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The Application of GARCH and EGARCH in Modeling the Volatility of Daily Stock Returns During Massive Shocks: The Empirical Case of Egypt

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Abstract

Modeling volatility during a financial crisis where massive shocks are generated presents an ideal environment for investigating the dynamics of volatility during periods of extreme fluctuations for comparison with volatility during more tranquil periods. The objective of this paper is to study volatility of daily stock returns listed on the Egyptian Exchange during the political turmoil of 2011. The analysis is based on employing both GARCH and EGARCH models. Daily closing prices of four Egyptian stock market indices, the EGX 30, EGX70, EGX 100, and the EGX 20 capped were used in the analysis. The time frame was from the inception of each index to the 30th of June 2012. The sample period covers the period of pre-and post the Egyptian revolution which was shaped by extreme volatile fluctuations in stock returns. The EGARCH model was the method of choice for modeling the volatility in order to investigate the long memory and the leverage effect in the volatilities of the two periods. The findings reveal higher volatility during the revolution period for all indices reflected in higher standard deviations for both daily returns and absolute returns, with the EGX 70 displaying the highest volatility. The leverage effect was more apparent during the revolution period. However, long memory was more apparent during the pre-revolution period.

Keywords: The Egyptian Exchange, ARCH, GARCH, EGARCH, Volatility, Revolution.
JEL Classification Code: C52, C53, G17

1. Introduction

Volatility is considered a measure of uncertainty in the changes of asset pricing. More accurately, it was used by Markowitz (1952) as a measure of risk. The need for an accurate forecast of volatility is continually increasing and an analytical solution for volatility is used in risk management, portfolio optimization and hedging. In addition, the introduction of the first Basel Accord in 1996, which sets minimum capital reserve requirements to be held by financial institutions proportional to their estimated risks, has further highlighted the significance of volatility prediction due to its essential role in calculating value-at-risk (VaR). Therefore, volatility has become a critical input in many applications in financial modeling and decision-making.

The investigation of modeling of stock market volatility has been studied by various researchers, a large part of which focuses on the estimation of the stock return volatility and the persistence of shocks to volatility. Although there are numerous empirical studies, most of the studies have been conducted for the developed markets such as US (Poterba and Summer,1986; Baillie and De

Gennaro,1990; Najand, 2002), Europe (Dimson and Marsh, 1990; McMillan et al, 2000), Japan (Tse, 1991), and Australia (Brailsford and Faff, 1996).

Concerning volatility studies, the macro-economic environment and periods of crises have gained importance in volatility evaluation. Macroeconomic instability accompanied with political instability have significant effects with no predictable direction. This is because higher uncertainty levels are typically associated with higher stock volatility that reflect diffuse and easily changed beliefs about the future. In particular, political instability (ie. during World War I, II and the Great Depression) produced great volatility. Recently, the situation in Egypt has created an ideal environment serving as a laboratory for examining stock index volatlity caused by political instability. Egypt has experienced groundbreaking developments in the beginning of 2011 that led to the Egyptian **revolution.**

So far there has been no study that has examined the impacts of the revolution on the volatility of the EGX 30, EGX70, EGX 100, and the EGX 20 indices. Previous studies have focused on modeling and forecasting the volatility of the Egyptian Exchange indices before the revolution (Abd El Aal, 2011; Floros, 2008; Omran and Girard, 2007). After the revolution, Egypt became a center of attention. Soon after the revolution began, the Egyptian Exchange fell by almost 27 percent and government authorities were forced to suspend trading for almost 2 months in order to avoid severe losses, Peaple (2011). When the Egyptian Exchange opened, it fell an additional 9 percent. Investors lost confidence in the economic and political environment as security became a major problem. Several banks were attacked by armed gunmen. The tourism industry dropped by 70 percent. Widespread strikes by workers in both the private and public sectors, requesting better working conditions, better benefits and higher pay, caused a major slowdown in manufacturing and the export market, Ferguson (2011). Foreign currency reserves fell from almost $30 billion in February 2011 to less than $20 billion by September of the same year. Also, many Egyptians transfered their savings into foreign currencies outside of Egypt, as a result of fear of restrictions on money outflows that were later implemented. Corporate earnings for the fiscal year ending June 30th for the public sector and December 31st for the private sector were all negatively affected by varying degrees according to the industry.

The motivation for this paper stems from seeking to understand how the volatility of the Egyptian Exchange indices was shaped during the pre and post revolution periods. The objective of this study is to investigate the characteristics of volatility during two periods with very different volatility dynamics. The first period includes pre-Egyptian revolution and the second period includes post-Egyptian revolution. The one and half years after the revolution presents the period of massive shocks and extreme volatility. Stylized facts of returns and absolute returns, as well as GARCH and EGARCH modeling, for both periods are compared.

This study contributes to the existing literature in two ways. First, the current paper explains volatility modeling using recent daily returns and absolute returns. In particular, this paper used the EGARCH model for leverage terms to capture asymmetry in volatility clustering. Second, this paper is one of the most up to date studies for evaluating the volatility variation in the Egyptian Exchange before and after the revolution. To the best of author’s knowledge, no study has investigated the volatility of stock returns on the Egyptian Exchange before and after the revolution. While there are studies on the volatility of Egpytian Exchange indices in the literature, scholars have not yet investigated the Egyptian Exchange stock indices during pre-and post revolution periods. This paper attempts to examine the volatility during periods of extreme fluctuations for comparison with volatility during more tranquil periods.

The remainder of this paper is organized as follows: Section 2 presents a literature review. Section 3 describes the data set. Section 4 describes the methodology. Section 5 presents the empirical findings and Section 6 shows the summary and conclusion.

2. Literature Review

An analytical solution for volatility is required in many applications in financial decision-making including risk management, portfolio management and asset allocation, option pricing, foreign exchange and the term structure of interest rates. A significant problem in forecasting volatility lies in the fact that volatility is a latent variable that is unobservable (Patton, 2006). This means that volatility is not observed directly and can only be inferred from other variables that can be observed and measured directly. A quantitative forecast is then generated through a mathematical model that combines several parameters to produce the forecast. Another problem in forecasting volatility is related to the variability of volatility across different countries as indicated by Roll (1992), Harvey (1995a), Bekaert and Harvey (1997), and Aggarwal et al. (1999), and also across different asset classes.

Empirical research on stock market volatility concerning emerging markets has been fewer in number than that of developed markets. Recently, however, such research has been experiencing considerable growth covering emerging markets worldwide. In a study by Rashid and Ahmad (2008), a comparison was made between linear and non-linear models in capturing the volatility characteristics in the daily closing prices of the Karachi Stock Price Index, KSE-100, from January 2001 through November 2007. Their study concluded that the ARCH/GARCH class of non-linear models provided a better forecasting tool for the volatility of the stock price index. Kilic (2004) analyzed long memory properties of Istanbul Stock Exchange Market (ISE) National 100 daily dollar index returns, absolute and squared returns using parametric and nonparametric tools. He concluded that the evidence of long memory dynamics in the conditional variance can be modeled adequately by a FIGARCH model. Liu, Lee and Lee (2009) examined .how specifications of return distribution influence the performance of volatility forecasting using two GARCH models (GARCH-N and GARCH-SGED) for Shanghai and Shenzhen composite stock indices. Su (2010) used the GARCH and EGARCH models to estimate financial volatility of daily returns of the Chinese stock market using daily data from January 2000 to April 2010. He concluded that the empirical results suggest that the EGARCH model fits the sample data better than GARCH model in modeling the volatility of Chinese stock returns. Tuyen (2011) examined whether or not stock return volatility changes over time using GARCH, EGARCH, TGARCH and GARCH-M for the Vietnamese stock market. He concluded that the standard GARCH(0,1) model provides the best description of return dynamics.

A few papers have attempted to examine volatility on the Egyptian Exchange. Among them, Mecagni and Sourial (1999) investigated the behavior of stock returns on the Egyptian Exchange including the relationship between returns and conditional volatility using GARCH -M. The results indicated the tendency for returns to exhibit volatility clustering and a significant positive link between risk and returns. Omran and Girard (2007) studied the relationship between trading volume and stock price volatility in Cairo and Alexandria Stock Exchange (CASE). The study provided empirical support for the TGARCH specification for explaining the daily time dependence in the rate of information arrival to the market for stocks traded on the CASE. Floros (2008) examined the use of GARCH-type models for modeling volatility and explaining financial market risk using daily data from Egypt (CMA General index) and Israel (TASE-100 index). Models used include GARCH, EGARCH, threshold GARCH, asymmetric component GARCH, the component GARCH and the power GARCH model. His results provide strong evidence that daily returns can be characterized by the GARCH models. Further, Abd El Aal (2011) examined Egyptian stock market return volatility from 1998 to 2009 and his findings show that EGARCH is the best model among other models for measuring volatility.

3. Data Set

All indices used are maintained by the Egyptian Exchange. The Egyptian Exchange indices used include the EGX 30, EGX 20 capped, EGX 70 and the EGX100. The sampling covers the period from inception up until the 30th of June 2012. The demonstrations started on the 25th of January 2011. The ensuing period experienced extreme stock market volatility with severe shocks followed by short periods of relative calm. This stock market behavior continued until the end of June 2012. The data for each index is divided into two segments. The first segment is the pre-revolution period starting at the date of inception of the index until December 31st 2010. The second segment covers the post-revolution period starting on January 1st 2011 until June 30th 2012. It is interesting to note that on the 25th of June 2012, the day following the election of the new president of Egypt, the EGX 30 rallied more than 7%. This was one of the biggest single day increases of all time. A brief overview of each index is presented.

The EGX 30 was originally called the CASE 30. The date of inception of the index is the 2nd of January 1998 with a base value of 1000 points. The EGX 30 index is market capitalization weighted and free float adjusted. The free float adjustment of the market capitalization for each company is calculated by multiplying the number of listed shares by the closing price of that company multiplied by the percent of freely floated shares. The companies listed on EGX 30 must have 15% free float.

The EGX 20 capped was designed to reflect the performance of the 20 most active companies in terms of liquidity and market capitalization. The weight of any company included in the index is capped at 10%. The date of inception of the index is the 30th of January 2003.

The EGX 70 was introduced on the 1st of March 2009 and retroactively calculated as of the 2nd of January 2008. The index is not market capitalization weighted and it is designed to reflect the performance of the 70 most active companies after excluding the companies in the EGX 30.

The EGX 100 was introduced on the 2nd of August 2009 and retroactively calculated as of the 1st of January 2006. The index is not market capitalization weighted and is designed to reflect the performance of the 100 most active companies including the companies in the EGX 30 and the EGX 70.

4. The Metdology

The ARCH/GARCH classes of models are some of the most widely used non-linear models for specifying volatility. These models and their variants can successfully capture the stylized facts of the volatility of stock returns, specifically volatility clustering, long memory, leptokurtosis and the leverage effect. ARCH models were introduced by Engle (1982) to specifically model and forecast conditional variances. The ARCH model assumes that the variance of the current period is an equally weighted average of the squared residuals of the previous days. The GARCH model introduced by Bollerslev (1986) uses declining weights for the squared residuals that are estimated by the model. The conditional variance equation of the standard GARCH model has the following form:

$$\sigma_t^2 = \omega + \sum_{j=1}^{a} \beta \, \sigma_{t-1}^2 + \sum_{t-1}^{p} \alpha \, \varepsilon_{t-1}^2 \tag{1}$$

Where ω , α , β are nonnegative parameters with $\alpha + \beta < 1$ but should be close to unity for an accurate model specification.

The standard GARCH model does not capture the asymmetric nature or skewness caused by the inverse correlation between volatility and returns referred to as the leverage effect. The exponential GARCH or EGARCH was introduced by Neslon (1991) to capture the leverage effect. The specification for the conditional variance in the EGARCH model is given by:

$$\log \sigma^2_{t} = \omega + \beta \log \sigma^2_{t-1} + \alpha \left| \frac{\varepsilon t\text{-}1}{\sigma t\text{-}1} \right| + \gamma \frac{\varepsilon t\text{-}1}{\sigma t\text{-}1} \tag{2}$$

The advantage of using EGARCH is that the positivity of the parameters is guaranteed since we are working with the log of the variance. Also, there are no restrictions on the parameters ω, α, and γ. However, to maintain stationarity, β must be positive and less than 1. The leverage effect is indicated by the value of γ. For the leverage effect to be present, γ must be negative and significant.

In this research both GARCH (1,1) and EGARCH(1,1) were used to model the volatility of Egyptian Exchange indices for the pre-revolution period and the period during the revolution. Before the GARCH models were applied, it was necessary to test for the presence of ARCH effects. This was performed by first applying the least squares (LS) method in order to generate regression residuals. Then the ARCH heteroskedasticity test was applied to the residuals to see if time varying volatility clustering does indeed exist.

Statistical analysis including the Kolmogorov-Smirnov (KS) test for normality, the autocorrelation function (ACF) and the Ljung-Box test for linear independence, and the Augmented Dickey-Fuller (ADF) test for unit roots were applied to the Egyptian Exchange indices during the pre-revolution period and the revolution period. Descriptive statistics were also generated. The two variables analyzed are daily price returns and the volatility.

The price returns R(t) used in this research are the percentage price returns defined as follows:

$$R(t) \equiv [P(t + \Delta t) - P(t)] \div P(t) \quad (3)$$

The absolute value of returns are used as a proxy for volatility defined as follows:

$$\text{Absolute Value of Returns} \equiv \text{Volatility} \equiv |\, [P(t + \Delta t) - P(t)] \div P(t) \,| \quad (4)$$

5. Empirical Findings

Descriptive statistics for all four indices are presented in Table 1 and 2. The findings for stock returns are demonstrated in Table 1 and the findings for absolute returns are demonstrated in Table 2 for both the pre- and during the revolution period.

Table 1: Descriptive Statistics of Stock Returns for the Egyptian Exchange Indices

PANEL A: Index **S**tatistics for Pre-Revolution Period				
Index	**EGX 30**	**EGX 20 Capped**	**EGX 70**	**EGX 100**
Observations	**3210**	**1950**	**739**	**1230**
Returns				
Mean	0.000770	0.001222	-0.000239	0.000264
Median	0.000334	0.002324	0.000000	0.001447
Maximum	0.201739	0.137000	0.064333	0.061381
Minimum	-0.164613	-0.159722	-0.138927	-0.149613
Std. Dev.	0.017757	0.017441	0.019903	0.016576
Skewness	0.048342	-0.637044	-1.161515	-1.281056
Kurtosis	12.88384	10.46553	8.110481	10.46897
Jarque-Bera	13067.33 (0.000)	4660.29 (0.000)	970.353 (0.000)	3195.437 (0.000)
K-S	3.884 (0.000)	3.313 (0.000)	2.023 (0.001)	3.316 (0.000)
PANEL B: Index Statistics During the Revolution				
Observations	**328**	**328**	**328**	**328**
Returns				
Mean	-0.001084	-0.000976	-0.001367	-0.001216
Median	-0.000454	-0.000280	0.000000	0.000000
Maximum	0.075852	0.077134	0.085317	0.071341
Minimum	-0.105071	-0.107832	-0.154331	-0.139942
Std. Dev.	0.019243	0.020025	0.022985	0.020540
Skewness	-0.485714	-0.423585	-1.115188	-1.221555
Kurtosis	7.528815	7.011445	10.88515	11.36404
Jarque-Bera	293.20 (0.000)	229.73 (0.000)	917.7189 (0.000)	1037.654 (0.000)
K-S	1.336 (0.056)	1.215 (0.104)	1.868 (0.002)	1.519 (0.020)

P- values are given in parenthesis

In Table 1, it is reported that, daily mean returns were highest for the EGX 20 capped index with a value of 0.001222 while the daily mean absolute returns were highest for the EGX 70 index with a value of 0.014394 before the revolution as indicated in Table 2. The EGX 70 index exhibited the highest volatility for both daily returns and absolute returns with a standard deviation of 0.019903 and 0.013737 respectively. During the revolution period, the EGX 70 had the most negative mean for daily returns with a value of -0.001367 and the highest mean for absolute returns with a value of 0.015593. Furthermore, the EGX 70 exhibited the highest volatility for both daily returns and absolute returns with a standard deviation of 0.022985 and 0.016921 respectively.

During the pre-revolution period, the daily returns for all indices are negatively skewed except the EGX 30 which is positively skewed. The EGX 70 was the most negatively skewed with a skewness value of -1.115188 indicating an extreme left tale. In addition to this, absolute returns for this period are all positively skewed with the EGX 30 exhibiting the highest positive skewness of 3.308856 indicating an extreme right tale. During the revolution period, all daily returns were negatively skewed with the EGX 100 being the most negatively skewed with a skewness value of -1.221555.

Table 2: Descriptive Statistics of Absolute Stock Returns for the Egyptian Exchange Indices

Panel A: Index Statistics for Pre-Revolution Period				
Index	**EGX 30**	**EGX 20 Capped**	**EGX 70**	**EGX 100**
Observations	**3210**	**1950**	**739**	**1230**
Absolute Returns				
Mean	0.012463	0.012380	0.014394	0.011690
Median	0.008901	0.009099	0.010898	0.008289
Maximum	0.201739	0.159722	0.138927	0.149613
Minimum	0.000000	0.000000	0.000000	0.000000
Std. Dev.	0.012671	0.012342	0.013737	0.011750
Skewness	3.308856	2.990571	2.695572	2.986626
Kurtosis	30.01176	22.08112	16.87479	22.33125
Jarque-Bera	103446.1 (0.000)	32488.88 (0.000)	6822.643 (0.000)	20980.58 (0.000)
K-S	9.216 (0.000)	6.973 (0.000)	4.006 (0.000)	5.607 (0.000)
Panel B: Index Statistics During the Revolution				
Observations	**3210**	**1950**	**739**	**1230**
Absolute Returns				
Mean	0.013791	0.014373	0.015593	0.014043
Median	0.010207	0.010504	0.010799	0.009979
Maximum	0.105071	0.107832	0.154331	0.139942
Minimum	0.000000	0.00000	0.000000	0.000000
Std. Dev.	0.013443	0.013955	0.016921	0.015019
Skewness	2.613431	2.430085	3.240530	3.418559
Kurtosis	13.96480	12.59510	20.23973	22.00489
Jarque-Bera	2016.476 (0.000)	1581.059(0.000)	4635.905 (0.000)	5575.070 (000)
K-S	2.761 (0.000)	2.744 (0.000)	3.231 (0.000)	3.167 (0.000)

The findings in Table 2 show that all absolute returns for all indices were positively skewed for both periods, with the EGX 100 being the most positively skewed with a skewness value of 3.418559, indicating an extreme right tale during the revolution period.

During the pre-revolution period, the daily returns for all indices exhibited leptokurtotic behavior with the EGX 30 having the highest kurtosis of 12.88384. The EGX 30 also exhibited the highest kurtosis of absolute returns with a value of 30.01176. For the revolution period, the EGX 100 exhibited the highest kurtosis for daily returns and absolute returns with a value of 11.36404 and 22.00489 respectively. The high kurtosis clearly indicates a deviation from the normal distribution. The kurtosis for absolute returns was higher for all indices than the kurtosis for returns during both periods. This indicates that the kurtosis of absolute returns is more leptokurtotic than the kurtosis of returns.

According to the Jarque-Bera test, both daily returns and absolute returns are non-normal for all indices for both periods. The null hypothesis of normality for the Jarque-Bera test was rejected for all indices for both periods. For the pre-revolution period, the null hypothesis for the KS test was also rejected for all indices for both daily returns and absolute returns indicating deviation from the normal distribution. However, for the revolution period, the KS null hypothesis was accepted for the daily returns of the EGX 30 and the EGX 20 capped at the 5% levels indicating acceptance of normality. Furthermore, the null hypothesis for the KS test was accepted for the EGX 100 daily returns for the revolution period at the 1% level indicating the acceptance of normality. As for absolute returns during the revolution period, the null hypothesis for the KS test was rejected for all indices indicating deviation from normality.

In Table 3, the ACF results are presented for the period before the revolution and Table 4 shows the ACF results during the revolution. The null hypothesis of the Ljung-Box test was rejected for all indices for both daily returns and absolute returns indicating the presence of linear dependencies in the series of returns and absolute returns for all indices for the pre-revolution period. The coefficients of the lags of absolute returns were in general higher than the coefficients of the lags of daily returns for each respective index. All coefficients were positive for the lags of absolute returns during the pre-revolution period. For the revolution period, the null hypothesis of the Ljung-Box test, that the data are independently distributed, was rejected for all indices for both daily returns and absolute returns indicating the presence of linear dependencies in the series of returns and absolute returns for all indices. In addition, the coefficients of the lags of absolute return were in general higher than the coefficients of the lags of daily returns for each respective index for the revolution period. Negative coefficients were present in the 10th and 15th lags in the ACF of absolute returns in all indices during the revolution period.

Table 3: ACF Statistics for the Pre-Revolution Period

EGX 30 Returns				**EGX 30 Absolute Returns**		
		Box-Ljung Statistics			**Box-Ljung Statistics**	
Lag	**ACF**	**Value**	**Sig.**	**ACF**	**Value**	**Sig.**
1	0.179	102.895	0.000	0.300	288.318	0.000
5	0.015	110.095	0.000	0.171	802.012	0.000
10	0.039	128.445	0.000	0.139	1166.699	0.000
15	-0.012	144.744	0.000	0.132	1497.357	0.000
20	0.013	150.666	0.000	0.091	1724.089	0.000
EGX 20 Capped Returns				**EGX 20 Capped Absolute Returns**		
		Box-Ljung Statistics			**Box-Ljung Statistics**	
Lag	**ACF**	**Value**	**Sig.**	**ACF**	**Value**	**Sig.**
1	0.150	43.749	0.000	0.284	157.566	0.000
5	0.023	49.104	0.000	0.199	461.769	0.000
10	0.046	67.847	0.000	0.146	753.003	0.000
15	-0.027	84.884	0.000	0.157	1024.218	0.000
20	0.046	96.825	0.000	0.085	1178.923	0.000
EGX 70 Returns				**EGX 70 Absolute Returns**		
		Box-Ljung Statistics			**Box-Ljung Statistics**	
Lag	**ACF**	**Value**	**Sig.**	**ACF**	**Value**	**Sig.**
1	0.168	20.819	0.000	0.163	19.798	0.000
5	0.058	34.443	0.000	0.093	48.731	0.000
10	0.109	48.585	0.000	0.035	91.072	0.000
15	0.022	57.674	0.000	0.046	122.617	0.000
20	0.044	61.278	0.000	0.049	136.414	0.000
	EGX 100 Returns			**EGX 100 Absolute Returns**		
		Box-Ljung Statistic			**Box-Ljung Statistic**	
Lag	**ACF**	**Value**	**Sig.**	**ACF**	**Value**	**Sig.**
1	0.170	35.758	0.000	0.222	60.497	0.000
5	0.025	47.681	0.000	0.180	189.236	0.000
10	0.075	60.702	0.000	0.117	344.104	0.000
15	0.017	81.648	0.000	0.105	500.276	0.000
20	0.055	91.285	0.000	0.074	591.761	0.000

Table 4: ACF statistics During the Revolution Period

EGX 30 Returns				**EGX 30 Absolute Returns**		
		Box-Ljung Statistics			**Box-Ljung Statistics**	
Lag	**ACF**	**Value**	**Sig.**	**ACF**	**Value**	**Sig.**
1	0.315	32.860	0.000	0.380	47.805	0.000
5	-0.017	36.162	0.000	0.074	68.579	0.000
10	0.062	41.753	0.000	-0.088	73.445	0.000
15	-0.001	44.448	0.000	-0.042	92.334	0.000
20	0.024	46.581	0.001	0.047	95.524	0.000

Table 4: ACF statistics During the Revolution Period - continued

EGX 20 Capped Returns				**EGX 20 Capped Absolute Returns**		
		Box-Ljung Statistics			**Box-Ljung Statistics**	
Lag	**ACF**	**Value**	**Sig.**	**ACF**	**Value**	**Sig.**
1	0.345	39.475	0.000	0.390	50.387	0.000
5	0.009	42.918	0.000	0.048	67.957	0.000
10	0.048	49.222	0.000	-0.110	73.590	0.000
15	0.006	53.888	0.000	-0.053	87.796	0.000
20	0.009	55.898	0.000	0.035	92.362	0.000
EGX 70 Returns				**EGX 70 Absolute Returns**		
		Box-Ljung Statistics			**Box-Ljung Statistics**	
Lag	**ACF**	**Value**	**Sig.**	**ACF**	**Value**	**Sig.**
1	0.280	25.878	0.000	0.401	53.234	0.000
5	0.008	32.813	0.000	0.153	102.429	0.000
10	-0.087	40.310	0.000	-0.031	110.972	0.000
15	-0.055	44.271	0.000	-0.005	114.258	0.000
20	-0.003	48.933	0.000	0.053	116.184	0.000
EGX 100 Returns				**EGX 100 Absolute Returns**		
		Box-Ljung Statistics			**Box-Ljung Statistics**	
Lag	**ACF**	**Value**	**Sig.**	**ACF**	**Value**	**Sig.**
1	0.322	34.342	0.000	0.405	54.199	0.000
5	0.002	39.724	0.000	0.149	97.335	0.000
10	-0.047	43.545	0.000	-0.053	102.315	0.000
15	-0.046	45.997	0.000	-0.028	109.847	0.000
20	0.024	50.126	0.000	0.020	112.061	0.000

P- values are given in parenthesis

The results of the ADF test for unit roots are reported in Table 5. Panel A shows the findings before the revolution and Panel B exhibits the results during the revolution. The ADF test was applied to index daily closing values, daily returns and daily absolute returns for both periods. The ADF null hypothesis is rejected for all indices for both periods. Accordingly, closing prices, daily returns, and daily absolute returns can be assumed to be stationary and hence mean reverting. This is important in order to insure model stability.

Table 5: Unit Root Results

Panel A: ADF **S**tatistics for Pre-Revolution Period				
Index	**EGX 30**	**EGX 20 Capped**	**EGX 70**	**EGX 100**
Observations	**3210**	**1950**	**739**	**1230**
Closing Value				
Intercept	-48.680 (0.000)	-37.853 (0.000)	-23.540 (0.000)	-29.885 (0.000)
Intercept and Trend	-48.675 (0.000)	-37.864 (0.000)	-23.556 (0.000)	-29.874 (0.000)
None	-48.665 (0.000)	-37.831 (0.000)	-23.542 (0.000)	-29.896 (0.000)
Returns				
Intercept	-22.601 (0.000)	-18.333 (0.000)	-15.790 (0.000)	-19.784 (0.000)
Constant and Trend	-22.598 (0.000)	-18.328 (0.000)	-15.780 (0.000)	-19.775 (0.000)
None	-22.604 (0.000)	-18.338 (0.000)	-15.801 (0.000)	-19.795 (0.000)
Absolute Returns				
Intercept	-24.418 (0.000)	-21.059 (0.000	-14.146 (0.000)	-18.745 (0.000)
Constant and Trend	-24.416 (0.000)	-21.053 (0.000)	-14.137 (0.000)	-18.737 (0.000)
None	-24.422 (0.000)	-21.064 (0.000)	-14.152 (0.000)	-18.751 (0.000)
Panel B: ADF Statistics During the Revolution				
Observations	**328**	**328**	**328**	**328**
Closing Value				
Intercept	-12.321 (0.000)	-11.866 (0.000)	-13.10 (0.000)	-12.351 (0.000)
Intercept and Trend	-12.432 (0.000)	-11.995 (0.000)	-13.11 (0.000)	-12.389 (0.000)
None	-12.291 (0.000)	-11.845 (0.000)	-13.056 (0.000)	-12.314 (0.000)

Table 5: Unit Root Results - continued

Returns				
Intercept	-12.419 (0.000)	-12.271 (0.000)	-11.926 (0.000)	-11.945 (0.000)
Constant and Trend	-12.409 (0.000)	-12.266 (0.000)	-11.921 (0.000)	-11.942 (0.000)
None	-12.436 (0.000)	-12.287 (0.000)	-11.945 (0.000)	-11.964 (0.000)
Absolute Returns				
Intercept	-14.067 (0.000)	-10.998 (0.000)	-13.959 (0.000)	-14.177 (0.000)
Constant and Trend	-14.042 (0.000)	-12.981 (0.000)	-13.935 (0.000)	-14.153 (0.000)
None	-14.088 (0.000)	-11.008 (0.000)	-13.981 (0.000)	-14.199 (0.000)

P- values are given in parenthesis

Table 6 displays the results of the ARCH heteroskedasticity test on the residuals after applying the LS regression. Evidence suggests that significant ARCH effects are present for all four indices. Therefore, the null hypothesis of homoskedasticity of the residuals is rejected and the presence of time varying volatility clustering is accepted.

Table 6: Heteroskedasticity Test Results

Panel A: ARCH(1) for Pre-Revolution Period				
Index	**EGX 30**	**EGX 20 Capped**	**EGX 70**	**EGX 100**
Observations	**3210**	**1950**	**739**	**1230**
F-statistic	281.7341	77.18703	6.826326	12.13843
Obs*R-squared	256.1376	74.31855	6.781913	12.03904
Prob. F	0.0000	0.0000	0.0092	0.0005
Prob. Chi-Square	0.0000	0.0000	0.0092	0.0005
Panel B: ARCH(1) During the Revolution				
Observations	**328**	**328**	**328**	**328**
F-statistic	118.1657	117.6953	98.42769	120.1860
Obs*R-squared	87.12121	86.86682	75.95957	88.20773
Prob. F	0.0000	0.0000	0.0000	0.0000
Prob. Chi-Square	0.0000	0.0000	0.0000	0.0000

Table 7 displays the results of the GARCH (1,1) model for both the pre-revolution period and the period during the revolution reported in Panel A and B. For the pre-revolution period, the GARCH (1,1) specification failed to model the volatility for the EGX 70 and the EGX 100 since failure to improve likelihood was encountered. GARCH(1,1) was successful in modeling the volatility during the pre-revolution period for the EGX 30 and the EGX 20 capped indices with statistically significant coefficients. The volatility persistence indicated by ($\alpha + \beta$) was 0.994763 and 0.974989 for the EGX 30 and the EGX 20 capped respectively indicating high persistence and slow decay of the volatility shocks. For the period during the revolution, the GARCH(1,1) specification failed to model the volatility for the EGX 30, the EGX 70 and the EGX 100 since failure to improve likelihood was encountered. The EGX 20 capped was successfully modeled using GARCH(1,1) for the period during the revolution. The volatility persistence indicated by ($\alpha + \beta$) was 0.703479 indicating a lower volatility shock persistence for the EGX 20 capped index during the revolution period.

Table 7: GARCH Results

Panel A: GARCH (1,1) for Pre-Revolution Period				
Index	**EGX 30**	**EGX 20 Capped**	**EGX 70**	**EGX 100**
Mean Equation				
C	0.000666 (0.0028)	0.002088 (0.0000)	0.001492 (0.0147)**	0.001517 (0.0000)**
Variance Equation				
ω	5.80E-06 (0.0000)	8.22E-06 (0.0002)	2.06E-05 (0.0208)**	3.66E-06 (0.0179)**
α	0.150856 (0.0000)	0.126638 (0.0000)	0.150529 (0.0000)**	0.133666 (0.0000)**
β	0.843907 (0.0000)	0.848351 (0.0000)	0.802993 (0.0000)**	0.860900 (0.0000)**

Table 7: GARCH Results - continued

Panel B: GARCH (1,1) During the Revolution				
Mean Equation				
C	-0.001533 (0.1198)**	-0.001682 (0.1089)	-0.000526(0.5840)**	-0.000346(0.6932)**
Variance Equation				
ω	0.000120 (0.0031)**	0.000117 (0.0020)	8.76E-05 (0.010)**	7.12E-05 (0.0090)**
α	0.366802 (0.0000)**	0.349915 (0.0000)	0.301542 (0.0010)**	0.335953 (0.0005)**
β	0.290775 (0.0564)**	0.353564 (0.0037)	0.533020 (0.0000)**	0.495307 (0.0000)**

** Indicates failure to improve likelihood
P- values are given in parenthesis

Table 8 displays the results of the EGARCH (1,1) model for both the pre-revolution period and the period during the revolution reported in Panel A and B. For the pre-revolution period γ is negative for the EGX 30, but it is not significant and hence the presence of the leverage effect is not accepted. This is consistent with the findings of Abd El Aal (2011), who applied EGARCH to forecast the volatility using daily stock returns of the EGX 30 index from 1998 through 2009 and found no evidence of the leverage effect. For the EGX 20 capped, γ is negative and the null hypothesis is rejected at the 5% level and hence some leverage effect is present. For the EGX 70 and the EGX 100, γ is negative and significant at the 1% level. The evidence supports the leverage effect. This is consistent with findings of Foloros (2008) who found a negative and significant γ parameter for EGX 100 index. The results reveal the fact that β is close to one indicating high persistence with slow decay of volatility shocks for the pre-revolution period. For the revolution period, γ is negative for the EGX 30 and significant only at the 5% level. For the EGX 20 capped the EGARCH (1,1) specification failed to model the volatility of the index since failure to improve likelihood was encountered. The findings of the EGX 70 and the EGX 100 indicate that γ is negative and significant at the 1% levels. For all indices, γ is considerably more negative for the period of the revolution than γ for pre-revolution period. However, for all indices, β is distinctly lower during the revolution period than β during the pre-revolution period. This indicates that shocks are less persistent, decaying faster during the revolution period.

Table 8: EGARCH Results

Panel A: EGARCH (1,1) for Pre-Revolution Period				
Index	**EGX 30**	**EGX 20 Capped**	**EGX 70**	**EGX 100**
Mean Equation				
C	0.0005 (0.018)	0.002 (0.000)	0.001 (0.044)	0.001 (0.000)
Variance Equation				
ω	-0.478 (0.000)	-0.550 (0.000)	-0.790 (0.000)	-0.376 (0.000)
α	0.273 (0.000)	0.255 (0.000)	0.245 (0.000)	0.221 (0.000)
γ	-0.007 (0.562)	-0.038 (0.028)	-0.079 (0.001)	-0.054 (0.003)
β	0.967 (0.000)	0.958 (0.000)	0.925 (0.000)	0.976 (0.000)
Panel B: EGARCH (1,1) During the Revolution				
Mean Equation				
C	-0.0011 (0.197)	-0.001 (0.262)**	-0.001 (0.331)	-0.001 (0.442)
Variance Equation				
ω	-2.395 (0.003)	-2.512 (0.006)**	-1.408 (0.000)	-1.663 (0.000)
α	0.494 (0.000)	0.498 (0.000)**	0.317 (0.001)	0.392 (0.000)
γ	-0.153 (0.034)	-0.143 (0.052)**	-0.268 (0.000)	-0.254 (0.000)
β	0.752 (0.000)	0.734 (0.000)**	0.853 (0.000)	0.833 (0.000)

** Indicates failure to improve likelihood
P- values are given in parenthesis

6. Conclusion

This paper investigated the volatility characteristics of long memory and the leverage effect during two distinct periods. The Egyptian revolution beginning on the 25th of January 2011 marked the dividing point between the two periods. The pre-revolution period was the first period and was characterized by having tranquil volatility. The second period was shaped by the revolution and extended 16 months after the revolution. This period was characterized by being extremely volatile with massive negative and positive shocks. The GARCH(1,1) and EGARCH(1,1) models were used to examine the volatility characteristics during both periods. The GARCH (1,1) failed to model volatility for the EGX 70 and the EGX 100 for the pre-revolution period. GARCH (1,1) also failed to model volatility for the EGX 30, the EGX70, and the EGX 100 for the period during the revolution. The EGARCH(1,1) was unsuccessful in modeling volatility only for the EGX 20 capped for the period during the revolution. Hence, EGARCH (1,1) is more superior to GARC(1,1) in modeling the volatility of the Egyptian Exchange indices for the periods being investigated. For the pre-revolution period, applying the EGARCH (1,1) model, significant leverage effects were detected for the EGX 20 capped at the 5% level and for the EGX 70 and the EGX 100 at the 1% level. High persistence was also detected in volatility shocks for all indices during the pre-revolution period implying slow decay and long memory of the volatility. For the period during the revolution, significant leverage effects were detected for the EGX 30 at the 5% level and for the EGX 70 and the EGX 100 at the 1% level. The leverage effect was more apparent during the revolution period demonstrated by more negative values of γ. However, for the revolution period β was consistently lower indicating lower persistence of volatility shocks during this period. These findings imply a faster decay and mean reversion of volatility during the revolution period. In conclusion, the EGARCH model indicated a more apparent leverage effect during the revolution period and a more apparent long memory in the pre-revolution period.

For all indices, the volatility was greater in daily returns and daily absolute returns during the revolution period than the pre-revolution period. This is indicated in higher standard deviations for all indices, in particular EGX 70 index exhibiting the highest volatility. This was expected since massive positive and negative shocks were affecting economic conditions during the revolution period. Normality was rejected by the JB test for all indices for both periods for both daily returns and absolute returns. However, normality was accepted as indicated by the KS test for the EGX 30 and EGX 20 capped daily returns during the revolution period at the 5% level, and the EGX 100 daily returns at the 1% level. This conclusion is considered a deviation from the expectation of the stylized facts of stock returns being non-normal.

The findings further suggest, as indicated by the ACF test and the Box-Ljung statistics, that linear independence is rejected for all indices during both periods for both daily returns and absolute returns, indicating the presence of serial correlations. One of the striking findings of this paper suggest that for both the pre-revolution period and the revolution period, the EGX 70, which is not market capitalization weighted, is the most volatile with the highest standard deviation in both daily and absolute returns. The EGX 70 demonstrates the most significant leverage effect for both periods and the most significant long memory for the revolution period.

References

[1] Abd El Aal M.A. (2011). Modeling and Forecasting Time Varying Stock Return Volatility in the Egyptian Stock Market, *International Research Journal of Finance and Economics* Issue 78.

[2] Aggarwal R., Inclan, C., and Leal, R. (1999). Volatility in Emerging Stock Markets, *Journal of Financial & Quantitative Analysis* 34, 33-55.

[3] Baillie, R. and Degennaro, R. (1990). Stock Returns and Volatility, *Journal of Financial and Quantitative Analysis* June, 25:203-214.

[4] Bekaert, G. and Harvey, C. (1997). Emerging Equity Market Volatility, *Journal of Financial Economics* 43, 29-78.

[5] Bollerslev, T. (1986). Generalized Conditional Heteroskedasticity, *Journal of Econometrics* 31, pp. 307-327.

[6] Brailsford, T. J. and Faff, R.W. (1996). An Evaluation of Volatility Forecasting Techniques, *Journal of Banking and Finance* 20, pp. 419-438.

[7] Dimson, E. and Marsh, P. (1990). Volatility Forecasting Without Data-Snooping, *Journal of Banking and Finance* 14, pp. 399-421.

[8] Engle, R. (1982). Autoregressive Conditional Hetescedasticity with Estimates of the Variance of UK Inflation, *Econometrics* 50, pp. 987-1008.

[9] Floros, C. (2008). Modelling Volatility Using GARCH Models: Evidence from Egypt and Israel, *Middle Eastern Finance and Economics* ISSN: 1450-2889 Issue 2.

[10] Ferguson, N., (2011). The Revolution Blows Up. *Newsweek Magazine*, [Online] 5 June. Available at: <http://www.thedailybeast.com/newsweek/2011/06/05/egypt-the- revolution-blows-up.html> [Accessed 3 August 2012].

[11] Harvey, C., (1995). The Cross-Section of Volatility and Autocorrelation in Emerging Markets, *Finanzmarkt und Portfolio Management* 9, 12-34.

[12] Kilic R. (2004). On the Long Memory Properties of Emerging Capital Markets: Evidence from Istanbul Stock Exchange, *Applied Financial Economics* 14, 915-922.

[13] Liu, H, Lee, Y & Lee, M 2009, 'Forecasting China Stock Markets Volatility via GARCH Models Under Skewed-GED Distribution', *Journal of Money, Investment and Banking* 11.

[14] McMillan, D., Speight, A., and Gwilym, O. (2000). Forecasting UK Stock Market Volatility, *Applied Financial Economics* 10, pp. 435-448.

[15] Markowitz, H. (1952). Portfolio selection, *Journal of Finance* 7, 77-91.

[16] Mecagni, M. and Sourial, M. S. (1999). The Egyptian Stock Market: Efficiency Tests and Volatility Effects, IMF Working paper No. 99/48.

[17] Najand, M., (2002). Forecasting Stock Index Futures Price Volatility: Linear vs. Nonlinear Models, *The Financial Review* 37, pp. 93-104.

[18] Nelson, D. B., (1991). Conditional Heteroscedasticity in Asset Returns: A New Approach, *Econometrica* 59, pp. 347-370.

[19] Omran, M. and Girard, E. (2007). On the Relationship Between Trading Volume and Stock Price Volatility in Case, Cairo and Alexandria Stock Exchanges Occasional Papers No. 1.

[20] Patton, A, (2006). Volatility Forecast Comparison Using Imperfect Volatility Proxies, Quantitative Finance Research, Center Research Paper 175.

[21] Peaple, A, (2011). Egypt's Stock-Market Slump Isn't Over Yet. *The Wall Street Journal*, [Online] 24 March. Available at: <http://online.wsj.com/article/SB10001424052748704050204576218854171228270.h tml > [Accessed 3 August 2012].

[22] Poterba, J. M. and Summers, L.H. (1986). The Persistence of Volatility and Stock Market Fluctuations, *American Economic Review* 76, pp. 1143-1151.

[23] Rashid, A. Ahmad, S. (2008). Predicting Stock Returns Volatility: An Evaluation of Linear vs. Nonlinear Methods, *International Research Journal of Finance and Economics* Issue 20.

[24] Roll, R., (1992). Industrial Structure and the Comparative Behavior of International Stock Market Indices, *Journal of Finance* 47, 3-42.

[25] Su, C. (2010). Application of EGARCH Model to Estimate Financial Volatility of Daily Returns: The empirical case of China, University of Gothenburg, School of Business, Economics and Law. Master Degree Project No.2010:142.

[26] Tse, Y. K., (1991). Stock Returns Volatility in the Tokyo Stock Exchange, Japan and the World Economy 3, pp. 285-298.

[27] Tuyen, T.M. (2011). Modeling Volatility Using GARCH Models: Evidence from Vietnam, *Economics Bulletin* Vol. 31 no.3 pp. 1935-1942.