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Pricing of risk and volatility dynamics on an emerging stock market: evidence from both aggregate and disaggregate data

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ABSTRACT

This study analyses risk-return trade-off and behaviour of various volatility dynamics including: volatility, its persistence, mean reversion and speed of mean reversion along with asymmetry and leverage effect on the Pakistani stock market by employing aggregate (aggregate market level) and disaggregate (sectoral level) monthly data for the period from 1998 to 2012. Three generalised autoregressive conditional heteroscedasticity models were applied: GARCH (1,1) for various volatility dynamics; EGARCH for asymmetric and leverage effect and GARCH-M for pricing of risk. The outcomes of the study are as follows: first, the volatility shocks are quite persistent but with varying degrees across the sectors. Both the ARCH effect (short-term effect) and GARCH effect (long-term effect) play their role in generating conditional future stock returns volatility. Further, overall the volatility process is mean reverting; however, the speed of mean reversion varies across the sectors. Secondly, the current study finds little evidence of asymmetry and leverage effect at both aggregate and disaggregates data. Thirdly, the pricing of risk (positive risk premium) is also evident, particularly at the disaggregate data in the Pakistani stock market. Finally, this research study sets the implications for both the policy makers and investors.

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Asymmetry and leverage effect; stock market volatility; risks-return trade-off and GARCH models

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1. Introduction

Historically, the landmark contribution of Markowitz (1952) stems from the idea that investors usually claim higher returns on market portfolio than the investment in risk-free securities. However, the emphasis on the association between risk and returns has been put under significant stress recently by the financial press. This designates the significance of risk while pricing the financial assets (Mandimika & Chinzara, 2012). More so, Merton (1973) signified that at aggregate market level, the required excess return is represented by a positive function of their conditional variance. Representing the aggregate wealth by W_t, indirect utility function by $J(.)$; between time t and t+1, the expected return on aggregate

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Table 1. Descriptive statistics and stationarity results. This table reports explanatory statistics consisting of: mean, standard deviation, skewness, kurtosis and Jarque Bera; unit root tests include ADF and PP and results of Ljung Box Q Statistics for both returns and square returns series.

Returns	Mean	S.D	SKU	KU	JB	ADF	PP	LBQ(12)	$LBQ^2(12)$
KSE 100 Index	0.017	0.091	−0.937	6.924	132.349*	−12.840*	−12.840*	6.510	8.563
Oil & Gas	0.007	0.124	−0.707	6.382	94.087*	−13.251*	−13.269*	10.572	20.803**
Chemical	0.006	0.070	−0.480	4.323	18.527*	−11.042*	−10.977*	10.110	19.581**
Tobacco	0.008	0.105	1.277	21.969	2,564.495*	−17.701*	−17.943*	22.737*	23.586*
Beverages	0.003	0.121	−0.030	4.342	12.627*	−15.679*	−15.814*	23.572*	13.454
Forestry	0.003	0.126	−1.084	25.100	3,451.687*	−16.579*	−16.543*	22.714*	32.520*
Electricity	−0.002	0.956	0.236	4.209	11.797*	−12.624*	−12.643*	7.661	10.765
Engineering	0.009	0.090	0.439	4.590	23.084*	−10.875*	−10.872*	10.330	8.192
Auto & Parts	0.009	0.092	−0.147	3.682	3.866*	−11.928*	−12.002*	10.821	22.035*
Gas & Water	0.004	0.192	−0.151	20.753	2,206.878*	−12.857*	−18.842*	27.512*	39.389*
Pharma & Bio	0.006	0.069	0.322	3.336	3.687	−10.743*	−10.749*	21.845*	19.173**
Personal Goods	0.006	0.059	0.065	5.403	40.548*	−10.180*	−10.942*	26.394*	21.316*
Life Insurance	0.008	0.122	0.468	4.642	25.012*	−15.528*	−15.325*	12.201	19.817**
Food Producer	0.009	0.059	0.006	4.170	9.593*	−12.735*	−12.735*	13.958	26.043*
Travel & Leisure	0.018	0.162	0.880	6.467	105.828*	−12.249*	−12.201*	11.659	23.219*
Financial Services	−0.007	0.083	−0.535	4.218	18.397*	−7.345*	−11.297*	19.036**	24.835*
General Industrial	0.009	0.094	−0.127	14.469	921.266*	−16.051*	−16.019*	18.356**	37.077*
Household Goods	0.000	0.106	0.611	5.124	41.537*	−11.374*	−11.399*	6.174	7.578
Non-Life Insurance	−0.002	0.080	−0.578	5.215	43.725*	−11.903*	−12.054*	17.358**	19.089**
Fixed Line Telecom	−0.001	0.117	−0.043	4.229	10.629*	−12.137*	−12.165*	19.467**	21.609*
Commercial Banking	0.000	0.101	−0.798	5.175	50.908*	−11.705*	−11.701*	11.392	6.564
Electronics & Electricity	0.000	0.120	0.316	4.249	13.722*	−11.938*	−11.921*	10.160	7.936
Industrial Metal and Min.	0.004	0.098	0.387	4.239	14.945*	−14.196*	−14.158*	11.218	25.822*
Construction & Material	0.008	0.117	0.710	5.287	50.719*	−10.923*	−11.013*	18.929**	5.534

Note: S.D – Standard Deviation, SKW – Skewness, KU – Kurtosis, JB – Jarque-Bera, Critical value for ADF and PP at 5% and 10% level is −2.87 and −2.57, SIC is used to select the appropriate lag, LBQ (12) and LBQ2 (12) – Ljung Box Q Statistics for returns and square returns series respectively.

*Represents level of significance at 5% and 10% respectively; **Represents level of significance at 5% and 10% respectively.

Table 2. Results – GARCH (1, 1), GARCH-M and EGARCH Models. This table shows the results regarding the level of statistically significant and insignificant coefficients of ARCH (α) and GARCH (β) effects together with persistence ($\alpha + \beta$) and mean reversion by employing GARCH (1, 1) model at each of the sectoral besides aggregate market level returns. Further, results related to pricing of risk (δ) and asymmetric and leverage effect (γ) by mean of GARCH-M and EGARCH models respectively are also reported therein.

Sectors	ARCH(α)	GARCH(β)	$\alpha + \beta$	Half-life	GARCH-M (δ)	EGARCH (γ)
KSE 100 Index	0.68*	0.02	0.70[a]	1.94	−0.49	0.08
Oil & Gas	0.72*	0.04*	0.76[a]	2.53	−0.95*	−0.11*
Chemical	0.03	0.86*	0.89[b]	5.95	0.60*	−0.04
Tobacco	0.37*	0.30*	0.67[a]	1.72	−0.34*	0.07
Beverages	0.21**	0.42**	0.63[b]	1.54	−1.77*	0.14
Forestry	0.24*	0.02	0.26[a]	0.51	−23.98	0.16
Electricity	−0.15*	1.01*	0.86[b]	4.59	0.95**	−0.21**
Engineering	0.01	0.47*	0.48[b]	0.94	0.14	0.01
Auto & Parts	0.06	0.42	0.48[b]	0.94	1.29**	−0.02
Gas & Water	1.41*	0.01	1.42[a]	-	0.65*	−0.39*
Pharma & Bio	−0.12*	1.05*	0.93[b]	9.55	0.55	−0.08*
Personal Goods	0.70*	0.20*	0.90[a]	6.57	−0.05	−0.20**
Life Insurance	0.20*	0.70*	0.90[b]	6.57	0.01	−0.18
Food Producer	0.50*	0.01	0.51[a]	1.02	0.25*	0.15
Travel & Leisure	0.44*	0.63*	1.07[b]	-	0.43*	0.02
Financial Services	0.45*	0.35*	0.80[a]	3.10	0.57*	−0.01
General Industrial	0.38*	0.04	0.42[a]	0.79 [a]	0.17	−0.11
Household Goods	0.31*	0.55*	0.86[b]	4.59	0.31	0.39*
Non-Life Insurance	0.00	0.88*	0.88[b]	5.42	−0.03	−0.03
Fixed Line Telecom	0.17	0.60*	0.77[b]	2.65	0.65	−0.30*
Commercial Banking	−0.18*	1.02*	0.84[b]	3.97	0.32*	0.01
Electronics & Electricity	0.03	0.61**	0.64[b]	1.55	−2.60	−0.01
Industrial Metal and Min.	0.04*	0.86*	0.90[b]	6.57	2.27*	−0.01
Construction & Material	0.52*	0.06	0.58[a]	1.27[a]	0.90*	0.01

*Represents significance level at 5% and 10% respectively.; **Represents significance level at 5% and 10% respectively.
[a]Represents if volatility is mainly due to ARCH effect.
[b] Represents if volatility is mainly due to GARCH effect, ARCH+GARCH.
($\alpha + \beta$)Denotes sum of coefficients of ARCH and GARCH effects representing the persistence.
HLRepresents half-life of volatility.
γ coefficient in case of EGARCH model indicates asymmetric and leverage effect.
δ coefficient in case of GARCH-M model represents risk-return trade-off.

wealth by e_{wt+1} and conditional variance on aggregate wealth by σ^2_{wt+1}, Merton (1973) noted that assuming the fixed investment opportunity set, the risk-return interconnectivity can be explained by the following functional equation:

$$(\varepsilon_{wt+1}) = \left[\frac{-J_{ww} W_t}{J_w}\right](\sigma^2_{wt+1}) = \lambda(\sigma^2_{wt+1}) \tag{1}$$

where λ indicates risk averseness of investors measured by $[-J_{ww}\ W_t / J_w]$.

Equation (1) above holds that the future expected return by the investor is directly proportional to the product of risk averseness and expected variations with returns. This is due to the reason that investors are usually risk averse, and hence they will only invest if the expected returns from the respective projects are attractive in order to pay off the expected risk of the project.

Over the last three decades, numerous empirical studies have focused on risk-return association that is targeted at developed, developing and emerging equity markets, though with mixed outcomes. At first, Chou (1988) and Turner, Startz, and Nelson (1989) concluded unstable risk-return linkage shifting from positive to negative over time. However, several studies in the financial press (e.g. see Balios, 2008; Campbell & Hentschel, 1991; Dimitriou & Simos, 2011; Fraser & Power, 1997; French, Schwert, & Stambaugh, 1987; Glosten, Jagannathan, & Runkle, 1993; Hansson & Hordahl, 1998; Jiranyakul, 2011; Koutmos, Negakis, & Theodossiou, 1993; Lanne & Saikkonen, 2004; Lebaron, 1989; Lettau & Ludvigson, 2010; Li, Yang, & Hsiao, 2005; and Mandimika & Chinzara, 2012), ascribed mixed evidence regarding the existence of risk premium in the stock markets of Australia, the USA, Europe, Asia and Africa by applying the GARCH-M model. For instance, Li et al. (2005) concluded negative risk premium for six out of 12 markets, and so does by Mandimika and Chinzara (2012) while examining the South African stock market. However, on the contrary, the study of French et al. (1987) and Yu and Hassan (2008) in the Middle East and North African region and Jiranyakul (2011) in Thailand accredited a positive risk-return trade-off declaring a positive risk premium.

Black (1976), and later on Christie (1982), Cheung and Ng (1992) and Duffee (1995), who mainly focused on the developed market of the NYSE, are considered to be the pioneers of asymmetry and leverage effect. The pioneer explanation of the leverage effect also hinges on the study of Black (1976) and later on Christie (1982). They reported that negative news (price fall) increases the financial leverage thereby resulting in rise in stock returns volatility. Furthermore, it is yet possible that the asymmetric volatility might rest on the three other theories, namely time varying risk premia theory, asymmetric volatility of economic factors theory and/or both leverage (financial) and volatility feedback effect theory simultaneously (e.g. see Duffee, 1995; French & Sichel, 1993; French et al., 1987; Karmakar, 2007; Mandimika & Chinzara, 2012; Pindyck, 1984 and Schwert, 1989) All these theories are discussed in detail in Section 3.2.

Targeting the persistence of volatility shocks at aggregate market level in the NYSE, Chou (1988) applied the GARCH (1, 1) model on the data from 1962–1985. He found volatility shocks to be highly persistent, having a half-life of volatility equal to one year. Such volatility behaviour in the NYSE was also reported by Baillie, Bollerslev, and Mikkelsen (1996), Carrol and Connor (2011), Elyasiani and Mansur (1998), Engle and Patton (2001), Ewing, Kruse, and Thompson (2005), Elyasiani, Mansur, and Odusami (2011) and Schwert (1989). More specifically, Ewing et al. (2005) denoted the existence of persistent volatility shocks together with asymmetry and leverage effect in the NYSE. In this manner, Elyasiani et al. (2011) recommended that future studies should address the mean reversion behaviour of volatility shocks across the sectors.

Despite the fact that the Pakistani stock market has performed well in the region, research studies conducted pertaining to the volatility dynamics and risk-return trade-off across the sectors are limited. For example, the studies conducted by Ali & Afzal, 2012; Mahmud & Mirza, 2011; Mushtaq, Shah, Rehman, & Murtaza, 2011; Qayyum & Anwar, 2011; Rashid, Ahmad, Azim, & Rehman, 2011 and Saleem, 2007 mainly focused on the stock returns' volatility at aggregate market level stock returns, whereas the aggregate market level analysis embarks on misleading results due to sectoral heterogeneity (Elyasiani et al., 2011). Hence, the current study's primary emphasis is to overcome the shortfall of the previous studies.

This current study is also in the spirit of a threefold motivational argument from the literature survey. First, the financial press found that increased globalisation has significantly reduced the risk minimisation benefits from diversifications of international markets through strengthening the correlations among international equity markets. This phenomenon indicates primarily that investment strategies that are based upon sectoral diversifications, within the country or across the countries, may surrender better pricing of risk, which might not be possible through international diversification and therefore is worthy of attention for researchers (Baca, Garbe, & Weiss, 2000 and Elyasiani et al., 2011).

Secondly, it is established that the rise or fall in macroeconomic variables stems from a dissimilar effect on stock returns across the sectors resulting is different volatility dynamics (Elyasiani et al., 2011). Thirdly, it is widely agreed in the financial press that investors always expect higher returns for holding risky assets. Therefore, the understanding of volatility dynamics of various sectors is a critical component for any investment decision (Elyasiani et al., 2011).

The rest of the paper is structured as follows. Section 2 details the data used and some of its characteristics. It further presents the methodology applied to determine the asymmetric volatility, pricing of risk and various volatility dynamics. Section 3 reports the discussion regarding the outcomes. Section 4 sums up the paper, and states policy implications together with future research.

2. Data, descriptive statistics and methodology

2.1. Data and descriptive statistics

Data used in this study consist of monthly return series for the Karachi Stock Exchange 100 Index along with 23 sectoral level returns of the Pakistani equity market for the period from June 1998 to June 2012, which were obtained from the Karachi Stock Exchange website and Business Recorder. The selection of sectors is primarily based upon data accessibility. However, the selection of monthly data is based on three primary reasons. First, the selection enables us to confine the long term movements and to prevent the impact of delays in clearing and settlements which considerably influences the stocks over a shorter interval (daily or weekly) and also prevents the issue of spurious correlation (Baillie & DeGennaro, 1990; Beirne, Maria, & Spagnolo, 2009; Elyasiani & Mansur, 1998; Faff & Chan, 1998; Faff, Hodgson, & Kremmer, 2005; Ibrahim, 1999 and Patra & Poshakwale, 2006). Secondly, the use of monthly data furnishes the opportunity to study a longer historical period by including such samples that can consequently provide better insight into the long-term volatility movements (Baillie & DeGennaro, 1990; Elyasiani & Mansur, 1998). Thirdly, thin trading along with non-trading days (i.e. holidays and weekends) generates serious concerns regarding the use of daily data (Mandimika and Chinzara, 2012). Furthermore, the use of monthly data is in accordance with strong financial literature (e.g. see Bloom, 2009; Braun, Nelson, & Sunier, 1995; Chinzara, 2011; Doukas, Hall, & Lang, 2003; Faff & Brailsford, 1999; Hansson & Hordahl, 1998; Khan, Muneer, & Anuar, 2013; Lanne & Luoto, 2008; Manolis, Stelios, & Angelos, 2002; Sadorsky, 2001 and West & Worthington, 2006).

Then, as is practice in the financial literature, the return series will be expressed in logarithmic difference between the two successive prices acquiring the continuous compounding returns (i.e. $\ln(P_t / P_{t-1})$, where ln is the natural log, P_t is current closing price and P_{t-1} is previous closing price).

The reported explanatory statistics consist of mean, standard deviation, skewness, kurtosis and Jarque Bera. Keeping Electricity, Non-Life Insurance, Financial Services and Fixed Line Telecom as exceptions, all the average returns are positive, setting a bullish trend in the Pakistani market over the data period. Risk (as a measure of standard deviation) is highest for the Electricity sector (i.e. 0.95), while Personal Goods and Food Producer sectors stand as least risky (i.e. 0.059). Theoretically, if the risk is a priced factors, then the highest average returns must be matched with the highest standard deviation, whereas this is not obvious from the descriptive statistics. For example, the highest standard deviation is for the Electricity sectors (i.e. 0.95), while the lowest is for Personal Goods and Food Producer sectors (i.e. 0.059); however, the highest average return is for the Travel & Leisure sector (i.e. 0.018), while lowest average return is for Financial Services (i.e. –0.007) followed by Electricity and Non-Life Insurance sectors (i.e. –0.002). Hence, from this casual inspection, the risk and return do not hold any discernible positive relationship. In fact there seems to be negative risk-return relationship for the electricity sector.

Generally, data series shows features that are common with financial time series (e.g. see Elyasiani and Mansur, 1998; Elyasiani et al., 2011; Mandimika & Chinzara, 2012). For instance, the statistical significance of Jarque-Bera statistics coupled with the values of skewness and kurtosis reveals that the distribution of data series departs from normality. The high value of kurtosis clearly implies that data series advocate the character of fat tails. Of the 24, 12 are positively skewed and 12 are negatively skewed. Both the ADF and PP unit root tests imply that all the data series are stationary.

The fact that most of the data series reflect serial correlation together with rejection of normality motivates and suggests that the application of GARCH type models can considerably improve the explanation of the return series (Elyasiani & Mansur, 1998; Elyasiani et al., 2011; Mandimika & Chinzara, 2012). Moreover, the Ljung Box Q Statistics are significant for both the (LBQ (12)) returns and (LBQ^2 (12)) squared returns series.[1] The former indicates the existence of serial correlation for majority of the returns and squared returns series, a contradiction to the stock market informational efficiency However, the latter case confirms the existence of heteroscedasticity and volatility clustering (time varying nature), hence mitigating the use of GARCH type models (as they confine the time-varying behaviour of conditional volatility) (Kovacic, 2008; Mandimika & Chinzara, 2012).

2.2. Methodology

2.2.1. GARCH (1, 1)

Following the hallmark contribution of Engle (1982), Bollerslev (1986) introduced a more generalised form of the ARCH model, termed as the GARCH model. In this Generalised ARCH model, he sets the current conditional variance as a function of the previous square error term and past conditional variance. It is indeed incredible that this one GARCH (1, 1) model can be sufficiently applied in any financial time series in order to comprehend the volatility dynamics (for example, see Chinzara, 2011; Engle, 2004 and Elyasiani et al., 2011). Following the strong financial literature (see, for example, Chinzara, 2011; Engle, 2004; Elyasiani et al., 2011 and Goudarzi & Ramanarayanan, 2010), this research study also applied GARCH (1, 1) to estimate various volatility dynamics. More so, it is also evident from Schwarz Information Criterion (SIC) that lag one is the most appropriate lags to capture the volatility dynamics. Hence, GARCH (1, 1) stands as most appropriate order for this purpose. The following is the general univariate equation regarding this model (Chinzara, 2011):

$$r_t = \mu_i + \sum_{i=1}^{k} a_i r_{t-i} + \varepsilon_t, \quad \varepsilon_t / I_{t-1} \sim N(0, h_t) \tag{2}$$

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j}, \quad \omega < 0, \ |\alpha_i + \beta_i| < 1 \tag{3}$$

Equation (2) is a mean equation whose current innovation is a function of previous innovation. I_{t-1} has zero mean and variance h_t. Further, lagged and current returns are denoted by r_{t-1} and r_t respectively. While, equation (3) is the variance equation of GARCH (p, q), where the conditional variance is displayed by $h_{t,}$; a constant is indicated by w; the coefficient of lagged square residuals developed from mean equation (e^2_{t-1}) are represented by α_i, but β_i holds the representation of the coefficient of lagged conditional variances. For stationarity to hold, it is necessary that the sum of ARCH (α_i) and GARCH (β_i) terms must be less than one (Chinzara, 2011; Elyasiani et al., 2011). If their sum is equal to one, the condition is said to be integrated in variance, whereas the current volatility shocks are to be considered in forecasting the future volatility for all future periods (Engle & Bollerslev, 1986; Karmakar, 2007). However, in the case where the sum exceeds one, then such a situation declares that volatility shocks are non-mean reverting and are exploding to infinity (Brooks, 2002; Elyasiani et al., 2011; Mandimika & Chinzara, 2012). In fact, there is a tendency in the real financial data (i.e. stock returns) to hold the property of non-mean reversion (Mandimika & Chinzara, 2012).

The autoregressive route leading towards the persistence of volatility shocks is the sum of ARCH and GARCH terms (e.g. see Ewing et al., 2005; Elyasiani et al., 2011; Mandimika & Chinzara, 2012; who applied it to study the persistence of shocks). The closer the sum is to one, the longer is the persistence of the volatility shock. In addition, another stand for measuring the persistence of volatility shock is the Half Life of volatility introduced by Engle and Bollerslev (1986), which was later applied by the financial press (e.g. see Carrol & Connor, 2011; Elyaisani et al., 2011). The following is the formula for computing the half-life:

$$HL = log(0.5)/log(ARCH + GARCH)$$

According to Engle and Bollerslev (1986), the half-life of volatility represents the time taken by the volatility shock to cover half the distance back towards its mean volatility after a deviation from it.

Next, the feature of mean reversion of stock returns volatility entails that, by and large, volatility shocks hold the property of mean reversion in the stock market (Carrol & Connor, 2011; Engle & Patton, 2001). Statistically, following the literature (e.g. see Elyasiani et al., 2011), mean reversion of stock returns volatility is examined by mean of ARCH and GARCH terms in the GARCH (1, 1) model. For the mean reversion pattern to hold, the sum of ARCH and GARCH terms must be less than one (Carrol & Connor, 2011; Elyasiani et al., 2011). Further, the half-life so computed for each stock leads us to determine the speed of the mean reversion model of stock returns volatility.

2.2.2. GARCH-M model

The GARCH in mean model developed by Engle, Lilien, and Robins (1987) has been a great hallmark in the field of financial literature. Technically, it is applied to determine the pricing of risk by way of testing the relationship between standard deviation or conditional variance and stock returns. In accordance with the strong stream of financial press (e.g. see French et al., 1987; Hansson & Hordahl, 1998; Jiranyakul, 2011; Lanne & Saikkonen, 2004;

Lanne & Luoto, 2008 and Mandimika & Chinzara, 2012; who applied GARCH-M model to determine the risk-return relationship), this study also applied the GARCH-M model to detect the pricing of risk in an emerging market. The following general equation represents this model (Mandimika & Chinzara, 2012):

$$r_t = \mu_i + \sum_{i=1}^{k} a_i r_{t-i} + \delta_i h_{t-i} + \varepsilon_t, \quad \varepsilon_t / I_{t-1} \sim N(0, h_t^2) \tag{4}$$

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j}, \quad \omega > 0, \ |\alpha_i + \beta_i| < 1 \tag{5}$$

where equation (4) is an appropriate mean equation, where r_{it} indicates the stock returns, ε_t is the error term, I_{t-1} indicates the previous period information, h_t stands for the variance and h_{t-i} denotes the conditional standard error of ε_t at time t–i. However, equation (5) depicts the variance equation for a general GARCH (p, q) model. In this case, h_t marks the conditional variance for the residuals ε_t, α_i displays lagged square residuals, β_i denotes lagged conditional variance whereas w is constant. In particular, with respect to this study, the coefficient of great importance is h_{t-i}. This coefficient (δ_i) holds the relation between conditional risk (h_t) and stock returns (r_t). In accordance with the conventional portfolio theory, the investors are compensated with higher returns for their higher risk craving, if the δ_i is positive and significant. In particular, it would entail that the risk has been priced for the period under concern.

2.2.3. EGARCH Model

Nelson (1991) made a significant contribution by introducing the Exponential GARCH model (EGARCH) which has the capability to pick the asymmetric volatility of stock returns. It separately shows how the stock return volatility is affected by the good news (price rise) and bad news (price fall) of the same magnitude (Ewing et al., 2005; Mandimika & Chinzara, 2012). In line with the financial literature (e.g. see Braun et al., 1995; Cheung & Ng, 1992; Engle & Patton, 2001; Ewing et al., 2005 and Mandimika & Chinzara, 2012 among others), this study also applied the EGARCH model to examine the asymmetric response of stock returns volatility, which is commonly known as the asymmetric and leverage effect. The following is the general equation representing EGARCH model (Ewing et al., 2005 and Mandimika & Chinzara, 2012):

$$\log(h_t) = \omega + \sum_{j=1}^{p} \beta_j \log h_{t-j} + \sum_{k=1}^{m} \gamma_k \frac{\varepsilon_{t-k}}{\sqrt{h_{t-k}}} + \sum_{i=1}^{q} \alpha_i \left[\left| \frac{\varepsilon_{t-i}}{\sqrt{h_{t-i}}} - E\left(\frac{\varepsilon_{t-i}}{\sqrt{h_{t-i}}} \right) \right| \right]; \tag{6}$$
$$\omega < 0, \left|\alpha_i + \beta_j\right| < 1; \ \gamma_k < 0, \ \textit{if volatility is asymmetric.}$$

where, in equation (6), α_i and β_i have the same meaning as in the case of the GARCH (1, 1) model. However, specifically related to this current study, the coefficient of importance is γ_k. If the coefficient $\gamma_k \neq 0$ in the above equation, the volatility is said to be asymmetric but when γ_k<0, then the negative news (price fall) has a greater role in increasing stock returns volatility than positive news (price rise) of same magnitude. However, if γ_k>0, in such a situation the positive news has a stronger impact in increasing stock returns volatility than the negative news of the same magnitude (Brooks, 2002; Ewing et al., 2005 and Mandimika & Chinzara, 2012).

3. Empirical findings

3.1. Behaviour of volatility dynamics

Setting GARCH (1, 1) as the most appropriate model,[2] various volatility dynamics (i.e. volatility against both last period's and previous period's shocks, its persistence, mean reversion and speed of mean reversion) and pricing of risk together with asymmetric and leverage effect)[3] were investigated at each sectoral level along with aggregate market level returns.

Results rest on the fact that, in general, the Pakistani market is quite volatile. However, it is subject to variations across the sectors. Focusing on the role of last period's shock (ARCH-short term effect) and the previous period's shocks (GARCH-long term effect) separately, it is evident from the study that in the case of the Oil & Gas, Forestry, Gas & Water, Personal Goods, Tobacco, Food Producer, Financial Services, General Industrial and Construction & Material sectors, together with aggregate market level returns, the last period's volatility shock (short term effect) is central (significant coupled with a larger magnitude) in creating conditional stock returns volatility. However, for the stock returns of the Chemical, Beverages, Electricity, Engineering, Auto & Parts, Pharma & Bio, Life Insurance, Travel & Leisure, Household Goods, Non-Life Insurance, Fixed Line Telecom, Commercial Banking, Electronics & Electricity and Industrial Metal and Mining sectors, the memory of the previous period's shocks (long term effect) plays a key role (significant coupled with larger magnitude) in generating future stock returns volatility.

Next, turning to the persistence of shocks (by means of sum of ARCH and GARCH coefficients); it is quite evident that the longest persistence of shocks prevails in the case of the Chemical, Electricity, Gas & Water, Pharma & Bio, Personal Goods, Life Insurance, Travel & Leisure, Financial Services, Household Goods, Non-Life Insurance, Commercial Banking and Industrial Metal and Mining sectors, and rather longer for the stock returns of Oil & Gas, Tobacco, Beverages, Fixed Line Telecom and Electronics & Electricity sectors along with aggregate market returns, while it appears to be short in the case of Food Producer and Construction & Material sectors. But, the persistence is shortest for the stock returns of Forestry, Engineering, Auto & Parts and General Industrial sectors.

The financial press embraces the economic theory, backing such variations in conditional variances of stocks. Lamoureux and Lastrapes (1990) stated that at the micro level, it is the manifestation of clustering in trading volume that feeds the ARCH effect. However, at the macro level; business cycle and information patterns together with macro-economic factors (e.g. interest rate, exchange rate, dividend yield, marginal requirements, and money supply and oil prices) have been projected as a vital source of volatility clustering (Bollesrev, Chou, & Kroner, 1992; Elyasiani & Mansur, 1998). More specifically, Engle, Ito, and Lin (1990) (cited by Elyasiani & Mansur, 1998) stated two possible reasons for volatility clustering: (i) new arrival process and (ii) market dynamics against the news. The first one implies that, if the information reaches and the stock market incorporates the information instantly and completely, this may result in returns displaying in clusters. Secondly, assuming that the stock market participants hold heterogeneous priorities and it takes time to solve their anticipational differences in order to absorb the information shocks, volatility clustering can be guided by market dynamics.

Further, mean reversion of the nature of stock returns volatility rests on the empirical fact that the volatility shocks are mean reverting across all the sectors together with aggregate market level (i.e. $\alpha + \beta < 1$) except the Gas & Water and Travel & Leisure sectors where the volatility is non-mean reverting, stating that the current period shocks must be considered for forecasting the future volatility of these two sectors for an indefinite future period (as $\alpha + \beta > 1$). The exploding volatility for Gas & Water sector might be the outcome of a governmental decision to decrease the gas price by almost 40% with the intension of providing an alternative source of energy at a cheaper rate to boost businesses in the country (State Bank of Pakistan (SBP), 2012); however, in the case of the Travel & Leisure sector, it might be the result of higher economic instability (particularly the rising oil prices) adversely affecting performance (Ministry of Finance, 2012). More so, from the context of the speed of mean reversion (measured by mean of half-life); empirical findings are also based on the fact that, by and large, the volatility process is mean reverting but holds varying speeds across the sectors. For instance, speed can be slowest for the returns of the Pharma & Bio, Personal Goods, Life Insurance and Industrial Metal and Mining sectors (such as $HL > 6$); relatively slower in the case of the Chemical, Electricity, Household Goods and Non-Life Insurance sectors (as $4 < HL < 6$); rather slow for the stock returns of the Oil & Gas, Financial Services, Fixed Line Telecom and Commercial Banking sectors (such as $2 < HL < 4$). However, speed seems to be faster in the case of the Tobacco, Beverages, Food Producer, Electronics & Electricity and Construction & Material sectors as well as aggregate market level returns (such as $1 < HL < 2$). But speed appears to be fastest for the returns of the Forestry, Engineering, Auto & Parts and General Industrial sectors (i.e. $HL<1$).

The hypothetical foundations set by the financial literature serve the mean reversion behaviour of volatility in the Pakistani market. Theoretically, it stems from volatility clustering, implying that volatility moves to and fro. Hence, the period of low volatility will ultimately give way to the period of high volatility and, likewise, the high volatile period will be traced by a normal one (Carrol & Connor, 2011; Engle & Patton, 2001). Therefore, the mean reversion of volatility simply reports the presence of mean level of volatility for every financial asset, which is eventually returned by the volatility. Even for a very long forecast of volatility, it will ultimately return to this normal level of volatility, no matter when it is achieved (Carrol & Connor, 2011; Engle & Patton, 2001). Such a property of a financial asset is termed as mean reversion of volatility. However, most of the practitioners might disagree on the mean level of volatility and whether it is stable over all the time and corporate changes; yet they do agree on one common belief that there is a mean level of volatility to which the volatility steadily returns (Engle & Patton, 2001).

3.2. *Asymmetry and leverage effect*

The results show that there is evidence of the asymmetry and leverage effect for the stock returns of the Oil & Gas, Chemical, Electricity, Auto & Parts, Gas & Water, Pharma & Bio, Personal Goods, Life Insurance, Financial Services, Fixed Line Telecom, General Industrial, Fixed Line Telecom, Electronics & Electricity and Industrial Metal and Mining sectors. However, the level is statistically significant only in the case of the Oil & Gas, Pharma & Bio, Personal Goods, Gas & Water, Electricity and Fixed Line Telecom sectors. The results further add that the magnitude of asymmetry and leverage effect is largest in the case of the Gas & Water followed by Fixed Line Telecom and then by the Electricity, Personal Goods and Oil & Gas sectors. This establishes that the bad news (price fall) increases stock returns volatility more than good news (price rise) of the same magnitude. Relatively, the largest role of bad news for the Gas & Water, Fixed Line Telecom, Electricity, Personal Goods and Oil & Gas sectors in increasing stock returns volatility might rest on some specific issues faced by them over the years. For example, in the case of the Gas & Water sector, it might be the result of unstable governmental policies damaging the profitability of this sector (SBP, 2012–2013).[4] However, the Electricity sector has been put under significant stress over the last six years due to growing electricity demands and rising supply-demand gap in the country, but there has been a lack and insufficiency of energy generation plans by the government to enhance the electricity supply to meet the growing demands in the country. As a result, several business units shifted to other countries, e.g. Bangladesh, Malaysia and Thailand etc. (SBP, 2012; Asian Development Bank Report (ADB), 2008; 2012; International Monitoring Fund Country Report (IMF), 2010). Further, the increasing corporate governance issues in the Electricity sector (for example, see IMF Country Report, IMF, 2010) might be embarked upon as another reason for the relatively higher asymmetry and leverage effect; whereas, in the case of Personal Goods, a relatively higher asymmetric volatility is not surprising. The extraordinary situation such as energy shortage, electricity shutdown, rising fuel prices, lack of R&D regarding cotton, lack of modernised technology, lack of new investments, cuts in imports of Pakistan's cotton by EU and USA, lack of efficient supply chain management and bad planning by the government added momentum to the decreasing profitability. This results in the closure of various units and also shifting of these units to other countries (SBP, 2012; 1; IMF Country Report, 2010; IMF, 2012; Chamber of Commerce, 2012). Next, the Oil & Gas sector overall dominated in the preferences of foreign investors; however, over the last five years a drift in FDI from the Oil & Gas sector to other sectors in the economy, might be an influential factor in creating a relatively higher asymmetry and leverage effect (IMF Country Report, 2010–2012; Ministry of Finance, 2011–2012). Further, the Fixed Line Telecom sector might be projecting such results owing to the decreasing demand for the fixed line communication system in the presence of mobile communication systems due to severe competition and huge investments (SBP, 2012; ADB Report, 2008, 2012).

The following four economic theories are also supporting the asymmetric and leverage effects. First, it hinges on the leverage effect theory, declaring that in the case of a fall in share price (negative news), the financial leverage rises, which consequently increases the stock return volatility (Black, 1976; Christie, 1982). This 'leverage effect' has become synonymous with asymmetric volatility and, however, it is probable that asymmetric volatility might basically reflect the time varying risk premium and/or asymmetric volatility of macroeconomic variables theory (Duffee, 1995; Mandimika & Chinzara, 2012). Secondly, the time varying risk premia theory focuses on the positive relation between volatility and expected return. It follows that in the course of the anticipated rise in volatility; the expected required rate of returns also rises, which consequently (according to asset valuation model) decreases the stock prices (Duffee, 1995; French et al., 1987; Mandimika & Chinzara, 2012; Pindyck, 1984). It happens because volatility is an indicator of risk, and if the investors are supposed to be risk averse, a rise in volatility (risk) will bring the demand for that stock down, resulting in a price fall. Hence, if volatility is priced then a rise in volatility raises the required rate of return on stock which immediately leads to share price decline, frequently termed as the volatility feedback effect (Karmakar, 2007; Mandimika & Chinzara, 2012).

Thirdly, asymmetric volatility can also be explained on the basis of asymmetric volatility of economic factors theory. As the empirical research has documented (see, for example, French & Sichel, 1993; Schwert, 1989), macroeconomic variables are more volatile during recession. Thus, if so, then it is quite reasonable to conjecture that a lower forecast of economic variable growth rate (e.g. GDP) results in an instant fall in stock prices, which is followed by higher stock return volatility in the period of low economic factors growth (Duffee, 1995). Fourthly, it is quite possible that asymmetric volatility might be the outcome of both leverage (financial) and the volatility feedback effect theory simultaneously (Mandimika & Chinzara, 2012). If, for instance, there is an expectation of rise in volatility in the stock market, resultantly, the market players will place more order to short than to long stocks. Consequently, the price will fall to balance the supply and demand forces. Hence, an expected rise in volatility results in an instant price fall in accordance with the hypothesis of volatility feedback. This fall in price will increase the leverage ratio, which in the light of the hypothesis of leverage effect, will bring the prices down further (Karmakar, 2007; Mandimika & Chinzara, 2012).

3.3. Risk-return trade-off

Holding the Oil & Gas, Chemical, Tobacco, Beverages, Electricity, Auto & Parts, Gas & Water, Food Producer, Travel & Leisure, Financial Services, Commercial Banking, Industrial Metal and Mining and Construction & Material sectors as an exception, the coefficients for all the rest of the estimated models showed that the risk-return connectivity is insignificant negative or insignificant positive. Further, the risk-return trade-off in the case of the Chemical, Electricity, Auto & Parts, Gas & Water, Food Producer, Travel & Leisure, Financial Services, Commercial Banking, Industrial Metal and Mining and Construction & Material sectors, stands statistically significant and positive, marking the pricing of risk. However, for the stock returns of the Oil & Gas, Tobacco and Beverages sectors, the relationship between risk and stock return is also statistically significant but negative, holding that risk is not a price factor and there is negative risk premium for the investors.

Risk premium might be positive or negative. Although negative risk premium contradicts the fundamental portfolio theory (i.e. Markowitz, 1952), it still has been determined in the empirical financial press (see, for example, Balios, 2008; Elyasiani & Mansur, 1998; Fraser & Power, 1997; Glosten et al., 1993; Lebaron, 1989; Lettau & Ludvigson, 2010; Mandimika & Chinzara, 2012). It is supported by the four reasons given in the financial literature. First, Lebaron (1989) and Balios (2008) featured such outcomes to non-synchronisation of trading when the stock market is accredited by thin trading and illiquidity, motivating the investors to give up a positive risk premium in chasing the successful transactions. Secondly, Koutmos et al. (1993) identified that the negative risk premium might be due to the fact that local investors are not open to the foreign exchange risk; therefore, they will not insist on the exchange rate risk premium (i.e. returns are considered in Pak Rupees). Added together, they stated that if returns are transformed to a foreign currency (e.g. US dollar), then there is a high probability that a positive risk premium can become evident. The third and fourth reasons rest on the argument of Elyasiani and Mansur (1998) and Glosten et al. (1993) who documented that the negative risk premium might be due to the fact that the riskier period coincides with the period when investors are relatively better in bearing risk or that if the investors are interested in saving more during a riskier period while holding all risky assets, the competition may increase the asset prices and, hence, decrease the risk premium.

4. Conclusion and future implications

This current study analysed various volatility dynamics (i.e. volatility against last period's and previous period's shocks, its persistence, mean reversion and speed of mean reversion), risk-return trade-off together with asymmetry and the leverage effect on the Pakistani stock market. Twenty-three sectoral returns along with aggregate market level returns were the pivotal element of the study. Results depicted that beside the aggregate market level, there is significant evidence of volatility across the sectors but there is little evidence of asymmetry and the leverage effect. For example, there is significant evidence of asymmetry and the leverage effect on six sectors out of 23. Moreover, the shocks are quite persistent but with varying degrees across the sectors. Further, the volatility process in the Pakistani stock market is, by and large, mean reverting; however, the speed of mean reversion varies over the sectors. The pricing of risk (positive risk premium) is also evident for ten sectors, whereas three of the sectors hold negative risk premium. Positive risk premium honours the fundamental portfolio theory. However, the negative risk premium might be the result of: (i) thin trading and illiquidity; (ii) due to the fact that local investors are not open to the foreign exchange risk as they measure the returns in domestic currency; (iii) a riskier period coincides with the period when investors are relatively better in bearing risk; and (iv) while holding all risky assets, if the investors are interested in saving more during a riskier period, competition may increase the asset prices; hence, decreases the risk premium.

This research study sets the implications for both the policy makers and investors. First, the pricing of risk varies across the sectors. It implies that, in situations where risk is not a priced factor, other sector-specific factors must be considered – they must "think outside the box". They might possibly give due importance to the skewness. The investors might prefer stocks that are right skewed over the ones that are left skewed (Harvey & Siddique, 2000). In addition, investors also need to value other factors, such as firm size, age and book-to-market ratio. Secondly, the general increase in volatility in most of the models opens another area of serious concern for the policy makers and investors. For the policy makers, rising volatility is an element of severe apprehension as it can trigger the economic instability by mean of huge capital outflow, thereby intensifying the financial instability. However, for investors, it will be worth diversifying their portfolio investments between stable and risky sectors. This research study sets two prospective avenues for the future research. Initially, given the scarcity of evidence, particularly regarding the asymmetric volatility (for 17 models – 16 sectoral and one aggregate market level – out of 24), further research studies should try to emphasise the micro-level analysis (i.e. firm level), first due to the fact that firms are heterogeneous in nature even in a very narrowly defined sectors (Ewing et al., 2005; Narayan & Sharma, 2011) and secondly due to the fact that firm level analysis is very scarce, particularly in Pakistan. In addition, the considerable significance granted by the influential literature to firm features (i.e. size, age, trading nature and nature of business), along with the negligence of existing scholars, leaves a potential avenue for future research in this respect. Thus, future research might find different and more improved results in this regard. Second, financial literature is of the view that any crisis or boom in one market can affect others. For example, capital flight to one specific country might worry the investors that something is wrong with other similar countries, hence pulling their investment out of those countries as well. A crisis in one country often forces financial agents to short their position from other markets in order to regain their liquidity position (see, for example, Ocampo, Spiegel, & Stiglitz, 2008). Thus signifying the cross-country comparison of volatility dynamics and risks-returns trade-off for the future research.

Notes

1. Ljung Box Q Statistics are significant for both the returns and squared returns series of Tobacco, Forestry, Gas & Water, Pharma & Bio, Personal Goods, Financial Services, General Industrial, Non-Life Insurance and Fixed Line Telecom sectors; however, in the case of Oil & Gas, Chemical, Auto & Parts, Life Insurance, Food Producer, Travel & Leisure, Industrial Metal and Mining sectors, Ljung Box Q Statistics are significant only for the square returns while for Beverages; it is significant only for the returns series.
2. For GARCH (p, q) model, GARCH (1, 1) is found to be best fitted for the return series being considered. During the testing phase, ARCH (1) and GARCH (1) order best described the volatility. For just inspection purposes, when a higher order GARCH model was tested, the results regarding the volatility were not as good as with a lower order GARCH (i.e. GARCH (1, 1)).
3. GARCH-M and EGARCH models are applied for investigating the pricing of risk and asymmetric effect respectively.
4. Governmental policies regarding the commercial use of Gas as an alternative source of energy were highly unstable over the years. Owing to limited supply and constant growing demand of gas as an alternative source of energy, the government put its decisions on and off regarding its commercial use. Further, governmental decisions of significantly (by almost 40%) cutting back the gas prices to enable this alternative source of energy available at a cheaper rate; adversely affected the profitability of the sector. Thus, growing uncertainty might have pushed for such empirical results.

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