



**Modeling volatility and financial market behavior using symmetric and asymmetric models : The case study of Athex stock exchange**

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***Abstract***

The estimation and modeling volatility of any financial market is the area highly interested for researchers, reader and investor. Volatility also reflects asset price changes in stock prices of respective financial markets. Estimation of volatility and financial market behavior represents some of highly important results for investment professional community all over the world. This article aims to estimate financial market volatility, asymmetric effect and effect of news on Athex stock index. In the process to derive accurate results of estimation of volatility GARCH (1, 1) and GARCH class models are used such as Exponential GARCH and GJR-GARCH. We worked on 3530 observations and daily data index from Jan 2000 to Jan 2014. The empirical results shows that conditional variances (volatility) are unstable in Athex return series. The result also provide positive risk premium at average level till 2010 and at great level post 2010. EGARCH model confirms the leverage effect in Athex series returns.

***Index Terms***— volatility, asymmetric effect, conditional variances, symmetric and asymmetric models, stock prices

**Introduction**

Ups and downs with larger degree of any financial market attract investors and motivate them to invest in. Financial market behavior can be categorized according to emerging and developed market. Emerging markets represents high degree of risks and volatility compared to developed financial markets. Financial market volatility represents ups and down shocks and that is one of highly important parameters of any financial market. There are plenty of research work has already been done throughout the world to estimate volatility of all financial markets. Birau



(2013) investigated cointegration and international linkage between Greek and Romanian stock markets. The author suggested that international financial markets behavior are influenced by the propagation of financial shock through causal transmission channels especially in the context of a globalized world wide economy. The independent factor for any financial market is market volume as first and market trend. The impact of group of developed market volatility and market trend reflect on emerging market behavior by transmitting pattern (Trivedi and Birau, 2013a). Stock market closing index are representative of ups and down at particular day and time considering volume and trend of market. This performance can be analyzed in terms of volatility shocks, heteroskedasticity, leverage effect, degree of standard deviation and so on. The systematic study and analysis of such data using advance statistics and econometrics can estimate volatility of that past performance and help investors to understand market behavior. The advancement in econometric modeling today helps investors and feeds primary idea to proceed or not to proceed for investment.

This study focuses on market behavior of one of Greece financial market, Athex stock index, one of developed financial market. I aimed to estimate market volatility, leverage effect and effect of news on Athex financial market. To do so, we are employing GARCH and asymmetric GARCH class models, Exponential GARCH and GJR-GARCH. Autoregressive conditional heteroskedasticity, particularly GARCH (1, 1) found by Engle (1982) and again developed by Bollerslev and Taylor (1986). Exponential GARCH or EGARCH model Nelson (1991) takes long logathematic form and models leverage effect in series returns. Glosten, Jagannathan and Renkle (1993) have introduced GJR-GARCH model which estimates leverage effect and effect of news on financial market series returns.

### **Methodological applications**

This paper is objected to compute volatility impact, leverage effect and effect of news on Athex financial market (proxy market from Greece). We employ Generalized Autoregressive Conditional Heteroskedistity known as GARCH. Here we implement GARCH (1, 1), that is combination of one term of ARCH and one term for GARCH. GARCH (1, 1) model is capable to estimate volatility more particularly and measures the impact of shocks on financial market. We also plan to measure leverage effect of Greece financial market, but GARCH (1, 1) cannot model leverage effect, hence we implement GARCH class model, known as Exponential GARCH or EGARCH model. EGARCH model is capable to model leverage effect for Athex market but that is limited to estimate effect of good and bad news on Greece market and GJR-GARCH (GARCH class model) is used to compute effect of news on financial time series of Athex.



We have used sample index series from first day transaction of Jan 2000 to Jan 2014 which is daily closing index prices. We have noticed unit root problems in all series and hence we have transformed the volatility daily returns as below;

$$R_t = \text{Log} (P_t/P_{t-1} ) * 100 \dots \dots (\log-1)$$

Where  $R_t$  represents daily returns of indices and  $P_t$  stands for daily closing prices of indices.

### GARCH (1, 1)

GARCH (1, 1) model which developed by Bollerslev and Taylor (1986). This model allows conditional variance of all variables to be dependent upon previous legs and it reflects on entire series. However the first leg of squared residual will be from mean equation and this presents idea about volatility from the previous time periods. General most used model for formulate GARCH (1, 1) as follows;

$$h_t = \omega + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1}$$

We need to follow hypothesis of covariance stationary as unconditional variance and to exist that it processed by the following equation :

$$\sigma^2 = \text{Var}(u_t) = E(u_t^2) = E(\omega + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1}) = \omega + \alpha_1 E(u_{t-1}^2) + \beta E(h_{t-1}) = \omega + \alpha_1 \sigma^2 + \beta \sigma^2$$



We form GARCH (1, 1) conditional variance equation  $\text{Var}(u_t | h_{t-1}) = E(u_t^2 | h_{t-1}) = h_t$ , And thus it can simply take form  $h_t = \omega + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1}$ .

Model explanations:

If there is presence of unconditional variance, it can be case where we employ the process to find  $\alpha_1 + \beta_1 < 1$  and for converting it into generates positive result, we require that  $\alpha_0 > 0$ . Positive result will indicate good news for market. For the constant, conditional mean we followed  $E(y_t | \square_{t-1})$ , where  $E = c + \phi y_{t-1} + 0$ , and  $y_{t-1}$  is included in  $\square_{t-1}$ . We would be able to conclude our result by  $h_t = \omega + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1}$ . Where,  $\alpha_1 u_{t-1}^2$  represents ARCH component and  $\beta_1 h_{t-1}$  GARCH component. Can be explored like this;

The above formulation of GARCH (1,1)  $h_t = \omega + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1}$  can be explored like this.

Nelson (1991) provides Exponential GARCH or EGARCH model which assures confidence for positivity of conditional variance. It covers the asymmetric impact. The specimen of EGARCH model can be explored as;

$$\text{Log } h_t = \omega + \beta_1 \log h_{t-1} + \alpha_1 [\theta V_{t-1} + \gamma \{|V_{t-1}| - E|V_{t-1}|\}]$$

This model takes a long form and adds an additional term for leverage effect which we call as asymmetric effect. This model guarantees positive variance because of  $h_t = \exp(\text{R.H.S.}) > 0$  always and  $\theta V_{t-1}$  covers asymmetric effect. Nevertheless this model is also limited to tell about effects of good news and bad news.

Glosten, Jagannathan and Renkle (1993) have developed GJR-GARCH model which estimates effects of good news and bad news from Athex financial markets. This model also covers asymmetric or leverage effect confidently. GJR-GARCH can be explored like;

$$h_t = \omega + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} + \theta I_{t-1} u_{t-1}^2$$



Model explanations:

Here  $I_{t-1} = 1$  if  $u_{t-1} < 0$  and  $I_{t-1} = 0$  or otherwise and if  $\theta > 0$ , we say that there is a leverage effect. This model also represents effect of good news or bad news on volatility. If ( $u_{t-1} > 0$ ), that has an effect of  $\alpha_1 u_{t-1}^2$  on the variance and represents effect of good news on volatility, while bad news effects ( $u_{t-1} < 0$ ) has an effect of  $(\alpha_1 + \theta) u_{t-1}^2$  on the variance. We deal with large series of data, first day transaction of January, 2000 to January, 2014 which covers daily closing indices of Athex financial market.

### Empirical Analysis

I have employed proxy indices from year Jan 00' to Jan 14' which represents daily closing stock market prices. First what we have noticed that there is large difference between min index and max index which has produced high standard deviation in regards of number of observation (3530). Log transformation has reduced degree with unchanged results. In following Table-1 we can see that the mean is close to zero and positive for time series returns. It also indicates of negative Skewness which represents an asymmetric tail which exceeds towards negative values rather than positive. This negative tail also indicates that all indices are non-symmetric returns and are leptokurtic as well since its large kurtosis (see table-1).

**Table – 1 Descriptive statistics using the observations (3530) 2000-01- to 2014-01**

Variance	Greece-Athex
Mean	0.00046
Median	0.00000
Min	-0.13431
Max	0.10214
Std.Dev	0.01788



Skewness	-0.02674
Kurtosis	4.36376

*Source: Author's computation using stock indices.*

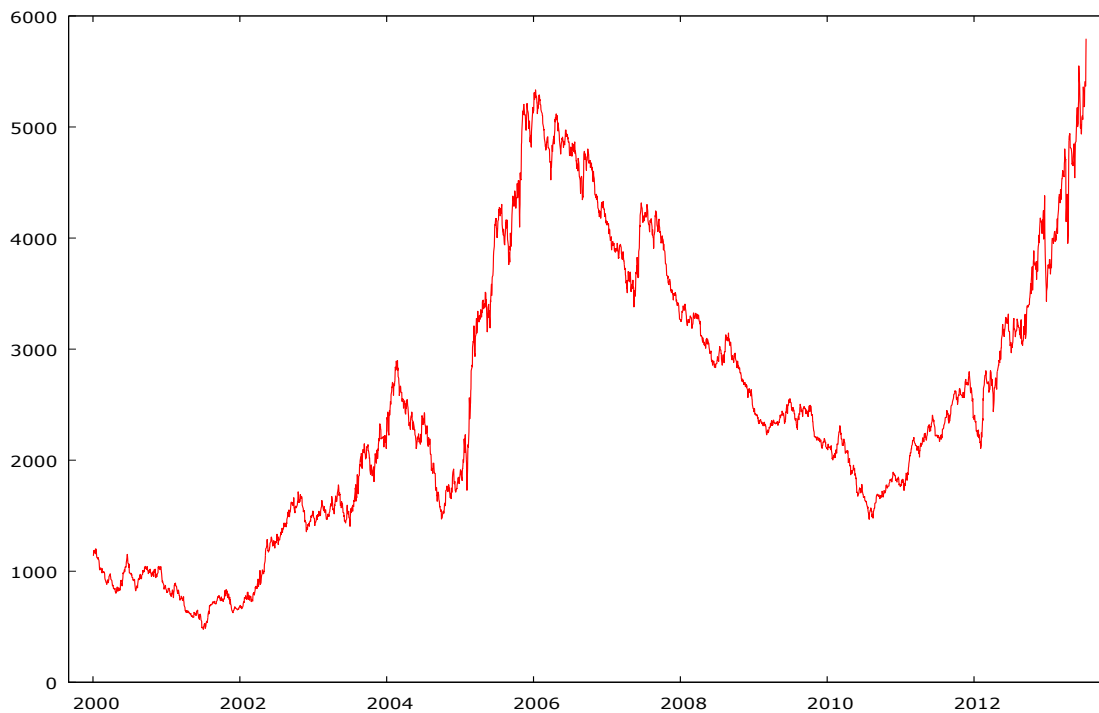
We can see that Mean value is almost zero and Median is zero itself. This is because we have used first log difference where valuations reaches near to zero. Nevertheless it still delivers the accurate degree of risks and effect of leptokurtosis. In the above table we can see that financial statistics for proxy financial series of Greece financial market, Athex (developed market) represents more than double reverse difference from Min to Max figures. Furthermore the standard deviation ratio (0.01788) represents degree of risk involved in entire financial series. Negative skewness (/0.02674) and kurtosis higher than 3 (4.36376) represents presence of long tail impact in the series (see Fig2). These large differences represent the degree of volatility in developed and emerging markets.

Here an opportunity for investors and decision makers. Nevertheless, Standard deviation presents degree of risks in Greece market. The degree of Skewness provides evidence of high Kurtosis, and force indices towards more negative trend instead of positive as indicated by its tail. However it also reveals that stock markets fall down more frequently than ups, but, investments at such time creates volatility of stock returns. This also remarks that upper side of index is not stronger than lower side and otherwise.

An original market moment of Athex financial market indicates results from Jan 2000 to Jan 2014 see Fig1 visible in graphical manner. It suggests that market moment imbibes major degree of ups and down and represents high degree of volatility. It lacks stable impact. It also indicates that if once market starts to go down, it go down to extreme level by normal degree of upper side shocks and vice versa. We cannot see shock reflections and degree of shocks in a stationary manner in Figure 1 because data is not stationary at this point of time. It needs to be stationary to process GARCH and GARCH class modeling. We processed Unit root test, Augmented Dickey Fuller test (ADF) tests. Augmented Dickey Fuller test (ADF) test statistics provides stationary of data and proves no unit root problems in financial series of Athex market and that allows ARCH effect to proceed.

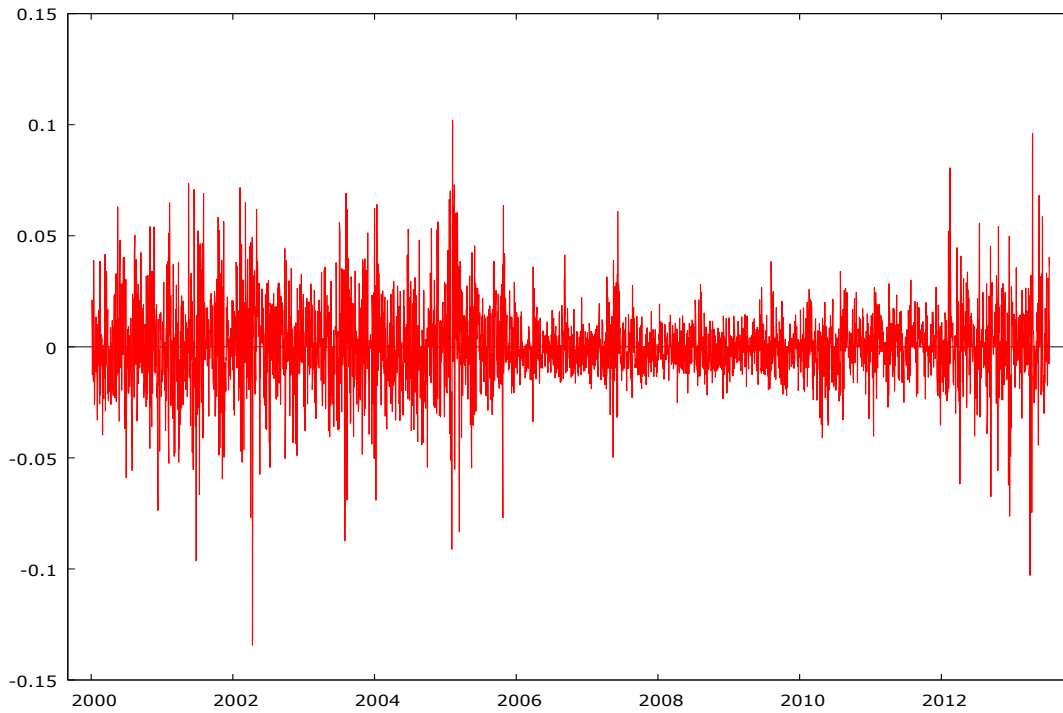


Figure 2 indicates stationary data series of Athex financial market and also represents degree and level of long sketches for upper level shocks and lower level of shocks.



**Fig1. Athex Financial series from Jan 2000 to Jan 2014 (original data series)**

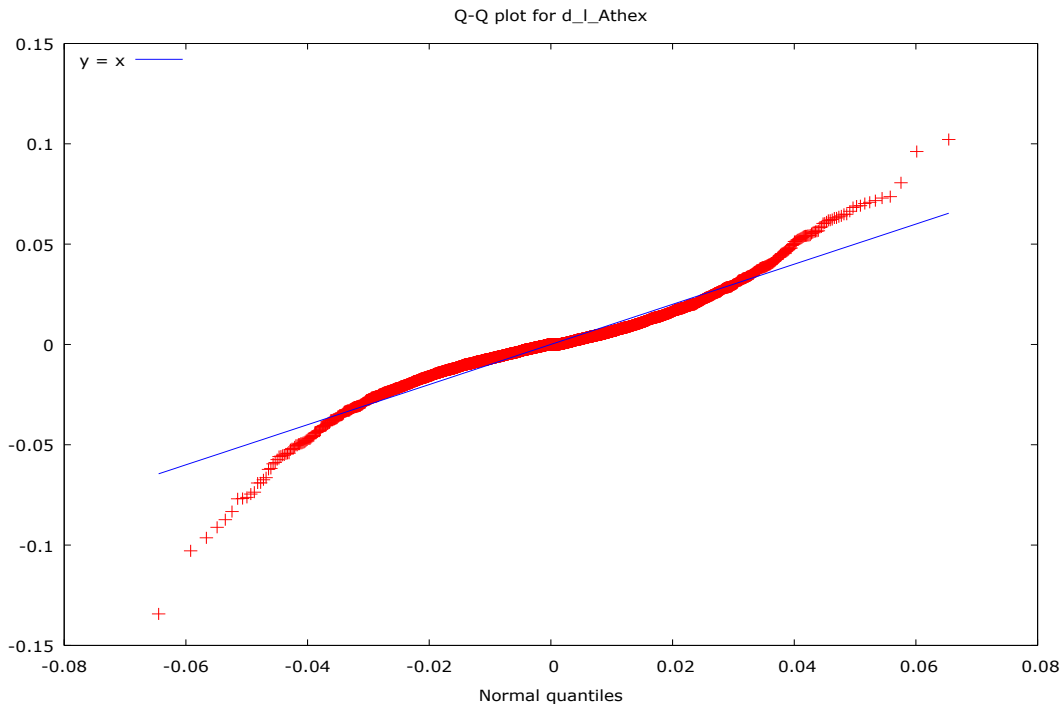
**Source: Author's computation using daily closing index of Athex financial market**



**Fig2. Athex Financial series log-difference from Jan 2000 to Jan 2014 (stationary series)**

**Source: Author's computation using daily closing index of Athex financial market**





**Fig3. Athex leptokurtosis effect (Q-Q) Plot using log-series data of Athex market**

**Source: Author's computation using daily closing index of Athex financial market.**

We can observe that initial time period of first five years is the time for highest degree of volatile period in entire study period time (see fig2). The comparative study of Fig1 and Fig2 suggests that market started to movements toward down side immediately after 2006 with visible and countable any higher upper and lower shocks. Market has approached to improve in year 2007 but again down forces has continued. Although during financial crisis period, there are no abnormal visible sketches observed in series data. The immediate recovery of Athex market after 2010 is seems to be so strong and capable enough to move comparatively high speed like emerging financial market. These would be great opportunity for investors to get highest return on their investment.

Furthermore Fig3 represents long tail impact of Greece financial market from year Jan 2000 to Jan 2014. This long tail indicates negative skewness and high (4.36376) kurtosis and also called as leptokurtosis effect. It indicates asymmetric or abnormal distributions. We now can proceed to estimate volatility and implementation of other GARCH class models to stationary



data series of Greece financial market. ADF test results are not mentioned in this paper but are acceptable and reveals presence of ARCH effect. Test was computed using 4 lag difference and significant at 5% level. Increased lag difference (8) represents significant level at 10% and 1% as well. We considered 5% level and processed for GARCH (1, 1) implementation.

Here are formulation for GARCH (1, 1) model for Greece Financial market series (Athex)

$$= 0.0845264 (\alpha_1 u_{t-1}^2) + 0.915284(h_{t-1}) 0.999810 = <1$$

The above model process has followed  $h_t = \omega + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1}$  conditional variance equation  $\text{Var}(u_t | h_{t-1}) = E(u_t^2 | h_{t-1}) = h_t$  for GARCH (1, 1) and includes one ARCH term and one GARCH term. The GARCH (1, 1) volatility estimation suggests and delivers results of 0.999810 which is GARCH (1, 1) model is combination of (1) ARCH and (1) GARCH term which is denoted by  $\alpha_1 + \beta_1$  which shows positively results for Greece financial market. It indicates that market generates high volatile returns and also indicates high investment priority to invest. The result is highly near to 1 which also represents both side high degree of volatility.

The above model formulation has come up with process using following data (see Table2). We have represented entire outcomes of GARCH (1, 1) which represents constants, omega, alpha and beta. These outcomes represented in table2 mentioned below. Investors and readers can go for more predictions and estimations using following calculated data.

**Table – 2 GARCH (1, 1) and GARCH class modeling for Athex Financial index**

Variable	Coefficient	p-value
$\pi$	0.000422534	0.0777*
$\omega$	1.66174e-06	0.0489



GARCH (1, 1)	$\alpha$	0.0845264	0.0000
	$\beta$	0.915284	0.0000
EGARCH	$\pi$	0.000680862	0.0219
	$\omega$	0.196934	0.0005
	$\alpha$	0.183846	0.0000
	$\gamma$	0.0296112	0.0341
	$\beta$	0.992645	0.0000
GJR-GARCH	$\pi$	0.000544533	0.0151
	$\omega$	1.44036e-06	0.0767*
	$\alpha$	0.0854002	0.0000
	$\gamma$	0.0996175	0.1213**
	$\beta$	0.915874	0.0000

*Source: Author's computation using series data.*

*\*indicates least significant. \*\* indicates not significant*

GARCH (1, 1) (see table-2) estimation value of mean covariance  $\pi$  provides all positive results. We can see that constant variables for Athex market are least significant since the value is more than 0.05 but we have considered the constant because we have supportive results from other GARCH class models.

The model estimation for EGARCH and GJR-GARCH is presented hereunder. The equation follows formula execution mentioned in methodology. EGARCH model examines the leverage effect in Athex financial index considering data series from Jan 2000 to Jan 2014.

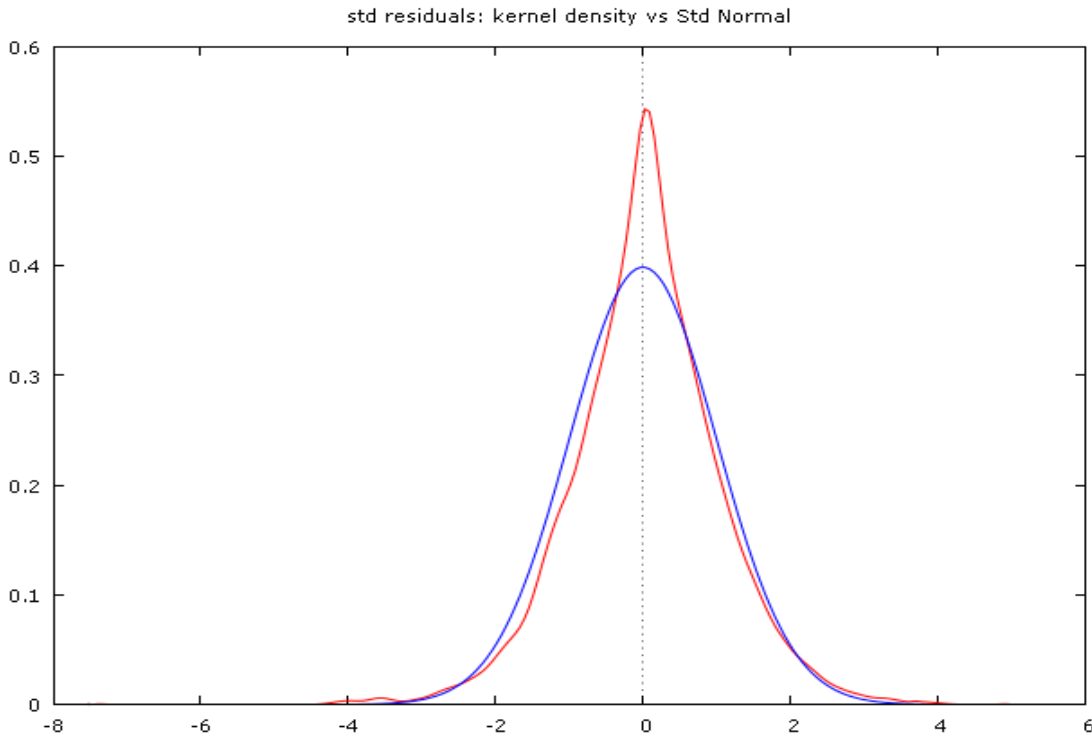


$$\text{Log } h_t = 0.196934(\omega) + 0.992645(\beta_1)\log h_{t-1} + 0.183846(\alpha_1)[\theta V_{t-1} + 0.0296112\{|V_{t-1}| - E|V_{t-1}|\}]$$

The above EGARCH executed model suggests that ‘y’ is non zero and indicates presence of asymmetric effect (leverage effect) in volatility of Athex market. EGARCH model does not estimate effect of good and bad news on financial market since that is particularly represents log of standard deviations or called log of variances as function of lagged logarithm of variances of standard deviations. That is called lagged absolute effort from regression model. The further and last explanation of study is estimating impact of news on financial market and is estimated by GJR-GARCH model, just hereunder;

$$h_t = 0.00000144036(\omega) + 0.0854002(\alpha_1)u_{t-1}^2 + 0.915874(\beta_1)h_{t-1} + 0.1213(\theta)I_{t-1}u_{t-1}^2$$

Although we have explained how to formulate GJR-GARCH model in model execution, even we failed to enlarge the model. We failed to get significant value for “y”. Thus we cannot process to compute effect of news on Athex financial markets. Nevertheless the model still represents strong presence of asymmetric effect in financial series of Greece market.



**Fig 4. Kernel density test against standard normal residuals**

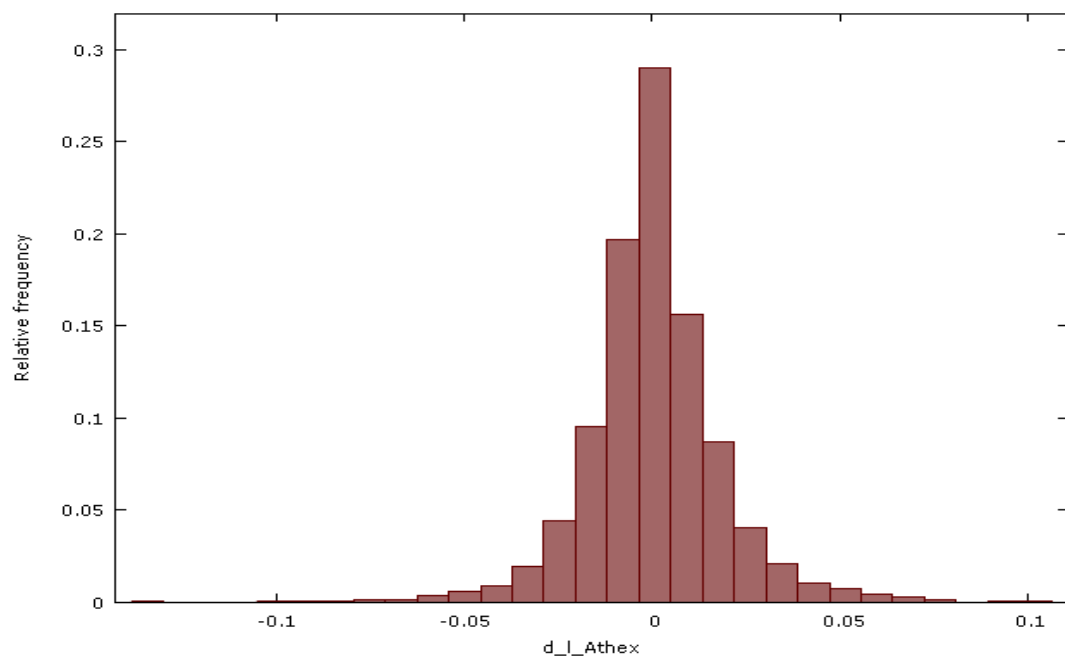
*Source: Author's computation using series data*

The focus of this research study is to understand volatility shock impact in detail and therefore we conducted some other tests like Kernel density test which is visible in Fig4. We have not disclosed residuals of test. The impact is broadly visible in Kernel density against standard normal motion market moment (see fig4). Kernel density estimation (KDE) is non parametric way to estimate probability density function of random variable. The aim to employ KDE test is to compare density of variables under normal standard residuals against kernel density residuals. We can notice the visible impact of RED (KDE) line with abnormal residual behavior against BLUE (std normal) residual behavior. Under the roof of volatility measurement we observe that line mark (RED) starts from - 4 (0) to 4 (4) with motions similar to (approx) KDE = Std normal up to range of 0.4 density mark, and KDE exceeds dramatically on and above mark of 0.5 density meter.



This parametric volatility moment is again traced by graphical presentation of Relative frequency. Relative frequency makes shocks visible and proves volatility shocks for upper side and lower side with degree of impact on Athex financial market (see fig5)

Fig. 5 Relative frequency for Athex financial market



Source: Author's computation using series data.

Relative frequency is also known as absolute frequency of financial index event. It is represented in histograms and in above histogram we can clearly see that considering (0) as level of incidents and relatively left sided histograms represents degree power of negative shocks on Athex market and right sided for positive shocks. We can see that negative shocks are comparatively more powerful than positive shocks. It is very interesting that Athex market have higher number of positive shocks comparatively less powerful than negative but higher in positioning. This has made Athex market more advanced to get higher (upper side) constantly.



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## Conclusions

I have studied Athex financial market data from Jan 2000 to Jan 2014 daily closing index by using econometric methods and advance statistics. Basic statistics results indicated that Athex market have negative skewness, long tail impact and -0.17 standard deviation but having great opportunity for investors to expect for best market returns. GARCH (1, 1) model fitted perfectly and indicated high degree of volatility and dramatic moments of upper side and lower side market moments. EGARCH model set accurately and proved asymmetric effect in financial series of Greece market. Furthermore, we attempted to employ GJR-GARCH to estimate impact of news and planned to measure degree of positive magnitude shocks and negative magnitude shocks and failed to formulate GJR-GARCH model. Kernel density model test and Reactive frequency test has successfully described shock impact at upper side and lower side in Athex financial market. Athex market has not significant impact (abnormal impact) of global recession measurable with abnormal sketches. We also found that after 2010 the market has generated outstanding returns for investors and provides great opportunity for investors for long term perspective.

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