



# **THE SPEED OF MEAN REVERSION: REGIONAL MARKET STUDY**

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## **1. INTRODUCTION**

### **1.1 Background of the Study**

The study undertaken by Spierdijk & Jacob (2012) it is to be said in economics what goes up, must come down. Regarding of stock prices this idea transforms into the concept of (long-run) mean reversion, which affirms that a decline in stock prices is most likely to be followed by an upward price movement, and vice versa.

According to Ahmad & Sara (2012) in buying and selling of gold the investors evaluate the risk such as hedging, prevailing economic conditions, currency fluctuations, social and political crises. In general the speculation for the investment in gold is depend upon the efficient market hypothesis including future informations, derivatives and stochastic volatility models i.e Heston model, the SABR model, the Chen model and the GARCH model.

According to Lien (2011) arguments on the existence of mean reversion of stock prices pull towards special concerns of financial analysts and investors because of its importance in investment strategies.

According to Pavlenko (2008), in the research about mean reversion speed in stock market. Researchers recently, in financial markets, are searching for the variable to agree on stock price actions. Conversely, so many ground rules grab the stock price such as company's

routine, opportunity, mood of the Speculators and others, it is very difficult to predict its future manners or other say, almost impossible. This perspective has been concluded and called random walk hypothesis that suggests that stock price movements are totally unpredictable. The random walk theory has dominated in the theoretical literature for several decades.

It is proved the presence of the mean reversion in the US market. However, since empirical evidence of random walk in stock price movements was not believable enough, a number of non-random walk hypothesis come out later. Recently the mean reversion hypothesis is one of the most empirically supported. The stock prices circle their essential values once they deviate from fundamental values, the reverse movement results. The evidence was found. According to (Pavlenko 2008).

According to Ronald & Yangru (2001) the researchers disclose that a momentum strategy of sorting (portfolios of) businesses by previous returns, holding those with the best prior performance and shorting those with the worst prior performance generates positive returns.

According to Kian (2009) the term market efficiency, formalized and operationalized in the seminal review of Fama (1970), is generally referred to as the informational efficiency of financial markets which emphasizes the role of information in setting prices. Furthermore particularly, the efficient markets hypothesis (EMH) defines an efficient market as one in which new information is immediately and properly reflected in its current security price.

According to Engle & Patton (2001) there is now many of researchers on volatility models have surveyed in several articles and continues to be a fruitful line of research for both academics and practitioners. As new approaches are offered and statistically tested, it is helpful to

originate the properties that these models should satisfy and at the same time it is useful to discuss properties that standard volatility models do not satisfy.

After research conducted by Pauline, (2010) it is pointed out that whether stock prices have a mean reverting component is of high interest to investors, since existence of mean reversion would suggest that long-horizon investment is probably less risky than short-horizon investment. This implies that the longer the horizons, the more investors benefit from investing in equity, a strategy which has termed time-diversification. In addition it has found that parametric contrarian investment strategies (selling past winners and buying past losers), which exploit mean reversion, outperform buy-and-hold and standard contrarian strategies.

## **1.2 Absolute Mean Reversion (Small Sample Size)**

The undertaken study by Pauline, (2010) the empirical verification on mean reversion is mixed though, and has been extremely discussed. Firstly research paying attention on absolute mean reversion, whereby the mean value remained unspecified. Hereby mean reversion is equated to negative autocorrelation in stock returns, caused by a stationary component in stock prices (Fama and French (1988a), Poterba and Summers (1988), Groppe (2004). But consistent evidence of absolute mean reversion is lacking due to small sample sizes and statistical tests that lack power.

## **1.3 Relative Mean Reversion**

In the meantime a new branch of research has been developed, which focuses on relative mean reversion. Hereby the fundamental value process around which stock prices are expected to mean revert is specified, which may substantially improve the estimation accuracy of mean reversion.

The assessment of relative mean reversion introduces the problem of specifying an accurate proxy for the fundamental value though. This thesis addresses several issues in existing research on relative mean reversion.

## 1.4 Mean Reversion Behaviour

It can be assumed that price will always return (revert) to the Mean (Moving Average).

## 1.5 Mean Reversion Characteristics

- Price reverts to the mean, cuts through, it and rises above it.
- Price then once again, reverts to the mean, cuts through it and, falls again
- The longer in (value) the moving average (mean) the more price will be able to extend away from the mean and thus the longer it will take for price to revert back to the mean. **mean-reversion-infographic**( 2013)

## 1.6 Application of Mean Reversion

- Mean reversion applies to all Moving Averages (MAs).all the currencies and instruments and on all the times. According to (**mean-reversion-infographic**, 2013)

## 1.7 Objectives of the Research Study

To examine the econometric analysis i.e volatility and the mean reversion speed in short horizon of stock price therefore the daily return form 1<sup>st</sup> Jan 2013 to Dec 31<sup>st</sup> 2017 of regional market of stocks of Karachi Stock Exchange(KSE), Bombay Stock Exchange (BSE), Shanghai Stock Exchange of China, KOSPI Stock Exchange of Korea, Hang Seng Stock Exchange of Hong Kong. Moreover the descriptive statistics also will be measured as per the previous research conducted or tested such as mean, standard deviation, skewness and kurtosis.

## 1.8 Scope of the Research Study

In this research the behaviour of the stock return and its risk impact for the portfolio investment is to be examined rather than the efficient market. It is to be found that the mean reversion represents that the volatility in the equity return is narrower than what is forecasted by random walk model. To be satisfied this conditions the most used model ARCH/ GARCH are applied for the estimation of the volatility in stock return and net of mean reversion. In this regard for the selection of portfolio and asset pricing and deciding whether condition mean dynamics or conditional variance involvement significantly. The most popular application is used that is very suitable for the univariate financial time series i.e ARCH /GARCH. The technique provides the mean reverting speed that is slow or fast as well as measures volatility in the stock return. Furthermore another technique *Half life* will also be taken to check the one half life of a volatility to reverts to its mean in long time or short time. There are few studies that examined the mean and variance simultaneously whereas many literature has worked only to check the heteroskedasticity in the mean separately.

## 1.9 Statement of the problem

The empirical examination is to be taken to check out that the volatility exists in stock price as well as mean reversion speed (slow or fast).

## 1.10 Hypothesis

$H_0$  : The Financial series contains unit root

$H_1$ : There is no ARCH effect ( $\alpha = 0$ )

$H_2$ : There is no GARCH effect ( $\beta = 0$ )

$H_3$ : There is fast mean reversion ( $\alpha + \beta \rightarrow 0$ )

$H_4$ : The shorter is the half life [ $\ln \frac{1}{2} \div \ln(\alpha + \beta) < 1$ ]

In this regard, this research is totally focus on that when the prices once deviate from its mean then whether it reverts to its original mean or stable above or below the mean other

than past in long run or short run time period by taking the data of regional stocks of Karachi Stock Exchange(KSE), Bombay Stock Exchange (BSE), Shanghai Stock Exchange ,China, KOSPI Stock Exchange, Korea Hang Seng Stock Exchange Hong Kong from Jan 1<sup>st</sup> 2007 to Dec 31<sup>st</sup> 2009.

## 2. LITERATURE REVIEW

In finance for several causes, the stock prices volatility is a key concept . The price fluctuations exist in stock price as many literatures available on that concept. The stock price volatility is one of the most debatable and key event. The regulator authority, speculators, portfolio management, professionals and academics agreed that the stock prices have dynamical effect and ups and downs or changes due to which factors its an important question and that question's answer is still ambiguity in the finance filed. Because the great and many invisible factors (variables) influence the stock prices which are not easy to find out or explore up to now many literatures have been conducted but there is still ambiguity. The researchers have explored the phenomenon by different dimensions and tried to find out the question in query. In this regard the ARCH model introduced and in developed countries and some of the developing countries the research has been conducted and accomplished and researchers used to use the ARCH in this area and applied technique differently. According to (HojatAllah Goudarzi 2010).

According to Engle (2001) for forecasting the mean ( $\mu$ ) and variance ( $\sigma^2$ ) of the return ( $r$ ) that ,depends upon the past information conditionally, it was the challenge for the econometrics. Many specifications have been used for mean return for forecasting the future mean returns, but there was no method to for variance before the ARCH models.

According to Pauline (2010) the stock prices reverting to its mean is very controversy phenomenon. In this regard many researchers have been conducted but still no decisive

empirical facts found on the mean reversion. The empirical evidence was firstly provided by Fama & French and Poterba & Summers (1988) of the reversion of stock prices in the long horizon. The research conducted by them on the hypothesis of that the stock prices have such stationary component that decrease (decay) them slowly but the stationary component are not be able to observable over short horizons, but in long horizons evidence are obviously provide the importance of mean-reverting price component. The basic model by Fama & French(1988) and Summers(1986) with the following components

$P_t$ = Mean reversion price process. (To be composed out of Permanent Component and Temporary Component:

$Q_t$ = Permanent Component

$U_t$ = Temporary Component

Therefore;

$$P_t = Q_t + \mu_t \dots\dots\dots(1)$$

The  $\mu_t$  (Temporary Component) can be modeled as a stationary AR (1) Process.

$$\mu_t = \alpha \mu_{t-1} + \nu_t \dots\dots\dots(2)$$

$\nu_t$ = Error term assumed as white noise.

If  $q_t$  the permanent component get any shock at the time t is incorporated completely in the future stock price where as the shock to the temporary component  $U_t$  consider as slowly decay towards zero and expected to be closed to one means long-run mean reversion stock prices but the model given by Fama & French (1988) and Summers (1986) just showing the random walk and stationary price component combination in general the permanent gain, when the stock prices get shock , is less than one.

According to Hojatallah & Ramanarayanan (2010) the research on securities volatility has value to study for portfolio manager, policy makers of securities, speculators and academics. To measure the risk the volatility in the security market is very important to economic agents to avoid the loss and make the investment secure. Stock price volatility generates serious consideration for the speculators and policy makers because the uncertainty exists when there is instability in the stock which also effect adversely on the growth prospects. It has been measured and experienced that the higher the volatile in the security market the more will be the barrier for the investors. The volatility may one of the cause of the consumer behavior when the consumers of the economy reduce their spending the market act as volatility. In the existence of the volatility in the stock price the stock return forecasting with the connectivity of volatility forecasting creates new opportunities and jobs for the portfolio policymakers and for personnel who tackles the problems of the volatility predicting Onyeaso and Rogers(2004). The stock price volatility is also very helpful for the economic policy makers and to formulate the policies and for making system regarding to the security market.

According to Cecchetti, Lam, & Mark, (1988) when the stock prices start random walk the stock prices do not follow it ,the hypothesis is rejected, has been tested by finding the variance ratio as suggested by the Poterba & Summers (1987) where as in long run horizon the autocorrelation exists as per suggested by Fama & French (1988). The market inefficiency does not take place on account of serial correlation in stock return. The mean reversion of security price does not accept the equilibrium models of rational asset pricing. Even when the security market work in rationalism mode the asset return may be serially correlated.

According to Chu (2012) the study of the mean reversion provided the approach to the firms to decide and make the policies to exit from the industry or the business leverage

policies under the mean reversion context. For making the exit policy the business bankruptcy and dissolution have negative effect and connected with the price level in long run horizon, while the mean reversion speed relates to the long run horizon to influence the exit trigger with the opposite ways that depends upon the total operating expenses. Regarding the leverage decision the low debt criteria in the long run price provides the predictable environment for the portfolio management for setting the order of the selected stocks. The different will be the mean reversion the behavior of the equity and debt also will be the different as well as the price level, in general the with the connection of the current prices the leverage ratios decreases.

According to Hillebrand (2003) the contrarian strategies concept was introduced in late 1980s according to this strategy the securities are pooled into the portfolio by keeping view on the past performance. Contrarian means that the losers at the last attempt of the portfolio generated considerably high return than the portfolio gain of last time. This happened on account of the mean reversion that's the force makes prices revert back to a certain medium level after they go up or down it. This concept created debates that in returns the mean reversion exists or not. The process of price back to the mean due to the force that push them towards the mean and contrarian strategies follow up the to get the success in next attempt for higher gain. If stock prices have the driver that make the price highly persistently to revert to its mean shows the random walk as declared by Summers(1986). There is time reliant composition with the  $k$ - period returns with mean consistently reverting in log prices. The concept with the evidence is still ambiguous because that the mean reversion findings in the stock prices is not reliable as suggested by the Summers (1986).

According to Den & Pieter (2010) the many researches have been conducted and focused on the mean reversion and the data set was complete and tested and found that there no variations in the mean reversion process as time passes. For further study the data was

taken from 1900 to 2008 from the 17 countries for checking the whether the mean reversion process exists or not over the years. It found that the political and economic factor influence the speed of security prices to revert to its mean and evidenced that the mean reversion speed has ability to deviate across the time. The *half-life* of the mean reversion process will be longer if the larger the time as tested form 1970-1996 and the half-life was 3.5 years and form 1900 to 2008 the half-life was 13.8 years and it also evidenced that the half-lives ranges from 2.1 years to 23.8 years as tested by taking the different time periods. Moverover, it is also found that in the long run horizon no mean reversion found significantlty.

According to Spierdijk, Bikker, & Den Hoek (2010) as we have taken the panel data model and found that a *half-life* of 13.8 years by taking the samlpe periods of 1900-2008. Many debates have been taken against the stayable mean reversion speed i.e Kim et al(1991) suggested that the mean reversion speed is the concept of pre-war phenomenon only. Moreover it was concluded by the Poterba & Summers (1988) the mean reversion speed had effected due to the great depression. Futher suggested by Balvers et al (2000) the difference in mean reversion in the large dataset and short data set conderted that the mean reversion speed changes over a time. The differnce in the mean reversion speed in the two time intervals is difficult to point out i.e the interval of 1981-2007 and 1982 to 2008 and their half-lives are 6.9 and 3.8 respectively the half-life decreasing value is 3.1 years which is effected due to the adding years. Further, many different periods have been tests i.e 1924-1950 and 1939 -1965 but the speed of meand reversion was not significantlty exists. We found that, in the period of 1939-1950, the mean reversion speed is very slow in some of the years due to the World War II.

According to Poterba & Summers (1987) the large size of samples have been analyzed such as the monthly returns of the period 1926 of the NYSE (New York Stock Exchange) to check the mean reversion secondly the annull returns of 19871 have been

examined on the standard and poor's stock price indexes but the annual returns were less trustworthy than the monthly returns but the dataset was available for much longer period. Third the monthly dataset returns after the World War II of the seventeen countries' stock exchanges excluding the USA and finally the data set after 1926 of different individual firms of the United States to examine the mean reversion speed in each stock prices and to check either share prices revert to a market average the post war period showed that the mean reversion effect are less than after the 1936 period.

According to Chaudhuri (2002) the mean reversion in seventeen countries' equity markets has been found the speed of the reversion is around 2 percent for each month which follows the half-life near 30 months the results have been matched and found that they are well for developed markets. The researchers have been interested to examine the mean reversion in the security prices that it follows up to random walk or not or the process of the mean reversion is the key concept for the efficient market and asset pricing in this regard many research used the data of developed markets to evaluate that the mean reversion exists or not and reported the contradictory in their evidence. Moreover, the result of mean reversion speed was also tested by the robustness and resulted that at 5 percent level the null hypothesis of there is no mean reversion related to the world market can be rejected.

According to Balvers & Wu (2000) the risk on the return and the costs of the transaction can make clear the excess return from exploiting the mean reversion but not be able to make clear that the mean reversion exists itself. Many literatures have been conducted regarding the mean reversion speed of security prices that widely covered the dimension of domestic market level.

According to Balvers & Wu (2000) it is suggested after the considerable losses in the shares equity the firm is more greatly leverage the more will be the leverage the more is the beta, if more is the beta the more will be the return on the ground that there is no change take

place in the corporate equity (capital) structure. It also examined when any country has lower priced indexes its expected returns are higher while others suggested that the low priced indexes stock may give shocks of abnormal returns. These researches showed that the stock return does not have persistency in return but explain mean reversion in results. It is also examined by researchers that in the short horizons the stock returns are positively correlated but negative correlated in long horizons.

According to Lavesson (2011) it has found that the relationship exists between the time horizon and the scale of the time series if the variance is near the zero means the long run factor exists in the time series and the such factor might be trend as suggested by Chatfield (1996). The longer the time horizon the significant will be the variation process to explain. If the scale of the time series is higher the information will be medium sized or short run sized process and if the scale of time series is distributed (the scale is flat) means that no time horizon overcome to another in explaining the series. It is, therefore, the importance of all the time horizons are equal for the variation process if the scale is flat represents white noise.

According to Lim (2009) the phenomenon behind the random walk of the stock prices is the new information received by the financial market. The stock markets and prices tend to fluctuate on account of news but it has been considered that the news are usually unpredictable on account of that the securities prices are unpredictable and jump randomly. On the contrary if it is considerably true news its impact only is that the grip on the prevailing time due to which predictable prices changes which shows positively autocorrelated. As suggested by Malkiel (1973) in his book "A random walk down Wall Street" there is a controversy on the random walk performance of the securities prices even though the market is related to the developed economy.

According to Manzan (2003) on account of changes in the fundamental variables make speedy changes in the stock prices. The debate is that the more will be the participate of

the investors in the stock market the lower is the required rate of return due to which consumers preferences also change. When the prices increase, the future discount rate will decrease and the same results also considered in case of dividend growth rate and earnings increases.

According to Poterba & Summers (1987) there should not be discussed or debate on the fundamental factors incorporate to changes in the stock prices. In the eras when the large collapses has taken place in stock prices the ratio of the stock price valuation not reached to the extraordinary level. The prices drifted from its intrinsic value of stock price due to the weak planning of the investors regarding expectations. Further, Summer (1986) suggested that when the fads created which does not provide rational judgement the behaviour of the stock prices will be continuously deviate from their intrinsic value and make the investor confuse to arbitrage the stock rationally. The mutual binding of the irrational expectation and stopping investors to the arbitrage of rational investors represents that the stock prices deviate from its rational valuation this concept is also incorporated with the empirical evidence of mean reversion speed and long horizon forecasting of stock prices. When the stock prices revert back to its intrinsic value in long run with the positive or negative deviation forecasts that the prices are increasing or decreasing and this process shows the negative relationship between changing in the prices and deviation from the elements that appears at long horizon.

According to Baker & Wurgler (2007) it is very difficult to determine the stock exact and true value when there is a new, recently not profitable but potentially growing firm, while the firm does not have any previous earning history and unpredictable future make the investor to be avoid make any prediction while the prices jump very high and very low to make profitable the stock. In the period of bubble, the speculation with high tendency, the investors debate on the high valuations chorously. Whereas the firm which has the previous

history of retained earnings, stable profitability distribution (dividend) and tangible assets is not much bias and provide relaxation to the speculators because the stock is less sensitive.

According to Bondt, Thaler, & Warner (1989) stock prices were unforecasting due to the short horizon data set and the investors / speculators felt stressed to make decision of arbitrage as investigated and it is also investigated by him whether there exists serial correlation in the day to day changes in the stock prices. The serial correlation in the day to day has been found which was positive statistically significant but the correlations were found very small if the time period is increased the new stocks jump in the market and the new pattern of the financial market appears. When the long horizon has been investigated the more correlations importance has found.

Moreover, the method which was applied by the Fama & French (1988) the return was regressed on the some period of time  $T$ , which had equal length. If there is found the random walk in the prices therefore the regression slope should be zero while the prices are reverting to mean then the regression negatively slope as Fama and French use the monthly return data from 1926 to 1985. The investigation shows that the regression has negative slope which obviously represents that the mean reversion exists when the time horizon increases 18 months to 5 years. As the  $T$  (time) is increased the  $R^2$  also increases. The firms that are small with small portfolios have more negative slope as compare to the large firms portfolios. As time passed away the mean reversion also diminishes as investigated in years of 1941-1985, it was weaker than before.

According to Psychoyios (2000) the volatility has made an important role for hedging the the stock and it incorporates with the risk of hedging. The risk of hedging volatility is considerable for investors, individuals and financial institutions. It is observed that after the the crash of 1987 the hedging volatility risk has been considering significantly. It has also investigated many major financial institutions i.e. Barings Bank, Long Term

Capital Management collapsed on account of wrong estimation and not effective hedging volatility risk due to the excess leverage and the fraud. The hedging volatility risk (HVR) consists of three concerns first is the robust volatility measure which handles the variability and remain effective for decision. Second the making the perfect model for the characteristics and the volatiles of this particular measure. Finally adjust the prices for hedging for the suitable stock or commercial papers. Habitually, the investors and individuals attempt futures trade standard and plain vanilla option to perform the hedging volatility risk but the instruments are prepared with the existence of the price risk. To treat the volatility, the recent development has been taken place, for a different asset and traded by using volatility derivatives which is in a portfolio. The derivatives are the characteristics of the instruments in which the volatility takes place. The derivatives may consist of swaps, futures and options.

According to Tajedini, Safari, & Shahveisi (2013) the random walk is followed by the stock prices as investigated and incorporate with the efficient market hypothesis. When at the time the prices behind the random walk means that the prices will change randomly. The stock markets become inefficient when abnormal movement occur in the stock exchange and one of the most abnormal movement is mean-reversion propensity. The relevant information regarding the stock prices make stock prices respond quickly. Following the random walk is one of the inherited flavour of the Efficient market. If the market follows such trend then the stock return is unpredictable on the basis of previous price variations. Yet the mean reversion is used to test the market is efficient or not and it also represents that the price shocks are temporary or permanent effect. If the effects are unstable and temporary, stock consists of mean-reversion continuously, then the price will be back to its trend path as time passes. In this regard it is considered that the prices are predictable on the basis of previous behaviour of the price trend otherwise it will be permanent shock effect and the stock prices achieve new balance and become unpredictable on the basis of previous movements.

According to Tajedini, Safari, & Shahveisi (2013) the various economic factors i.e local currency devaluation, recession, inflation, recession in inflation, fluctuation in interest rate similarly political factors, government policies, government decisions, political instability international relations etc. influence the mean-reversion to come to existence and make the capital market inefficient, insecure and irrational. Many researches have been conducted regarding the mean reversion speed, efficient and inefficient market and different results have found and concluded that there has given a vivid definition of the mean-reversion is really complicated because there is no comprehensive definition which is mutually agreed upon. In this regard different definitions declared as per the various researchers according to the prevailing time and market efficient and inefficient situations.

According to Bernay (2008) it is focused to dig out the empirical testing with the econometric model and theory and consider to take a rational judgment their checking. Resulted that the prevailing discussions on market efficiency and mean reversion are still in questions. If market is in the efficient condition the time horizon not to be supposed to force the asset to be optimized. The tomorrow market is not to be forecasted, but the best speculated by the geometric Brownian motion. In the (GBM) a normal distribution of mean ( $\mu dt$ ) and variance ( $\sigma^2 dt$ ) persistently is followed by compounded return of asset price. The equity return variance and mean develop linear moment in time as well as standard deviation. Therefore, in long horizon the risk is rarely computable. It is observed that, the habitually existence of mean-reversion in the stock price, by the standard approach for risk of equity returns and resulted that when the volatility of stock return is annualized it decline with the time.

According to Thomas (2008) the investors do not connect their expectations regarding the corporate profit with the phenomena of the mean reversion exists in it. Whereas the phenomena has come into being for more than half a century. It is investigated and found that

the speed of the mean reversion regarding the net income (NI) and earning before interest and tax (EBIT) is nearly 4.5 % to 6.5 % which is found rarely which in turn may provide overvaluation of the companies which are flourishing in performance and undervaluation in the reverse case.

According to Stevenson (2002) it is observed that there is continuous derivation or changing the performance of market index and a stock in the short horizon and medium horizon. The criteria generates that when any well behaved stock or securities in a period have propensity to sustain that behaviour in short horizon into the succeeding period on the other hand similarly in the case of poor behaved stock or securities propensity to sustain over the short horizon. It is investigated that the action reversals and mean reversion, in the long horizon, exists. The consequences declares that the behaviour persists to revert over long horizons if the behaviour continuously the same. The well behaved securities and markets in the long horizon have poorer than those which are underperformed in the early period. A portfolio manager of a firm has many suggestions regarding the impact of mean reversion and momentum but not predictability checking for the performance in short and long horizon.

According to Maribu, Galli, & Armstrong (2007) when the unfavourable prices are prevailing of the electricity then the plant should be shut down because the cost of production will be higher than that estimated meanwhile the prices of electricity and gas should be modeled checking their relationship with technique of correlation as they often correlated with each other the two broad categories are used to model the commodity to test the stochastic process i.e. geometric Brownian motion and mean-reversion. By both types of models the spark-spread choice of value used for selling the power plant of gas-fired by Southern California. The spark-spread overvalued as resulted by the Geometric Brownian Motion option, the prices can drift outlying from the long-term expectation. When there is a

considerable volatility then the mean-reverting technique is used with a seasonal trend of both electricity and gas.

According to Kim & Ryu (2013) the panel data has been collected by Balvers et al (2000) to consider the existence of the mean-reversion theory with the 18 countries of growing developed stock markets and resulted the obvious indication of mean reversion. Moreover, it is also found the short half-life incorporate with the 3 years which exposed that the stock prices reversal may take place in the short horizon or halfway speculation horizon. Whereas many weak indication has been found for this strategy because of single control of serial correlation and cross section dependence this bias has been removed and reported of 5 to 13 years half life as the Morgan Stanley Capital International (MSCI) and World index and US index have been put into investigation. On the contrary, very slow reversal rate of asset price fluctuations from their intrinsic values shows the high performance of the momentum plan opposing plan. Moreover, the linear model is used on the basis of half-life approximates are biased to upward whereas the real data generates the process of nonlinear. It is, therefore, nonlinear models have been used for the financial series successfully. The arbitrage takes place only when the fluctuations are wide spread which represents the non-linear series structure and the nonlinear models have been used to analyze the stock price adjustment dynamics.

According to Poulsen, Schenk-Hopp & Ewald (2009) the hedging strategy of risk minimizing is investigated by using the US and European stock index and currency option markets includes the four and half year (4.5 years) period in which the the stock market led the eggs of sub-prime crisis and the credit crunch. It has been seen that returns and volatility are negatively correlated with each other. When the volatility strikes across the hedging strategy increases significant to minimize the risk and changing in hedges depends upon the stochastic volatility model. The normal behaviour of changing the hedging when the daily

profit and loss ratio shows the reduction of 50%. There is strong correlation symmetrically between underlying returns and volatility in the USD/EURO which represented the higher degree of symmetry near to Zero and obviously there is no gain from the delta hedge strategy which also presented by the hedging formula as well as there is no loss. As the model of the Heston (1993) stochastic volatility by the Hagan , Kumar , Lesniewski & Woodward(2002).

According to Ahmad & Sara (2012) the financial models that are provided by econometrics to check that is there any volatility existence? in the financial series. The matter is still in chorus and many researchers going on working for making a vivid conclusion or taking sound decision regarding it. The investors and speculators will feel relaxation for hedging the gold or stock in the commodity and financial markets. In this regard the test has been taken and found that there is a volatility exists but the chorus is still under consideration that whether it is in long or short horizon. In our research technically speaking it is found that there is unequal dispersion of residuals which is known as heteroskedasticity. Furthermore, it also investigated that the obvious existence of the mean reversion. The behaviour of the mean reversion has showed that the alpha and beta addition is far from 1 therefore it is not wrong to say that there is a volatility in the gold price.

According to Engle & Patton (2001) the volatility, in the stock prices, is incorporated with the news that are reached in the financial market if there is asymmetry in the financial market on account of the news then it is said to be the good news when it is compared with the bad news. The more the volatility when the bad news flew in financial market this is also has the same importance as the good news. The up and down (volatility) is known as "*leverage effect*" also suggested the "*leverage effect*" but their model does not grasp the asymmetry.

### 3. METHODOLOGY

#### 3.1 Population and Sampling

The Karachi, Bombay, China, Korea and Hong Kong stock exchanges have taken for the capturing the daily returns from Jan1, 2007 to Dec31, 2009. The sample of 2007 to 2009 will be tested specifically for mean reversion speed of the volatility by using appropriate methods to measure the speed of reverting of the volatility to its mean.

##### 3.1.1 Software

The previous researches have tested the mean reversion speed on Eviews. We will also be using the same software for the different techniques as examined by the previous researchers for making sound decision.

#### 3.2 Models of Volatility

##### 3.2.1 ARCH Model

The undertaken study by Hojatallah & Ramanarayanan, (2010) in the return time series as well as time changing volatility. The major competency of the ARCH models is that it grabs many facts and laid out important variables which are related to volatility fashion.

The autoregressive conditional heteroskedasticity (ARCH) model of **Engle (1982)**, which is usually referred to as the ARCH(p) model. The residuals are tested that they effected by ARCH or not. When the ARCH effect are not found in the residuals, then it is, therefore, unnecessary to apply ARCH model for the financial time series.

The two steps have to be taken before apply ARCH model first it is necessary to grab the residuals have unit roots as well as influenced by ARCH. Whenever the return time series become stationary, to stabilize the variance, this needs log transforming the data . until the data become non-stationary, the estimation of ARCH effect in not valid ,therefore, the time

series are converted into logs rather than its self and then the existnace of unit root in a return time series is tested. When the GARCH(1,0) is applied it will be the ARCH(1) process.

According to (Hojatallah & Ramanarayanan 2010).

### 3.2.2 GARCH Model

According to Hojatallah & Ramanarayanan (2010) the GARCH does not like the ARCH which is connected with the variance conditional squared ( $\sigma^2_{t-1}$ ) terms which is excess explanatory variables. It is to be restricted by the GARCH model that all the explanatory variables must be positive in the ARCH which is called the non-negative constraint. It is obvious that the negativity in the variance is not possible because it consists of squared variables. To avoid the spread of the lag range structure of the ARCH(q) the generalized the ARCH model has been developed by the Engle (1982), Bollerslev (1986) which is known as GARCH in which the lagged values are included of the conditional variance. Therefore the GARCH(1,1) model much better and parsimonious than ARCH because it provides much better information then the larger lagged numbers of ARCH.

The GARCH ( $p,q$ ), where the  $p$  lags is known as conditional variance ( $\sigma^2$ ) and the  $q$  on the squared error term( $\epsilon^2$ ).

$$\sigma_t^2 = \omega + \sum_{i=1}^p \alpha_i \epsilon_{t-1}^2 + \sum_{j=1}^q \beta_j \sigma_{t-1}^2$$

### 3.2.3 Specification of GARCH Model

The GARCH (Generally Autoregressive Conditional Heteroskedasticity) was created Tim Peter Bollerslev in (1986). In the model the two diversified lags has been introduced in which one of the able to confine the frequency effect and the information about the equity volatility while the other measures the value of variance on lagged to bound the long term impacts.

Therefore GARCH(1,1)

$$\sigma^2_t = \omega + \alpha_i \varepsilon^2_{t-1} + \beta_j \sigma^2_{t-1}$$

where :

Omega( $\omega$ ), Alpha( $\alpha$ ) and Beta ( $\beta$ ) are coefficients

$\varepsilon^2_{t-1}$  = Squared residual lags with 1<sup>st</sup> lag (ARCH(1))

$\sigma^2_{t-1}$  = Variance trailing (GARCH(1))

### 3.2.4 Asymmetric GARCH

According to Hojatallah & Ramanarayanan (2010) the GARCH model is asymmetric as compare to ARCH. The GARCH asymmetric due to the leverage effect with asset prices. When there is a positive shock the lesser will be the effect on the conditional variance ( $\sigma^2_{t-1}$ ) as compared to the negative shock. This asymmetry is only incorporated with the GARCH model as introduced by Glosten, Jangathann and Runkel (1988). Furthermore, with the asset prices the asymmetric adjustment was an important phenomenon. The asymmetry generates the dummy variable  $I$  which holds the value of 1 when the negative shock less than 0 and 0 otherwise. The asymmetry adjustment is significantly determined by using the t-statistics. This refers that the shocks in the conditional variance will be exceedingly constant. If this happens for the long horizon but value existence is lesser than 1 then the mean reverting consistently while the volatility residence habitually for a long horizon but fortunately be stable to the mean of instability just like a pendulum movement back and forth to set at the equilibrium position again after bob has been released from the equilibrium position. It means that there is no long run effect ,on account of the prevailing information, of prediction.

### 3.3 Mean reversion

According to Hojatallah & Ramanarayanan, (2010) the GARCH model usually has one of the better ability is to capture the high or low volatility persistence in its coefficients of a stationary GARCH model. The rate of Omega, Alpha and Beta which is and their the sum which is laid by ARCH and GARCH coefficients ( $\omega + \sigma + \beta$ ) that are usually nearer to one (1) shows that the volatility mean reverting long run behavior or slow mean reversion in the GARCH stationary model. The Half-life volatility shock measures the usual figure of the time periods of the volatility to be reverted to its lengthy time. The (1/2) half-life is also used to predict the stock prices unpredictability on moving average basis as suggested by Banerjee and sarkar (2006).

#### 3.3.1 Measurement of Half-life of Volatility Shock for GARCH(1,1)

The continuous existence of volatility can also be measured by Half-life. It is considered as the volatility has come to half path revert to back to the unconditional mean. The ( $\sigma + \beta$ ) is the most appropriate measurement rate which is considered the best fitted model to measure the half life which is usually close to 1. The mean reversion speed is controlled by ( $\sigma + \beta$ ) magnitude. The volatility shock in case of half-life is measured by the following formula:

$$L_{half} = \ln(1/2) / \ln(\sigma + \beta)$$

The closer the ( $\sigma + \beta$ ) to one the longer will be the half-life of the volatility. According to (Hojatallah & Ramanarayanan, 2010)

### 3.4 Descriptive Statistics

#### 3.4.1 Skewness

According to investopedia.com/quantitative-methods/statistical-skew-kurtosis.asp, (2014) there can be considered the three results from the skewness by the investors positive, negative and symmetric. If the skew computation shows the value greater than zero the distribution is positively skewed and negatively skewed at less than zero. If it results equal to zero means symmetric.

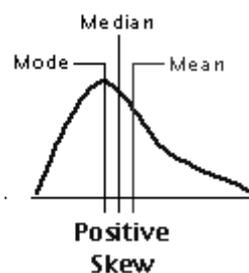
$$\text{Skewness} = \frac{3(\text{mean} - \text{median})}{\text{Standard Deviation}(\sigma)}$$

The measure of central tendency provides us an estimate of the representative value of the data. The measures of dispersion give us an idea of the variation of the values or closeness of the value from the central value (representative value) of the data.

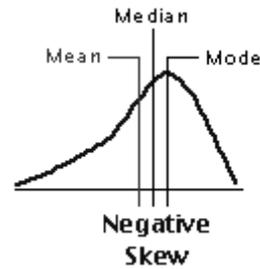
Skewness indicates that lack of symmetry in a distribution around some central value i.e mean , median and mode.

If the right tail of a frequency curve is longer than left, the skewness is said to be *positive* or the distribution is said to be positive by skewed. Mean > Median > Mode

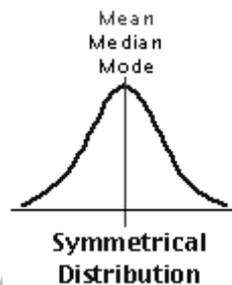
**Figure 1 Positively Skewed**



If the left tail of a frequency curve is longer than right; the skewness is said to be *negative* or the distribution said to be negatively skewed. Mode > Median > Mean

**Figure 2 Negatively Skewed**

If the both tails of a frequency curve are of equal distance from some central values the skewness is said to be zero (there is no skewness) or the distribution is said to be *symmetric*. Mean=Median=Mode

**Figure 3 Symmetry**

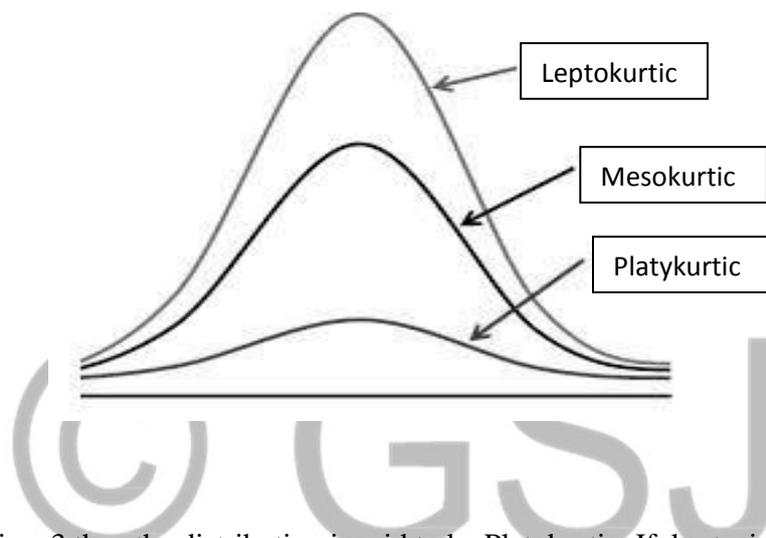
The skewness is used to interpret and analyze the risk at downside. When the results are negatively skewed then the distribution is said to be left tail long and the investor of the stock market can realize that the chances of facing the severe negative outcomes and positively skewed means frequent small negative outcomes and the likelihood severely bad shocking will reduce. By focusing the investment returns, the positively skewed distribution shows that the likelihood of facing frequently small losses and few sever profits.

On the contrary, the negatively skewed distribution shows that the likelihood of facing frequently small profits and few sever losses. According to ([investopedia.com/quantitative-methods/statistical-skew-kurtosis.asp](http://investopedia.com/quantitative-methods/statistical-skew-kurtosis.asp), 2014, April).

### 3.4.2 Kurtosis

According to (investopedia.com/quantitative-methods/statistical-skew-kurtosis.asp, 2014), Kurtosis represents the degree of the peak in a distribution. The fatter the tails show that more peak than normal (leptokurtic). When the kurtosis in the position of leptokurtic shows that the existence of sever outcomes are slighter as compare to normal distribution.

*Figure 4 Kurtosis*



If kurtosis < 3 then the distribution is said to be Platykurtic; If kurtosis > 3 then the distribution is said to be Leptokurtic; if kurtosis = 3 then the distribution is said to be Mesokurtic or Normal distribution.

### 3.4.3 Mean

According to (investopedia.com/quantitative-methods/statistical-skew-kurtosis.asp (2014) the most commonly used measure of center is the mean. The mean of the data set is the sum of the observations divided by the number of observations.

$$\text{Mean} = \frac{\sum X}{N}$$

### 3.4.4 Standard Deviation

According to Ahmad & Sara, (2012) this is the measure of dispersion which shows how much the data is closer or away from its mean. The more spread the data with the distance the higher will be the deviation. It is calculated by taking the square root of variance. To measure the volatility of return of an investment the standard deviation is applied on annual rate of return. The standard deviation represents as historical volatility and the investors, speculators and portfolio managers also use this technique to estimate the amount of the expected volatility.

If there is high volatile stock means the higher the standard deviation which tells the investors how much will be the fund deviated from the expected normal return.

When the variation is narrow means the average is very close to standard deviation and far in case of high variations. Population standard deviation ( $\sigma$ ) and for sample (S) data set.

Formula: 
$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

S= sample standard deviation

n= number of observations

X= Observations

## 4. RESULTS & INTERPRETATION

### 4.1 Descriptive Statistics

*Table no 1. Descriptive Results of financial return series*

<i>Descriptive Measures</i>	<i>Pakistan Stock</i>	<i>Bombay Stock</i>	<i>Japan Stock</i>	<i>Shanghai Stock</i>	<i>Hong Kong Stock</i>
<i>Mean</i>	0.000960	0.000418	0.000708	0.000306	0.000101
<i>Standard Deviation</i>	0.008793	0.009355	0.061850	0.015621	0.010734
<i>Skewness</i>	-0.404533	-0.372995	0.213541	-1.158318	-0.176460
<i>Kurtosis</i>	6.121081	5.745048	251.1125	9.644472	6.215779

*Sample: Jan 01, 2013 to Dec 31, 2017*

In the table no1 all the calculations has been taken from Eviews software program. The mean, standard deviation, skewness and kurtosis has been measured to justify the behaviour of stock markets of the regions in this connection the Pakistan, Bombay, China, Japan and Hong Kong stock exchanges have been considered.

The standard deviation ( $\sigma = 0.008793$ ) of Pakistan Stock is lower than all others means that Pakistan stock exchange is low volatile equity market while the highest volatile equity market is Japan exchange as its standard deviation ( $\sigma = 0.061850$ ) is the highest in all the regional market.

The kurtosis of all the stock market are  $> 3$ , that represents the normal value, and all the stock markets followed the Leptokurtic means that the severe outcomes will be lesser as compare to the normal, Mesokurtic (Kurtosis = 3) or it can be said that the shocks in the equity market will no longer be extreme. Furthermore, all regional markets are relaxed for the decision makers.

The majority of the stock markets have negatively skewed because their values of skewness are in negative and their left tail specifically long. Negatively skewed shows that the equity market will face frequently small profits and few severe losses. On the contrary the

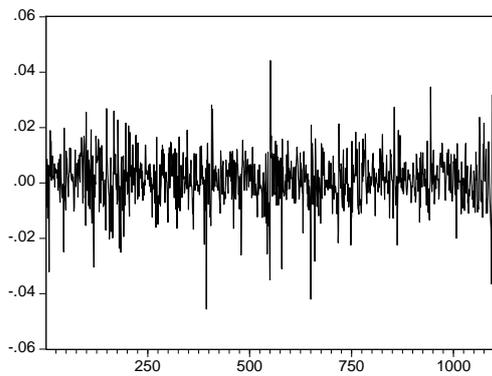
equity market volatility is under the control and the investor, speculators are very relaxed to buy and sell the shares in the financial markets.

Moreover, the negatively skewed distribution shows that the likelihood of facing frequently small profits and few severe losses. The Shanghai stock exchange skewness is (-1.158318) which is the lowest value in the regional market means that the investors of this market will earn smallest profits as well as losses. The shocks of the market at both side (Profits & Losses) are not much severe. Furthermore the speculators and investors are more relaxed to decision for their portfolio.

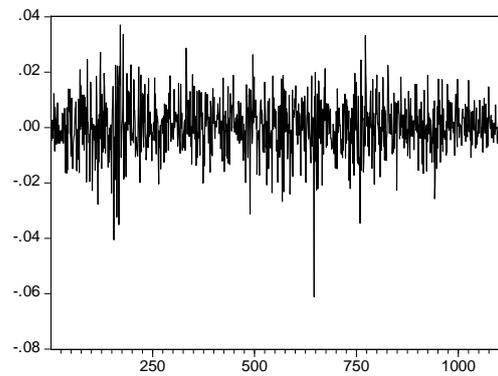
The Pakistan equity market skewness is (-0.404533) which shows that the left tail of the skewness is the most thick. The Pakistan equity market shocks are severe for both profits and losses and the investors of the equity market will not feel relaxed because the market shows the high volatility while the Japan stock market has the positively skewed means that its right tail is specifically long. The positively skewed distribution shows that the likelihood of facing frequently severe profits and extreme losses. Therefore, the investors of the Japan stock exchange faced not so much relaxed because they face either high profits or high losses from their decisions.

It is significantly evident that there is a volatility in the all regional stock markets because the standard deviations of all the equity markets are very far from their mean ( $\bar{X}$ ). The distance of the mean and standard deviation ( $\sigma$ ) of the regional markets is very high. Therefore the investors of the regional markets had to handle the portfolio funds in the critical conditions in time period of the data set taken. The era of 2013 to 2017, which daily returns have been taken to examine, has the high volatility periods but there is a possibility of the volatile stability which might provide the investors to hedging the stock in the equity market.

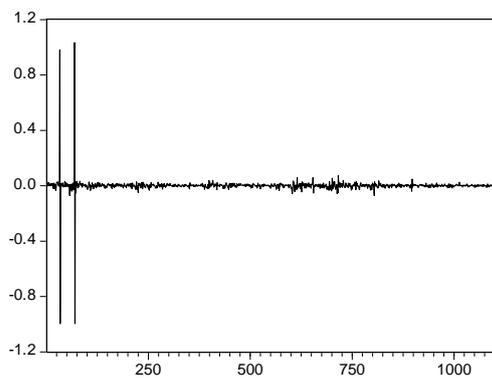
## 4.2 Graphical presentation of unit root test



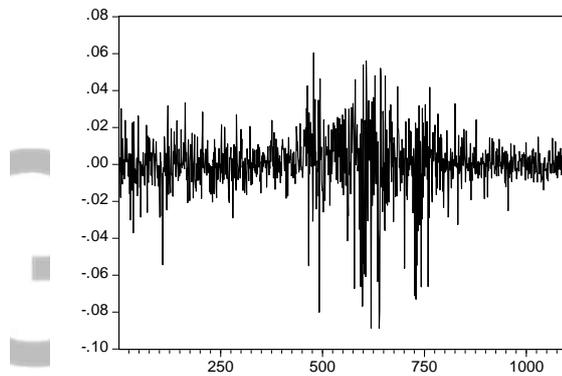
**Pakistan Stock Returns**



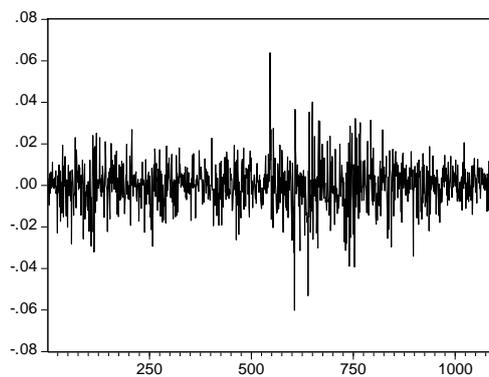
**Bombay Stock Returns**



**Japan Stock Returns**



**Shanghai Stock Returns**



**Hong Kong Stock Returns**

### 4.3 Econometric Analysis

All the results have been extracted from the Eviews software regarding the unit root test , GARCH(1,1) model and found that the results are significant of all the regional market

#### 4.3.1 Unit Root Test

The unit root test has been conducted by the Augmented Dickey-Fuller test of the regional stock markets on return  $R_t$  series. The univariate financial time series is tested for unit root. The returns  $R_t$  , the Augmented Dicky-Fuller (ADF) test regressed the financial time series on level without taking any difference.

**Table no 2.** *Econometric Analysis: Showing that the financial time series contain unit root. And significant t-stats and Prob values.*

<i>Econometric Measures</i>	<i>Pakistan Stock</i>	<i>Bombay Stock</i>	<i>Japan</i>	<i>Shanghai Stock</i>	<i>Hong Kong Stock</i>
<i>t-statistics</i>	<b>-2.864016**</b>	<b>-2.864008**</b>	<b>-2.863972**</b>	<b>-2.863960**</b>	<b>-2.863960**</b>
<i>Prob Value</i>	<b>0.0000</b>	<b>0.0000</b>	<b>0.0000</b>	<b>0.0000</b>	<b>0.0000</b>

\*MacKinnon (1996) one-sided p-values.

\*\*5% level

The above table 2 ,as results taken from the appendix I, shows that all the regional stock markets return  $R_t$  series are stationary therefore the rejected that the time series contains unit root. ADF test rejects the null hypothesis of unit root in the return series. As shown in the table no 2 that all the values are statistically significant as MacKinnon critical represents that all the prob values are less than 0.05 level and the t-stats values of all the regional stock markets are greater than 2(t-stats >2).

The return series now is stationary therefore more tests can be taken on the series satisfactorily such as ARCH (auto regressive conditional heteroskedascity) and GARCH (Generally Autoregressive Conditional Heteroskedasticity).

It is debated that the all time series variance need to be stabilized and before that it should be log transformed to make the raw data stationary. The both criteria has been applied

to achieve the results as shown in the table 2 Appendix II. According to (Ahmad & Sara, 2012). The daily returns of the regional equity market has been transformed into log return:

$$R_t = \text{Ln}(P_t / P_{t-1})$$

where  $R_t$  is stock return at time,

Ln= Natural Log

$P_t$  is stock price at time

$P_{t-1}$  is stock price at 1<sup>st</sup> lag of time

### 4.3.2 GARCH (1,1)

#### 4.3.2.1 Mean reversion speed

The GARCH model usually has one of the better ability is to capture the high or low volatility persistence in its coefficients of a stationary GARCH model. The rate which is given by the sum of ARCH and GARCH coefficients ( $\sigma + \beta$ ) which is usually close to 1 shows that the long run level of volatility to reverts to its mean or slow mean reversion in the GARCH stationary model otherwise fast mean reversion which is far from 1.

#### 4.3.2.2 Interpretation of GARCH(1,1) Model

**Table no 3 .Econometric Analysis: Measurement of Mean reversion speed by summing up ARCH and GARCH Co-efficient**

Stock Exchange	$\omega$	$\sigma$	$\beta$	$\sigma + \beta$
Pakistan	8.09E-06	0.197328	0.707840	1.174085
Bombay	2.02E-06	0.051492	0.926299	0.977791
Japan	3.34E-03	2.153581	-0.199103	1.954478
Shanghai	4.47E-07	0.006133	0.938644	0.944777
Hong Kong	3.43E-06	0.051677	0.918619	0.970296

In table no 3 ,as results taken from the appendix II.In the Variance Equation table the first column shows the variables that are considered as Omega( $\omega$ ) , Alpha ( $\sigma$ ) and Beta( $\beta$ ) which measured the mean reversion speed by taking the sum of Alpha and Beta ( $\sigma + \beta$ ).

The GARCH(1,1) results are in table no 3 in appendix II, which calculated standard errors using the robust method of Bollerslev-Wooldridge (1986) by using Eviews. The two coefficients are computed in variance equation each of the region equity market and the sum of these coefficients are less than 1 ( $\sigma + \beta < 1$ ) and should be close or far to 1 that is required to measure the process of mean reverting variance.

The tables no 3 results have been taken from Appendix II, represents that all the regional equity market mean reversion is slow as the sum of Alpha and Beta ( $\sigma + \beta$ ) is closer to 1 as Pakistan Stock Exchange is (1.174085), Bombay Stock (0.977791), Japan (1.954478), Shanghai Stock (0.944777) and Hong Kong Exchange has (0.970296).

The Standard err, Z-stats and prob values of the three coefficients of all the regional stock markets are also computes by the GARCH(1,1) as shown in table no 4. Whereas z-stats and prob values of all regional stock markets of the three coefficients are statistically significant as their Z-stats prob values are less than 0.05.

**Table no 4 .Econometric Analysis: ARCH and GARCH Co-efficient Significant Z-stats and Prob values**

Stock Exchange	$\omega$		$\sigma$		$\beta$	
	Z-stats	Prob value	Z-stats	Prob value	Z-stats	Prob value
Pakistan	4.855145	0.0000	7.232344	0.0000	18.81647	0.0000
Bombay	2.711141	0.0067	4.215401	0.0000	52.58345	0.0000
Japan	15.08953	0.0000	7.062935	0.0000	-14.52442	0.0000
Shanghai	1.766680	0.0077	9.916245	0.0000	184.7485	0.0000
Hong Kong	4.380028	0.0000	5.078226	0.0000	58.85761	0.0000

The z-stat values of omega, alpha and beta of Pakistan stock exchange (PSX) are (4.855145, 7.232344, 18.81647) and prob values (0.0000, 0.0000 and 0.0000) respectively. Similarly Bombay stock exchange (SENSEX) z-stats and prob values are significant (2.711141, 4.215401, 52.58345) and (0.0067, 0.0000 and 0.0000) and Japan stock exchange (NIKKEI) z-stats are (15.08953, 7.062935, -14.52442) and prob values are (0.0000,0.0000

and 0.0000). Similarly Shanghai stock exchange has significant z-stats are (1.766680, 9.916245, 184.7485) and prob values are (0.0077,0.0000 and 0.0000) and in last the Hong Kong(HSI) z-stats significant values are (4.380028, 5.078226 and 58.85761) and prob values are (0.0000,0.0000 and 0.0000).

### 4.3.3 Measurement of Half-life of Volatility Shock for GARCH(1,1)

The continuous existence of volatility can also be measured by Half-life. It is considered as the volatility has come to half path revert to back to the unconditional mean. The  $(\sigma + \beta)$  is the most appropriate measurement rate which is considered the best fitted model to measure the half life which is usually close to 1. The mean reversion speed is controlled by  $(\sigma + \beta)$  magnitude. The volatility shock in case of half-life is measured by the following formula:

$$L_{half} = \ln(1/2) / \ln(\sigma + \beta)$$

The closer the  $(\sigma + \beta)$  to one the longer will be the half-life of the volatility. According to (Hojatallah & Ramanarayanan, 2010)

**Table no 5 .Econometric Analysis: Mean reversion speed by Half-life**

Stock Exchange	Alpha( $\alpha$ )	Beta ( $\beta$ )	$\ln(1/2) / \ln(\alpha + \beta)$
Karachi	0.197328	0.707840	6.956884
Bombay	0.051492	0.926299	30.862322
Japan	2.153581	0.199103	1.034359
Shanghai	0.006133	0.938644	12.201929
Hong Kong	0.051677	0.918619	22.986807

The null hypothesis of the non stationary of the time series or ARCH and GARCH effect in the regional stock returns have been tested. The ADF test shows that the time series of stock returns is stationary when the time series stock return once the stationary then the stock returns are mean reverting and volatility reverts to its long run average and the GARHC(1,1) another way of measuring long run reverting of volatility to its mean. When the coefficients

are sum up of ARCH and GARCH, that are usually close to one(1) of the financial time series.

There is another way of measuring the long run reverting of volatility to its mean, in the time period such as days, months or in years, by the half life  $L_{half} = \ln(1/2) / \ln(\alpha + \beta)$ .

The sum of the ARCH and GARCH ( $\alpha + \beta$ ) is closer to one that is 0.99 in our research regarding regions stock market. The rate ( $\alpha + \beta$ ) of mean reverting in our research is very close to one by sum of ( $\alpha + \beta$ ) which is the best fitted model. The sum of alpha and beta ( $\alpha + \beta$ ) is the magnitude of controlling the mean reversion speed. The average time to decrease of one half life is measured by the half life of a volatility shock. When ( $\alpha + \beta$ ) is closer to means it takes the longer time to revert to its mean and longer will be the half life ( $L_{half}$ ) of the volatility shocks. The [ $\ln(1/2) \div \ln(\alpha + \beta) > 1$ ] rejects our null hypothesis of [ $\ln(1/2) \div \ln(\alpha + \beta) < 1$ ] particularly for the half life ( $L_{half}$ ).

#### 4.3.3.1 Interpretation of Half-life Model

In table 5 the half life of the volatility shock has been measured and results found that all the regional stock markets have [ $\ln(1/2) \div \ln(\alpha + \beta) > 1$ ] which clearly declared that the null hypothesis of sum of Alpha and Beta is lesser [ $\ln(1/2) \div \ln(\alpha + \beta) < 1$ ] than one is rejected for the one half life volatility reverting to its mean .

In our regional stock market the Bombay Stock Exchange takes one half life in 30 days which is a months that is the most longer time of reverting the volatility to its mean. The Hong Kong Stock Exchange is at second number for the longer time taken of the volatility shock reverting to its mean that is 23 days approximately.

The Japan stock exchange has taken the lowest time to revert to its volatility mean by one half life i.e approximately 1 day on a month. The Shanghai Stock Exchange has taken

second lowest time 12 days in one month and the third last is Pakistan Stock Exchange 7 days approximately in one month for one half life to reverts to the volatility to its mean.

The one half life of a volatility has been measured for the regional stock markets that has been undertaken as shown in the table 5 . Resulted that the most longer taken time of one half life of a volatility to its mean by Bombay Stock Exchange while the most shorter time by Japan Exchange. The longer will be the half life of a volatility the more will be the stable equity market therefore the Bombay Stock Exchange provide has the most stability while as compare to Japan Stock Exchange.

#### **4.4 Discussion**

The daily stock returns of 5 regional markets (Pakistan, Bombay, Shanghai, Japan and Hong Kong) have been taken from the period of Jan1,2013 to Dec31,2017.

The priority of this research to examine mean reversion speed of equity indexes over short run time period therefore we use 5 years daily stock returns rather than the yearly returns. Because of seasonal effect can be covered, the higher the frequency of the data help to determine the slow mean reversion. In the case of short run horizon the sample data of regional market is reliable to achieve the objective of measuring the mean reversion speed.

To make the more reliability and perfection of the results the daily stock returns has been transformed into log returns.

#### 4.4.1 Descriptive Statistics

According to Engle R.(2001) when the standard deviation of the daily return series is high the equity market volatility is also high and low standard deviation shows low volatility in stock market and kurtosis exceeds 3 that shows the fat tail represents normality of the data and if the skewness is negative shows that the left tail is longer and in positive skewness the right tail is longer.

According to this research the descriptive statistics has been taken. In this regard the mean, standard deviation, kurtosis and skewness applied to check the volatility and the normality of the data sample undertaken and other predictions that are possible have been taken. As Bombay stock exchange higher standard deviation means that it is the high volatile market while the Karachi stock exchange has the lowest standard deviation means low volatile market as per our regional market undertaken.

The second beta of kurtosis is greater than 3 shows that the undertaken sample data distribution is normal and all the time series stock return follows Leptokurtic. The Leptokurtic represents that the stock market is reliable to take better decision as compare to the Mesokurtic. Therefore it is said after taking the kurtosis results that the shocks in our regional stock will not be severe and therefore the portfolio managers, investors and speculators are very relaxed to make their funds more safe for determined future return.

In our undertaken regional markets, the skewness of the most of the regions is negative skewed means that the equity market faces small profits and few losses therefore in our undertaken regional markets the majority equity markets volatility is stable and investors are here also not so much disturb to make decisions and all these negatively skewed financial equity markets are better for the investors to pool their funds for making better profits.

#### 4.4.2 Econometrics Analysis (Augmented-Dickey Fuller test)

According to Hojatallah & Ramanarayanan (2010) when the return series rejects the null hypothesis of unit root test by applying the ADF and it becomes the stationary by considering critical value 5% and prob values.

In this research the Augmented-Dickey Fuller (ADF) test has been applied to make the financial time series stationary for further model applications. As table no 2 above from Appendix I showing all the z-stats Prob values are  $< 0.05$  therefore it indicates all the regional equity market have volatility and the volatility definitely reverts to its mean as the return series once become the stationary and the existence of the mean reversion also proved.

#### 4.4.3 Econometrics Analysis: GARCH (1,1)

According to Engle R. (2001) , Hojatallah & Ramanarayanan (2010) the GARCH model usually has one of the better ability is to capture the high or low volatility persistence in its coefficients of a stationary GARCH model. The rate which is given by the sum of ARCH and GARCH coefficients  $\sigma + \beta$  which is usually close to 1 shows that the long run level of volatility to reverts to its mean or slow mean reversion in the GARCH stationary model otherwise fast mean reversion which is far from 1.

In our research the GARCH(1,1) model has also been applied to check the speed of the mean reversion of the volatility (Conditional Heteroskedasticity). This model provide the co-efficient  $(\sigma, \beta)$  regarding the ARCH and GARCH and the sum of these coefficients  $(\sigma + \beta)$  measures the mean reversion speed whether slow or fast. When the sum of ARCH and GARCH coefficients is closer to one the mean reversion speed is slow, if far from one the mean reversion speed is fast.

In table no 3 from Appendix IV the sum of ARCH and GARCH coefficients  $\sigma + \beta < 1$  are lesser than 1 the Japan stock exchange (NIKKEI) has the largest  $\sigma + \beta = 1.954478$  and Shanghai Stock Excahgne has the smallest  $\sigma + \beta = 0.944777$  and also closer to one 1 of our

undertaken regional financial markets, means that the mean reversion speed of existing volatility (Conditional Heteroscedasticity) is slow, therefore the forecasting of future stock prices are very critical for the portfolio managers and investors but slower the mean reversion provides the stability in the volatility it is still vague to consider the mood of the volatility (Conditional Heteroscedasticity) whether it suddenly become faster or slower.

#### **4.4.4 Econometrics Analysis: Measurement of half-life**

According to Den & Pieter (2010) it has found that the political and economic factor influence the speed of security prices to revert to its mean and evidenced that the mean reversion speed has ability to deviate across the time. The *half-life* of the mean reversion process will be longer if the larger the time as tested form 1970-1996 and the half-life was 3.5 years and form 1900 to 2008 the half-life was 13.8 years and it also evidenced that the half-lives ranges from 2.1 years to 23.8 years as tested by taking the different time periods.

In the last by this research, the one half-life of volatility also measured by the coefficients of ARCH and GARCH i.e sum of alpha and beta ( $\alpha + \beta$ ). The natural log of sum of alpha and beta

$\ln(\alpha + \beta)$  becomes the denominator of natural log of half  $\ln(1/2)$ . The one half life of the volatility can be measured by  $\ln(1/2) \div \ln(\alpha + \beta)$ .

The results of  $\ln(1/2) \div \ln(\alpha + \beta)$  must be greater than one. As in our table no 5 the undertaken regional markets' the one half life values are greater than one. The minimum one half life of mean reverting of the volatility is approximately 1 day of Japan stock exchange while the maximum is 1 month (30.86 days) of Bombay stock exchange. Therefore the Japan stock exchange is the most volatile stock market which mood changes in short period of time as compare to Bombay stock market which volatility mood changes slowly. But it cannot be said that the Bombay stock is better to make for making better forecasting as compare to Japan Stock Exchange. The second slower one half life of the mean reverting of an existing

volatility is related to Hong Kong (23 days) and the second faster is Pakistan stock exchange approximately one month(7 days) while the Shanghai Stock exchange the third faster one half life of mean reverting of the volatility (12 days).

The mean reverting speed of one half life is still not the better phenomenon to test the volatility (conditional heteroscedasticity) of financial market. It is still ambiguous to check the mood of the volatility by one half life because the in financial markets the conditional heteroscedasticity usually is seen that's why the predictions are very difficult over a period of time.

In this research Augmented-Dickey Fuller ,GARCH(1,1) and the Hal-life methods have been applied for checking the existence of volatility in stock price and results showed that its obviously exists as models showed and discussed above but the forecasting regarding the stock market future returns is still the ambiguous phenomena due to conditional heteroscedasticity .



## **5. CONCLUSION, LIMITATION AND RECOMMENDATION**

## 5.1 Conclusion

This research has been conducted to check the volatility subsistence and mean reversion speed of existing volatility and its stylized facts. For this purpose the famous and frequently used GARCH(1,1) method applied and found the results that the volatility (conditional heteroskedasticity) resides in the undertaken regional financial markets Karachi, Bombay, China, Korea and Hong Kong stock exchanges. The data sample has been taken from Jan 1, 2013 to Dec 31, 2017 (5 years) to test the volatility and mean reversion speed of volatility.

The empirical results of GARCH(1,1) showed the stylized facts and described the undertaken financial regional markets behavior regarding the volatility and volatility speed of mean reverting. The GARCH (1,1) results suggested that the volatility exists in the undertaken financial regional markets and the volatility mean reverting behavior. The volatility (conditional heteroscedasticity) is obvious persistence. The GARCH(1,1), which relate to the ARCH family, extracted volatility satisfactorily and it is also the suitable model to check the volatility clustering, fat tail and existence of volatility mean reversion in undertaken financial time series. The valuable results have been conducted by the study for the policy maker regarding the portfolios and regulatory authority of the undertaken regional financial markets.

Now the traditional methods like Moving Average, exponentially-weighted moving average (EWMA) for examining the stylized facts of financial markets i.e volatility clustering and mean reversion speed should be reviewed and use the GARCH and enhancement of GARCH model should be used for risk management decisions.

## 5.2 Limitations

The limitations of the mean reversion approach are discussed here. Firstly, the assumption is taken that the stock in the financial market and the stock exchange index has the same mean reversion, but we saw that the coefficients of the approach for the undertaken regional market are different with each market this may lead to misrepresentation for decision maker as well as create the wrong results.

Secondly, the time period has been taken for the dataset is small time observations which may not provide the unbelievable results and create the confusion.

Thirdly, the different undertaken markets of the different regions could not work for few days simultaneously and some of the days have gone without any variability in the stock prices.

Fourth is that the market might not behave on rumors and run smoothly and capture the high natural price volatility. In this condition it is difficult to make differentiate in between mean reversion process and random walk to make a clear results the random walk will be removed but there is no such method has been developed as yet for this purpose.

In last, there are no statistical evidence that speed of mean reversion increases proportionately as the return horizon increases. Thus, while I received very high speed of mean reversion, compared to other studies, this may be due to non-comparability of the return horizons used.

### **5.3 Recommendation**

This research paper has taken the volatility process of the regional market and concluded results but the process of volatility, stylized facts, volatility clustering and the speed of volatility reverting to its mean can also be seen by various aspects and need of many more forecasting and for that purpose the different models have to be applied in future.

The existing results from the many researches might not be worked satisfactorily and in future need to extract more results from a model's variables that are laid by the model like co-efficient, standard error or others variables that may be different from this research and necessary in future to make better predictions regarding the financial markets specifically stock markets.

The researchers, persistently, have been testing the volatility and its behavior since many decades because it is an interesting to know. Therefore, the studying of volatility in the stock price may spark new discovery on account of continuously work over it and open new and better ways to handle the risk management.

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## Appendix I

**Econometric Analysis:** *unit root test undertaken of financial time series.*

<p><b>Pakistan Stock Exchange</b>            Null Hypothesis :PSX has unit root            Exogenous : Constant            Lag Length :0 (Automatic based on SIC, MAXLAG=21)</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="width: 30%;"></th> <th style="width: 10%;"></th> <th style="width: 15%;">t-statistic</th> <th style="width: 45%;">Prob.*</th> </tr> </thead> <tbody> <tr> <td>Augmented Dickey –Fuller test</td> <td>Statistic</td> <td style="text-align: center;">-26.43250</td> <td style="text-align: center;">0.00000</td> </tr> <tr> <td>Test Critical values</td> <td>1% level</td> <td style="text-align: center;">-3.4360</td> <td></td> </tr> <tr> <td></td> <td>5% level</td> <td style="text-align: center;">-2.8639</td> <td></td> </tr> <tr> <td></td> <td>10%level</td> <td style="text-align: center;">-25681</td> <td></td> </tr> </tbody> </table> <p>*Mackinnon(1996) one-sided p-values.</p>			t-statistic	Prob.*	Augmented Dickey –Fuller test	Statistic	-26.43250	0.00000	Test Critical values	1% level	-3.4360			5% level	-2.8639			10%level	-25681		<p><b>Bombay Stock Exchange</b>            Null Hypothesis :SENSEX has unit root            Exogenous : Constant            Lag Length :0 (Automatic based on SIC, MAXLAG=21)</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 10px;"> <thead> <tr> <th style="width: 30%;"></th> <th style="width: 10%;"></th> <th style="width: 15%;">t-statistic</th> <th style="width: 45%;">Prob.*</th> </tr> </thead> <tbody> <tr> <td>Augmented Dickey –Fuller test</td> <td>Statistic</td> <td style="text-align: center;">-30.27122</td> <td style="text-align: center;">0.00000</td> </tr> <tr> <td>Test Critical values</td> <td>1% level</td> <td style="text-align: center;">-3.4360</td> <td></td> </tr> <tr> <td></td> <td>5% level</td> <td style="text-align: center;">-2.8639</td> <td></td> </tr> <tr> <td></td> <td>10%level</td> <td style="text-align: center;">-25681</td> <td></td> </tr> </tbody> </table> <p>*Mackinnon(1996) one-sided p-values.</p>			t-statistic	Prob.*	Augmented Dickey –Fuller test	Statistic	-30.27122	0.00000	Test Critical values	1% level	-3.4360			5% level	-2.8639			10%level	-25681	
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## Appendix II

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**Table no 5. Econometric Analysis: GARCH effect of Pakistan Stock Exchange (PXS)**

Dependent Variable: PXS  
 Method: ML - ARCH  
 Date: 03/01/18 Time: 22:56  
 Sample: 1 1100  
 Included observations: 1100  
 Convergence achieved after 6 iterations  
 Presample variance: backcast (parameter = 0.7)  
 GARCH = C(3) + C(4)\*RESID(-1)^2 + C(5)\*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.09E-19	2.21E-08	9.46E-12	1.0000
PXS	1.000000	11.49919	0.086963	0.9307
Variance Equation				
C	3.34E-39	8.08E-40	4.136144	0.0000
RESID(-1)^2	0.150000	0.033017	4.543143	0.0000
GARCH(-1)	0.600000	0.079235	7.572424	0.0000

**Table no 6. Econometric Analysis: GARCH effect of Bombay Stock Exchange (SENSEX)**

Dependent Variable: SENSEX  
 Method: ML - ARCH  
 Date: 03/01/18 Time: 22:34  
 Sample: 1 1100  
 Included observations: 1100  
 Convergence achieved after 5 iterations  
 Presample variance: backcast (parameter = 0.7)  
 GARCH = C(3) + C(4)\*RESID(-1)^2 + C(5)\*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	5.23E-20	2.34E-08	2.23E-12	1.0000
SENSEX	1.000000	9.707444	0.103014	0.9180
Variance Equation				
C	4.90E-41	4.14E-42	11.83556	0.0000
RESID(-1)^2	0.150000	0.024516	6.118414	0.0000
GARCH(-1)	0.600000	0.031197	19.23248	0.0000

**Table no7. Econometric Analysis: GARCH effect of Japan Stock Exchange (NIKKEI)**

Dependent Variable: NIKKIER  
 Method: ML - ARCH  
 Date: 03/01/18 Time: 22:32  
 Sample: 1 1100  
 Included observations: 1100  
 Convergence achieved after 5 iterations  
 Presample variance: backcast (parameter = 0.7)  
 GARCH = C(3) + C(4)\*RESID(-1)^2 + C(5)\*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.05E-19	2.53E-08	4.14E-12	1.0000
NIKKIER	1.000000	0.335319	2.982233	0.0029
Variance Equation				
C	4.19E-40	5.58E-41	7.511142	0.0000
RESID(-1)^2	0.150000	0.027323	5.489812	0.0000
GARCH(-1)	0.600000	0.046187	12.99074	0.0000

**Table no 8. Econometric Analysis: GARCH effect of Hong Kong Stock Exchange (HSI)**

Dependent Variable: HSI  
 Method: ML - ARCH  
 Date: 03/01/18 Time: 22:29  
 Sample: 1 1100  
 Included observations: 1100  
 Convergence achieved after 4 iterations  
 Presample variance: backcast (parameter = 0.7)  
 GARCH = C(3) + C(4)\*RESID(-1)^2 + C(5)\*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.31E-20	2.34E-08	5.58E-13	1.0000
HSIUR	1.000000	7.740476	0.129191	0.8972
Variance Equation				
C	1.08E-42	5.72E-44	18.97975	0.0000
RESID(-1)^2	0.150000	0.029753	5.041516	0.0000
GARCH(-1)	0.600000	0.020278	29.58942	0.0000