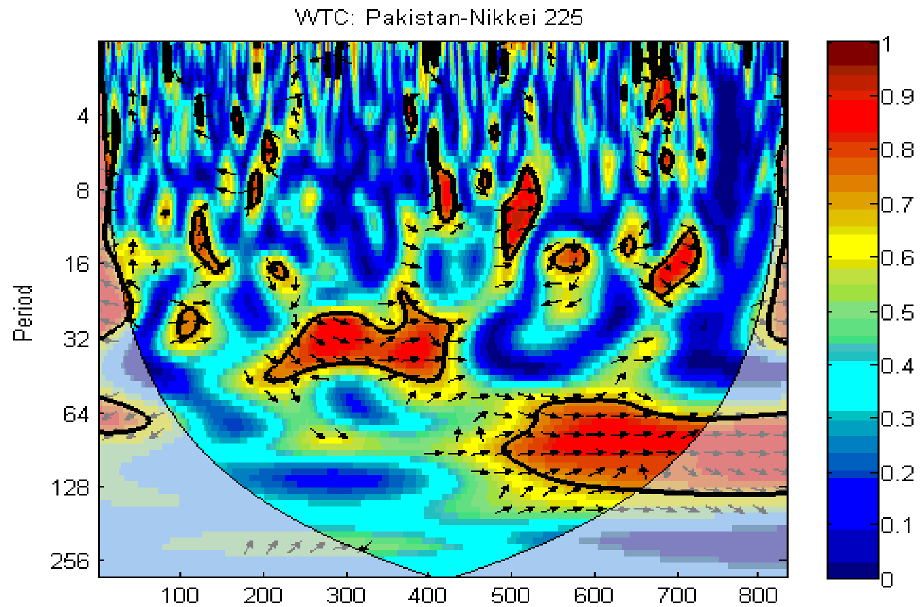

Fig. 4: Cross-wavelet coherency or squared wavelet coherence.
The dense black outline indicates the 5% significance level against the red noise. The lighter shade cone shows the edge effect also named as cone of influence (COI). Color code is indicated to the right of each picture where blue indicates the low power and red shows high power. Y-axis measures the frequencies or scale and X-axis represent the time in weeks. Arrows indicate the phase difference between the two series. Interpretation of the direction is a follow:
(→) = variables are in phase (cyclical effect on each other); (↗) = Pakistan is lagging; (↘) = Pakistan is leading; (←) = variables are out of phase (anti-cyclical effect); (↖) = Pakistan is leading; (↙) Pakistan is lagging.

Conclusion

This study examined the linkages of Pakistan stock exchange with Indian, US and Japan stock markets. KSE 100, BSE 30, S&P 500 and Nikkei 225 weekly data from period 1998 to 2013 is used for the empirical work. ADF and PP tests are used to ascertain the stationarity of the price series in natural logarithm form. Short- and long-run relationship is determined through Granger-causality and Zhou's (1996) long horizon equation, respectively. The time-frequency relationship between the stock markets is analyzed by continuous wavelet, cross wavelet and wavelet coherency approaches.

The findings reveal that all the stock markets are integrated of order one i.e. *I*(I). There is bi-directional causality between Pakistan and Indian stock markets. Nikkei 225 also Granger cause Pakistan market index in short run. All stock markets have a positive long-run relationship with Pakistan stock market and the predictive power of changes in the regional and developed indexes in explaining the Pakistan stock index increases with the time period. Time frequency analysis through continuous wavelet power spectrum indicate some common power regions for India, US and Japan index during 2008-09. Further, the cross wavelet transformation indicates covariance between the stock markets, however, no clear cut conclusion on the in phase and out phase (i.e.

cyclical and anti-cyclical) relationship over different durations can be drawn. Finally, the cross (squared) wavelet coherency, an indicator of possible correlation, indicate that all the markets are in phase with Pakistan stock exchange during the entire sample period to the 32~128 week scale for S&P 500 & Nikkei 225 and 64~256 weeks scale for India. These findings suggest that causal relationship of Pakistan with regional and developed international markets vary across scale. There is strong evidence of cyclical relationship between the markets however, in most of the period studied other markets were leading and passing cycle effects on Pakistan stock exchange.

The empirical analysis reveals a strong evidence that the portfolio diversification benefits vary across frequencies and time. This analysis is unique and have several practical implications for regional and international investors while assigning the optimal weightage of different assets in portfolio formulation. Local and international investors should also consider the short- and long-run co-movements between the markets while formulating their portfolios and keep in mind that the long-run relationship is dominant.

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