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STOCK RETURNS VOLATILITY IN AN EMERGING MARKET: The Pakistani Evidence

Fazal HUSAIN and Jamshed UPPAL

This paper examines stock returns volatility in the Pakistani equity market. Using daily stock prices of 36 companies, 8 sector indices, and a market index, the AutoRegressive Conditional Heteroscedasticity (ARCH) class of models were applied. The analyses suggest that one of the factors causing high serial dependence in stock returns in the Pakistani equity market is the presence of conditional heteroscedasticity or volatility in stock returns and that even after controlling for volatility the returns in the market are, in general, predictable. The results show GARCH (1, 1) to be an appropriate representation of conditional variance implying that current volatility in the market is significantly affected by past volatilities. There is also strong evidence of persistence in variance in returns implying that shocks to volatility continue for a long period. However, after accounting for the structural shift due to opening of the market, the persistence was found to decline significantly.

I. Introduction

A common characteristic of stock returns behavior observed in empirical studies is the clustering of stock price changes, that is, large price changes tend to be followed by large changes while small changes are followed by small ones. In the presence of this characteristic, known as volatility clustering, any conclusion regarding the efficiency of the market must be interpreted with caution. This is particularly vital in the case of emerging markets which are, in general, found to be inefficient in the sense that these markets are predictable. However, the extent of inefficiency may be overestimated as these markets are also more volatile. It is, therefore, suggested in the literature, e.g., Errunza et al. (1994) that efficiency tests should be conducted after controlling for volatility.

Volatility clustering is found to be successfully explained by the class of AutoRegressive Conditional Heteroscedasticity (ARCH) models which impose an autoregressive structure on conditional variance that permits volatility shocks to persist over time. The ARCH process and its various generalizations, particularly Generalized ARCH (GARCH) have been used extensively to study stock market

volatility. For example, French, Schwert, and Stambaugh (1987); Chou (1988); Akgiray (1989); Baillie and DeGennaro (1990); etc., used GARCH models to examine stock returns volatility in the U.S. capital market. Similarly, Poon and Taylor (1992) and Jong, Kemna, and Kloek (1992) applied these models in the U.K. and Dutch capital markets respectively. Corhay and Rad (1994) extended the ARCH framework to the European capital markets whereas, Errunza, Hogan, Kim, and Padmanabhan (1994) examined the ARCH effects in some of the developed and emerging markets.[1]

These studies show the presence of significant ARCH effects in daily stock returns. However, in the case of monthly returns these effects are found in emerging markets but not in developed markets. Further, GARCH (1, 1) is found to be an adequate representation of the process generating returns implying that current volatility is significantly affected by past volatilities. The evidence suggests that stock returns in emerging markets are predictable even after controlling for ARCH effects.

This paper attempts to extend the ARCH framework to the Pakistani equity market that has been the subject of significant changes in recent years. Like other developing nations, Pakistan has also taken significant steps toward development of its capital market. Measures have been taken for privatization, economic liberalization, relaxation of foreign exchange controls, and easing of regulations on repatriation of profits, investment and operations of financial institutions. The most significant step was opening of the equity market to international investors in February 1991.

The paper is organized as follows. The next section describes the data and the sample. Section III discusses the methodology, whereas, empirical results are evaluated in Section IV. The final section consists of the summary, conclusions and policy implications.

II. Data and Sample

The data consist of 36 individual stocks, 8 sector indices and a market index, covering the period from January 1, 1989 to December 30, 1993. Information on individual stocks regarding closing prices, volumes, dividends (cash and stock), and rights issues were collected from the Exchange (KSE), the Securities and Exchange Commission (a body that regulates stock exchanges in Pakistan), and the Business Recorder (a daily newspaper).

[1] The markets studied by Corhay and Rad are France, Germany, Italy, the Netherlands, and U.K. whereas Errunza et al. studied Canada, France, Germany, Italy, Japan, U.K. and U.S. as developed markets and Argentina, Brazil, Chile, Greece, India, Korea, Mexico, and Thailand as emerging markets.

The data on sector indices as well as on the market index were obtained from the files of the State Bank of Pakistan, the Central Bank, that prepares and maintains these indices. The market index, called the State Bank General Price Index, covers all the stocks listed on the exchange and therefore provides a complete representation of the market.

The analysis was done for the full sample period as well as for three sub-samples to examine the impact of liberalization measures, particularly the opening of the market to international investors, announced on February 7, 1991. The first sub-sample consists of the period before the market was opened.

The market became bullish after its opening and unprecedented trends were observed. It appears, however, that the market overreacted in that period because it was followed by the period that may be called a correction phase [International Finance Corporation (1993)]. This first year of the opening of the market, characterised by overreaction and/or correction phase, constitutes the second sub-sample period. Finally, the third sub-sample consists of the period from one year after opening of the market to the end of the sample period.

III. Methodology

The ARCH process imposes an autoregressive structure on conditional variance that permits volatility shocks to persist over time. The general form of the model, denoted by ARCH(p), is:

$$Y_t = X_t\beta + e_t \tag{1}$$

$$e_t | \psi_{t-1} \sim N(0, h_t) \tag{2}$$

$$h_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i e^2_{t-i} \tag{3}$$

where the dependent variable, Y_t, is modelled as a linear function of explanatory variables, X_t's, and β is a vector of regression parameters. The error term, e_t, conditional to ψ_{t-1}, is assumed to be distributed normally with mean zero and variance h_t, where ψ_{t-1} represents all available information at time t-1. The conditional variance, h_t, is supposed to be a linear function of p past squared errors.

Bollerslev (1986) generalized the ARCH process by allowing the conditional variance to be the linear function of q lagged conditional variances in addition to p past squared errors. In other words GARCH(p, q) implies the following form of the conditional variance:

$$h_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i e^2_{t-i} + \sum_{j=p+1}^{q} \alpha_j h_{t-j} \tag{4}$$

The parameters of the model are estimated by using non-linear estimation techniques such as Berndt-Hall-Hall-Hausman algorithm, that involves recursive calculation of the variance, h_t. The orders of p and q are identified by applying Box-Jenkins identification techniques.

The ARCH models are applied to stock returns in this paper to examine volatility in the Pakistani equity market. However, an ARCH model requires certain conditions to be met before its application. The first condition is that the series to be analyzed must be stationary. The stock returns, calculated as the first log difference, are expected to be stationary. Nevertheless, unit root tests are performed on all stocks and indices which confirmed the stationarity of the series in all cases.

The second condition requires that the error term in the regression equation should be white noise, that is, should be serially independent. This implies that if stock returns exhibit serial dependence, they should be removed. One way is to identify the AutoRegressive Moving Average (ARMA) process that can explain the autocorrelation structure of stocks by using autocorrelation and partial autocorrelation functions of stocks. Significant values in autocorrelation functions indicate a MA process whereas significant values in partial autocorrelation functions imply an AR process. The combination of AR and MA (ARMA) is also possible. Husain and Forbes (1999), while analyzing the same data set, report strong serial dependence in stock returns that has to be removed. Therefore, the autocorrelation and partial autocorrelation functions of all stocks and indices are obtained to identify an ARMA process. These functions suggest that stock returns in the Pakistani market generally follow an AR process.

Finally, after removing the serial dependence one can apply a diagnostic procedure to test for the presence of ARCH effects in the series. The test used in this study is the Ljung-Box Q statistic for squared residuals. Significant Q values imply the presence of ARCH effects. After accounting for the above conditions the following GARCH model was estimated:

$$R_t = \beta_0 + \sum_{i=1}^{k} \beta_i R_{t-i} + e_t \tag{5}$$

$$e_t \mid \Psi_{t-1} \sim N(0, h_t) \tag{6}$$

$$h_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i e^2_{t-i} + \sum_{j=p+1}^{q} \alpha_j h_{t-j} \tag{7}$$

where the return is modelled as an autoregressive process of order k, which is determined by the Ljung-Box Q values of the residuals. Similarly, the orders of p and q in the variance equation are determined by the Ljung-Box Q values of the normalized squared residuals, e^2_t / h_t.

In order to examine the effects of opening of the market, dummy variables, D1 and D2, are included in both the return and the variance (h_t) equations, where:

D1 = one for sample II and zero otherwise (February 91 – February 92).
D2 = one for sample III and zero otherwise (March 92 – December 93).

A useful analysis in the ARCH framework is to find persistence in variance, referring to the property of momentum in conditional variance, that is, how permanent is a shock to volatility, [Lamoureux and Lastrapes, (1990)]. It is measured by the sum of parameters in the variance equation, that is, $\Sigma \alpha_i + \Sigma \alpha_j$. The closer is the sum to unity the greater is the persistence of shock to volatility.

A related aspect to the concept of persistence is the concept of Half Life (HL) of volatility shocks, which measures the number of days over which a shock to volatility diminishes to half its original size, [Lamoureux and Lastrapes, (1990)]. HL is measured as:

$$HL = 1 - [\log 2 / \log \lambda]$$

where λ is the sum of parameters in the variance equation. HL are found for all stocks and indices.

Finally, the persistence in variance and HL are estimated again after incorporating dummy variables (defined above) to test the Lamoureux and Lastrapes (1990) hypothesis that persistence in variance declines if shifts in variance are accounted for.

IV. Empirical Results

As mentioned above, the ARCH models require that the series to be analyzed should be serially independent. Since Husain and Forbes (1999) found the presence of strong serial dependence which has to be removed before the application of ARCH models, the first step is to estimate autocorrelation and partial autocorrelation functions for all stocks and indices. An analysis of autocorrelation structure of these series suggested the presence of autoregressive (AR) processes (of various orders) in the series. Hence the AR processes are applied to all the series to remove the serial dependence.

Table 1 shows the AR processes for individual stocks and indices. The orders of process are determined by examining the Ljung-Box Q statistics. The insignificant values of Ljung-Box Q statistics indicate that the AR processes have adequately removed the serial dependence from all stocks and indices. It can be noted that the number of lags for AR processes is generally higher in indices indicating that serial dependence is much higher in indices. As discussed in Husain and Forbes (1999) the presence of higher serial dependence appears to be due to the

TABLE 1

Auto Regressive Processes by Indices and Securities***

	C*100	LAG1	LAG2	LAG3	LAG4	LAG5	LAG6	LAG7	LAG8
GENERAL INDEX	0.118*	0.264**	–	0.078**	0.062*	–	–	0.086**	–
SECTOR INDICES									
1. TEXT	0.067	0.221**	–	0.065*	–	0.067*	–	–	0.087**
2. CHEM	0.134**	0.301**	0.091**	0.075*	–	–	–	–	–
3. SUGAR	0.051	0.103**	0.152**	0.095**	0.088**	–	–	–	–
4. PAPER	0.080	0.181**	0.077**	–	–	-0.083**	0.096**	–	–
5. CEMENT	0.160**	0.178**	0.140**	0.075*	–	–	–	–	–
6. FUEL	0.149**	0.226**	–	0.127**	–	–	–	–	–
7. TRANS	0.052	0.083**	–	–	–	–	0.072*	–	–
8. INSUR	0.086	0.161**	–	0.062*	–	0.093**	–	–	–
SECURITIES									
1. GRINDL	0.163*	0.101**	–	–	–	–	–	–	–
2. LTVC	–	–	–	–	–	–	–	–	–
3. NDLC	0.184**	0.063*	–	–	–	–	–	–	–
4. PICIC	0.136*	0.209**	–	–	–	–	–	–	–
5. ADAMJEE	0.277**	0.239**	–	–	–	–	–	–	–
6. SHAHM	0.120	0.193**	–	–	–	–	–	–	–
7. SHAKER	0.067	0.138**	0.125**	–	–	–	–	–	–
8. PAKLA	0.231*	0.208**	–	–	–0.082**	–	–	–	–
9. PAKT	0.171**	0.090**	–	–	–	–	–	–	–
10. KESC	0.133	0.160**	–	–0.075*	–0.091**		–	–	–
11. NATR	0.198*	0.274**	–	–	–	–	–	–	–

(continued)

TABLE 1 (continued)

	C*100	LAG1	LAG2	LAG3	LAG4	LAG5	LAG6	LAG7	LAG8
12. PSO	0.233**	0.107**	0.056	0.078**	–	–	–	–	–
13. SUIN	0.194*	0.159**	–	–	–	–	–	–	–
14. SUIS	0.172	0.258**	–	–	–	–	–	–	–
15. GENT	0.231**	0.158**	–	–	–	–	–	–	–
16. MILLT	0.104	0.192**	0.070*	–	–	–	–	–	–
17. PAKSU	0.073	0.207**	–	–	–	–	–	–	–
18. PHILI	0.194**	0.115**	0.079**	–	–	–	–	–	–
19. PNSC	0.106	0.089**	–	–	–	–	–	–	–
20. ABBOTT	0.133*	0.131**	0.168**	0.156**	–	–	–	–	–
21. DAWOOD	0.081	0.219**	–	0.110**	–	–	–	–	–
22. ENGRO	0.155*	0.245**	0.110**	–	–	–	–	–	–
23. GLAXO	0.168**	0.265**	0.117**	–	–	–	–	–	–
24. HOECHT	0.181**	0.177**	0.078**	–	–	–	–	–	–
25. ICI	0.179*	0.102**	–	–	–	–0.071*	–	–	–
26. RECKI	0.139	0.203**	0.149**	–	–	–	–	–	–
27. WELLC	0.175*	0.185**	0.087**	–	–	–	–	–	–
28. WYTH	0.138**	0.236**	0.144**	0.062*	–	–	–	–	–
29. PACK	0.177**	0.174**	0.130**	–	–	–	–	–	–
30. BATA	0.080	0.196**	–	0.087**	–	–	–	–	–
31. BROOK	0.193**	0.335**	0.141**	–	–	–	–	–	–
32. LEVER	0.200**	0.230**	–	–	–	–	–	–	–
33. MILK	0.143	0.231**	0.228**	0.095**	–	–	–	–	–
34. RAFHAN	0.189**	0.176**	0.089**	–	–	–	–	–	–
35. SHEZ	0.138**	0.164**	–	–	–	–	–	–0.104**	–
36. BALOCH	0.134*	–	–	–0.081**	–	–	–	–	–

(continued)

TABLE 1 (continued)

	LAG9	LAG10	LAG11	LAG12	LB(5)	LB(10)	LB(20)	LB*2(10)	LB*2(20)
GENERAL INDEX	–	0.078**	–	0.073*	0.82	6.21	22.90	242.46**	366.39**
SECTOR INDICES									
1. TEXT	–	–	–	–	2.77	9.32	27.04	121.73**	143.10**
2. CHEM	–	–	–	–	4.78	8.50	27.01	175.56**	206.88**
3. SUGAR	–	–	–	–	3.76	6.63	16.67	19.30*	23.72
4. PAPER	–	–	0.094**	–	2.32	7.50	24.54	142.26**	248.47**
5. CEMENT	–	–	–	–	5.69	8.57	27.26	133.24**	195.88**
6. FUEL	–	–	–	–	0.59	11.76	18.54	318.06**	386.99**
7. TRANS	–	–	–	–	5.49	9.01	25.00	133.06**	280.47**
8. INSUR	–	0.075*	–	–	2.18	5.12	28.55	177.32**	231.60**
SECURITIES									
1. GRINDL	–	–	–	–	1.80	7.88	22.50	35.08**	61.22**
2. LTVC	–	–	–	–	1.74	9.86	23.25	56.05**	110.72**
3. NDLC	–	–	–	–	7.25	14.70	19.84	150.22**	180.73**
4. PICIC	–	–	–	–	7.48	15.29	21.81	272.22**	292.44**
5. ADAMJEE	–	–	–	–	6.02	11.16	19.92	151.46**	177.32**
6. SHAHM	–	–	–	–	4.72	10.85	26.00	181.86**	210.92**
7. SHAKER	–	–	–	–	3.25	8.02	21.46	31.65**	53.75**
8. PAKLA	–	–	–0.054	–	5.13	11.24	28.17	138.29**	197.40**
9. PAKT	–	–	–	–	1.56	10.73	30.40	61.56**	100.80**
10. KESC	–	–	–	–	0.99	4.81	23.74	375.19**	612.22**
11. NATR	–	–	–	–	0.26	10.30	14.73	104.20**	113.83**

(continued)

TABLE 1 (continued)

	LAG9	LAG10	LAG11	LAG12	LB(5)	LB(10)	LB(20)	LB*2(10)	LB*2(20)
12. PSO	–	–	–	–	1.13	8.56	34.69*	124.49**	181.82**
13. SUIN	–	–	–	–	3.91	11.80	35.59*	254.47**	369.44**
14. SUIS	–	–	–	–	5.12	8.19	23.44	131.55**	136.84**
15. GENT	–	–	–	–	7.18	10.05	20.21	114.54**	138.49**
16. MILLT	–	–	–	–	7.72	11.66	27.85	112.93**	114.47**
17. PAKSU	–	–	–	–	1.07	6.05	15.64	55.35**	72.94**
18. PHILI	–	–	–	–	0.25	1.96	27.28	42.26**	56.19**
19. PNSC	–	–	–	–	1.50	8.53	20.05	46.89**	72.22**
20. ABBOTT	–	–	–	–	3.76	14.24	27.07	46.38**	56.85**
21. DAWOOD	–	–	–	–	2.65	5.55	21.57	44.71**	75.05**
22. ENGRO	–	–	–	–	5.00	12.07	21.06	123.27**	280.74**
23. GLAXO	–	–	–	–	8.43	13.40	15.82	50.88**	68.16**
24. HOECHT	–	–	–	–	5.21	10.89	17.61	68.71**	73.63**
25. ICI	–	–	0.074*	–	5.28	13.75	33.33*	558.20**	862.66**
26. RECKI	–	–	–	–	2.11	5.86	24.41	153.13**	166.83**
27. WELLC	0.067	–	–	–	3.90	9.23	31.40	103.11**	130.59**
28. WYTH	–	–	–	–	5.85	13.05	24.64	127.68**	208.07**
29. PACK	–	–	–	–	5.28	13.32	27.00	143.32**	201.01**
30. BATA	–	–	–	–	6.88	10.67	24.59	59.01**	67.49**
31. BROOK	–	–	–	–	8.90	16.59	27.64	84.97**	90.49**
32. LEVER	–	–	–	–	8.93	13.78	28.23	57.66**	64.29**
33. MILK	–	–	–	–	0.99	8.25	15.15	101.91**	132.74**
34. RAFHAN	–	–	–	–	6.04	12.95	21.40	26.32**	41.20**
35. SHEZ	–	–	–	–	5.28	7.84	22.64	146.94**	174.66**
36. BALOCH	–	–	–	–	2.68	11.36	13.34	113.76**	128.76**

Note: ***Sample Period (January 1989 - December 1993), **and *indicate significance level at 1 per cent, and 5 per cent respectively.
LB(k) is the Ljung – Box statistics.

inclusion of inactive stocks as well as due to the presence of the cross correlations among stock returns in indices.

Table 1 also reports the Ljung-Box Q statistics for squared residuals from AR processes. The significant values of Q suggest that although the AR processes have adequately removed the linear dependence from stock returns, the nonlinear dependence is still there. The presence of nonlinear dependence suggests that the ARCH and GARCH models may be more appropriate. In contrast to AR models, where the variance of error term is assumed to be constant, in ARCH/GARCH models, the variance is assumed to be a linear function of past squared errors and/or past conditional variances.

Table 2 shows results of estimating ARCH and GARCH models. The insignificant values of LB*2 suggest that the ARCH and GARCH models have adequately accounted for the conditional heteroscedasticity. Further GARCH (1, 1) that is, one lag for squared residuals and one lag for conditional variance, is found to be appropriate for most of the stocks and indices. This specification is consistent with empirical findings by other researchers. Of the parameters of the GARCH model, the coefficients of lagged variance are found to be significant and higher in magnitude, which indicate that the current volatility is significantly affected by past volatilities.

Table 2 shows that after controlling for conditional heteroscedasticity (i.e., volatility) in stock returns, the coefficients for higher lags in the AR processes have become insignificant. This result strengthens the empirical observation that one of the factors causing high serial dependence in stock returns is the volatility in stock returns and that the serial dependence is reduced if this volatility is accounted for. However, after controlling for volatility the lower lags of the AR processes are still significant indicating that the returns in the market, in general, are predictable.

In order to find the persistence in variance, that is, how permanent is a shock to volatility, the sums of the ARCH and GARCH parameters are computed and are reported in Table 3. It can be seen that these sums are generally very close to one, suggesting substantial persistence in variance. The sum is greater than one for some stocks and indices including the General Market Index. For these cases the persistence should be considered very large indicating that shocks to volatility do not decay overtime.

Table 3 also reports the half life of volatility shocks. The half life for the average sum across indices is 5.6 days and across stocks is 7.4 days. The half life of the General Market Index as well as for some stocks cannot be computed because in these cases, the sum of the parameters exceeds one.

In order to examine the effects of the opening of the market on the volatility as well as on the persistence, dummy variables, D1 and D2 for Samples II and III respectively, are introduced in both the return and the variance equations. However, for the sake of simplicity only the results of the variance equation are reported in Table 4. The generally significant and positive values of dummies indicate that

TABLE 2

GARCH Processes by Indices and Securities***

	RETURNS									
	C*10000	LAG1	LAG2	LAG3	LAG4	LAG5	LAG6	LAG7	LAG8	LAG9
GENERAL INDEX	0.905	0.282**	–	0.072*	0.044	–	–	–0.040	–	–
SECTOR INDICES										
1. TEXT	1.608	0.324**	–	0.035	–	0.036	–	–	0.056*	–
2. CHEM	4.521*	0.329**	0.142**	0.053	–	–	–	–	–	–
3. SUGAR	–1.033	0.196**	0.126**	0.079**	0.090**	–	–	–	–	–
4. PAPER	1.217	0.165**	0.056	–	–	–0.055	0.054*	–	–	–
5. CEMENT	0.058	0.107**	0.104**	0.070*	–	–	–	–	–	–
6. FUEL	0.869	0.269**	–	0.039	–	–	–	–	–	–
7. TRANS	–11.080**	0.048	–	–	–	–	–0.023	–	–	–
8. INSUR	4.987*	0.175**	–	0.097**	–	0.097**	–	–	–	–
SECRITIES										
1. GRINDL	9.540	0.116**	–	–	–	–	–	–	–	–
2. LTVC	–	–	–	–	–	–	–	–	–	–
3. NDLC	12.210**	0.079**	–	–	–	–	–	–	–	–
4. PICIC	–2.207	0.230**	–	–	–	–	–	–	–	–
5. ADAMJEE	16.666**	0.222**	–	–	–	–	–	–	–	–
6. SHAHM	4.039	0.214**	–	–	–	–	–	–	–	–
7. SHAKER	1.888	0.220**	0.178**	–	–	–	–	–	–	–
8. PAKLA	5.174	0.185**	–	–	–0.064*	–	–	–	–	–
9. PAKT	8.917**	0.110**	–	–	–	–	–	–	–	–
10. KESC	4.619	0.173**	–	–0.091**	–0.053	–	–	–	–	–
11. NATR	0.344	0.247**	–	–	–	–	–	–	–	–
12. PSO	11.560**	0.181**	0.018	–0.015	–	–	–	–	–	–

(continued)

TABLE 2 (continued)

	RETURNS									
	C*10000	LAG1	LAG2	LAG3	LAG4	LAG5	LAG6	LAG7	LAG8	LAG9
13. SUIN	8.202*	0.243**	–	–	–	–	–	–	–	–
14. SUIS	–3.666	0.296**	–	–	–	–	–	–	–	–
15. GENT	9.539	0.233**	–	–	–	–	–	–	–	–
16. MILLT	6.921	0.209**	0.060	–	–	–	–	–	–	–
17. PAKSU	0.833	0.170**	–	–	–	–	–	–	–	–
18. PHILI	9.860**	0.154**	0.155**	–	–	–	–	–	–	–
19. PNSC	0.215	0.113**	–	–	–	–	–	–	–	–
20. ABBOTT	3.125	0.188**	0.302**	0.143**	–	–	–	–	–	–
21. DAWOOD	–1.950	0.359**	–	0.092*	–	–	–	–	–	–
22. ENGRO	4.953	0.252**	0.140**	–	–	–	–	–	–	–
23. GLAXO	7.668**	0.339**	0.125**	–	–	–	–	–	–	–
24. HOECHT	10.211**	0.201**	0.148**	–	–	–	–	–	–	–
25. ICI	12.910**	0.070*	–	–	–	–0.010	–	–	–	–
26. RECKI	5.953	0.323**	–	–	–	–	–	–	–	–
27. WELLC	0.213	0.442**	0.013	–	–	–	–	–	–	0.039
28. WYTH	6.729**	0.301**	0.307**	0.066**	–	–	–	–	–	–
29. PACK	9.061**	0.205**	0.136**	–	–	–	–	–	–	–
30. BATA	7.021**	0.348**	–	0.059	–	–	–	–	–	–
31. BROOK	8.927**	0.394**	0.126**	–	–	–	–	–	–	–
32. LEVER	10.617*	0.302**	–	–	–	–	–	–	–	–
33. MILK	1.666	0.220**	0.183**	0.157**	–	–	–	–	–	–
34. RAFHAN	11.146**	0.242**	0.160**	–	–	–	–	–	–	–
35. SHEZ	9.567*	0.238**	–	–	–	–	–	–0.059*	–	–
36. BALOCH	6.050	–	–	–0.065	–	–	–	–	–	–

(continued)

TABLE 2 (continued)

	CONDITIONAL VARIANCE								
	LAG10	LAG11	LAG12	C*10000	e(–1)*2	e(–2)*2	h(–1)	LB*2(10)	LB*2(20)
GENERAL INDEX	0.025	–	0.029	0.009**	0.307**	–	0.724**	9.55	22.09
SECTOR INDICES									
1. TEXT	–	–	–	0.038**	0.315**	–	0.666**	5.13	11.34
2. CHEM	–	–	–	0.250**	0.225**	0.272**	–	5.69	14.74
3. SUGAR	–	–	–	0.267**	0.657**	–	–	1.57	10.41
4. PAPER	–	0.032	–	0.085**	0.180**	–	0.731**	2.83	14.33
5. CEMENT	–	–	–	0.167**	0.471**	–	0.469**	2.26	12.12
6. FUEL	–	–	–	0.140**	0.448**	–	0.506**	5.57	11.74
7. TRANS	–	–	–	0.084**	0.179**	–	0.829**	8.52	17.53
8. INSUR	0.013	–	–	0.099**	0.310**	–	0.625**	6.00	8.97
SECRITIES									
1. GRINDL	–	–	–	0.470**	0.182**	–	0.735**	6.43	16.50
2. LTVC	–	–	–	0.286**	0.064**	–	0.906**	4.44	7.35
3. NDLC	–	–	–	0.079**	0.195**	–	0.826**	6.97	10.08
4. PICIC	–	–	–	0.451**	0.350**	–	0.559**	7.45	21.74
5. ADAMJEE	–	–	–	0.302**	0.129**	–	0.786**	3.05	6.20
6. SHAHM	–	–	–	0.391**	0.433**	–	0.519**	5.38	7.72
7. SHAKER	–	–	–	1.211**	0.442**	0.139**	–	8.97	15.08
8. PAKLA	–	–0.023	–	1.121**	0.308**	–	0.547**	3.39	8.51
9. PAKT	–	–	–	0.612**	0.697**	–	0.366**	2.87	22.08
10. KESC	–	–	–	0.176**	0.325**	–	0.702**	7.49	18.88
11. NATR	–	–	–	0.317**	0.425**	–	0.602**	3.99	9.06
12. PSO	–	–	–	0.062**	0.187**	–	0.816**	7.82	13.67

(continued)

TABLE 2 (continued)

	CONDITIONAL VARIANCE								
	LAG10	LAG11	LAG12	C*10000	e(–1)*2	e(–2)*2	h(–1)	LB*2(10)	LB*2(20)
13. SUIN	–	–	–	2.430**	0.667**	0.265**	–	2.26	21.81
14. SUIS	–	–	–	0.183**	0.439**	–	0.696**	5.89	11.21
15. GENT	–	–	–	0.478**	0.175**	–	0.721**	6.43	14.83
16. MILLT	–	–	–	0.696**	0.541**	–	0.409**	2.45	15.38
17. PAKSU	–	–	–	0.170**	0.097**	–	0.879**	8.25	12.57
18. PHILI	–	–	–	0.999**	0.341**	–	0.353**	3.40	20.35
19. PNSC	–	–	–	2.191**	0.142**	–	0.727**	4.58	14.57
20. ABBOTT	–	–	–	0.081**	0.496**	–	0.640**	3.14	7.19
21. DAWOOD	–	–	–	0.653**	0.538**	–	0.332**	7.36	15.35
22. ENGRO	–	–	–	0.078**	0.170**	–	0.824**	12.30	15.88
23. GLAXO	–	–	–	0.207**	0.309**	–	0.576**	2.39	11.75
24. HOECHT	–	–	–	0.656**	0.336**	–	0.433**	15.77	20.92
25. ICI	–	0.040	–	0.062**	0.100**	–	0.889**	4.00	6.25
26. RECKI	–	–	–	0.203**	0.142**	–	0.798**	6.03	9.80
27. WELLC	–	–	–	0.262**	0.404**	–	0.632**	8.52	15.76
28. WYTH	–	–	–	0.371**	0.640**	0.342**	–	4.52	24.33
29. PACK	–	–	–	0.079**	0.190**	–	0.782**	7.99	11.84
30. BATA	–	–	–	0.292**	0.420**	–	0.465**	6.82	17.43
31. BROOK	–	–	–	0.490**	0.305**	–	0.360**	4.09	8.03
32. LEVER	–	–	–	0.758**	0.312**	–	0.369**	5.23	7.41
33. MILK	–	–	–	0.171**	0.260**	–	0.665**	1.94	10.22
34. RAFHAN	–	–	–	0.964**	0.314**	0.044*	–	7.00	20.70
35. SHEZ	–	–	–	0.258**	0.249**	–	0.643**	8.44	12.81
36. BALOCH	–	–	–	2.066**	0.335**	–	0.307**	4.82	24.90

Note: ***Sample Period (January 89 – December 93), **and *indicate significance level at 1 per cent and 5 per cent respectively.
LB(k) is the Ljung – Box statistic.

TABLE 3

Persistence in Variance***

	C*10000	e(−1)*2	e(−2)*2	h(−1)	SUM	HL
GENERAL INDEX	0.009**	0.307**	–	0.724**	1.031	–
SECTOR INDICES						
1. TEXT	0.038**	0.315**	–	0.666**	0.981	37.13
2. CHEM	0.250**	0.225**	0.272**	–	0.497	1.99
3. SUGAR	0.267**	0.657**	–	–	0.657	2.65
4. PAPER	0.085**	0.180**	–	0.731**	0.911	8.44
5. CEMENT	0.167**	0.471**	–	0.469**	0.940	12.20
6. FUEL	0.140**	0.448**	–	0.506**	0.954	15.72
7. TRANS	0.084**	0.179**	–	0.829**	1.008	–
8. INSUR	0.099**	0.310**	–	0.625**	0.935	11.31
AVERAGE	–	–	–	–	0.860	5.609
SECURITIES						
1. GRINDL	0.470**	0.182**	–	0.735**	0.917	9.00
2. LTVC	0.286**	0.064**	–	0.906**	0.970	23.76
3. NDLC	0.079**	0.195**	–	0.826**	1.021	–
4. PICIC	0.451**	0.350**	–	0.559**	0.909	8.26
5. ADAMJEE	0.302**	0.129**	–	0.786**	0.915	8.80
6. SHAHM	0.391**	0.433**	–	0.519**	0.952	15.09
7. SHAKER	1.211**	0.442**	0.139**	–	0.581	2.28
8. PAKLA	1.121**	0.308**	–	0.547**	0.855	5.42
9. PAKT	0.612**	0.697**	–	0.366**	1.063	–
10. KESC	0.176**	0.325**	–	0.702**	1.027	–
11. NATR	0.317**	0.425**	–	0.602**	1.027	–

(continued)

TABLE 3
(continued)

	C*10000	e(–1)*2	e(–2)*2	h(–1)	SUM	HL
12. PSO	0.062**	0.187**	–	0.816**	1.003	–
13. SUIN	2.430**	0.667**	0.265**	–	0.932	10.84
14. SUIS	0.183**	0.439**	–	0.696**	1.135	–
15. GENT	0.478**	0.175**	–	0.721**	0.896	7.31
16. MILLT	0.696**	0.541**	–	0.409**	0.950	14.51
17. PAKSU	0.170**	0.097**	–	0.879**	0.976	29.53
18. PHILI	0.999**	0.341**	–	0.353**	0.694	2.90
19. PNSC	2.191**	0.142**	–	0.727**	0.869	5.94
20. ABBOTT	0.081**	0.496**	–	0.640**	1.136	–
21. DAWOOD	0.653**	0.538**	–	0.332**	0.870	5.98
22. ENGRO	0.078**	0.170**	–	0.824**	0.994	116.18
23. GLAXO	0.207**	0.309**	–	0.576**	0.885	6.67
24. HOECHT	0.656**	0.336**	–	0.433**	0.769	3.64
25. ICI	0.062**	0.100**	–	0.889**	0.989	63.67
26. RECKI	0.203**	0.142**	–	0.798**	0.940	12.20
27. WELLC	0.262**	0.404**	–	0.632**	1.036	–
28. WYTH	0.371**	0.640**	0.342**	–	0.982	39.16
29. PACK	0.079**	0.190**	–	0.782**	0.972	25.41
30. BATA	0.292**	0.420**	–	0.465**	0.885	6.67
31. BROOK	0.490**	0.305**	–	0.360**	0.665	2.70
32. LEVER	0.758**	0.312**	–	0.369**	0.681	2.80
33. MILK	0.171**	0.260**	–	0.665**	0.925	9.89
34. RAFHAN	0.964**	0.314**	0.044*	–	0.358	1.67
35. SHEZ	0.258**	0.249**	–	0.643**	0.892	7.06
36. BALOCH	2.066**	0.335**	–	0.307**	0.642	2.56
AVERAGE					0.898	7.415

Note: HL is the half life of volatility.
***Sample Period (January 1989 – December 1993),
**and *indicate significance level at 1 per cent and 5 per cent respectively.

volatility increased in both the periods after opening of the market. Moreover, the magnitudes of the coefficients in the first dummy are greater in most cases implying that volatility was the highest in the second period, that is, the first year of the opening of the market. This is consistent with the results found by Husain and Uppal (1998) that the stock returns volatility increased highly when the market was opened but was reduced to some extent after one year.

Table 4 also shows that the inclusion of dummy variables to account for the shifts in variance overtime has reduced the sums of the GARCH parameters and in turn the half life of volatility. However, there are still two stocks for which the sum exceeds one and the half life cannot be computed. The reduction in half life is more evident in stocks where on average the half life has been reduced to half, that is, from 7.4 days to 3.7 days. This supports the Lamourex and Lastrapes (1990) hypothesis that conclusions regarding the persistence in variance may be misleading if the shifts in variance in the sample are ignored.

V. Summary, Conclusions, and Policy Implications

The objective of the paper was to examine stock returns volatility in the Pakistani equity market. Using daily stock prices of 36 companies, 8 sector indices, and a market index, the AutoRegressive Conditional Heteroscedasticity (ARCH) class of models was applied to examine the nature of volatility.

The analysis suggests that one of the factors causing high serial dependence in stock returns in the Pakistani equity market, is the presence of conditional heteroscedasticity in stock returns. However, if heteroscedasticity in stock returns is controlled the serial dependence is generally reduced, but is not eliminated. It appears that even after controlling for volatility, the returns in the market are, in general, predictable.

The results suggest that GARCH (1, 1) is found to be an appropriate representation of conditional variance that underlies the stock return process. This specification is consistent with empirical findings and is found in previous studies for other markets. This implies that the current volatility in the market is significantly affected by the past volatilities.

There is also strong evidence of persistence in variance in returns implying that shocks to volatility continue for a long period. However, after accounting for the structural shift due to opening of the market, the persistence was found to decline significantly.

The existence of ARCH effects in the Pakistani equity market may be related to the information arrival process and adjustment of the market to this information. Husain and Forbes (1999) found that the Pakistani market adjusts slowly to new information pointing to the weaknesses of the market regarding the dissemination of pertinent information to potential investors. This suggests that effective mea-

TABLE 4

Shifts in Stock Returns Volatility due to Opening of the Market

	C*10000	D1	D2	e(-1)*2	e(-2)*2	h(-1)	SUM	HL
GENERAL INDEX	0.078**	0.096**	0.060**	0.290**	–	0.605**	0.895	7.25
SECTOR INDICES								
1. TEXT	0.41**	0.231**	0.100**	0.379**	–	0.450**	0.829	4.70
2. CHEM	0.194**	0.246**	0.098**	0.165**	0.231**	–	0.396	1.75
3. SUGAR	0.122**	0.107**	0.132**	0.836**	–	–	0.836	4.87
4. PAPER	0.094**	0.074**	0.040**	0.165**	–	0.686**	0.851	5.30
5. CEMENT	0.150**	0.205**	0.283**	0.428**	–	0.354**	0.782	3.82
6. FUEL	0.125**	0.160**	0.230**	0.404**	–	0.433**	0.837	4.90
7. TRANS	0.119**	0.589**	0.260**	0.157**	–	0.763**	0.920	9.31
8. INSUR	0.101**	0.075**	0.038	0.348**	–	0.561**	0.909	8.26
AVERAGE	–	–	–	–	–	–	0.795	4.021
SECURITIES								
1. GRINDL	0.604**	0.906**	0.765**	0.205**	–	0.578**	0.783	3.83
2. LTVC	1.908**	3.151**	4.516**	0.208**	–	0.288**	0.496	1.99
3. NDLC	0.129**	0.800**	0.323**	0.210**	–	0.742**	0.952	15.09
4. PICIC	0.446**	0.197	0.073	0.345**	–	0.538**	0.883	6.57
5. ADAMJEE	0.442**	0.585**	0.070**	0.162**	–	0.666**	0.828	4.67
6. SHAHM	0.355**	0.601**	0.079	0.413**	–	0.483**	0.896	7.31
7. SHAKER	0.674**	1.747**	0.836**	0.364**	0.099**	–	0.463	1.90
8. PAKLA	0.938**	1.729**	0.833**	0.241**	–	0.491**	0.732	3.22
9. PAKT	0.285**	0.318**	2.020**	0.658**	–	0.254**	0.912	8.52
10. KESC	0.185**	0.608**	0.487**	0.344**	–	0.621**	0.965	20.46

(continued)

TABLE 4 (continued)

	C*10000	D1	D2	e(−1)*2	e(−2)*2	h(−1)	SUM	HL
11. NATR	0.209**	0.374**	0.291**	0.446**		0.573**	1.019	–
12. PSO	0.353**	2.287**	0.748**	0.584**		0.161**	0.745	3.35
13. SUIN	0.906**	5.643**	5.125**	0.286**	0.186**		0.472	1.92
14. SUIS	0.595**	0.687**	2.356**	0.540**		0.379**	0.919	9.21
15. GENT	0.666**	-0.104	−0.254**	0.169**		0.707**	0.876	6.24
16. MILLT	0.669**	0.551**	0.786**	0.464**		0.313**	0.777	3.75
17. PAKSU	1.243**	5.305**	2.705**	0.258**		0.069	0.327	1.62
18. PHILI	0.839**	0.774**	0.026	0.341**		0.353**	0.694	2.90
19. PNSC	1.962**	0.605**	0.896**	0.139**		0.715**	0.854	5.39
20. ABBOTT	0.052**	0.107**	0.177**	0.421**		0.611**	1.032	–
21. DAWOOD	0.465**	1.767**	0.129**	0.561**		0.228**	0.789	3.92
22. ENGRO	0.237**	1.152**	1.186**	0.415**		0.346**	0.761	3.54
23. GLAXO	0.112**	0.200**	0.271**	0.277**		0.563**	0.840	4.98
24. HOECHT	0.921**	−0.421**	−0.363**	0.312**		0.432**	0.744	3.34
25. ICI	0.104**	0.590**	0.215**	0.146**		0.768**	0.914	8.71
26. RECKI	0.179**	0.035	0.178**	0.150**		0.775**	0.925	9.89
27. WELLC	0.250**	0.310**	0.107**	0.403**		0.595**	0.998	347.23
28. WYTH	0.271**	0.416**	0.257**	0.539**	0.216**		0.755	3.47
29. PACK	0.112**	0.756**	0.459**	0.257**		0.490**	0.747	3.38
30. BATA	0.244**	0.231**	0.400**	0.246**		0.443**	0.689	2.86
31. BROOK	0.367**	0.308**	0.035	0.323**		0.388**	0.711	3.03
32. LEVER	0.605**	0.444**	0.109**	0.331**		0.371**	0.702	2.96
33. MILK	0.168**	0.113**	0.096**	0.283**		0.607**	0.890	6.95
34. RAFHAN	0.733**	0.915**	0.222**	0.275**	0.038**		0.313	1.60
35. SHEZ	0.251**	0.204**	0.030**	0.247**		0.616**	0.863	5.70
36. BALOCH	1.823**	1.788**	0.491**	0.324**		0.255**	0.579	2.27
AVERAGE	–						0.773	3.698

Note: D1 and D2 are the dummies for the first year and subsequent years of opening of the market respectively.

sures should be taken to develop systems which facilitate dissemination of pertinent information.

Even if the information is available it is not effective until a thorough analysis is done, so that the investors are advised on the basis of sound financial analysis rather than on informal tips or intuition. Hence, measures need to be taken to enhance the analytical and technical abilities of the market participants. In Pakistan, there is no training program or professional examination for the members of stock exchanges, in contrast to the developed exchanges, where one has to pass the professional examination to qualify as securities broker [Khan, (1993)]. The enforcement of such a requirement in the Pakistani equity market is likely to enhance the professional standards of the market participants and will increase investors' confidence.

The existence of ARCH effects also hint at the possible dominance of groups of investors, which trade infrequently but heavily and influence stock price movements significantly. For example, some institutional investors may not trade frequently, but when they do, they trade in large quantities.[2] Often their actions are followed by small or individual investors. The occasional but large trades cause price clustering and can lead to market inefficiencies. A larger number of market participants, on the other hand, is conducive to market efficiency and liquidity. In Pakistan, the share of individual ownership is 28 per cent compared to around 60 per cent in USA. Suitable measures for greater public dissemination of information and educational programs may be undertaken to encourage individual participation in the market.

Pakistan Institute of Development Economics
Islamabad, Pakistan, and
Catholic University of America
Washington, D.C., USA

[2] A similar explanation is offered by Errunza et al. (1994) for observing ARCH effects in the Indian equity market.

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