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BEHAVIOUR OF VARIOUS VOLATILITY DYNAMICS OF FIRM STOCK RETURNS

This study analyses volatility dynamics of firm returns at the emerging stock market of Pakistan by employing the monthly data for the period from 1998 to 2012. GARCH (1, 1) model is applied to capture the volatility dynamics. The study comes up with the following findings. Firm level stock returns are quite volatile at Pakistani stock market. Short-term effect is much more prominent in increasing future stock returns volatility over the long-term effect. In the case of shocks persistence, the overall volatility shocks are rather durable but are subject to sectoral location of the firm effect. Large volatility shocks at Pakistani stock market are mean reverting at the firm level, they are however subject to variations across sectors. The final outcome is that the speed of mean reversion at firm level stock returns significantly varies across sectors.

Keywords: *volatility dynamics; firm stock returns; GARCH model; Pakistani stock market.*

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РІЗНОМАНІТТЯ ДИНАМІКИ ВОЛАТИЛЬНОСТІ ПРИБУТКІВ НА ФОНДОВІЙ БІРЖІ

У статті проаналізовано волатильну динаміку прибутків компаній на фондовій біржі на прикладі відносно молодого ринку Пакистану. Для аналізу використано щомісячні дані з 1998 по 2012 роки. Побудовано GARCH-модель, яка демонструє динаміку волатильності. Яскраво вираженою є волатильність прибутків на рівні аналізу спостережень за окремими компаніями. При цьому короткотривалі ефекти проявляються набагато яскравіше за довготривалі. Нестабільність в цілому може бути тривалою, але її тривалість багато в чому визначається галуззю, до якої належить компанія. Значні, загальні для всього фондового ринку, шоки впливають на нестабільність прибутків окремих компаній, проте міра цього негативного впливу визначається галуззю приналежності.

Ключові слова: *динаміка волатильності; прибуток від акцій компанії; модель GARCH: фондовий ринок Пакистану.*

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РАЗНООБРАЗИЕ ДИНАМИКИ ВОЛАТИЛЬНОСТИ ПРИБЫЛЕЙ НА ФОНДОВОЙ БИРЖЕ

В статье проанализирована волатильная динамика прибылей компаний на фондовой бирже на примере развивающегося фондового рынка Пакистана. Для анализа использованы ежемесячные данные с 1998 по 2012 годы. Построена GARCH-модель, демонстрирующая динамику волатильности. Ярко выраженная волатильность прибылей отмечается на уровне анализа отдельных компаний. При этом краткосрочные эффекты проявляются более явственней, чем долгосрочные. Нестабильность в целом может быть длительной, при этом её длительность во многом определяется отраслью предприятия. Значительные, общие для всего фондового рынка, шоки склонны влиять на нестабильность прибыли отдельных компаний, однако и здесь мера влияния во многом определяется отраслью.

Ключевые слова: *динамика волатильности; прибыль акций компании; модель GARCH; фондовый рынок Пакистана.*

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1. Introduction. Extreme stock market volatility may derail smooth operations of other financial markets in the country and consequently can have a negative impact on investments, savings, performance of real economy and economic growth (Mandimika and Chinzara, 2012). Forecasting volatility is a critical factor in risk management, portfolio strategies, hedging and market timings for the stock market (Engle and Patton, 2001; Ewing et al., 2005).

How persistent the volatility shocks are at a stock market, is a crucial indicator in detecting the association between volatility and return, since the persistence volatility changes permit to the adjustments in risk premia (Elyasiani and Mansur, 1998). In financial literature, the clustering of large changes and small changes in pricing is one of the primary concerns in relation to volatility (Engle and Patton, 2001). Moreover, Mandelbrot (1963) and Fama (1965) reported that large change in asset price is followed by another large change, whereas small change is followed by another small change. Such behaviour of volatility is also documented by several other studies (Chou, 1988; Schwert, 1989; Baillie et al., 1996; Engle and Patton, 2001; Ewing et al., 2005). Such volatility clustering implies that volatility shocks today will influence the future expected volatility for many horizons.

Next, the feature of mean reversion of stock returns volatility entails that volatility shocks hold the property of mean reversion at a stock market (Engle and Patton, 2001; Carroll and Connor, 2011). Theoretically, it stems from volatility clustering, implying that volatility comes and goes. Thus, it simply reports the presence of mean level of volatility for every financial asset which is eventually returned by volatility. In majority of the existing financial literature, the studies examining stock returns volatility together with its persistence and mean reversion mainly are targeted at the aggregate market and/or sectoral level returns. For example, Engle and Patton (2001), Ewing et al. (2005), West and Worthington (2006), Carroll and Connor (2011) and Elyasiani et al. (2011) are among others for developed markets. However, the research work of Chinzara and Aziakpono (2009), Chinzara (2011) and Mandimika and Chinzara, (2012) for the South African stock market and Goudarzi and Ramanarayanan (2010) for Indian stock market explore the aggregate market and/or sectoral level returns. However, due to firm heterogeneity aggregate market and sectoral level analysis provide deceptive results (Ewing et al., 2005; Chinzara, 2011). Therefore, the microlevel analysis (i.e. firm level) can be more fruitful. Elyasiani et al. (2011) recommended that mean reversion pattern of stock return volatility should be examined across the sectors keeping in view the unique features of various sectors.

Specifically related to this research, there are 4 facts motivating the analysis of firm level volatility. First, in the view of Shleifer and Vishny (1997), for some stocks higher idiosyncratic variance might be mispriced and hence resulting in lower expected returns. Second, Campbell et al. (1997) noted the considerable importance of firm level volatility, since the statistically significance of abnormal returns are contingent on firm level volatility rather than sectoral or aggregate market volatility. They further added that most investors hold individual stock. For such investors, as viewed by Campbell et al. (1997), variations in firm level volatility matters as much as the aggregate market volatility. Third, because volatility is a measure of risk, in the view of incomplete market models (Constantinides and Duffie, 1996), investors lack perfect

diversification of their risk, and as a consequence the firm level volatility (risk) matters for asset pricing. In similar vein, Merton (1987) argued that since investors hold imperfectly diversified portfolio, in order to compensate them, higher firm volatility must furnish higher average returns. Fourth, since firm level volatility is expected to increase over the year than the aggregate market volatility (Sharma et al., 2014), its roots are worth investigating for the volatility dynamics at firm level.

Thus, it is quite reasonable to argue that volatility, its persistence, mean reversion and speed of mean reversion of volatility shocks is of a considerable significance for stock market players. Unfortunately, studies in this respect are limited up, particularly at firm level (Sharma et al., 2014), specifically for emerging markets like Pakistan. Such scholars as (Hameed and Ashraf, 2006; Saleem, 2007; Zafar et al., 2008; Mahmud and Mirza, 2011; Rafique and Rehman, 2011; Rashid et al., 2011; Qayyum and Anwar, 2011; Mushtaq et al., 2011; Arshad et al., 2012; Ali and Afzal, 2012) examined the stock returns volatility only at the aggregate market level in Pakistan. More so, heterogeneity of firms (Ewing et al., 2005) can bring some different and interesting outcome. Hence, this current study aims to close this gap.

Remaining of the article is intended as follows. Section 2 gives details on the data used. Section 3 holds the methodology applied. Section 4 spells the discussion regarding the results. Section 5 sums up the paper, policy implications together with future research directions are provided.

2. Data and description. This study used monthly returns series for 208 firms across 23 sectors for the period from June 1998 till June 2012, which was obtained from Karachi Stock Exchange website and Business Recorder. Use of monthly data is in accordance with financial press (Chinzara, 2011; Khan et al., 2013).

Generally, data series shows the features common with financial time series (Mandimika and Chinzara, 2012). For example, descriptive statistics reveals that the distribution of data series is departing from normality. The verity 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 significantly advance the justification of the return series (Elyaisani et al., 2011). Both augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests declare that all data series are stationary. The results for descriptive statistics, unit roots tests and Ljung Box Q Statistics (for each firm) are not reported here because of the briefness of paper format.

3. Methodology. ***GARCH (1, 1) Model.*** Bollerslev (1986) developed a more generalized form of ARCH model, termed as GARCH. Following other financial studies, this research also applied GARCH (1, 1) to estimate various volatility dynamics. Following is the general equation regarding GARCH model (Chinzara, 2011):

$$r_t = u_i + \sum_{i=1}^{k} \alpha_i r_{t-i} + \varepsilon_t, \frac{\varepsilon_t}{I_{t-1}} \sim N(0, h_t); \quad (1)$$

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

Equation (1) is a mean equation whose current innovation is a function of previous innovation. I_{t-1} hold zero mean, h_t indicating a variance which is serially uncorrelated. Further, lagged and current returns are denoted by r_{t-i} and r_t respectively. Equation (2) is the variance equation of GARCH (p, q), where the conditional vari-

ance is displayed by h_t; constant is indicated by ω; the coefficient of lagged square residuals developed from mean equation (ε^2_{t-1}) is represented by α_i but β_j holds the representation of coefficient of lagged conditional variances. For the stationarity to hold, the sum of ARCH (α_i) and GARCH (β_j) terms must be less than one (Elyaisani et al., 2011). If their sum is equal to one, the condition is said to be integrated in variance. However, in the case where the sum exceeds one, such situation declares that volatility shocks are non-mean reverting and are exploding to infinity.

The autoregressive route leading towards the persistence of volatility shocks is the sum of ARCH and GARCH terms (Ewing et al., 2005). The more closer the sum is to one, the longer is the persistence of volatility shock. More so, following is the formula for computing the half life: $HL = \log(0.5) / \log(ARCH+GARCH)$.

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

Statistically, mean reversion of stock returns volatility is examined by way of ARCH and GARCH terms in GARCH (1, 1) model (Elyasiani et al., 2011). For the mean reversion pattern to hold, the sum of ARCH and GARCH terms must be less than one. Further, the half life thus computed for each stock leads us to determine the speed of mean reversion model of stock returns volatility.

4. Empirical findings. Table 1 below presents the results regarding various volatility dynamics for each sector. Firms belonging to different sectors have shown diversified results regarding stock returns volatility, persistence and mean reversion of volatility. Stock returns volatility is measured in terms of both last periods' volatility shock (ARCH short-term effect) and previous period's volatility shocks (GARCH long-term effect). For majority of the firms related to Oil & Gas, Tobacco, Beverages, Engineering, Auto & Parts, Gas & Water, Pharma & Bio, Food Producer, Personal Goods, Travel & Leisure, Financial Services, General Industrial, Household Goods, Commercial Banking, Construction & Material and Industrial Metal & Mining sectors, it is the last period's volatility shock (ARCH short-term effect) which dominates in increasing stock returns volatility (ARCH effect is significant for relatively higher percentage of firms in these sectors than the GARCH effect). However, for majority of the firms belonging to Forestory, Electricity, Fixed Line Telecom and Electronics & Electricity sectors, it is the memory of previous period's volatility shocks (GARCH) that leads to increasing conditional stock returns volatility (GARCH effect is significant for relatively higher percentage of firms in these sectors than the ARCH effect). But in the case of Chemical, Life Insurance and Non-Life Insurance sectors, both the last period's shock and the previous period's shocks create future stock returns volatility in almost equal proportion. The earlier studies (Chou, 1988; Engle and Patton, 2001; Ewing et al., 2005; West and Worthington, 2006; Magnus and Fosu, 2006; Su and Bilson, 2011; Elyasiani et al., 2011; Mandimika and Chinzara, 2012) also documented the role of ARCH (the last period's shock) and GARCH (previous period's shocks) effects in increasing stock returns volatility but mainly focusing at either sectoral (few) and/or aggregate market level (most).

It is worth highlighting here that contrary to the existing studies (Chou, 1988; Engle and Patton, 2001; Carroll and Connor, 2011; Ewing et al., 2005; Elyasiani et

Table 1. **GARCH (1, 1) model results,** *authors'*

Sectors	*Volatility Dynamics*							
	ARCH effect			*GARCH effect*		*Mean reversion*	*Speed of mean reversion*	
	Sig (+)	Sig (-)	Insig (+)	Sig (+)	Insig (+)		HL < 2	HL ≥ 2
Oil & Gas	5 (71.43)	0 (0.00)	2 (28.57)	3(42.86)	4 (57.14)	5 (71.43)	2 (40.00)	3 (60.00)
Chemical	7(58.34)	1 (8.33)	4 (33.33)	7(58.33)	5 (41.67)	12 (100.00)	3 (25.00)	9 (75.00)
Tobacco	3(100.00)	0 (0.00)	0 (0.00)	1 (33.33)	2(66.67)	3(100.00)	2(66.67)	1 (33.33)
Beverages	3(100.00)	0 (0.00)	0 (0.00)	2(66.67)	1 (33.33)	3(100.00)	1 (33.33)	2(66.67)
Forestry	1 (33.33)	2 (66.67)	0 (0.00)	2 (66.67)	1 (33.33)	3(100.00)	1 (33.33)	2 (66.67)
Electricity	8 (72.73)	1 (9.09)	2 (18.18)	10 (90.91)	1 (9.09)	8 (72.73)	2 (25.00)	6 (75.00)
Engineering	4 (57.14)	0 (0.00)	3 (42.86)	3 (42.86)	4 (57.14)	7 (100.00)	3 (42.86)	4 (57.14)
Auto & Parts	7 (70.00)	0 (0.00)	3 (30.00)	6 (60.00)	4 (40.00)	9 (90.00)	4 (44.45)	5 (55.55)
Gas & Water	2 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (100.00)	1 (50.00)	1 (100.00)	0 (0.00)
Pharma & Bio	6 (100.00)	0 (0.00)	0 (0.00)	3 (50.00)	3 (50.00)	6 (100.00)	2 (33.33)	4 (66.67)
Personal Goods	26 (86.67)	1 (3.33)	3 (10.00)	24 (80.00)	6 (20.00)	17 (56.67)	4 (23.53)	13 (76.47)
Life Insurance	2 (100.00)	0 (0.00)	0 (0.00)	2 (100.00)	0 (0.00)	2 (100.00)	0 (0.00)	2 (100.00)
Food Products	24 (82.76)	1 (3.45)	4 (13.79)	20 (68.97)	9 (31.03)	17 (58.62)	9 (52.94)	8 (47.06)
Travel & Leisure	2 (100.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (100.00)	1 (50.00)	1 (50.00)
Financial Services	16 (100.00)	0 (0.00)	0 (0.00)	12 (75.00)	4 (25.00)	13 (81.25)	4 (30.77)	9 (69.23)
General Industrial	4 (80.00)	0 (0.00)	1 (20.00)	2 (40.00)	3 (60.00)	3 (60.00)	1 (33.34)	2 (66.67)
Household Goods	4 (100.00)	0 (0.00)	0 (0.00)	2 (50.00)	2 (50.00)	2 (50.00)	2 (100.00)	0 (0.00)
Non-Life Insurance	10 (66.67)	2 (13.33)	3 (20.00)	10 (66.67)	5 (33.33)	12 (80.00)	2 (16.67)	10 (83.33)
Fixed Line Telecom	2 (66.67)	0 (0.00)	1 (33.33)	3 (100.00)	0 (0.00)	3 (100.00)	0 (0.00)	3 (100.00)
Commercial Banking	11 (73.34)	0 (0.00)	4 (26.66)	10 (66.67)	5 (33.33)	11 (73.34)	4 (36.36)	7 (63.64)
Electronics & Electricity	2 (66.67)	0 (0.00)	1 (33.33)	3 (100.00)	0 (0.00)	3 (100.00)	2 (66.67)	1 (33.33)
Construction & Material	11 (73.34)	1 (6.66)	3 (20.00)	9 (60.00)	6 (40.00)	12 (80.00)	6 (50.00)	6 (50.00)
Industrial Metal &Mining	4 (80.00)	0 (0.00)	1 (20.00)	2 (40.00)	3 (60.00)	3 (60.00)	2 (66.67)	1 (33.33)

The table shows the number of firms in each sector and their level of statistically significant and insignificant ARCH and GARCH effects with positive and negative trends together with mean reversion and speed of mean reversion of volatility. The results are also converted into percentage for each sector and reported in the parenthesis.

al., 2011) related to developed markets (all these studies examined the developed stock market of NYSE and found that the previous period's volatility shocks (GARCH long-term effect) are significant and larger in magnitude as compared to the last period's volatility shock (ARCH short-term effect) in increasing future stock returns volatility), this study uncovered that from the prospective of developing markets (Pakistan), largely; the last period's volatility shock (ARCH short-term effect) dominates in terms of both significance and magnitude in increasing future stock returns volatility, its persistence and mean reversion, over the previous period's volatility shocks (GARCH long-term effect). These results confirm the theoretical statement of Iqbal (2012) that investors are rather shortsighted at Pakistani stock market. Therefore, if it is the case, then they are more concerned about the last period's price change (short-term effect) rather than previous period's price changes (long-term effect). Such results are also reported by West and Worthington (2006), who concluded the dominance of ARCH effect (short-term) in terms of both significance and magnitude over the GARCH effect (long-term) in increasing future stock returns volatility.

Addressing the persistence of volatility shocks (by mean of both half life and the sum of ARCH & GARCH terms), the results uncovered that most firms belonging to Personal Goods, Food Products, General Industrial, Household Goods, Commercial Banking, Construction & Materials, Financial Services, Oil & Gas, Chemical, Forestry, Industrial Metal & Mining, Electricity, Pharma & Bio, Life Insurance, Non-Life Insurance and Fixed Line Telecom sectors have shown relatively higher persistence of volatility shocks in contrast to firms belonging to Engineering, Automobile & Parts, Electronics & Electricity, Tobacco, Beverages, Gas & Water and Travel & Leisure sectors. Chou (1988), Engle and Patton (2001), Ewing et al. (2005), West and Worthington (2006), Su and Bilson (2011), Elyasiani et al. (2011) and Mandimika and Chinzara (2012) also reported the persistence of volatility shocks but focusing at either sectoral (few) and/or aggregate market level (most) stock returns data.

Aiming mean reversion and speed of mean reversion of volatility, some appealing findings are untied. First, mean reversion of volatility displays that all the firms (100%) related to Chemical, Tobacco, Beverages, Forestry, Engineering, Pharma & Bio, Life Insurance, Travel & Leisure, Fixed Line Telecom and Electronics & Electricity sectors denoted mean reverting nature of their stock returns volatility. Whereas around 80–90% of the firms from Auto & Parts, Financial Services, Non-Life Insurance and Construction & Material sectors have employed the mean reversion nature of their stock returns volatility. But the stock returns of about 70–75% of the firms associated with Oil & Gas, Electricity and Commercial Banking sectors are mean reverting in terms of their volatility shocks. However, the mean reversion is relatively found to be least (only around 50–60% of the firms) for the stock returns of the firms belonging to Personal Goods, Food Products, Gas & Water, General Industrial, Household Goods and Industrial Metal & Mining sectors.

Examining the speed of mean reversion (by mean of half life of volatility), the results disclosed that comparatively the firms related to Tobacco, Gas & Water, Household Goods, Electronics & Electricity and Industrial Metal & Mining sectors posses the fastest speed of mean reversion of their volatility shocks (for 2 sectors 100%

and for 3 sectors around 70% of the firms have half life of less than two months). Followed by the firms belonging to the Oil & Gas, Engineering, Auto & Parts, Food Products, Travel & Leisure and Construction & Material sectors, holding relatively slower speed of mean reversion. For example, about 40–50% of the firms in these sectors reflect half life of less than two months. However, the firms belonging to the remaining sectors (Chemical, Beverages, Forestry, Electricity, Pharma & Bio, Personal Goods, Life Insurance, Financial Services, General Industrial, Non-Life Insurance, Fixed Line Telecom and Commercial Banking) have the slowest speed of mean reversion. Around 70% of the firms in these sector scores half life of more than two months. Chou (1988) and Engle and Patton (2001) also reported the mean reversion behaviour of stock returns volatility at the aggregate market level at NYSE.

5. Conclusion. This study analyzed various volatility dynamics (i.e., volatility due to ARCH and GARCH effects, its persistence, mean reversion and speed of mean reversion) at the firm level stock returns across 23 sectors at Pakistani equity market. By mean of applying GARCH (1, 1) model, our main findings are as follows. First, we uncovered that firm level stock returns are quite volatile at Pakistani stock market. Second, we argue that short-term effect is much more prominent in terms of significance as well as magnitude in increasing future stock returns volatility over the long-term effect. Third, as for the persistence of shocks, the results explored that overall volatility shocks are rather persistent but are subject to sectoral location of the firm effect. Third, from the context of mean reversion, volatility shocks at Pakistani stock market are mean reverting at firm level, but are however subject to variations across the sectors. Firms in some sectors display relatively higher means reversion than the others. In the process of examining the speed of mean reversion, the final results revealed that the speed at the firm level stock returns considerably varies across sectors. Hence, the concluding remarks prove the view of financial literature arguing that the firms are of heterogeneous nature and thus the empirical findings can be rather different in contrast to aggregate market or sectoral level returns.

These findings implicate that it will be quite worthy for investors to diversify their portfolio investments between stable and risky sectors. However, for policy makers, in order to control the flows of capital and attract investments, it will be of immense importance to develop an economic policy keeping in view the volatility dynamics across sectors. Future research should try to address firm characteristics in order to investigate these dimensions in more detail.

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