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## **Volatility Spillover between the Stock Market and the Foreign Exchange Market in Pakistan**

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PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS

*PIDE Working Papers*  
*2006:7*

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ISLAMABAD**

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## **ABSTRACT**

Our paper examines the volatility spillover between the stock market and the foreign exchange market in Pakistan. For the long-run relationship we use the Engle Granger two-step procedure and the volatility spillover is modelled through the bivariate EGARCH method. The estimated results from cointegration analysis show that there is no long-run relationship between the two markets. The results from the volatility modelling show that the behaviours of both the stock exchange and the foreign exchange markets are interlinked. The returns of one market are affected by the volatility of the other market. Particularly, the returns of the stock market are sensitive to the returns as well as the volatility of the foreign exchange market. On the other hand, returns in the foreign exchange market are mean-reverting, and they are affected by the volatility of stock market returns. There is a strong relationship between the volatility of the foreign exchange market and the volatility of returns in the stock market.

*Keywords:* Stock Market, Forex Market, EGARCH, Volatility Spillover, Stock Market Returns, Foreign Exchange Return, Pakistan

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## 1. INTRODUCTION

Our paper examines the volatility spillover between the stock market and the foreign exchange market in Pakistan. Pakistan has gone through financial sector reforms during last two decades. The two important outcomes of the financial sector reforms in Pakistan has been the opening up of the stock markets and adoption of flexible exchange rate system. Opening up of the stock markets resulted in a sharp increase in the inflows of portfolio investment. On one side such an investment helps in raising the investable funds and on other side it produced wild swings in the stock exchange market. For example, the Karachi Stock Exchange (KSE)-100 Index increased to 2600 in 1995 but declined sharply to just 878 in 1998. From this low level it crossed 10 thousand mark in early 2005 and by may 2005 it had declined to around 7 thousand mark. It is argued that the volatility is high in the 'bullish' market then the in the 'bear' market.

The exchange rate market over these years has also shown volatility. Since 1998 the Rupee depreciated against Dollar from Rs 43.19 per dollar in 1998 to Rs 61.41 per dollar in 2001-02. However, since then it appreciated against and touched Rs 57.5 per dollar in July-August 2004, but since then it has depreciated to around Rs 60 per dollar.

The relationship between the foreign exchange market and the stock market performance is well established [see, Dornbusch and Fisher (1980), Branson (1983) and Frankel (1983)]. The main objective present study is to explore the relationship between the stock market and the foreign exchange market in Pakistan. In particular we focus on the relationship between the stock market returns and exchange rate returns, and volatility spillovers between the exchange rate returns and stock returns.

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*Acknowledgements.* The authors are thankful to Dr Nadeem Ul Haque, Director, PIDE, for his invaluable suggestions. Further, they are grateful to Dr Usman Mustafa, Lubna Hasan, Saba Anwar, and other participants of the PIDE—Nurturing Minds Seminar Series for their comments and suggestions.

The study is arranged as follows. After this introductory part, Section 2 Overview of the Stock Market and the Foreign Exchange Market. The Section 3 elaborates the methodological framework. The data availability and preliminary data analysis is discussed in Section 4. Cointegration analysis results are presented in Section 5. The results of EGARCH model are contained in Section 6. Final section concludes the study.

## **2. OVERVIEW OF THE STOCK MARKET AND THE FOREIGN EXCHANGE MARKET**

The stock market in Pakistan consists of three stock exchanges, namely the Karachi Stock Exchange (KSE), the Lahore Stock Exchange (LSE) and the Islamabad Stock Exchange (ISE). These markets are established on 1947, 1974, and 1997, respectively. The capital market is regulated by the Security and Exchange Commission of Pakistan (SECP) established in 1997. It has succeeded the Corporate Law Authority established 1994.

Out of the stock exchanges, the Karachi Stock Exchange (KSE) is the main and leading stock exchange. The KSE started functioning with 90 members and 13 listed companies. The growth of the equity market during the decade of 1960s was industrialisation policies pursued by the government of Pakistan. The number of the listed companies has risen to 318 in 1971.

The decade of 1970s started with political turmoil and unrest in the eastern part of the country. The worsening domestic situation in the East Pakistan and war with India disaggregated Pakistan. The out come was the separation of former East Pakistan and emergence of new country Bangladesh. After separation of the East Pakistan in 1971, 60 companies that belonged to that territory were delisted. During 1973-74 the Government nationalised all types of private sector industrial and financial institutions. This policy of nationalisation had eliminated sector out of the country.

On the policy front during the year 1985-86 the policy of nationalisation adopted in 1970s has been reversed. The policy of denationalisation and privatisation of industries and financial

institutions has been formulated. The decade of 1990s witnessed changes in the policies and functioning of the stock market. In the beginning of 1991 significant measures were taken including the opening of the market to international investors; removal of constraints to repatriation on investment proceeds, gains, and dividend; deregulation of economy and allowing commercial banks in the private sector; liberalisation of foreign exchange restrictions and allowing Pakistanis to have foreign currency accounts. The KSE responded positively to these measures and by the end of that year, listing of companies rose to 542. The bullish trends were observed in the first year. In terms of its performance, the market was ranked third in 1991.

The stock market situation is described by the number of market indicators presented in Table 1. As can be seen from the Table, the market was moving slowly during 1980s till the liberalisation in early 1991. The market responded positively to liberalisation measure and unprecedented increase in all indicators was observed in the first year of the opening of the market. The market capitalisation and trading value went up by three times. Further, the local index increased by 133 percent while the increase in international index, IFC return, was 172 percent. In

Table 1

*Preliminary Data Analysis: Summary Statistics*

	EXR	SPI	RX	RS
1. Mean	56.70	3513.51	0.03	0.25
2. Median	58.30	1925.75	0.00	0.37
3. Maximum	64.48	12136.83	5.35	5.66
4. Minimum	46.12	777.26	-1.90	-7.65
5. Std. Dev.	4.81	2924.84	0.37	1.74
6. Skewness	-1.02	1.22	7.04	-0.52
7. Kurtosis	3.06	3.46	109.72	5.36
8. Jarque-Bera	72.15	106.20	199408.20	114.29
9. Probability	0.00	0.00	0.00	0.00
10. ADF Test	-2.03	-1.30	-21.62	-17.67
11. Lung-Box Q <sup>2</sup>	408.16	407.30	0.01	16.27
12. Observations	413	413	413	413

terms of its performance the market was ranked third after Argentina and Columbia during 1991. Nevertheless in terms of listings the market deepened. The new companies (i.e., 86) were listed during the year that helped to increase the turnover of shares and market capitalisation. The market improved significantly in terms of size and activity. As a result, the ratio of market capitalisation to GDP increased from 7 percent to almost 18 percent in the first year of liberalisation and further to 26 percent after two years.

Due to domestic political crisis and a discouraging economic outlook Pakistani equities market collapsed in 1995. Average monthly turnover remained very low and reached US \$266.2 million, while total market capitalisation dropped from 24.3 percent to US \$9.3 billion at end of year. The Karachi Stock Exchange has shown improvement during 1997-98. The listed capital on KSE had increased to 208.8 billion while the turnover of shares more than doubled from 5,707 million shares during 1996-97 to 11,438 in 1998. KSE established a 'Defaulting Companies Counter' in August 1997 for those companies which had committed various defaults under listing regulations of the exchange. By the end of March 1998, the number of companies were reduced to 126 on removing the defaults or offered to buy-back the shares by the sponsors.

The Karachi Stock Exchange introduced a computerised trading system i.e. a KATS (Karachi Automated Trading System) in order to provide a fair, transparent, efficient and cost effective market place for the investors. Due to different measures the number of listed companies rose to 762 in 2000. In addition the listed capital and market capitalisation are 229,314.8 million and 394,445.7 million respectively. After considerable fluctuations it ended at 23.7 percent in 2003. On the other hand, the growth in activity indicated by trading value and turnover ratio was tremendous. Since late 90s the turnover ratio has been phenomenal and increased to almost 500 percent in 2003. As a result Pakistan ranks first in the world in terms of turnover ratio. The KSE has been among the best performing markets for the last two years.

State Bank of Pakistan, under the Foreign Exchange Regulation Act 1947, is responsible to formulate and conduct the exchange rate policy and regulate foreign exchange market. All commercial banks are Authorised Dealers (ADs) of foreign exchange. SPB fixed dollar rate at which it buy and sell US dollars from the ADs. All transactions of foreign exchange are processed through Ads and authorised money changers at given rate.

Pakistan's foreign exchange system has gone through a number changes during the last four decades. Pakistan currency was linked with British pond sterling before 1970. During 1971 the Rupee was de-linked from the Pound and pegged with the US Dollar at the official rate of Rs 4.76 per dollar. Pakistan rupee was devalued by 56.7 percent in terms of gold in 1972. Moreover 4.5 percent fluctuation rage of the currency was also introduced. The Rupee was trading at 11.00 per dollar. During 1981 Pakistan has change fixed exchanged rate system to the managed float system. Where the Rupee is linked to the trade weighted currency basket. During 1991 a comprehensive package of exchange and payment reform was announced. Under the package resident Pakistanis are permitted to open foreign currency accounts (FCA) with banks in Pakistan. Non resident Pakistanis are also allowed invest in the stock market by opening a Special Convertible Rupee Account with AD in Pakistan. In 1991 the Rupee was made convertible to international currency. Pakistani national and firms are given license to act as money changers subject to the payment of prescribed fee. Pakistan government has accepted the obligation of Article VIII, section 2, 3 and 4 of the IMF Articles of Agreement in 1994, which made Pak Rupee convertible on current international transactions.

Multiple exchange rate system was adopted in 1998. It consists of three types of exchange rate such as official exchange rate pegged to the US dollar by SBP, a Floating Inter Bank exchange Rate (FIBR) and composite rate that combines the official and FIBR rates. Further the banks were allowed to quote their own exchange rates for currencies other than dollar and the

rates for US dollar within the State bank of Pakistan buying and selling band. Three tier exchange rate system was change into the unified exchange rate pegged with US dollar in 1999. Under the unified exchange rate system Rupee was allowed to fluctuate within a specified band, that is Rs 52.10 to 52.30 per dollar. In another step the bands from the exchange rate was removed during 2000 and rupees become free to float. It implies that the exchange rate is determined by the market forces.

### 3. METHODOLOGY

The study uses techniques of time series econometrics. First the time series properties of data are investigated. The financial time series, particularly stock market return, are not distributed normally; they generally are assumed highly Kurtic and we hypothesise that they are Leptokurtic. We used tests of skewness, Kurtosis and Jarque-Bera test of normality to test our hypotheses. The Augmented Dickey Fuller (ADF) test of unit roots is used to test stationarity of the data [Dickey and Fuller (1981)]. The volatility of the stock returns and exchange returns is judged by plotting the data.

To test the existence of cointegrating relationship between the stock market prices and the exchange rate we used Engle and Granger (1987) two step method. As a fist step we estimate the long run equation and then apply ADF test on the residual from the cointegrating equation. The Engle-Granger method consists of two equations such as

$$LSPI_t = \alpha + \beta LEXR_t + \varepsilon_t \quad \dots \quad \dots \quad \dots \quad \dots \quad (3a)$$

$$\Delta\varepsilon_t = \rho\varepsilon_{t-1} + \beta_1\Delta\varepsilon_{t-1} + \beta_2\Delta\varepsilon_{t-2} + \dots + \beta_p\Delta\varepsilon_{t-p} + \mu_t \quad \dots \quad (3b)$$

where  $LSPI_t$  is log of stock price index,  $LEXR_t$  is log of nominal exchange rate,  $\varepsilon_t$  is residual from cointegrating equation and  $\mu_t$  is residual from the equation of ADF unit root test which is assumed to be white noise.

Because the tendency of stock prices to be negatively correlated with changes in the stock volatility, therefore, volatility

spillover effect between the two markets, i.e., stock market and foreign exchange market is estimated by utilising ARCH-GARCH methods proposed by Engle (1982). The simple GARCH ( $p, q$ ) model cannot capture the leverage effect. Keeping in view the importance of leverage effect in stock assets returns Bollerslov (1986) and Nelson (1991), amongst others, have developed the Exponential Generalised Autoregressive Conditional Heteroskedecity (EGARCH) model. Braun, *et al.* (1995), Kroner and Ng (1996, 1998), Henry and Sherma (1999) and Engle and Cho (1999) have extended Exponential Generalised Autoregressive Conditional Heteroskedecity (EGARCH) model in bivariate version. The model helps us in the estimation both static as well as dynamic forecast of the mean, forecast standard error and the conditional variance. Apte (2001-02) applied bivariate EGARCH( $p, q$ ) specification to investigate inter-relationship between stock market and foreign exchange market and the volatility spillover effect between these two markets for India.

This paper applies a bivariate EGARCH model to investigate volatility spillover between the stock market and forex markets. The EGARCH( $p, q$ ) model for the stock market is given in the following two equations;

$$RS_t = \alpha_0 + \sum_{i=1}^n \beta_i RS_{t-i} + \sum_{j=0}^m \beta_j RX_{t-j} + \ln \sigma x_{t-1}^2 + \gamma ECS_{t-1} + \varepsilon_t \quad (1a)$$

$$\ln(\sigma s_t^2) = \alpha + \delta_s \ln \sigma s_{t-1}^2 + \theta_s zs_{t-1} + \beta_s (|zs_{t-1}| - E(|zs_{t-1}|)) \\ \ln \sigma x_{t-1}^2 + \theta_x zx_{t-1} + \beta_x (|zx_{t-1}| - E(|zx_{t-1}|)) \quad (1b)$$

Where  $i = 1, 2, \dots, n$  and  $j = 0, 1, \dots, m$   $\varepsilon_t | \Omega_{t-1} \sim N[0, (\sigma s_t)^2]$

The Equation (1a) is vector autoregressive (VAR) model of the conditional mean equation of returns on stock market assets ( $RS_t$ ). It indicates that  $RS_t$  depends on the past values of stock returns ( $RS_{t-i}$ ), the current and past values of foreign exchange returns ( $RX_{t-j}$ ), the error correction term ( $ECS_{t-1}$ ) representing the cointegrating relationship between the stock market prices and exchange rate, and the random variable. The random variable

(i.e.,  $\varepsilon_t$ ) is assumed to have zero mean and conditional variance. Hence the second equation of the model (i.e., Equation 1b) represents the conditional variance of the stock market returns.

The exponential conditional variance of stock market returns (i.e., Equation 1b) assumed to be dependent on the lagged value of innovation of the stock returns and the exchange rate returns, lag of conditional variance of stock market and the terms to capture asymmetric effect. The parameters  $\theta_s$  and  $\beta_s$  capture the last period forecast variance and stock market news effects, respectively. Whereas the parameters  $\beta_x$  and  $\theta_x$  indicates the foreign exchange market's spillover effects on the stock market returns conditional variance. Further, the  $\theta$ 's allow asymmetry in effects of news from the respective market. The estimated parameter of GARCH term that is  $\delta_s$  indicates persistence of volatility in the stock market asset returns.

The  $EGARCH_{(p, q)}$  model for the forex market is given in the following two equations;

$$RX_t = \alpha_0 + \sum_{i=1}^n \beta_i RX_{t-i} + \sum_{j=0}^m \beta_j RS_{t-j} + \ln \sigma_{s_{t-1}}^2 + \gamma ECX_{t-1} + \varepsilon_t \quad (2a)$$

$$\ln(\sigma_{x_t}^2) = \alpha + \delta_x \ln \sigma_{x_{t-1}}^2 + \theta_x zx_{t-1} + \beta_x (|zx_{t-1}| - E(|zx_{t-1}|)) \\ + \ln \sigma_{s_{t-1}}^2 + \theta_s zs_{t-1} + \beta_s (|zs_{t-1}| - E(|zs_{t-1}|)) \quad \dots \quad (2b)$$

Where  $i = 1, \dots, n$  and  $j = 0, 1, \dots, n$   $\varepsilon_t | \Omega_{t-1} \sim N[0, (\sigma_{x_t})^2]$

The Equation (2a) is VAR model of the conditional mean equation of returns on foreign exchange ( $RX_t$ ). The  $RX_t$  is assumed to depend on the past values of foreign exchange rate returns ( $RX_{t-i}$ ), the current and past values of the stock market returns ( $RS_{t-j}$ ) and the error correction term ( $ECX_{t-1}$ ) and random variable. The residual is assumed to have conditional variance. Therefore, the second Equation (2b) represents the conditional variance of returns on foreign exchange market. The exponential conditional variance of the foreign exchange market returns are effected by the lagged value of innovation of exchange rate returns, stock returns and lag of previous period variance and the terms to capture

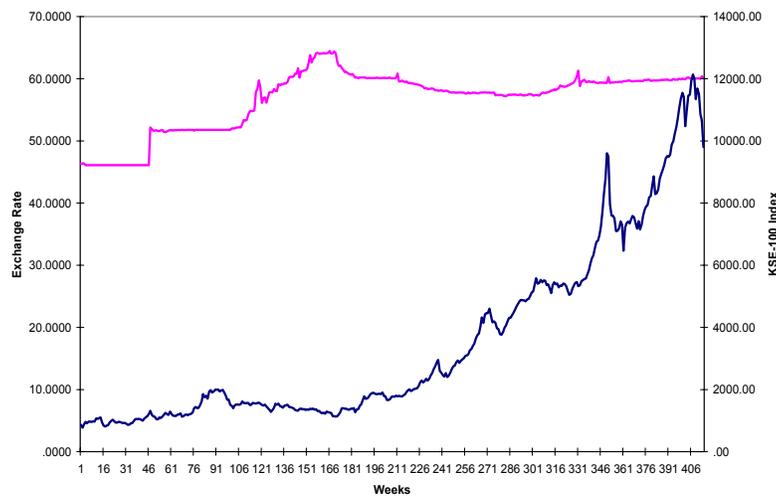
asymmetric effect. The parameters  $\theta_f$  and  $\beta_f$  capture effects of exchange market volatility of foreign exchange returns. The parameters  $\beta_s$  and  $\theta_s$  indicate spillover effect of volatility of stock market on the exchange rate returns, they capture the cross market spillover effects. Moreover, the  $\theta$ 's allow asymmetry in effects. The estimated parameter of GARCH term,  $\delta_x$ , indicates the persistence of volatility.

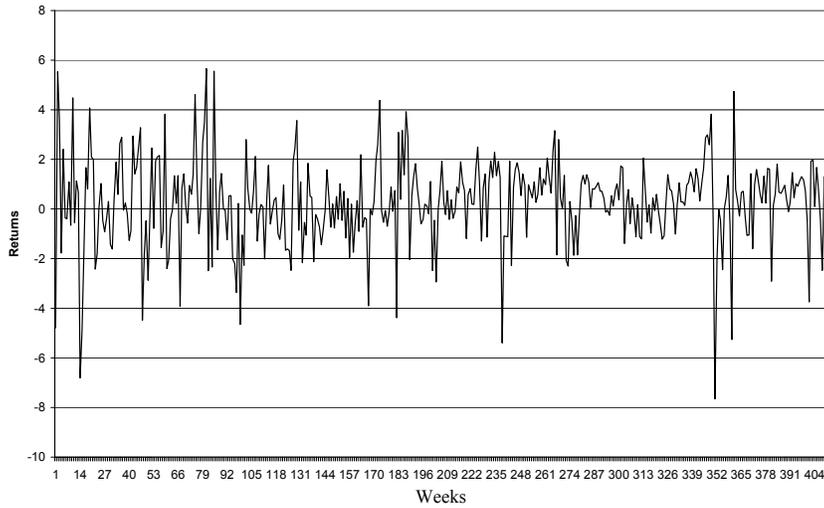
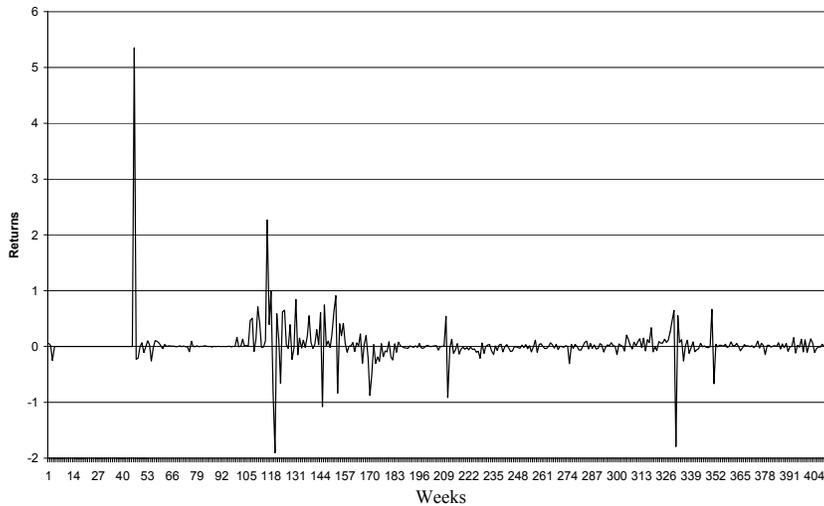
#### 4. PRELIMINARY DATA ANALYSIS

For the analysis we use weekly data from 1st July 1998 to 31 May 2006. The data on stock index (i.e., KSE-100 index) are obtained from the Karachi Stock Exchange and the data on exchange rate that is Rupee per US dollar are obtained from the State Bank of Pakistan.

The data on stock market returns and foreign exchange returns are presented in Figure 1. The Figure 2 indicates the volatility clustering in the stock market returns. A similar result is contained in the weekly Dollar/Rupee exchange rate returns (Figure 3). However, the phenomenon of the volatility clustering is particularly strong in the stock market returns series.

**Fig. 1. KSE-100 Index and Exchange Rate**



**Fig. 2. Return on Stock Prices****Fig. 3. Return on Foreign Exchange**

The summary statistics from preliminary analysis are presented in Table 1. As can be seen from the Table, the data are not normally distributed (see Table 1, row 9). Moreover, all series show skewness. The test of Kurtosis indicates that the series particularly  $RS_t$  and  $RX_t$  are Leptokurtic i.e., they have thick tail.

The ADF test of stationarity indicates that the series of stock market price index ( $LSPI_t$ ) and foreign exchange rate ( $LEXR_t$ ) are not stationary, they have unit root at frequency one (see Table 1, row 10). However, the stock market returns ( $RS_t$ ) and the foreign exchange returns ( $RX_t$ ) series are stationary. Furthermore, Lung-Box  $Q^2$  test (which have chi-square distribution) indicates the presence of Autoregressive Conditional Heteroscedasticity (ARCH) in the stock markets returns.

## 5. COINTEGRATION ANALYSIS

Before estimating the specified bivariate EGARCH model it is necessary to check a possible long run relationship between the series. This step leads to decide whether error correction term be included into the model or not. The long run relationship between the stock prices and the exchange rate is investigated by applying Engle-Granger (1987) two step method. In the first step the stock market prices are regressed on the foreign exchange rate and the results are presented below ( $t$ -statistics are in parentheses).

$$LSPI_t = 17.18 + 0.007 T - 2.69 LEXR_t \quad \dots \quad \dots \quad (4)$$

(35.25) (64.98) (-21.65)

$R$ -squared 0.94  $F$ -statistic 2703.8  $ADF$  -2.79 (-3.81)

As a second step we tested the presence of cointegrating relationship between the two variables by applying the ADF test of unit roots on the residual obtained from the cointegrating equation. The results indicate that there is unit root in the residual series. This implies that the two series are not cointegrated for the period under analysis. The result of this study is consistent with Granger, *et al.* (2000), Nieh and Lee (2001) and Smith and Nandha (2003). The finding of no cointegration between the stock prices and the exchange rate has clear methodological implications. This leads us to estimate the EGARCH model without error correction term in the conditional mean equations.

## 6. EGARCH MODEL OF STOCK RETURNS

The bivariate EGARCH model is estimated by the Maximum Likelihood Method proposed by Bollerslov and Wooldridge (1992). The results are presented in the Table 2.

Table 2

### *Results of the Multivariate EGARCH Model*

Variables	RS <sub>t</sub>	t-statistics	RX <sub>t</sub>	t-statistics
<b>Conditional Mean</b>				
Constant	-0.31	-4.97	-0.01	-2.26
RS <sub>t-1</sub>	0.21	3.58	-	-
RX <sub>t-1</sub>	-0.59	-3.96	-	-
T	-	-	-0.0001	-2.69
ln σ <sup>2</sup> <sub>t-1</sub>	-	-	-0.002	-3.02
ln σ <sup>2</sup> <sub>x,t-1</sub>	-0.03	-5.02	-	-
<b>Conditional Variance</b>				
Constant	0.37	0.09	-9.53	-12.09
ln σ <sup>2</sup> <sub>t-1</sub>	0.87	20.02	-0.20	-1.66
zS <sub>t-1</sub>	0.03	0.59	0.44	10.78
( zS <sub>t-1</sub>   - ( zS <sub>t-1</sub>  ))	0.45	5.58	-0.27	-3.13
ln σ <sup>2</sup> <sub>x,t-1</sub>	0.16	0.4	0.16	2.95
zX <sub>t-1</sub>	-0.16	-2.07	-0.13	-1.68
( zX <sub>t-1</sub>   - E( z <sub>x,t-1</sub>  ))	-0.04	-0.39	0.3	2.96

As can be seen from the Table, there is significant price spillover from the forex market to the stock market. It implies that appreciation of the currency drags down stock prices in Pakistan. However, there is no evidence of price spillover from the stock market to the forex market. The results imply that the changes in the exchange rate movement signal important information about the future stock prices movements. Whereas stock prices movement has no information about the exchange rate.

The estimated conditional variance equations (Table 2) indicate that there exists volatility spillover from the stock markets to the foreign exchange market. Whereas there is no volatility spillover from foreign exchange market to the stock market in Pakistan.

Further it can be said that the news about the volatility of foreign exchange market has asymmetric impact on the volatility of stock returns. The significance of ARCH term from stock market returns also indicates that news impact on the volatility of foreign exchange returns is asymmetric.

The parameter  $\theta$  in the models measures asymmetric impact of innovation. If  $\theta$  is negative, a negative innovation tends to reinforce the size effect, while a positive innovation tends to partial out. Therefore a significant and negative  $\theta$  provides evidence of asymmetry. The relative importance of negative innovation to positive innovations in the volatility process is measured by the ratio  $|-1+\theta|/(1+\theta)$ .

We also measured the volatility persistence of stock prices and exchange rate. The volatility shocks in the stock markets lasted for 5 weeks and in the foreign exchange market it lasted within one week. This result is based on the assumption of half life of a shock.

By using estimated bivariate EGARCH model we perform simulation on the different impacts of good and bad news on the cross market spillover.

## 7. CONCLUSIONS

We have investigated the linkage between the stock market and the foreign exchange market of Pakistan. For this purpose first we use Engle Granger two step procedure and the returns are modelled by bivariate EGARCH method. The estimated results from cointegration analysis show that there is no long run relationship between the two markets.

The results from the volatility modelling are interesting. The behaviour of both the stock exchange and the foreign exchange markets are interlinked. The returns of one market are affected by the volatility of other market. Particularly the returns of stock market are sensitive to the returns as well as the volatility of foreign exchange market. On the other hand returns in the foreign exchange market are mean reverting and they are affected by the volatility of stock market returns. There is strong relationship

between the volatility of foreign market and the volatility of returns in stock market. It implies the existence of volatility spillover between the markets in Pakistan.

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