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The Effect of 9/11 on the Stock Market Volatility Dynamics: Empirical Evidence from a Front Line State

Sheraz Ahmed
Department of Finance and Statistics
Hanken - Swedish School of Economics and Business Administration
PB. 479, FIN-00101, Helsinki, Finland
E-mail: sheraz.ahmed@hanken.fi
Tel: +358-41-5014-501; Fax: +358-9-431-33393

Omar Farooq
School of Business Administration, Al Akhawayn University
PB. 104, 53000 Ifrane, Morocco
E-mail: o.farouq@aui.ma
Tel: +212-35-86-2311; Fax: +212-35-86-2060

Abstract

Did the terrorist attacks of September 11, 2001 change the volatility dynamics of stock markets? Using daily returns data from Pakistan, a front line state in the war against terror, we investigate whether important time series characteristics, for example first-order time dependence in the mean and conditional variance, the conditional variance risk premium, and the asymmetric response of the conditional variance to innovations, have changed during the post-9/11 period in comparison to these characteristics during the pre-9/11 period. Our results show that the volatility behavior changed significantly after the terrorist attacks of 9/11. We show that this sudden shift in the volatility behavior cannot be explained by the implementation of regulatory reforms. We divide pre-9/11 period into the pre- and the post-reform periods and show that the volatility behavior during both of these periods was qualitatively the same.

Keywords: Volatility Modeling; Conditional Heteroskedasticity; Leverage Effect; Karachi Stock Exchange.
JEL Classification Codes: C32, G15

1. Introduction

This paper investigates the effects of Al-Qaeda led terrorist attacks of September 11, 2001 (hereafter 9/11) on the volatility dynamics of the key benchmark index (KSE-100) of the Karachi Stock Exchange (hereafter KSE). The KSE is the main stock exchange of Pakistan, the front-line state in the war against terror. This paper uses exponential GARCH (EGARCH) model to investigate whether important time series characteristics, such as first-order time dependence in the mean and conditional variance, the conditional variance risk premium, and the asymmetric response of the conditional variance to innovations changed during the post-9/11 period relative to these characteristics during the pre-9/11 period. One of the main reasons behind studying the volatility dynamics during the post-9/11

period is that the Government of Pakistan's (hereafter GoP) decision to be the part of US-led alliance on war against terror resulted in significant gains for Pakistani economy. Some of benefits that resulted due to this alliance were rebirth of ties with the US, increase in export quotas for textiles to the EU and the US, surge in remittances via the formal channels,[1] strengthening of rupee value, and lightening of external debt as a result of debt rescheduling in December 2001. As a result, the KSE-100 index doubled in value over the next twelve months and claimed milestones after milestones with in few years.[2] Few observers would have predicted this surge after the terrorist attacks of 9/11, since it was hard to see how a war in Afghanistan and a wave of Al-Qaeda terror could be anything but bad for the country.

In order to fully understand whether the terrorist attacks of 9/11 affected the volatility dynamics of the KSE, we compare the volatility behavior during the post-9/11 period with the volatility behavior during the pre-9/11 period. The pre-9/11 period experienced one of the major reforms in the history of capital markets in Pakistan, i.e. the formation of the Securities and Exchange Commission of Pakistan (hereafter SECP) in 1999. The SECP, an independent capital market watchdog in Pakistan, was formed to lay down the foundations of good governance by building institutional, legal, and regulatory frameworks. The reforms initiated by the SECP resulted in improving the transparency in the operations of not only the KSE but also the firms (Raees and Saeed, 2005). Some instances of governance reforms in the KSE include the hiring of a full time professional Managing Director, induction of outside directors on its board, implementation of automated trading system, and introduction central depository. These reforms made the working of the KSE more transparent and free from interference of the vested interests, i.e. brokers. Furthermore, the SECP also introduced reforms that improved governance and disclosure mechanisms of the firms. It, for example, strengthened investor protection and anti-director rights, instructed firms to adopt international accounting standards, ensured enforcement of accounting standards, and improved governance of conglomerates.[3] Since it may be possible that the reforms initiated by the SECP affected the volatility behavior of the KSE, we further divide the pre-9/11 period into pre-reform and the post-reform periods. If the reforms had any impact on the volatility dynamics, there would be significant difference in the volatility dynamics of the pre-reform and the post-reform periods. However, if it were the not the reforms, but the aftereffects of the terrorists attacks that changed the volatility behavior of the KSE, we will see a significant change in the volatility behavior during the post-9/11 period relative to the pre-reform and the post-reform periods.

This paper also contests the claims made by the GoP that the reforms undertaken by the SECP resulted in changing the behavior of the stock markets in the country. The GoP claims that the reforms restored the public confidence in the stock markets and resulted in the upsurge in stock markets. The GoP is of the point of view that this renewed public confidence is achieved through constant watch and professional vigilance of the SECP authorities on the functioning and performance of listed firms and the stock exchanges. However, our results show that the governance reforms did not have significant impact on behavior, especially the volatility behavior, of the stock markets in Pakistan. We show that the volatility behavior during the post-reform period (first three years of reforms) was qualitatively the same as the volatility behavior during the pre-reform period. For example, the ARMA characteristics, the conditional variance risk premium, and the asymmetric response of the conditional variance to innovations are qualitatively the same in both periods. It suggests that the SECP initiated reforms were not able to appreciably change the volatility dynamics of the KSE. However, our results show that the volatility behavior of the KSE changed significantly after the terrorist attacks of 9/11. We show that the ARMA characteristics, the conditional variance risk premium, and the asymmetric response of the conditional variance to innovations changed significantly from their pre-9/11 levels during the post-

[1] Most of the remittances found their way into real estate sector or the stock market. This resulted in not only improving the performance of firms belonging to the construction sector (among the blue chip sectors of the KSE) but also helping in improving liquidity and investor base in the KSE. Furthermore, remittances through formal channels also helped in improving performance of the banks (also among the blue chip sectors of the KSE).

[2] The KSE-100 index value was 1255.99 on September 11, 2001. The index surged to 12663.41 on the last day of our sample period (May 24, 2007).

[3] See Farooq and Ahmed (2007) for greater details on the reforms initiated by the SECP.

9/11 period. We claim that this sudden shift in the volatility dynamics of the KSE was not due to the reforms initiated by the SECP but due to the unexpected beneficial effects of the terrorist attacks of 9/11. Had the reforms been successful, they would have shown their effect during the post-reform period. We argue that the unexpected benefits that Pakistan attracted, as an aftermath of terrorist attacks may be responsible for affecting the volatility dynamics of the KSE. Some of the benefits, such as surge in remittances via formal channels, increase in export quotas for textiles to the EU and US, and debt rescheduling of country's debt, not only helped in improving the firm performances but also enhanced the liquidity and investor participation in the KSE. It has been argued by many analysts that most of the remittances found their way into real estate sector or the stock market. This resulted in not only improving the performance of firms belonging to the construction sector (the blue chip sectors of the KSE) but also helping in improving liquidity and investor base in the KSE. Furthermore, remittances through formal channels also helped in improving performance of the banks (also among the blue chip sectors of the KSE). Most of these improvements may not have been possible with the governance reforms initiated by the SECP.

It is also important to mention here that there is no paper, to the best of our knowledge, which looks at the detailed volatility behavior of returns in the KSE. The Bloomberg has declared the KSE as the best performing stock market of the world for the year 2002. While, the Business Week consistently ranked it for more than 6 years as one of the best performing markets of the world. This paper, therefore, aims to fill this gap by documenting the stylized properties of daily returns in the KSE. The findings of this study may help fund managers and investors to have a better understanding of the KSE's volatility and may allow them to make better decisions regarding derivative pricing, VaR calculation, and portfolio diversification. Furthermore, detailed study of volatility behavior of the KSE will also help in gauging the effectiveness of the governance reforms initiated by the SECP.

The remainder of the paper is organized as follows. Section 2 discusses in greater details different sub-periods used in this study. Section 3 describes data and provides descriptive statistics. Section 4 models the KSE return index series using ARMA methodology. Section 5 briefly discusses EGARCH model and provide the estimation results. Section 6 provides discussion of our results and the paper concludes with Section 7, where we present conclusions.

2. Sample Period

This paper comprehensively studies the time series properties of daily returns of KSE-100 index, the main benchmark index of the Karachi Stock Exchange during the period ranging from January 1, 1996 to May 24, 2007. This time period was chosen so that we can compare post-9/11 period with the pre-9/11 period. The pre-9/11 period includes implementation of significant governance reforms in Pakistan; therefore we further sub-divided pre9/11 period into pre-reform and the post-reform periods.

2.1. Pre-reform period

The pre-reform period ranges from January 1, 1996 to December 31, 1998. This period was characterized by no independent governance of capital markets in Pakistan. Most of regulation was done by the Corporate Law Authority, a division of the Ministry of Finance and under the Ministry's control. Significant amount of regulatory matters were also used to be undertaken by other agencies such as the Controller of Capital Issues, the State Bank of Pakistan, and the Stock Exchanges. Involvement of many different organizations, most of them not independent, made effective regulation and enforcement a cumbersome task.

2.2. Post-reform period

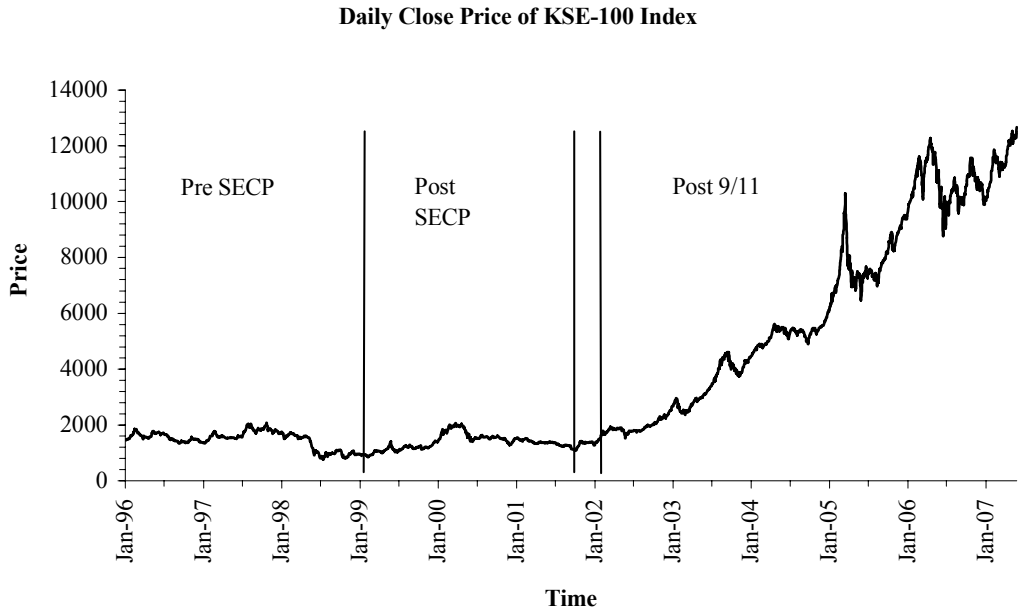
The post-reform period spans from January 1, 1999 to September 10, 2001. This period corresponds to the formation of the SECP. The SECP, which became functional in January 1999, was authorized to oversee the efficient functioning of capital markets in Pakistan. Since its inception, the SECP

introduced a number of reforms that improved transparency in the operations of the stock exchanges and the firms.

2.3. Post-9/11 period

The post-9/11 period ranges from January 1, 2002 to May 24, 2007. We intentionally leave out the first fourth month of the post-9/11 period to eliminate the effect of the uncertainties that engulfed Pakistan immediately after the terrorists attacks of 9/11.

Figure 1: Daily Close Price of KSE-100 Index for the period January 1, 1996 to May 24, 2007



3. Data and Descriptive Statistics

3.1. Descriptive statistics

The data consist of daily closing price, expressed in local currency (rupees), of the KSE-100 index from January 1, 1993 to May 24, 2007. The sample consists of a total of 3755 observations. The daily return series was generated as follows:

$$R_{KSE,t} = \log\left(\frac{KSE_t}{KSE_{t-1}}\right) * 100, \quad (1)$$

where KSE_t represents the closing value of the KSE-100 index on the day t.

The return series in equation (1) is the time series of continuously compounded daily returns expressed as percentage. We would like to mention that the series is adjusted neither for dividends nor for risk-free interest rate. Nelson (1991) mentions that ignoring dividends and interest rates do not cause any significant errors while forecasting volatility of market indices.

Summary statistics for of our return series, as given in equation (1), are shown in Table 1.

Table 1: Descriptive Statistics and Auto-correlations of KSE-100 Daily returns in all sub periods.

Descriptive Statistics	Time Periods[§]		
	Pre-reform Jan, 96 – Dec, 98	**Post-reform Jan, 99 – Sep, 01**	**Post-9/11 Jan, 02 –May, 07**
Mean	-0.0255	0.0176	0.0709
Median	0.0000	0.0000	0.0766
Maximum	5.5427	3.3503	3.6946
Minimum	-5.7389	-3.3500	-3.7620
Std Deviation	0.8940	0.7270	0.6671
Skewness	-0.3871	-0.1395	-0.4523
Excess Kurtosis	10.3324	7.1396	6.2028
No. of observations	784	703	1408
Normality Test			
Jarque-Bera	1775.87***	504.23***	649.80***
Auto-correlation in Returns			
ρ(1)	0.063*	0.022	0.055**
ρ(2)	0.064**	0.046	-0.047**
ρ(3)	0.066**	0.031	0.035**
ρ(4)	0.014**	0.019	-0.002*
ρ(5)	-0.038**	0.068*	0.004
Box-Ljung Q χ^2 (5)	11.002**	6.110	9.106

* Significant at 10% level
** Significant at 5% level
[§] Pre-SECP period corresponds to Jan 01, 1996 to Dec 31, 1998, Post-SECP period corresponds to Jan 01, 1999 to Sep 11, 2001, Post-9/11 period corresponds to Jan 01, 2002 to May 24, 2007.

Table 1 suggests that the average returns are positive in the post-reform and the post-9/11 periods, while they are negative in the pre-reform period. Furthermore, returns series indicate that mean returns gradually increased from -0.0255 in the pre-reform period to 0.0709 in the post-9/11 period. The statistics also show that returns are negatively skewed during all sub-periods. The negative skewness implies that the return distributions of the shares traded in the KSE have a higher probability of earning negative returns. The value of the kurtosis is greater than 3 in all sub-periods, meaning that it has a heavier tail than the standard normal distribution. The Jarque-Bera test statistic provides clear evidence to reject the null hypothesis of normality for the unconditional distribution of daily returns.

The first five autocorrelations for daily returns are also reported in Table 1. The autocorrelations indicate significant time dependence in the pre-reform and the post-9/11 periods. However, the Ljung-Box-Pierce statistic rejects the null hypothesis of no serial dependence in daily returns only in the pre-reform period. In the last two sub-periods, the Ljung-Box-Pierce statistic shows no time dependence.

3.2. Volatility Clustering

Some preliminary indications regarding volatility clustering are presented in Figure 2.

Figure 2-A: Daily returns of KSE-100 Index for Pre-reform Period – January 1, 1996 – December 31, 1998

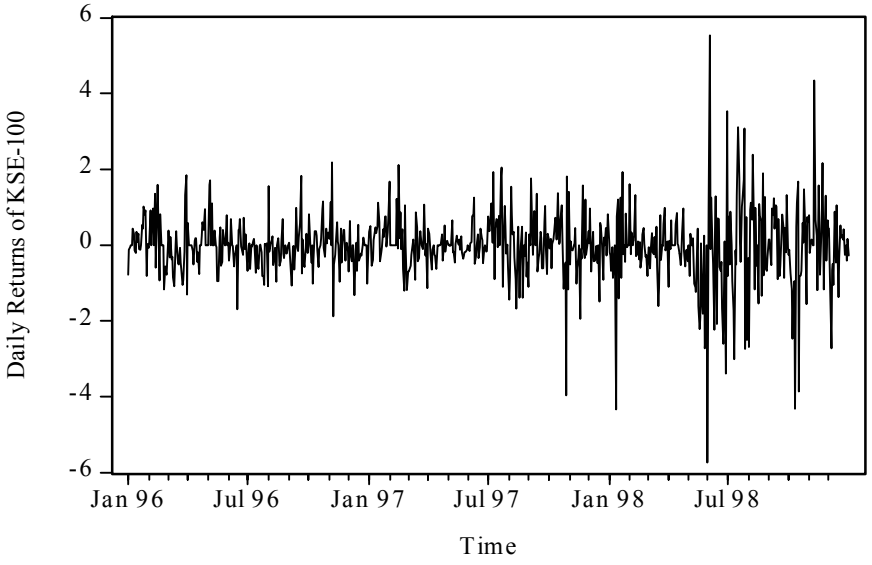


Figure 2-B: Daily returns of KSE-100 Index for Post-reform Period – January 1, 1999 – September 11, 2001

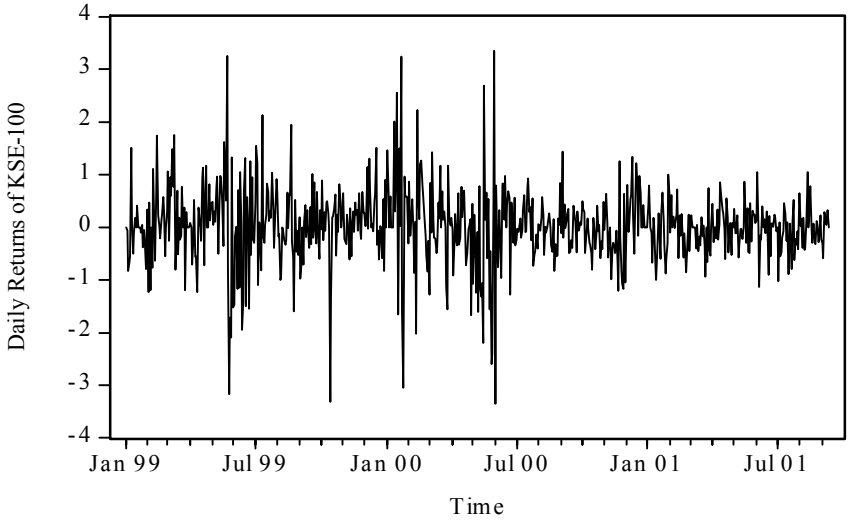


Figure 2-C: Daily returns of KSE-100 Index for Post-9/11 Period – January 1, 2002 – May 24, 2007

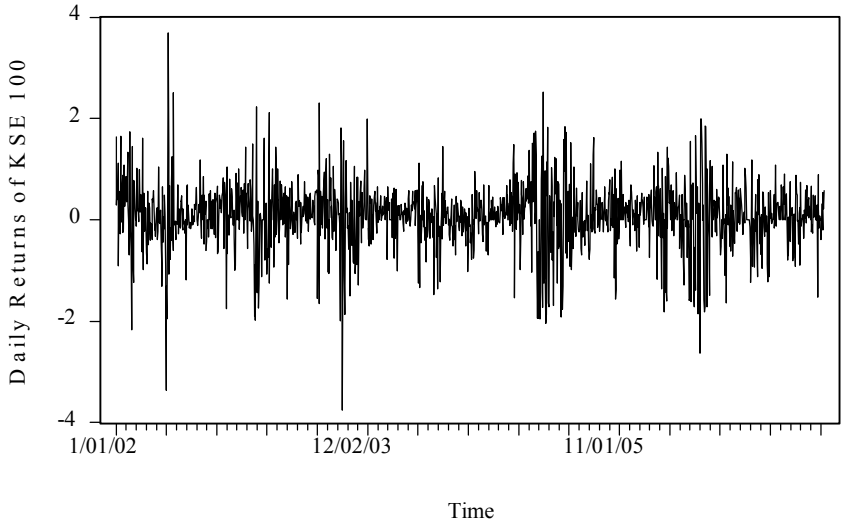


Figure 2 shows the return series of the data for all the three sub-periods. From the figure it appears that there are stretches of time where the volatility is relatively high and stretches of time where the volatility is relatively low. For example, in the pre-reform period, we can see relatively high volatility at the end of the period. Similar observations can be made for other sub-periods. These observations suggest volatility clustering in all sub-periods.

Statistically, volatility clustering implies a strong autocorrelation in squared returns. A simple method for detecting volatility clustering is to calculate the first-order autocorrelation coefficient in squared returns. Table 2 shows the autocorrelation statistics for squared returns.

Table 2: Volatility Clustering: Auto-correlations of squared returns

ρ(lag)	**Pre-reform Jan, 96 – Dec, 98**	**Post-reform Jan, 99 – Sep, 01**	**Post-9/11 Jan, 02 –May, 07**
ρ(1)	0.092**	0.278***	0.262***
ρ(2)	0.288***	0.302***	0.255***
ρ(3)	0.117***	0.243***	0.211***
ρ(4)	0.132***	0.200***	0.311***
ρ(5)	0.121***	0.123***	0.189***
Box-Ljung Q χ^2 (5)	108.30***	199.91***	438.89***

** Significant at 5% level
*** Significant at 1% level

Table 2 shows that the value of Q-statistic is greater than the critical value during all sub-periods and thereby rejects the joint hypothesis that all the serial correlations of the squared returns for lags 1 through 5 are simultaneously equal to zero. Our results, therefore, indicate the presence of volatility clustering in the return series during all three sub-periods.

3.3. ARMA modeling

Main motivation behind the ARMA modeling is to shed light on properly specifying the equation of the GARCH framework. Our results suggest that ARMA (1,1) is an appropriate model for all the sub-periods in our study. The results of modeling the daily return series as an ARMA (1,1) are presented in Table 3.

Table 3: Results of Modeling KSE-100 Daily Returns Series as ARMA (1,1)
Estimated Model:

$$R_t = \beta_0 + \beta_1 R_{t-1} + \beta_2 \tilde{\varepsilon}_{t-1} + \varepsilon_t$$

$$\varepsilon_t \sim N(0, \sigma^2)$$

Parameters	Pre-reform Jan, 96 – Dec, 98	Post-reform Jan, 99 – Sep, 01	Post-9/11 Jan, 02 –May, 07
β_0	-0.0240 (-0.589)	0.0206 (0.584)	0.0708*** (3.853)
β_1	0.7787*** (2.766)	0.8674*** (4.183)	-0.6768*** (-4.120)
β_2	-0.7168** (-2.412)	-0.8324*** (-3.675)	0.7414*** (5.054)
Observations Ad. R-square Standard Error of Estimates	784 0.007 0.891	703 0.003 0.726	1408 0.009 0.664
ARCH LM Test χ^2 (5)	16.641***	24.332***	56.286***

Note: Bollerslev-Wooldrige robust t-stats are in parenthesis
** Significant at 5% level
*** Significant at 1% level

We employ Engle's LM test to check whether all coefficients are equal to zero in a regression. Our results reject the null hypothesis of no conditional heteroscedasticity, up to 5 lags, at the 1% significance level. The statistics show that there is ARCH effect present in squared residuals of ARMA (1,1) model up to 5 lags for all sub-periods.

Furthermore, we also employ modified Box-Ljung Q statistics to test for autoregressive conditional heteroscedasticity in the residuals and squared residuals of the estimated ARMA (1,1) model. Table 4, Panel A, presents the estimates of modified Box-Ljung Q statistics of auto-correlations of residuals for all sub-periods, while Panel B presents similar statistics for squared residuals. The test results into rejection of null hypothesis of no conditional heteroscedasticity in autocorrelations of squared residuals at the 1% levels of significance for all sub-periods. We also conducted the ARMA modeling omitting the positive and negative outliers in the daily return series. The exclusion of outliers does not affect our ARMA modeling results.

Table 4: The Box-Ljung Q statistics for conditional heteroscedasticity in autocorrelations in estimated residuals of ARMA (1,1) model

Panel A: Auto-correlation in Residuals of ARMA (1,1) Model

ρ(lag)	Pre-reform Jan, 96 – Dec, 98	Post-reform Jan, 99 – Sep, 01	Post-9/11 Jan, 02 –May, 07
ρ(1)	-0.007	-0.018	-0.003
ρ(2)	0.011	0.012	-0.008
ρ(3)	0.027	0.002	0.008
ρ(4)	-0.019	-0.007	0.015
ρ(5)	-0.067	0.047	-0.008
Box-Ljung Q χ^2 (5)	4.552	1.946	0.584

Panel B: Auto-correlation in Squared Residuals of ARMA (1,1) Model

ρ(lag)	Pre-reform Jan, 96 – Dec, 98	Post-reform Jan, 99 – Sep, 01	Post-9/11 Jan, 02 –May, 07
ρ(1)	0.116***	0.304***	0.263***
ρ(2)	0.289***	0.293***	0.263***
ρ(3)	0.100***	0.228***	0.199***
ρ(4)	0.124***	0.183***	0.318***
ρ(5)	0.111***	0.128***	0.188***
Box-Ljung Q χ^2 (5)	105.92***	197.40***	444.31***

*** Significant at 1% level

4. EGARCH Modeling

We follow Nelson (1991) to allow for the asymmetric response of volatility to innovations and Engle et al. (1987) for 'in Mean' effects. We include ARMA (1,1) dynamics in the mean equation based on the residuals of our ARMA modeling. More specifically, we estimate the following model:

$$R_t = a_0 + a_1 R_{t-1} + a_2 \varepsilon_{t-1} + g\sqrt{h_t} + e_t, \quad (2)$$

$$e_t \mid y_{t-1} : N(0, h_t), \quad (3)$$

$$\log h_t = f + b\left(\left|\frac{e_{t-1}}{\sqrt{h_{t-1}}}\right| - E\left|\frac{e_{t-1}}{\sqrt{h_{t-1}}}\right|\right) + d\left(\frac{e_{t-1}}{\sqrt{h_{t-1}}}\right) + l \log(h_{t-1}) \quad (4)$$

Where φ, β, γ, δ, and λ are the parameters that will be estimated by the model. The parameters β measures the impact of the innovation in equation (2) on conditional volatility at time t. The parameter λ is the auto-regressive term on lagged conditional volatility, reflecting the weight given to the previous period's conditional volatility in the conditional volatility at time t. In other words, it captures the persistence (clustering) of conditional volatility. The parameter δ permits asymmetric response of conditional variance to innovations of different sign. If δ is negative (positive), then negative realizations of the innovation in equation (2) generate more (less) volatility than do positive realizations. The 'in Mean' parameter is captured by γ while α_1 and α_2 are the AR (1) and MA (1) parameters respectively.

Specifications of EGARCH (1,1)-M model were estimated using the method of quasi-maximum likelihood. Bollerslev and Wooldridge (1992) note that maximizing a misspecified likelihood function in a GARCH framework provides consistent parameters estimates.[4] Therefore, we correct the covariance matrix as per White (1982). This provides standard errors that are robust to deviations from the assumed probability density function. The estimation results are reported in Table 5.

[4] However, the standard errors will be understated in such a setting.

Table 5: Results of Estimation of KSE-100 Index Daily Returns Series Using EGARCH (1,1) in mean with ARMA(1,1) for all periods.

Estimated Model:

$$R_t = a_0 + a_1 R_{t-1} + a_2 \varepsilon_{t-1} + g\sqrt{h_t} + e_t,$$

$$e_t \mid y_{t-1} : N(0, h_t),$$

$$\log h_t = f + b\left(\left|\frac{e_{t-1}}{\sqrt{h_{t-1}}}\right| - E\left|\frac{e_{t-1}}{\sqrt{h_{t-1}}}\right|\right) + d\left(\frac{e_{t-1}}{\sqrt{h_{t-1}}}\right) + l \log(h_{t-1})$$

Parameters	Time Periods[§]		
	Pre-reform Jan, 96 – Dec, 98	**Post-reform Jan, 99 – Sep, 01**	**Post-9/11 Jan, 02 –May, 07**
α_0	0.0613 (0.687)	-0.1541 (-1.585)	0.1670*** (3.915)
α_1	0.8811*** (10.423)	0.6721** (2.043)	-0.7521*** (-4.007)
α_2	-0.7953*** (-8.047)	-0.6144* (-1.787)	0.7845*** (4.456)
γ	-0.1040 (-0.784)	0.2853* (1.770)	-0.1530* (-1.815)
ϕ	-0.1707*** (-2.585)	-0.2238*** (-4.300)	-0.4044*** (-7.115)
β	0.2195*** (2.870)	0.2521*** (4.209)	0.3879*** (6.697)
δ	-0.0304 (-0.623)	0.0369 (0.758)	-0.1146*** (-3.368)
λ	0.9681*** (41.562)	0.9583*** (65.656)	0.8984*** (42.576)
Observations	784	703	1408
Log Likelihood	-906.06	-679.09	-1196.68
Durbin Watson	2.053	2.067	1.974
ARCH-LM Test χ^2 (5)	0.620	0.361	2.117*

Note: Bollerslev-Wooldrige robust z-values are in parenthesis
* Significant at 10% level
** Significant at 5% level
*** Significant at 1% level
[§] Pre-reform period corresponds to Jan 01, 1996 to Dec 31, 1998, Post-reform period corresponds to Jan 01, 1999 to Sep 11, 2001, Post-9/11 period corresponds to Jan 01, 2002 to May 24, 2007.

5. Discussion of Results

5.1. Predictability of Returns

The magnitude of the AR(1) parameter is significant in all three sub-periods, which means that the current returns are able to predict one day ahead returns in all sub-periods. However, in contrast to the pre-reform and the post reform periods, the AR(1) coefficient is negative in the post-9/11 period.

Lo and Mackinlay (1988) suggest that asynchronous trading in a portfolio of stocks can help explain the first-order auto-correlation in a time series of portfolio returns. Our results suggest that the estimated AR(1) coefficients roughly correspond to a probability of non-trading (i.e. the percentage of stocks that do not trade in a time interval) of approximately 0.88, 0.67, and 0.75 respectively for the pre-reform, the post-reform, and the post-9/11 periods. In the absence of spurious autocorrelation (i.e. when the probability of non-trading is zero), a random walk requires that all autocorrelations be zero. We conjecture that the required probability of non-trading is too high to fully explain the first order autocorrelations. Thus, we conclude that there is time dependence in the daily returns even after modeling the moving average of estimated residuals. However, with our data we cannot separate the confounding effects of a possible improvement in the price adjustment process and the certain decrease

in the probability of non-trading (as a result of greatly increased volume) that occurred in the later periods especially during the post-9/11 period. The post-9/11 period saw massive influx of remittances from expatriates living abroad.[5] Analysts believe that substantial amount of these remittances have found their way into the stock markets. Such massive investments from expatriates along with increased foreign portfolio investments[6] resulted in increased trading and also the surge in stock markets.

5.2. Own conditional variance risk premium

Risk as measured by own conditional variance, a priced factor, is captured by γ. Our results show that risk premium is insignificant during the pre-reform period (-0.1040) and significant for the post-reform period (0.2853). However, risk premium becomes negative and significant (-0.1530) during the post-9/11 period. The level of significance in both post-reform and post-9/11 periods is merely 10%. The finding of a significant risk premium in both periods can be explained by significant positive auto-correlation during post-reform period and significant negative auto-correlation during post-9/11 period. Whereas, finding of an insignificant own conditional risk premium during pre-reform period suggest that the own conditional risk was not priced in KSE-100 portfolio returns before year 2000. Backus and Gregory (1993) show that the relationship between risk premium and conditional variances can be increasing, decreasing, flat, or non-monotonic. They document that the shape of relationship depends not only on the preferences of investors but also on the structure of the economy. This result may also be sensitive to methodology because earlier literature has provided conflicting results as of risk as a measure of own conditional variance.

5.3. Lagged conditional variance behavior

The first order auto-regressive parameter of conditional variance (λ) is a measure of persistence in conditional volatility of time series of daily stock returns. It shows how historical stock price volatility is reflected in the present conditional variance. Our results show that the parameter value of the lagged conditional variance (λ) declines gradually with time. For example, it decreases from 0.9681 in the pre-reform period to 0.9583 in the post-reform period to 0.8984 in the post-9/11 period. The result shows that the biggest decline in the parameter occurred in the post-9/11 period. This dramatic decline may also be attributed to high growth of KSE-100 index after 9/11 as volatility persistence decreased. These characteristics of persistence in conditional volatility of daily returns of KSE-100 index may also be an interesting area for further research.

5.4. Volatility asymmetry

The volatility asymmetry is captured by δ. Our results show insignificant value of δ in the pre-reform (-0.0304) and the post reform periods (0.0369). This is in contrast to the behavior of developed markets that display a significantly negative asymmetry parameter due to a leverage effect. This result not only points towards the immaturity of the KSE during the pre-reform and the post-reform periods but also indicates relative ineffectiveness of governance reforms implemented during the post-reform period. However, our results indicate that the asymmetry parameter becomes significant and negative (-0.1146) during the post-9/11 period. This result is consistent to the view that market started to move towards maturity during the post-9/11 period.

6. Conclusion

This paper investigates the effects of Al-Qaeda led terrorist attacks of September 11, 2001 on the volatility dynamics of the Karachi Stock Exchange (KSE). The KSE is the main stock exchange of Pakistan, the front-line state in the war against terror. In order to find out whether the terrorist attacks of 9/11 affected the volatility dynamics of the KSE, we compare the volatility behavior during the

[5] According to official statistics Pakistanis abroad have sent home around 24.50 billion dollars in the shape of remittances after 9/11 incidents.

[6] Official estimates show that foreign portfolio investment gradually reached to $1 billion dollars in the post-9/11 period.

post-9/11 period with the volatility behavior during the pre-reform and the post-reform periods. Our results show that volatility behavior during the post-9/11 period is significantly different from the pre-reform and the post-reform periods. We show that the ARMA characteristics, the conditional variance risk premium, and the asymmetric response of the conditional variance to innovations changed significantly from their pre-9/11 levels during the post-9/11 period. Our results, for example, show that in contrast to the pre-reform and the post reform periods, the AR(1) coefficient is negative in the post-9/11 period. Similarly, in contrast to the pre-reform and the post reform periods, the risk premium becomes significantly negative during the post-9/11 period. Furthermore, the persistence in conditional volatility show significant decline in the post-9/11 period when compared against the pre-reform and the post reform periods. Another important measure, the volatility asymmetry, also becomes significantly negative during the post-9/11 period. Our results show insignificant measure of volatility asymmetry during the pre-reform and the post reform periods.

We claim that this sudden shift in the volatility dynamics of the KSE was not due to the reforms initiated by the SECP but due to the unexpected beneficial effects of the terrorist attacks of 9/11. Had the reforms been successful, they would have shown their effect during the post-reform period. We argue that the unexpected benefits that Pakistan attracted, as an aftermath of terrorist attacks may be responsible for affecting the volatility dynamics of the KSE. Some of the benefits were the rebirth of alliance with the US, increase in export quotas for textiles to the EU and US, surge in remittances via formal channels, and debt rescheduling of country's debt. All of these factors not only helped in improving the firm performances but also enhanced the liquidity and investor participation in the KSE. It has been argued by many analysts that most of the remittances found their way into real estate sector or the stock market. This resulted in not only improving the performance of firms belonging to the construction sector (among the blue chip sectors of the KSE) but also helping in improving liquidity and investor base in the KSE. Furthermore, remittances through formal channels also helped in improving performance of the banks (also among the blue chip sectors of the KSE). Most of these improvements may not have been possible with the governance reforms initiated by the SECP.

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