RISK RETURN AND ASYMMETRIC VOLATILITY AT THE KARACHI STOCK EXCHANGE

Eatzaz Ahmad*

ABSTRACT: This study finds strong evidence of volatility inertia in returns at Karachi Stock Exchange and a mixed evidence for the presence of risk premium. The main finding of the study is that contrary to theory the positive return shocks have greater effect on volatility than the negative shocks. The study concludes that current recession in the stock market reflects weak fundamentals rather than pessimistic sentiments. Government interventions to artificially improve the market outlook are unlikely to produce sustainable effects and can result in market inefficiency.

1. INTRODUCTION

In recent years Pakistan has taken significant steps to develop its equity markets. In particular opening of the market to foreign investors during 1991 can be regarded as a turning point in transforming the stock market from a passive entity to a vibrant indicator of economic activity in the country. The activities at the Karachi Stock Exchange (KSE), which is by far the most active stock market in Pakistan, are often seen with keen interest as an early signal to what lies ahead for the economy. As a result of various liberalization measures in early 1990s the volume of trade has increased manifold and the market has been subjected to a greater level of speculative activities.

The analysis of stock market behaviour in Pakistan has also gained importance in economics research. The most analyzed issue has been the nature and consequences of erratic stock price movements or what is known as market volatility. Khiligi (1993, 1994) investigates time series behaviour of stock returns and volatility. Uppal (1993) studies the spill over effects of price changes and volatility from Australia, India, Japan, Korea, U.K and the USA on the KSE. Husain and Uppal (1998) analyze the distributional characteristics of stock prices. Ahmad and Zaman (1999, 2000) investigate the relationship between expected returns and volatility.

A well-known behaviour in stock markets observed around the world is that the volatility caused by an unexpected event has a much longer life than the event itself. That is, unexpected return shocks increase volatility not only in the current time period but also in future. This behaviour results in strong inertia in volatility wherein spells of volatility clusters and relative tranquillity follow in cycles. This behaviour has been consistently observed in a large number of studies including a few for Pakistan (e.g. Uppal (1993) and Zaman (1997)).

While the traditional analysis of volatility does not distinguish between good and bad news, a case may be made to give differential treatment to the two types of shocks. That is, the time paths of volatility following positive and negative shocks of equal intensity do not have to match. In theory this asymmetry can be explained by the behaviour of risk-averse agents in response

* Professor of Economics, Quaid-i-Azam University Islamabad

to increase in volatility. In particular an unexpected decline in stock prices causes an increase in volatility and therefore risk-averse agents expect an increase in risk premium. This further reduces the prices, thereby reinforcing the impact of negative shock on volatility. By the same line of argument, one can argue that, on the other hand, the effect of a positive shock on volatility is partially offset by the behaviour of risk-averse agents.

The objective of the present study is to gather empirical evidence on the above propositions using price indices data for the KSE. In particular the study aims to determine the nature of volatility clusters, risk-return relationship and the asymmetric effects of positive and negative shocks on volatility. These objectives are addressed simultaneously in the extended framework of ARCH (autoregressive conditional heteroskedasticity) family of models, namely asymmetric or threshold ARCH-in-Mean model. The study is based on daily price indices of the overall market and its major industrial groups.

The study is planned as follows. The model is presented in Section 2. Section 3 describes data and estimation procedure. Results of the analysis are presented in Section 4, while Section 5 consists of concluding remarks.

2. THE MODEL

It is typically observed that the instability in stock markets introduced by an unexpected event usually initiates a string of fluctuations. Volatility inertia may arise due to inefficiency in dissemination of information and sticky expectations about the future course of uncertainty. Another reason could be that not all the agents jump on the 'band-wagon'; some of the reaction to the shock could be delayed. Furthermore if the market had over-reacted to the news, the price variation in the following periods could reflect the so-called 'technical correction'. The ARCH (autoregressive conditional heteroskedasticity) models, introduced by Engle (1982), provide the most appealing tool for studying the nature of volatility inertia. Engle, Lilian and Robins (1987) extended ARCH model to study the nature of risk return relationship. The extended model, called ARCH-in-Mean or ARCH-M model, assumes that mean of the series is a function of ARCH variance.

In traditional ARCH models positive and negative shocks are given symmetric treatment. However, the financial literature now recognizes that negative shocks are expected to cause greater volatility than the positive shocks. Beckaert and Wu (1997) provide the following theoretical argument to explain this asymmetry. An unexpected return shock causes volatility, which in turn also increases the level of expected volatility in future. Assuming that the agents are mostly risk averse, the increase in volatility has to be compensated by an increase in risk premium, or else the stock assets become relatively less attractive. In either case the expected rate of return rises and the unexpected shock results in a decline in the current stock prices. This price decline further reinforces or partially offsets the initial shock when the initial shock is negative or positive respectively. This explains why negative shocks are likely to produce more volatility than the positive shocks.

Glosten, Jaganathan and Runkle (1994) have proposed threshold ARCH model (also known as asymmetric ARCH model) to allow for the differential treatments of positive and negative shocks. The complete model for any stochastic variable Y is given as follows.

$$y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{j=0}^{q} \beta_j \varepsilon_{t-j} + \theta h_t^{\delta}, \ \beta_0 = 1 \tag{1}$$

$$\varepsilon_t = v_t \sqrt{h_t} \tag{2}$$

$$h_t = \phi_0 + \sum_{k=1}^{r} \phi_k \ \varepsilon_{t-k}^2 + \sum_{m=1}^{s} \lambda_m h_{t-m} + \phi_1^* D\varepsilon_{t-1}^2 \tag{3}$$

$$D = 1 \ \text{if} \ \varepsilon_{t-1} < 0 \qquad = 0 \ \text{if} \ \varepsilon_{t-1} \geq 0 \tag{4}$$

Equation 1 is a standard ARMA equation extended to allow mean return to depend on ARCH variance $(\delta = 1)$ or standard deviation $(\delta = \frac{1}{2})$. If risk-averse agents dominate the stock market, the rate of return will rise with risk as measured by the ARCH variance or standard deviation and, therefore, the parameter θ will be positive. In case the average behaviour in the market is that of risk-neutral agents then θ will be zero. Finally a negative value of θ indicates that either the agents are by-and-large risk loving or the perverse behaviour can be attributed to lack or misinterpretation of information.

According to equation (2) the random error is decomposed into a homoscedastic component v_t with $\sigma_{v_t}^2 = 1$, and a heteroscedastic component $\sqrt{h_t}$ with the ARCH process given by (3), which parameterizes heteroscedastic residuals. The parameters ϕ_k and λ_m are called ARCH and GARCH (generalized ARCH) coefficients respectively. The ARCH equation (3) is further extended to allow asymmetry such that the effect of most recent shock depends on the direction of the shock. When the shock is positive, its effect on volatility is equal to ϕ_1 and when the shock is negative its effect is equal to $\phi_1 + \phi_1^*$. If negative shocks cause greater volatility as compared to the positive shocks, as expected, then ϕ_1^* would be positive.

3. DATA AND ESTIMATION PROCEDURE

Stock price market indices for the KSE are prepared and maintained by the State Bank of Pakistan (SBP) and are available in the files of SBP. These indices are properly adjusted for dividends, bonus shares and right issues. The present study covers the overall market price index, and the price indices for eleven sectors and the four sub-sectors in banking and other financial institutions. The study is based on daily observations for the period July 1992 to March 1998.

Like all the stochastic models, an ARCH model applies to stationary series. Therefore as a first step one needs to examine stationarity properties of the series of stock price indices by applying Augmented Dickey-Fuller (ADF) tests for the existence of unit roots. The typical first round of the test is based on the original series. If a series turns out to be stationary, the task is complete. Otherwise the test is applied to the first difference of the series. If the first difference is also non-stationary, the test is applied on the second difference and so on. In most cases the first difference of natural log turns out to be stationary.

For the diagnostic of ARCH model one needs to determine the order of AR and MA terms in the ARMA and ARCH equations. The most reliable route to the specification of ARMA process is based on Box-Jenkins procedure (see Box and Jenkins (1976) and Enders (1995)). The first step is to draw correlogram for the stationary series and make a tentative decision on the autoregressive (AR) and moving average (MA) terms on the basis of the shapes of ACF (autocorrelation function) and PACF partial autocorrelation functions). The next step is to estimate the chosen ARMA model and draw correlogram for the regression residuals. If some autocorrelation is still present, the ARMA specification needs to be adjusted accordingly. This step-wise procedure is continued until the regression residuals approximate white noise. To confirm that the residuals are white noise, Q-statistic is applied on the cumulative autocorrelation coefficients for sufficient lag lengths (see Maddala (1992) for Q-statistic). Performance criteria such as AIC (Akaike Information Criterion) and SBC (Schwartz Bayesian Criteria) are used to choose among competing specifications (see Enders (1995) and Maddala (1992)).

The diagnostic steps for AR and MA terms in the ARCH equation are the same as for the simple ARMA model except that the correlograms are drawn for the squared residuals. However since correlograms for residuals and squared residuals are interdependent, the diagnostics for the ARMA and ARCH equations cannot be carried out in isolation of each other. Apart from this problem the specification also depends on whether ARCH-M effect is included in the equation. Furthermore statistical significance of the ARCH-M coefficient also depends on the specification of ARMA and ARCH equations. Therefore in addition to the above diagnostic procedure some element of hit-and-trial is also involved in specifying the complete model.

4. THE RESULTS

Following the above procedure first of all we determine stationarity properties of stock prices indices. The application of ADF tests indicates that all the stock price indices and their natural logs are non-stationary. Furthermore the first difference of the natural log for each price index series, which approximates the series of rates of return, is stationary. This means that the ARCH models need to be estimated for the daily rates of return.

The results of estimated TARCH models for the 16 price indices are arranged in Table 1, which consists of two parts. The top half shows the parameter estimates of ARMA equation, while the bottom half shows parameter estimates of the TARCH equation. In ARMA equations AR(p) and MA(q) indicate the coefficients of autoregressive and moving average processes at lag lengths p and q respectively, while ARCH-M indicates the parameter representing the effect of ARCH standard deviation on the expected return. In the ARCH equation ARCH(r) and GARCH(s) indicate the ARCH and GARCH coefficients at lag lengths r and s, while Threshold ARCH(1) indicates the additional ARCH effect at lag length one when the shocks are negative.

The table shows that out of the 108 parameters 99 are statistically significant. With the exception of a threshold ARCH coefficient, all the insignificant parameters are intercepts in various equations. Thus the statistical performance of all the estimated models appears quite impressive.

The results show that in eight cases intercepts of the estimated ARIMA equations are significantly different from zero, implying that the average rate of return is not zero. Out of sixteen intercept estimates fourteen have a negative sign and seven are statistically significant. Thus in these seven cases the average rate of return is negative. On the other hand the estimates of the intercepts for banks and other financial institutions and leasing companies are positive, though statistically insignificant, indicating that the average rates of return in these sectors are positive.

In 11 of the 16 cases there exists a strong AR(1) process. This means that the current movements in the rates of return are dependent on the shocks experienced in the past but the relationship becomes weaker as the lag length increases. We also observe that AR(3) process is present in the fuel and energy sector. Moving average (MA) parameters are also present in most of the cases. The order of MA process determines the nature of one-off relationship between the current and past fluctuations in rates of return. For example with MA(1) process a shock occurring in one period has an effect on the rate of returns in the next consecutive period. This shock is however eliminated from the system within one period.

Intercepts in all the estimated ARCH equations are positive and statistically significant, indicating that a sizable portion of volatility remains constant over time. The presence of ARCH(1) process indicates significant autocorrelation in volatility that persists over one period only. ARCH(2) process is present in two cases only, indicating autocorrelation at a lag of two periods. The GARCH(1) process is also found in nine cases, which indicates autoregressive nature of volatility inertia. That is, volatility shocks occurring during a specific period of time show persistence but as time passes the size of volatility caused by the shock declines geometrically. Thus with the passage of time the impact of a shock diminishes and it is soon forgotten in the rapidly adjusting market. In any case the results clearly show the presence of volatility clusters in the rates of return.

Table 1: Estimates of Threshold GRACH-M Models

	Cotton and other textile	Chemical-s and Pharmac-euticals	Engine-ering	Auto and allied	Cables and Electrical goods	Sugar and allied	Paper and allied	Cement
ARIMA Equation								
Intercept	-0.006785	-0.009855	-0.000414	-0.005101	-0.000453	-0.00034	-0.00518	-0.00043
	(-5.54*)	(-3.11*)	(-0.63)	(-2..63*)	(-0.73)	(-0.93)	(-4.83*)	(-0.49)
AR(1)			0.882		0.938	0.097		0.759
			(15.76*)		(3.76*)	(2.40**)		(13.24*)
MA(1)			-0.812		-0.858			-0.567
			(-11.1*)		(-22.35*)			(-7.60*)
MA(2)		0.126				0.052		
		(3.55*)				(1.72***)		
MA(3)		0.099						
		(3.30*)						
MA(4)		0.09				0.135		
		(2.49**)				(6.65*)		
MA(5)		0.076						
		(2.08**)						
ARCH-M	0.565	0.851		0.249			0.371	
	(4.08*)	(3.02*)		(1.83***)			(4.01*)	
TARCH Equation								
Intercept	0.000067	0.000167	0.000065	0.00028	0.000004	0.00006 3	0.000102	0.000037
	(59.68*)	(18.98*)	(11.96*)	(110.92*)	(9.19*)	(62.39*)	(37.69*)	(7.81*)
ARCH(1)	0.702	0.081	0.33	1.061	0.155	0.427	1.226	0.381
	(11.88*)	(2.75*)	(7.95*)	(5.85*)	(11.29*)	(5.17*)	(12.35*)	(9.85*)
GARCH(1)		-0.324	0.403		0.858			0.632
		(-5.01*)	(9.11*)		(102.82*)			(18.22*)
Threshold ARCH(1)	-0.479	0.026	-0.204	-1.058	-0.096	-0.322	-1.031	-0.215
	(-6.24*)	(0.71)	(-4.98*)	(-5.82*)	(-6.89*)	(-3.65*)	(-9.34*)	(-5.06*)

Note: The t-values significant at 1%, 5% and 10% levels are indicated by *,**and *** respectively

Table 1 (Continued): Estimates of Threshold GRACH-M Models

	Fuel and energy	Transport and communication	Banks and other financial institutions	Banks and investment companies	Modarbas	Leasing companies	Insurance	General Index
ARIMA Equation								
Intercept	-0.00052	-0.00847	-0.00015	0.000491	-0.0018	-0.00496	-0.00447	-0.00007
	(-0.92)	(-3.19*)	(-0.28)	(0.45)	(-2.79*)	(-2.35**)	(-2.74*)	(-0.06)
AR(1)	0.238		0.584	0.612	0.594	0.252	0.915	0.978
	(6.68*)		(4.77*)	(4.78*)	(5.06*)	(6.94*)	(49.47*)	(77.53*)
AR(3)	0.061							
	(2.05**)							
MA(1)			-0.413	-0.439	-0.498		-0.798	-0.742
			(-2.88*)	(-2.89*)	(-3.73*)		(-29.86*)	(-22.65*)
MA(2)								-0.18
								(-5.49*)
ARCH-M		0.33				0.299	0.26	
		(2.68*)				(1.89***)	(4.82*)	
TARCH Equation								
Intercept	0.000019	0.0003	0.000014	0.000044	0.000266	0.000088	0.000343	0.000022
	(3.22*)	(34.12*)	(6.03*)	(10.43*)	(34.99*)	(10.27*)	(89.07*)	(7.76*)
ARCH(1)	0.445	0.338	0.425	0.285	0.971	0.532	0.212	0.504
	(10.15*)	(5.77*)	(10.07*)	(5.77*)	(8.50*)	(9.70*)	(4.70*)	(8.44*)
ARCH(2)	-0.267	0.231						
	(-5.13*)	(7.36*)						
GARCH(1)	0.775		0.685	0.755		0.338		0.516
	(12.77*)		(35.61*)	(38.85*)		(6.61*)		(12.52*)
Threshold ARCH(1)	-0.053	-0.178	-0.174	-0.149	-0.715	-0.345	1.027	-0.246
	(-1.7***)	(-2.45**)	(-3.09*)	(-3.09*)	(-5.38*)	(-5.39*)	(4.72*)	(-3.69*)

Note: The t-values significant at 1%, 5% and 10% levels are indicated by *,**and *** respectively

The results also show that the ARCH-M coefficient is positive and statistically significant in seven industries, indicating that in these industries increase in risk is rewarded by better returns. From the regression equations for the other eight industries the ARCH-M term was dropped because the associated regression coefficient was statistically insignificant. In any case the results at least partially confirm the earlier findings in Ahmad and Zaman (1999, 2000) that on average the agents are risk averse and they anticipate compensation for taking risk as measured by the expected volatility of returns. Since in no case the ARCH-M coefficient is negative and significant, it appears that risk aversion and risk neutrality are norms, while risk loving is exception.

Finally coming to the main focus of the study, we now analyse the nature of asymmetry between positive and negative return shocks. The results show that the threshold ARCH(1) coefficient, which measures the additional effects of negative shocks on volatility as compared to the effect of positive shocks, is significant in all the cases except for chemicals and pharmaceuticals sector. Thus it is confirmed that good and bad news have asymmetric effects on expected volatility. All the estimated coefficients of threshold ARCH(1) process are found to be negative, meaning that negative shocks have relatively smaller effect on volatility as compared to the positive shocks.

The above result is contrary to theoretical proposition that negative shocks cause greater volatility than the positive shocks as explained in Section 2. Since this result is observed in all but one case, the evidence is too strong to be regarded as one of the perverse cases due to poor data or sampling error. We can nevertheless attempt to relate the results with some kind of observed events or behavioral patterns that result in the market outcomes going contrary to the theoretical proposition. A possible explanation for the unexpected results could be that the agents do not have complete information or their behavior is not consistent with the assumption of rationality. However, these arguments would contradict the efficient market hypothesis that has been confirmed in a number of studies (e.g. Ahmad and Zaman (1999, 2000) and Khilji (1993)). Besides, the evidence is too strong to warrant a more convincing reasoning.

One plausible explanation goes as follows. If we trace the history of major shocks in the stock markets of Pakistan we would inevitably find that after most of the major negative shocks the government had stepped-in with some package to stem the recession, while there had been no intervention to halt the pace of rising market. Thus the impacts of major negative shocks on volatility have been partially offset by government interventions, though only temporarily, whereas the effects of positive shocks have by and large gone unchecked.

Another explanation can be developed on the basis of agents' behavior in responding to unexpected shocks under alternative circumstances. If one assumes that agents follow the behavior of so-called 'stabilizing speculators', one would expect that following an unexpected rise (fall) in rates of return, they would expect the prices to fall (rise). In this case the unexpected shocks would quickly evaporate and the market would immediately adjust to its long-term trend. In contrast when the agents follow the behavior of 'destabilizing agents', the unexpected positive (negative) shock will initiate a perpetual boom (recession) in the market. Since the stock markets neither adjust too quickly, nor do they display perpetual instability, one can infer that both types of agents are present in the market.

The only question that remains to be answered is as to what type of agents are likely to take the leading role in determining the market outcome in a particular empirical situation. One can expect that the stabilizing agents would dominate the market outcomes when the prices cross a so-called 'psychological barrier'. In case of Karachi Stock Exchange, following the price boom of 1994, the market has mostly remained in recession and the general price index has crossed the psychological barriers on the lower side of spectrum more often than it did on the upper side. One would, therefore expect that the negative shocks that cross the downward psychological barriers would create a perception among agents that the prices are unlikely to decrease further. The optimistic perception can therefore weaken the effects of negative shocks on volatility. This behavior is analogous to the well-known liquidity trap in Keynesian macroeconomic model of recession.

The above result implies that, since the negative shocks are relatively less destabilizing than the positive shocks, the prolonged recession at the KSE during the past four years or so reflects weak fundamentals rather than pessimistic perceptions. Therefore any form of government intervention to artificially improve outlook of the market is unlikely to produce sustainable effects on the market performance. Furthermore, the perception developed among the agents that negative shocks would be offset by bullish reaction, whether based on psychological mindset or observed rescue packages by government, can trigger temporary 'technical corrections' following the negative shocks. But the underlying forces causing erosion in the first place are likely to reemerge to haunt the investors.

5. CONCLUDING REMARKS

This study attempts to provide empirical evidence on the nature of volatility clusters, risk return relationship and asymmetry between the effects of good and bad news on volatility using daily data on stock price indices for the general market and its major industrial groups at the Karachi Stock Exchange. The study finds that the movements in rates of return are significantly affected by current as well as past shocks and have strong volatility inertia, implying that the time paths of rates of return contain clusters of volatility and tranquility following in cycles. It is further observed that for seven of the 16 stock price indices the rates of return include risk premium that increases with the amount of risk.

The major finding of the study is that contrary to the theoretical expectations positive return shocks have relatively greater effect on volatility as compared to the negative shocks. Therefore there must be special features surrounding stock market activity in Pakistan that produce the rather unexpected results, though there is no comparable empirical evidence to strengthen the assertion. One explanation is that after every major negative shock the government had stepped-in with some package to stem the recession, while there had been no intervention to reverse rising market. Another explanation could be that the stock market has mostly remained in recession and the general price index has crossed the 'psychological barriers' on the lower side of spectrum more often than it did on the upper side. Therefore major negative shocks could have created a perception among agents that the prices are unlikely to decrease any further. This optimistic perception can weaken the effects of negative shocks on volatility.

The above result has a number of interesting implications. First, since the negative shocks are relatively less destabilizing than the positive shocks, the prolonged recession in the stock market during the past four years or so reflects weak fundamentals rather than sentiments based merely on pessimistic perceptions. Therefore any form of government intervention to artificially improve outlook of the market is unlikely to produce sustainable effects on the market performance. Second, the perception developed among the agents that negative shocks would be offset by bullish reaction, whether based on psychological mindset or observed rescue packages by government, is likely to have resulted in market inefficiency. Although such perceptions might trigger a temporary 'technical correction' following the negative shocks, underlying forces causing erosion in the first place are likely to reemerge to haunt the investors. As long as market fundamentals are weak, optimistic perceptions can only result in misallocation of funds.

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