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Abstract

This paper examines sector specific volatility in order to determine how different sectors respond to volatility shocks within the same equity market. The Egyptian Exchange sector indices are used where firms are disaggregated and classified into twelve different sectors. Volatility is modeled using GARCH, EGARCH and TGARCH in order to examine the temporal volatility dynamics of each specific industry. Stylized facts such as volatility clustering, long memory and the leverage effect are investigated for each sector. Furthermore, the data is divided into two periods. The first period includes sector returns prior to the Egyptian revolution of January 25th 2011. This period was characterized by tranquil volatility. The second period includes the period of the revolution extending one and a half years after the revolution till June 30th 2012. This period was characterized by turbulent volatility. The findings indicate that TGARCH is the preferred model providing successful model specification for all sector indices during both periods. Although the stylized facts where apparent for most sectors for both periods, there was strong evidence of heterogeneous response of sector volatility due to the exogenous shocks of the revolution.

Key words: The Egyptian Exchange, EGARCH, TGARCH, Idiosyncratic Risk, Revolution.

JEL Classification Code: C14, C32, C58, D53, G17

1. Introduction

The volatility in the returns of financial time-series is a main focus of attention among researchers, investors, portfolio managers, and other market practitioners. The reason is that volatility is used as a proxy for risk or uncertainty. Volatility was first applied by Markowitz (1952) as a measure of risk in portfolio selection. Accurate forecasts for the standard deviation or the variance of returns has become indispensible since it is a critical parameter in asset allocation in portfolio management, hedging, options pricing, and the calculation of value-at-risk (VaR). The volatility in the returns of financial time-series is characterized by stylized features commonly exhibited in most financial time-series in varying degrees. These stylized facts are volatility clustering, long memory, leptokurtosis and the leverage effect. Volatility clustering also referred to as pooling implies that the variance is time-varying (heteroskedastic). Volatility clustering describes the tendency of large changes in asset prices to follow large changes and small changes to follow small changes. Long memory refers to the long-term dependencies or the persistence of autocorrelation in the volatility of financial time-series. Leptokurtosis refers to the heavy (fat) tails of the volatility indicating a non-normal distribution. The leverage effect refers to the negative correlation between volatility and asset returns (Black 1976). Among the various methods by which the variance can be estimated, the ARCH model introduced by Engle (1982) to specifically model and forecast conditional variances and the GARCH model introduced by Bollerslev (1986) have become the standard tools for variance modeling. These models are able to capture the stylized features of volatility persistence, volatility clustering and leptokurtosis, but not the asymmetric feature described as the leverage effect. The exponential GARCH or EGARCH introduced by Nelson (1991) and the threshold GARCH or TGARCH introduced by Zakoian (1994) can capture the leverage effect stylized fact where positive and negative shocks have asymmetric effects with negative shocks having a greater impact on volatility than positive shocks.

The popularity of the GARCH class of models as described by Poon and Granger (2003) led to a vast and extensive volume of research being conducted on the modeling of the variance of financial time-series. However, Kredler (2005) stated that there has been almost no interest in the volatility of investment below the aggregate level. The aggregate level refers to the broad market indices constructed by combining different stocks from different sectors providing a representative sample reflecting the performance of the entire market. Similarly, Bakry and Ham (2009) indicated that the application of GARCH models in developed and emerging markets mostly included studies on modeling the volatility of stock returns based on aggregated market indices. Kouki, Harrathi, and Haque (2011) pointed out that no significant work has been undertaken to study the volatility transmission mechanism among the sector returns of national or international financial markets. Bakri and Ham (2009) supported the argument that highly aggregated indices do not reflect the significant differences in the variations in the pattern of volatility of different stocks. Studying the cross-sectoral variation in the structure of volatility helps identify the idiosyncratic risk associated with each individual industry. This assists investors in the diversification of their portfolios by allowing the allocation of assets according to the volatility characteristics of each sector.

The objective of this research is twofold. The first objective is to model the time-varying volatility of different sectors in the Egyptian Exchange (EGX) using GARCH, EGARCH, and TGARCH. The second objective is to study the differences between the temporal volatility of returns across different sectors in response to the exogenous shocks of the Egyptian revolution of 2011. In order to obtain disaggregated daily returns for different sectors, the 12 EGX sector indices were used in the analysis. Sector indices for the Banks, Basic Resources, Chemicals, Construction and Materials, Financial Services excluding Banks, Food and Beverage, Healthcare and Pharmaceuticals, Industrial Goods and Services and Automobiles, Personal and Household Products, Real Estate, Telecommunications, and Travel and Leisure indices were obtained from the EGX. Furthermore, data for each index is divided into two segments. The first segment is the pre-revolution period starting on the 3th of January 2007 and ending on the 31st of December 2010. The second segment covers the post- revolution period starting on the 1st of January 2011 until the 30th of June 2012. The purpose of dividing the data into two segments is to study the idiosyncratic response of each sector to the exogenous shocks associated with the political, social, and economic instability during the revolution period. To the best of the author's knowledge, no other research was available at the time of writing of this paper that studied the effect of the Egyptian revolution on the volatility of specific industries in the EGX. A study on the effect of the Egyptian revolution on the volatility of aggregated market indices was conducted by Ezzat (2012) using daily returns of the EGX 30, EGX 70, EGX 100, and the EGX 20 capped broad market indices using GARCH and EGARCH models.

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 presents the summary and conclusion.

2. Literature Review

Current literature on volatility modeling using GARCH methods is vast in number and extensive in scope, covering many regions and applied to different asset classes. Studies covering developed markets include Poterba and Summer (1986) on the S&P 500, Baillie and De Gennaro (1990) on the CRSP value weighted index with dividends, Najand (2002) on the S&P 500 futures index, Chapel, Padmore and Pigeon (1998), Dimson and Marsh (1990), McMillan et al (2000) on the UK stock market, Tse (1991) on the Japanese stock market, Brailsford and Faff (1996) on the Australian stock market, Adjaoute, Bruand and Gibson-Asner (1998) on the Swiss stock market, Akgiray (1989) on the CRSP value weighted and equal weighted indices, Najand and Yung (1991) on the treasury bonds futures contracts. Bollerslev, Chou and Kroner (1992) provided an extensive overview of GARCH processes. Literature on emerging markets, although less in number, has recently experienced rapid growth. Studies covering developing markets include Rashid and Ahmad (2008) on the Karachi Stock Price Index, Ahmad and Sulaiman (2011) on the Khatoum Stock Exchange, Kilic (2004) on the Istanbul Stock Exchange, Liu, Lee and Lee (2009) on the Shanghai and Shenzen stock markets, De Santis and Imrohoroglu (1997) on the European, Mideast, Asian, and Latin American markets, Su and Fleisher (1998), Su (2010) on the Chinese stock markets and Tuyen (2011) on the Vietnamese stock market among others. Studies that apllied GARCH methods on the EGX include Mecagni and Sourial (1999), Sourial (2002), Tooma and Sourial (2004), Omran and Girard (2007), Floros (2008), Abd El Aal (2011), Ezzat (2012), and Moursi (1999) among others.

All research in the literature mentioned above was conducted using aggregated broad market indices. Empirical research using data on individual stocks or specific sectors has been considerably fewer in number. Veredas and Luciani (2012) conducted analysis on 90 individual firms included in the S&P 100, from January 2001 to December 2008. Their findings indicated that volatilities share co–movements, clustering, long–memory, dynamic volatility, skewness, and heavy–tails. They also found that periods of turmoil are associated with increases in the memory and the homogeneity across assets. Kredlar (2005) studied the differences between time patterns in the volatility of investment across six different sectors in the UK. He found that investment volatility patterns are in general very different across sectors, suggesting that sector-specific factors are more important in determining investment volatility than the macroeconomic environment. Kouki, Harrathi and Haque (2011) examined volatility spillover among sector indices of international stock markets covering both the developed and the emerging markets. They concluded that the linkage between international financial markets depend on the type of the sector and reported evidence of high integration between some sectors through the volatility like the Banking, Real Estate and Oil sectors, while the Financial Services and Industrial sectors are less integrated. These findings indicate that the effect of volatility shocks on the different sectors is not homogeneous. Castro, Clementi and Lee (2011) studied the cross–sectoral variation in plant–level idiosyncratic risk in U.S. manufacturing using volatility as a proxy. They reported that the extent of cross–sectoral variation in idiosyncratic risk is remarkable. Yeo (2004) studied the time-varying conditional variance of daily returns on seven Australian environmental sectors including

Gold Mining, Other Mining, Mining Finance, Oil & Gas, Farming & Fishing, Forestry and Paper. The paper suggested that the risks faced by environmental sectors in financial markets are generally well-explained by the ARMA(1,1)-GARCH(1,1). Arshanapalli, Doukas and Lang (1997) examined the common volatility process among asset prices of nine industry groups for the US, Europe and the Pacific Rim capital markets. They found that industry return series exhibit intra-industry common time-varying volatility processes. They concluded that investors would gain more benefit if they invest across regions and industries rather than diversify within an industry across different geographical regions. Bakri and Ham (2009) estimated pooled-panel models using sector indices and stocks from the EGX to study the similarities and differences between the conditional variance structures of stocks from the same or different industries in the same equity market. Their results indicated that there are similarities in the temporal volatility structures of stocks from the same sector or industry. However, there are significant differences in the temporal volatility structures of stocks from different sectors or industries. Ismail (2011) examined the existence of asymmetric volatility and leverage effect for the Egyptian stock market index as well as the individual stocks that constituted the index during the period from January 2003 to December 2009. The paper indicated that firm-level and aggregate-level returns behave differently. The paper also concluded that the leverage effect cannot be accepted for all individual stocks.

There has been yet no paper investigating the volatility of sector indices for stocks traded on the EGX during the pre and post revolution period. Therefore, this paper will fill the gap by applying GARCH, EGARCH, and TGARCH models to sector indices of the EGX. Furthermore, it is the particular interest of this paper to capture the time-varying volatility dynamics of different sectors during periods of tranquility and instability related to Egyptian revolution.

3. The Data Set

The EGX sector indices were launched in 2007. The objective of the indices is to track the different sectors of the Egyptian market in order to help investors make better-informed investment decisions (The Egyptian Exchange 2012). The 12 indices include Banks, Basic Resources, Chemicals, Construction and Materials, Food and Beverage, Financial Services excluding Banks, Healthcare and Pharmaceuticals, Industrial Goods and Services and Automobiles, Personal and Household Products, Real Estate, Telecommunications, and Travel and Leisure. Only companies with no trading limits are included in each index. Each index is free-float market capitalization weighted. The sector indices are rebalanced every six months and are adjusted for stock dividends and splits. The data for each index is divided into two segments. The first segment is the pre-revolution period starting on the 3th of January 2007 and ending on the 31st of December 2010. The second segment covers the revolution period starting on the 1st of January 2011 until the 30th of June 2012. The first segment is characterized by relative tranquility and lower volatility than the second segment except for the period during the 2008 world financial crisis. The second period spanning 18 months inclusive of the revolution is characterized by extreme volatility resulting from exogenous shocks caused by the political, social, and economic instability.

4. The Methodology

Descriptive statistics were generated for the 12 sector indices for both periods for daily returns. This was to compare statistical properties such as the mean, standard deviation, skewness and kurtosis for the daily returns for each of the 12 sectors during the periods of tranquility and instability. The purpose was investigate the idiosyncratic behavior of the volatility specific to each industry in response to the exogenous shocks caused by the political, social, and economic instability associated with the revolution.

To test for the stationarity of the time-series of returns, the Augmented Dickey-Fuller (ADF) test was used. The ADF is a test for a unit root in a time-series. The null hypothesis is that there is a unit root and the test statistic is a negative number where higher negativity means greater rejection of the null hypotheses that there is a unit root. If the null hypothesis of the existence of a unit root is rejected, then the process would be considered stationary and hence mean reverting. The stationarity of a time-series means that the mean and variance are constant over time. If the time-series is not stationary, then a spurious regression could be generated where the results are statistically significant but are actually random with a unit root (Granger and Newbold 1974). The level of the time-series was tested for a unit root. For the ADF test, the returns R (t) for price P(t) were defined as follows:

$$R(t) \equiv \ln(P_t/P_{t-1}) \qquad (1)$$

Testing for the presence of ARCH effects was first applied before the GARCH models were generated. This was to ensure that time-varying volatility clustering is present. 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.

In this research the ARCH/GARCH classes of models were used. The ARCH method was introduced by Engle (1982) to model the time-varying conditional variance of returns, with the assumption that the variance of the current period is an equally weighted average of the squared residuals of the previous period. The GARCH model introduced by Bollerslev is more parsimonious and uses declining weights for the squared residuals, thus giving more weight to more recent observations in the variance specification. The conditional variance equation of the standard GARCH model has the following form:

$$\sigma^2_t = \omega + \sum_{j=1}^{q} \beta_j \sigma^2_{t-1} + \sum_{i=1}^{p} \alpha_i \varepsilon^2_{t-1} \qquad (2)$$

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

The EGARCH model introduced by Nelson (1991) is a logarithmic extension of the GARCH model. The EGARCH has two major advantages over the standard GARCH model. First, positivity is guaranteed since the log of the variance is used and therefore there are no restrictions on the parameters ω, α, and γ. However, β must remain less than 1 to maintain stationarity. Second, the EGARCH model captures the different responses in the volatility to positive and negative shocks. Therefore, the EGARCH model captures the asymmetric nature or skewness caused by the inverse correlation between volatility and returns referred to as the leverage effect. The specification for the conditional variance in the EGARCH model is given by:

$$\log \sigma^2_t = \omega + \sum_{j=1}^{q} \beta_j \log \sigma^2_{t-j} + \sum_{i=1}^{p} \alpha_i \left| \frac{\varepsilon_{t-i}}{\sigma_{t-i}} \right| + \sum_{k=1}^{r} \gamma_k \frac{\varepsilon_{t-k}}{\sigma_{t-k}} \qquad (3)$$

If the parameter γ is negative and significant then negative shocks increase volatility and hence the leverage effect is present. The parameter β is a measure of the persistence of the shock or long memory of the volatility.

The TGARCH model introduced independently by Zakoïan (1994) and Glosten, Jaganathan, and Runkle (1993) is another asymmetric model used in this research that can capture the leverage effect. The specification for the conditional variance in the TGARCH model is given by:

$$\sigma^2_t = \omega + \sum_{j=1}^{q} \beta_j \sigma^2_{t-j} + \sum_{i=1}^{p} \alpha_i \varepsilon^2_{t-i} + \sum_{k=1}^{r} \gamma_k \varepsilon^2_{t-k} I_{t-k} \quad (4)$$

Where ω , α , β are nonnegative parameters with $\alpha + \beta < 1$ but should be close to unity for an accurate model specification. $I_t = 1$ if $\varepsilon_t < 0$ and 0 otherwise. Good news is indicated when $\varepsilon_{t-i} > 0$ and has an impact on α_i. Bad news is indicated when $\varepsilon_{t-i} < 0$ and has an impact on $\alpha_i + \gamma_i$. If $\gamma_i \neq 0$, then we have an asymmetric news impact. If $\gamma_i > 0$, then volatility increases with bad news and we have leverage effect of the i-th order. The standard GARCH model is a special case of the TGARCH model if the threshold term is given a zero value.

5. Empirical Findings

Descriptive statistics for all indices are presented in Table 1. Statistics for the pre-revolution period are presented in Panel A and the statistics for the period during the revolution are presented in panel B.

In Table 1 panel A, data indicate that all sector indices had a wide range between the value of maximum and minimum returns. This is reflected in a high standard deviation of returns compared to mean returns for each index. For the pre-revolution period, the Banks index produced the highest mean returns with a value of 0.00099. The positive performance of the banking sector can be attributed to the major reforms initiated by the government during the pre-revolution period. The objective of the reforms was to help troubled banks eliminate non-performing loans, improve asset quality and capital adequacy (Global Investment House 2008). Furthermore, the Egyptian banking sector during this period witnessed major consolidation through mergers and acquisitions enabling banks to become more competitive. For this period the most negative mean returns were for the Telecom index with a value of -0.00067. This can be attributed to the high competitiveness of the industry and the entry of a third global provider of mobile telecommunication in the Egyptian market. The high standard deviation reflects the high level of fluctuations among the sectors. The highest standard deviation for returns was for the Travel and Leisure index with a value of 0.02444. The lowest standard deviation for the returns during the pre-revolution period was for the Personal and Household Products index with a value of 0.01765

During the pre-revolution period, all sector index returns demonstrated negative skeweness except the Telecom index which demonstrated slightly positive skewness with a value of 0.371. The most negatively skewed index was the Personal and Household

Products index with a value of -2.058 indicating a long left tail. The evidence of negative skewness in 11 out of the 12 sector indices reflects the non-symmetric distribution of returns.

For the pre-revolution period, all sector index returns demonstrated leptokurtosis except the Travel and Leisure index with a slightly platykurtotic value of 2.579. The Personal and Household Products index exhibited the highest kurtosis with a value of 21.209 exceeding the normal value of 3, demonstrating fat tails. The existence of fat tails indicates the greater presence of outliers or extreme events. One explanation for the presence of fat tails is the discontinuous nature of trading. Since the market is closed over weekends and holidays, significant news released during the period of market closure would cause a shock to price levels once the market opens. The closure of the market does not allow prices to react smoothly to news released during the period of market closure. Once the market opens, spikes in prices could result leading to higher kurtosis in price returns.

In Table 1 panel B, data indicate that for all sector indices mean returns during the revolution period where all negative without exception. The least negative mean return was for the Telecom index with a value of -0.00005. This finding is in line with the fact that the telecom sector was one of the least negatively affected by the revolution (Fitch 2011). The most negative mean returns during the revolution period was for the Basic Resources index with a value of -0.00239 followed by the Travel and Leisure index with a value of -0.00217. Among the constituents of the Basic Resources index are steel production companies that rely primarily on the construction industry. Hence, these results are expected since both the property development and the tourism industries where among the most severely affected sectors during the revolution period (Fitch 2011). According to Bly (2011), inbound tourism from the US and other countries was down 75 to 90 percent by April 2011. These two industries also exhibited the highest standard deviation during the revolution period with values of 0.03033 and 0.02852 for the Basic Resources and the Travel and Leisure indices respectively. The lowest standard deviation of returns for the revolution period was for the Personal and Household Products index with a value of 0.01534 followed by the Healthcare and Pharmaceuticals index with a value of 0.01652. The healthcare and pharmaceuticals sector is considered a defensive industry that is generally least affected by a downturn in the economy. For such sectors, the level of risk is lower since people continue to receive healthcare services regardless of the state of the economy.

During the revolution period, all sector index returns demonstrated negative skeweness except the Telecom Index which demonstrated slightly positive skewness with a value of 0.672. The most negatively skewed was the Healthcare and Pharmaceuticals index with a value of -0.947 indicating a long left tail and a non-symmetric distribution of returns. The Banks index was the least skewed of all indices during the revolution period with a skewness value of -0.164.

For the revolution period, all sector index returns demonstrated leptokurtosis except the Basic Resources and the Real Estate indices exhibiting slightly platykurtotic values of 1.446 and 2.492 respectively. The Personal and Household Products index exhibited the highest kurtosis with a value of 12.017. Also, the Banks, Telecom and Travel and Leisure indices exhibited kurtosis values close to 3 which is the kurtosis value of the normal distribution.

In general, the kurtosis of returns for 9 out of the 12 indices was lower during the revolution period. Out of the 11 indices that were negatively skewed during the pre-revolution period 7 demonstrated less negative skewness during the revolution period. The normal distribution of returns was rejected by the Jarque-Bera test for all indices during both periods. Despite the rejection of the normal distribution for daily returns, results indicate that during the revolution period, which is a period of turmoil, the returns seemed to be converging toward the normal distribution in the form of lower kurtosis and less skewness. Ezzat (2012) applied the Kolmogorov-Smirnov (KS) test for normality on the EGX 30 and the EGX 20 capped indices during a similar period. He reported that normality of returns was rejected for the pre-revolution period but were accepted for the more volatile period of the revolution.

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

PANEL A: Index **S**tatistics for Pre-Revolution Period								
Index	**Mean**	**Median**	**Max.**	**Min.**	**Std. Dev.**	**Skewness**	**Kurtosis**	**Jarque-Bera**
Banks	0.00099	0.00137	0.13305	-0.20630	0.01926	-1.104	17.017	11930.39
Basic Resources	0.00004	0.00000	0.15165	-0.15844	0.02353	-0.673	7.836	2559.280
Chemicals	0.00006	0.00105	0.08144	-0.12992	0.01911	-0.898	6.117	1645.395
Construction & Materials	0.00071	0.00131	0.08943	-0.19801	0.02219	-1.042	8.262	2940.439
Financial Services excluding Banks	0.00001	0.00129	0.08571	-0.12021	0.02124	-0.755	3.597	615.789
Food & Beverage	0.00029	0.00088	0.13502	-0.16433	0.02385	-0.363	5.83	1396.871
Healthcare & Pharmaceuticals	0.00065	0.00000	0.15762	-0.18036	0.0229	-0.06	9.259	3471.907
Industrial Goods & Services and Automobiles	0.00093	0.00114	0.18088	-0.17591	0.02416	-0.687	10.441	4492.118
Personal & Household Products	-0.00035	0.00000	0.06897	-0.2086	0.01765	-2.058	21.209	18918.38
Real Estate	0.00058	0.00121	0.08397	-0.21597	0.02439	-1.021	8.035	2783.744
Telecom	-0.00067	0.00000	0.14286	-0.10601	0.02158	0.371	3.74	587.7133
Travel & Leisure	-0.00028	0.00000	0.10746	-0.1265	0.02444	-0.309	2.576	283.2574

Table 1: continued

PANEL B: Index Statistics During the Revolution								
Index	**Mean**	**Median**	**Max.**	**Min.**	**Std. Dev.**	**Skewness**	**Kurtosis**	**Jarque-Bera**
Banks	-0.00152	-0.00167	0.09	-0.09773	0.02188	-0.164	3.537	165.5103
Basic Resources	-0.00239	00.00000	0.09818	-0.13499	0.03033	-0.292	1.446	31.63363
Chemicals	-0.00063	-0.00058	0.0738	-0.06821	0.01696	-0.198	3.748	186.4516
Construction & Materials	-0.00033	0.00000	0.08347	-0.10402	0.01987	-0.401	4.792	310.7288
Financial Services excluding Banks	-0.00175	0.00000	0.08043	-0.12394	0.02291	-0.639	3.888	220.6001
Food & Beverage	-0.0011	-0.00118	0.09218	-0.12459	0.02029	-0.72	7.678	805.6348
Healthcare & Pharmaceuticals	-0.00065	0.00000	0.05385	-0.08887	0.01652	-0.947	6.355	580.7485
Industrial Goods & Services and Automobiles	-0.00186	-0.00112	0.073	-0.10483	0.01951	-0.792	5.594	446.0936
Personal & Household Products	-0.00133	0.00000	0.08772	-0.09766	0.01534	-0.853	12.017	1947.622
Real Estate	-0.00177	-0.00129	0.09233	-0.13995	0.0272	-0.28	2.492	85.34474
Telecom	-0.00005	0.00000	0.09859	-0.0801	0.0214	0.672	3.097	150.0671
Travel & Leisure	-0.00217	-0.00327	0.09005	-0.15968	0.02857	-0.4	3.128	136.8441

Table 2 displays the percentage change between the two periods of the volatility of daily returns for each sector index. The percentage change of the volatility between the two periods demonstrates the individual response of each sector to the exogenous shocks of the revolution. From Table 2, it is evident that the response is highly heterogeneous with great variations in the volatility of daily returns between the two periods among the different sectors. The highest percentage increase in volatility was for the Basic Resources index with a value of 28.91%. The highest percentage decrease in the volatility of daily returns was for the Healthcare and Pharmaceuticals index with a value of -27.84%. The Telecom index exhibited a slight change of only -0.86% indicating almost no change between the two periods which is in line with the fact that the telecom sector was among the least negatively affected by the turmoil of the revolution. Out of the 12 sector indices, 5 sectors exhibited increases in volatility while 7 exhibited decreases in the volatility of daily returns between the two periods. The decrease in the volatility of daily returns in some sectors comes as a surprise since the negative exogenous shocks of the revolution were expected to increase the level of risk in each sector and hence the volatility of daily returns. In general, the data indicate a high degree of heterogeneity in the response of each sector to the exogenous shocks of the revolution.

Table 2: Standard Deviation Comparison for Daily Returns

Index	Standard Deviation Pre-Revolution	Standard Deviation During Revolution	Standard Deviation % Change
Banks	0.019265	0.021877	13.56%
Basic Resources	0.023529	0.030331	28.91%
Chemicals	0.019109	0.016962	-11.24%
Construction & Materials	0.022186	0.019874	-10.42%
Financial Services excluding Banks	0.021243	0.022905	7.83%
Food & Beverage	0.023848	0.020292	-14.91%
Healthcare & Pharmaceuticals	0.022895	0.016522	-27.84%
Industrial Goods & Services and Automobiles	0.024161	0.019512	-19.24%
Personal & Household Products	0.017652	0.015342	-13.09%
Real Estate	0.024387	0.027202	11.54%
Telecom	0.021585	0.021400	-0.86%
Travel & Leisure	0.024436	0.028570	16.92%

The results of the ADF test for unit root are reported in Table 3. Panel A shows the findings before the revolution and Panel B exhibits the results during the revolution. The ADF test was applied to the level of the series of the natural logarithm returns for each index for both periods. The ADF null hypothesis was rejected for all indices for both periods at the 1% significance level. Accordingly, the natural logarithm returns for each index for both periods can be assumed to be stationary and hence mean reverting. This is important in order to insure model stability.

Table 3: ADF Unit Root Results for the Level of the Series

Index	Intercept	Intercept and Trend	None
PANEL A: ADF Statistics for Pre-Revolution Period			
Banks	-30.34261 (0.0000)	-30.35217 (0.0000)	-30.30702 (0.0000)
Basic Resources	-27.47249 (0.0000)	-27.46008 (0.0000)	-27.48425 (0.0000)
Chemicals	-2475038 (0.0000)	-24.73793 (0.0000)	-24.76162 (0.0000)
Construction & Materials	-25.69157 (0.0000)	-25.68343 (0.0000)	-25.69511 (0.0000)
Financial Services excluding Banks	-26.42809 (0.0000)	-26.41502 (0.0000)	-26.43915 (0.0000)
Food & Beverage	-26.33802 (0.0000)	-26.33073 (0.0000)	-26.35146 (0.0000)
Healthcare & Pharmaceuticals	-21.81592 (0.0000)	-21.81289 (0.0000)	-21.80931 (0.0000)
Industrial Goods & Services and Automobiles	-28.07799 (0.0000)	-28.11631 (0.0000)	-28.07510 (0.0000)
Personal & Household Products	-26.06633 (0.0000)	-26.05502 (0.0000)	-26.06254 (0.0000)
Real Estate	-25.39230 (0.0000)	-25.38213 (0.0000)	-25.40283 (0.0000)
Telecom	-26.01023 (0.0000)	-25.99690 (0.0000)	-25.98250 (0.0000)
Travel & Leisure	-26.26764 (0.0000)	-26.27317 (0.0000)	-26.26812 (0.0000)
PANEL B: ADF Statistics During the Revolution			
Banks	-14.31053 (0.0000)	-14.48713 (0.0000)	-14.26504 (0.0000)
Basic Resources	-13.18983 (0.0000)	-13.37153 (0.0000)	-13.12226 (0.0000)
Chemicals	-13.98434 (0.0000)	-13.96754 (0.0000)	-13.98128 (0.0000)
Construction & Materials	-13.70675 (0.0000)	-13.70046 (0.0000)	-13.72164 (0.0000)
Financial Services excluding Banks	-12.86981 (0.0000)	-12.94810 (0.0000)	-12.81409 (0.0000)
Food & Beverage	-14.43144 (0.0000)	-14.46190 (0.0000)	-14.39812 (0.0000)
Healthcare & Pharmaceuticals	-21.81592 (0.0000)	-21.81289 (0.0000)	-21.80931 (0.0000)
Industrial Goods & Services and Automobiles	-13.31206 (0.0000)	-13.34668 (0.0000)	-13.22203 (0.0000)
Personal & Household Products	-14.15394 (0.0000)	-14.13201 (0.0000)	-14.07368 (0.0000)
Real Estate	-12.60142 (0.0000)	-12.79581 (0.0000)	-12.56589 (0.0000)
Telecom	-12.86221 (0.0000)	-12.86773 (0.0000)	-12.88106 (0.0000)
Travel & Leisure	-13.34328 (0.0000)	-13.47817 (0.0000)	-13.27197 (0.0000)

P- values are given in parenthesis

Table 4 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 sector indices except the Banks and Personal and Household Products indices for the pre-revolution period and the Healthcare and Pharmaceuticals index during the period of the revolution. Therefore, for the Banks and Personal and Household Products indices for the pre-revolution period and the Healthcare and Pharmaceuticals index during the period of the revolution, the null hypothesis of homoskedasticity of the residuals is accepted and the presence of time varying volatility clustering is rejected. For those sectors, the outputs of the GARCH models are reported but are not accepted as successful model specifications.

Table 4: Heteroskedasticity Test Results

PANEL A: ARCH(1) for Pre-Revolution Period				
Index	**F-statistic**	**Obs*R-squared**	**Prob. F**	**Prob. Chi-Square**
Banks*	1.862016	1.862278	0.1727	0.1724
Basic Resources	300.6671	230.5479	0.0000	0.0000
Chemicals	20.92974	20.53392	0.0000	0.0000
Construction & Materials	35.67201	34.4894	0.0000	0.0000
Financial Services excluding Banks	60.08629	56.73062	0.0000	0.0000
Food & Beverage	41.25931	39.67321	0.0000	0.0000
Healthcare & Pharmaceuticals	76.13115	70.78741	0.0092	0.0092
Industrial Goods & Services and Automobiles	219.347	179.5967	0.0000	0.0000
Personal & Household Products *	0.122752	0.122987	0.7261	0.7258
Real Estate	10.72168	10.62729	0.0011	0.0011
Telecom	16.67013	16.42476	0.0000	0.0001
Travel & Leisure	50.45673	48.08402	0.0000	0.0000

Table 4: continued

PANEL B: ARCH(1) During the Revolution				
Index	**F-statistic**	**Obs*R-squared**	**Prob. F**	**Prob. Chi-Square**
Banks	119.113	87.6319	0.0000	0.0000
Basic Resources	23.97146	22.45786	0.0000	0.0000
Chemicals	52.23518	45.2607	0.0000	0.0000
Construction & Materials	90.27363	71.03808	0.0000	0.0000
Financial Services excluding Banks	130.0189	93.35772	0.0000	0.0000
Food & Beverage	107.1374	81.01083	0.0000	0.0000
Healthcare & Pharmaceuticals *	1.478701	1.481069	0.2249	0.2236
Industrial Goods & Services and Automobiles	139.0093	97.87501	0.0000	0.0000
Personal & Household Products	80.95263	65.1695	0.0000	0.0000
Real Estate	76.95344	62.56792	0.0000	0.0000
Telecom	64.96925	54.45154	0.0000	0.0000
Travel & Leisure	56.67896	48.53786	0.0000	0.0000

* Signifies no ARCH effect indicated by the heteroskedasticity test

Table 5 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 of 3 out of the 12 indices where failure to improve likelihood was encountered. Out of the remaining 7 indices with successful model specification, 3 had a high volatility persistence indicated by ($\alpha + \beta$) slightly lower than 1 providing strong indication of high persistence and slow decay of the volatility shocks. For the Construction & Materials, Financial Services excluding Banks, Healthcare & Pharmaceuticals and the Real Estate indices the value of ($\alpha + \beta$) was almost 1 indicating the presence of a unit root. Engle and Bollerslev (1986) suggested that a time-series with a unit root can be modeled using Integrated GARCH or (IGARCH) model. A persistence equal to 1 indicates no mean reversion and volatility shocks have a more permanent effect. Permanent shocks to volatility require adjustments to be made in the risk premium as uncertainty increases and asset returns are considered more risky.

For the period during the revolution, the GARCH(1,1) was successful in modeling the volatility only for the Chemicals and the Construction and Materials indices with statistically significant coefficients. Persistence for the Chemicals index was slightly lower than 1 indicating slow decay of volatility and long memory. For the Construction and Materials index, persistence was equal to unity indicating the presence of a unit root and the absence of mean reversion.

The GARCH(1,1) model was not successful in modeling 5 out of the 12 indices for the pre-revolution period and 10 out of the 12 indices for the period of the revolution and therefore would not be recommended as a suitable method for modeling volatility for the given data set. Also, the GARCH model has an inherent weakness in its tendency to exaggerate the presence of volatility persistence (α + β) as demonstrated in the pre-revolution period which may lead to inferior volatility forecasts.

Table 5: GARCH Results

PANEL A: GARCH (1,1) for Pre-Revolution Period					
	Mean Equation	**Variance Equation**			
Index	**C**	**ω (Constant)**	**α (Arch Effect)**	**β (Garch Effect)**	**α + β (Persistence)**
Banks *	0.001258 (0.0071)	1.06E-05 (0.0000)	0.174871 (0.0000)	0.818459 (0.0000)	0.993330
Basic Resources	*0.000575 (0.2876)*	*6.06E-06 (0.0005)*	*0.107841 (0.0000)*	*0.886143(0.0000)*	*0.993984*
Chemicals	0.000544 (0.3343)	2.18E-05 (0.0000)	0.134581 (0.0000)	0.814242 (0.0000)	0.948823
Construction & Materials	0.001300 (0.0152)	4.19E-06 (0.0035)	0.109495 (0.0000)	0.891149 (0.0000)	1.000644
Financial Services excluding Banks	0.000740 (0.1887)	1.22E-05 (0.0001)	0.158712 (0.0000)	0.823938 (0.0000)	0.982650
Food & Beverage	0.000746 (0.1873)	5.7E-06 (0.0169)	0.148709 (0.0000)	0.857967 (0.0000)	1.006676
Healthcare & Pharmaceuticals	0.000616 (0.2319)	8.71E-06 (0.0000)	0.120725 (0.0000)	0.875389 (0.0000)	0.996114
Industrial Goods & Services and Automobiles	*0.000998 (0.0760)*	*5.66E-06 (0.0001)*	*0.119912 (0.0000)*	*0.879392 (0.0000)*	*0.999304*
Personal & Household Products *	0.000193 (0.6550)	1.15E-06 (0.0214)	0.085767 (0.0000)	0.922173 (0.0000)	1.007940
Real Estate	0.001535 (0.0138)	8.98E-06 (0.0001)	0.135001 (0.000)	0.860625 (0.000)	0.995626
Telecom	*-8.40E-05 (0.8929)*	*7.63E-06 (0.0103)*	*0.087664 (0.0000)*	*0.898912 (0.0000)*	*0.986576*
Travel & Leisure	0.000488 (0.4486)	6.31E-06 (0.0070)	0.087213 (0.0000)	0.904982 (0.0000)	0.992195

Table 5: continued

PANEL B: GARCH (1,1) During the Revolution					
	Mean Equation	**Variance Equation**			
Index	**C**	**ω (Constant)**	**α (Arch Effect)**	**β (Garch Effect)**	**α + β (Persistence)**
Banks	*-0.001374 (0.2029)*	*0.000188 (0.0001)*	*0.423306 (0.0000)*	*0.199196 (0.1478)*	*0.622502*
Basic Resources	*-0.002820 (0.0867)*	*0.000300 (0.0033)*	*0.302027 (0.0001)*	*0.382867 (0.0022)*	*0.684894*
Chemicals	-0.001080 (0.2087)	6.27E-05 (0.0018)	0.235902 (0.0022)	0.556583 (0.0000)	0.792485
Construction & Materials	-0.000846 (0.4305)	0.000114 (0.0054)	0.222048 (0.0001)	0.459584 (0.0010)	0.681632
Financial Services excluding Banks	*-0.001890 (0.1364)*	*0.000219 (0.0000)*	*0.273320 (0.0000)*	*0.288859 (0.0070)*	*0.562179*
Food & Beverage	*-0.001216 (0.1165)*	*9.13E-05 (0.0000)*	*0.432681 (0.0000)*	*0.372078 (0.0001)*	*0.804759*
Healthcare & Pharmaceuticals *	*-0.000809 (0.3936)*	*5.89E-05 (0.0002)*	*0.113603 (0.0136)*	*0.686969 (0.0000)*	*0.800572*
Industrial Goods & Services and Automobiles	*-0.001787 (0.0471)*	*0.000152 (0.0000)*	*0.422146 (0.0000)*	*0.176678 (0.0717)*	*0.598824*
Personal & Household Products	*-0.001066 (0.0973)*	*4.93E-05 (0.0000)*	*0.307890 (0.0000)*	*0.455171 (0.0000)*	*0.763061*
Real Estate	-0.002323 (0.0908)	0.000320 (0.0040)	0.320192 (0.0000)	0.245687 (0.1521)	0.565879
Telecom	*-0.000973 (0.3505)*	*9.91E-05 (0.0004)*	*0.297532 (0.0008)*	*0.480922 (0.0001)*	*0.778454*
Travel & Leisure	-0.002105 (0.1320)	0.000499 (0.0000)	0.360365 (0.0000)	0.022648 (0.8698)	0.383013

P- values are given in parenthesis
Italics indicate failure to improve likelihood
* Signifies no ARCH effect indicated by the heteroskedasticity test

Table 6 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 Basic Resources, Construction and Materials, Financial Services excluding Banks, Industrial Goods and Services and Automobiles, Real Estate, and Telecom γ was significant at the 1% level indicating the presence of the leverage effect. For the Chemicals and Travel and Leisure indices, γ was negative and significant at the 5% and the 10% levels respectively. The presence of the leverage effect is therefore evident for 8 out of the 12 sectors where γ was negative and significant demonstrating that negative shocks have a bigger impact on volatility than positive shocks. For the pre-revolution period β was above 0.9 in value and significant at the 1% level for all 10 sector indices that were correctly specified. This is an indication of the high persistence of the volatility during the pre-revolution period where the effect of shocks have a slow decay. For this period, the value of ($\alpha + \beta$) for all indices for the EGARCH(1,1) model were greater than 1. Similar findings were reported by Malmsten (2004) who reported that a time-series generated by a stationary fisrt-order EGARCH model has a high probability of estimating the sum of ($\alpha + \beta$) greater than unity. This implies that the model is unstable and is not preferred in modeling the data set.

For the period during the revolution in Panel B, γ was negative and significant at the 1% level for the Construction and Materials, Food and Beverage, Industrial Goods and Services and Automobiles, and Personal and Household Products indices. At the 5% level γ was negative and significant for the Banks, Chemicals, and Financial Services excluding Banks indices. For sector indices demonstrating negative and statistically significant γ during both periods, γ was considerably more negative during the period of the revolution indicating a more evident leverage effect. A similar result was reported by Ezzat (2012) where the leverage effect was more apparent during the revolution period demonstrated by more negative values of γ for the EGX 30, EGX 70, and the EGX 100 indices.

For the period during the revolution in Panel B, β was significant at the 1% level for all sector indices except the Healthcare and Pharmaceuticals and the Travel and Leisure indices where failure to improve likelihood was encountered. For the indices that were correctly specified by the EGARCH model during the revolution period, the value of β ranged from 0.612371 for the Real Estate index to 0.847629 for the Personal and Household Products index. For sector indices demonstrating statistically significant β during both periods, β was considerably lower during the period of the revolution indicating a lower persistence of volatility where shocks are less persistent, decaying faster during the revolution period. Bollerslev, Chou and Kroner (1992) mentioned that markedly lower persistence is reported during volatile periods, specifically for the period after the October 1987 crash in the US market. This effect could be a result of the higher frequency of shocks during the more turbulent period of the revolution causing the volatility persistence to be lower. In the more tranquil pre-revolution period, shocks were less frequent allowing volatility persistence to be higher. For the EGARCH(1,1), the value of ($\alpha + \beta$) for 11 of the indices during the revolution period was greater than 1. This implies that the model is unstable and is not preferred in modeling the data set.

Table 6: EGARCH Results

PANEL A: EGARCH (1,1) Pre-Revolution Period						
	Mean Equation	**Variance Equation**				
Index	**C**	**ω (Constant)**	**α (Arch Effect)**	**β (Garch Effect)**	**γ (Leverage Effect)**	**α + β (Persistence)**
Banks *	0.000531 (0.2687)	-0.420464 (0.0000)	0.231760 (0.0000)	0.968835 (0.0000)	-0.058782 (0.0003)	1.200595
Basic Resources	0.000328 (0.5297)	-0.304490 (0.0000)	0.220254 (0.0000)	0.982443 (0.0000)	-0.041788 (0.0003)	1.202697
Chemicals	0.000707 (0.1859)	-0.712826 (0.0000)	0.250443 (0.0000)	0.934269 (0.0000)	-0.034108 (0.0110)	1.184712
Construction & Materials	0.001184 (0.0152)	-0.252020 (0.0000)	0.186247 (0.0000)	0.986114 (0.0000)	-0.045639 (0.0011)	1.172361
Financial Services excluding Banks	0.000363 (0.4714)	-0.455496 (0.000)	0.241651 (0.0000)	0.966194 (0.0000)	-0.075857 (0.0000)	1.207845
Food & Beverage	0.000773 (0.1821)	-0.349463 (0.0000)	0.277569 (0.0000)	0.981913 (0.0000)	-0.002503 (0.8477)	1.259482
Healthcare & Pharmaceuticals	0.000595 (0.2239)	-0.371421 (0.0000)	0.230798 (0.0000)	0.972776 (0.0000)	-0.008094 (0.5681)	1.203574
Industrial Goods & Services and Automobiles	0.000615 (0.2890)	-0.278279 (0.0000)	0.201713 (0.0000)	0.983676 (0.0000)	-0.061914 (0.0000)	1.185389
Personal & Household Products *	*5.78E-08* *(0.9999)*	*-0.139430* *(0.0000)*	*0.132212* *(0.0000)*	*0.994672* *(0.0000)*	*-0.039073* *(0.0000)*	1.126884
Real Estate	0.001373 (0.0167)	-0.364668 (0.0000)	0.238908 (0.0000)	0.976555 (0.0000)	-0.055159 (0.0002)	1.215463
Telecom	-0.000529 (0.3799)	-0.328132 (0.0000)	0.165097 (0.0000)	0.974482 (0.0000)	-0.092435 (0.0000)	1.139579
Travel & Leisure	0.000320 (0.6195)	-0.247496 (0.0000)	0.172277 (0.0000)	0.984949 (0.0000)	-0.023874 (0.0744)	1.157226

Table 6: continued

PANEL B: EGARCH (1,1) During the Revolution						
	Mean Equation	**Variance Equation**				
Index	**C**	**ω (Constant)**	**α (Arch Effect)**	**β (Garch Effect)**	**γ (Leverage Effect)**	**α + β (Persistence)**
Banks	-0.001278 (0.2180)	-2.683517 (0.0000)	0.493608 (0.0000)	0.705222 (0.0000)	-0.158210 (0.0102)	1.198830
Basic Resources	-0.002846 (0.0792)	-3.049956 (0.0002)	0.535128 (0.0000)	0.628784 (0.0000)	-0.056809 (0.3377)	1.163912
Chemicals	-0.001037 (0.2062)	-1.806710 (0.0009)	0.306520 (0.0007)	0.809635 (0.0000)	-0.115388 (0.0162)	1.116155
Construction & Materials	-0.001735 (0.0902)	-1.783813 (0.0002)	0.324880 (0.0000)	0.807311 (0.0000)	-0.160185 (0.0002)	1.132191
Financial Services excluding Banks	-0.001929 (0.0990)	-2.367048 (0.0001)	0.409475 (0.0000)	0.732842 (0.0000)	-0.128052 (0.0147)	1.142317
Food & Beverage	-0.001841 (0.0259)	-2.250688 (0.0000)	0.478741 (0.0000)	0.764892 (0.0000)	-0.187627 (0.0001)	1.243633
Healthcare & Pharmaceuticals *	*-0.000657 (0.4973)*	*-2.122521 (0.0000)*	*0.352509 (0.0000)*	*0.769107 (0.0000)*	*-0.068648 (0.1097)*	1.121616
Industrial Goods & Services and Automobiles	-0.001739 (0.0365)	-2.577246 (0.0000)	0.503730 (0.0000)	0.729139 (0.0000)	-0.150171 (0.0000)	1.232869
Personal & Household Products	-0.001273 (0.0362)	-1.587273 (0.0000)	0.357755 (0.0000)	0.847629 (0.0000)	-0.162783 (0.0000)	1.205384
Real Estate	-0.002967 (0.0307)	-3.271760 (0.0021)	0.555776 (0.0000)	0.612371 (0.0000)	-0.061633 (0.2701)	1.168147
Telecom	-0.000825 (0.4533)	-2.349195 (0.0000)	0.538334 (0.0000)	0.753898 (0.0000)	-0.058360 (0.3412)	1.292232
Travel & Leisure	*-0.003140 (0.0263)*	*-5.056797 (0.0014)*	*0.572104 (0.0000)*	*0.362406 (0.0937)*	*-0.109194 (0.0834)*	0.934510

P- values are given in parenthesis
Italics indicate failure to improve likelihood
* Signifies no ARCH effect indicated by the heteroskedasticity test

Table 7 displays the results of the TGARCH (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 in Panel A, γ was positive and significant at the 1% level for the Financial Services excluding Banks, Industrial Goods and Services and Automobiles, Real Estate, and Telecom indices indicating the presence of the leverage effect. For the Basic Resources and the Construction and Materials indices γ was positive and significant at the 5% and the 10% levels respectively. The presence of the leverage effect is therefore evident using the TGARCH (1,1) model for 6 out of the 12 sectors where γ was positive and significant indicating that negative shocks have a bigger impact on volatility than positive shocks. For the pre-revolution period the value of (α + β) was slightly lower than unity for 11 of the sector indices and significant at the 1% level for all sector indices. This is an indication of the high persistence of the volatility during the pre-revolution period for the 11 sector indices where the effect of shocks have a slow decay and long memory is evident. The value of (α + β) for the Food and Beverage index for the pre-revolution period was 1.009446 indicating that the time-series is not mean reverting and shocks have a more permanent effect on volatility. It is therefore reported that for the pre-revolution period when using TGARCH(1,1) the high persistence of volatility demonstrated a homogenous presence among the different sectors while the presence of the leverage effect was less homogenous.

For the period during the revolution in Table 7 Panel B, γ was positive and significant at the 1% level for the Banks, Chemicals, Construction and Materials, Food and Beverage, and Personal and Household Products indices. At the 5% level γ was positive and significant for the Travel and Leisure index. At the 10% level γ was positive and significant for the Financial Services excluding Banks index. For those mentioned sectors, the presence of the leverage effect was accepted. For sector indices demonstrating positive and statistically significant γ during both periods, γ was considerably greater during the period of the revolution indicating a more evident leverage effect. This was apparent for the Construction and Materials and the Financial Services excluding Banks indices.

For the period during the revolution in Table 7 Panel B, the value of (α + β) was considerably lower than unity for all sector indices. This is an indication of a much lower persistence of the volatility with much faster decay during the revolution period. This effect, as was also apparent when using the EGARCH (1,1) model could be a result of the higher frequency of shocks during the more turbulent period of the revolution causing the volatility persistence to be lower. In the more tranquil pre-revolution period, shocks were less frequent causing volatility persistence to be higher.

Table 7: TGARCH Results

PANEL A: TGARCH (1,1) for Pre-Revolution Period						
	Mean Equation	**Variance Equation**				
Index	**C**	**ω (Constant)**	**α (Arch Effect)**	**β (Garch Effect)**	**γ (Leverage Effect)**	**α + β (Persistence)**
Banks *	0.000872 (0.0783)	1.30E-05 (0.0000)	0.080149 (0.0002)	0.827872 (0.0000)	0.139024 (0.0000)	0.908021
Basic Resources	0.000413 (0.4552)	6.61E-06 (0.0004)	0.089340 (0.0000)	0.884151 (0.0000)	0.036347 (0.0394)	0.973491
Chemicals	0.000484 (0.3962)	2.27E-05 (0.0000)	0.113094 (0.0000)	0.812690 (0.0000)	0.035843 (0.1279)	0.925784
Construction & Materials	0.001090 (0.0454)	4.46E-06 (0.0033)	0.083719 (0.0001)	0.893857 (0.0000)	0.041744 (0.0766)	0.977576
Financial Services excluding Banks	0.000417 (0.4635)	1.32E-05 (0.0000)	0.095174 (0.0000)	0.829107 (0.0000)	0.098030 (0.0003)	0.924281
Food & Beverage	0.000765 (0.1897)	5.65E-06 (0.0210)	0.151395 (0.0000)	0.858051 (0.0000)	-0.004946 (0.8005)	1.009446
Healthcare & Pharmaceuticals	0.000579 (0.2797)	8.76E-06 (0.0000)	0.116691 (0.0000)	0.875478 (0.0000)	0.007759 (0.7320)	0.992169
Industrial Goods & Services and Automobiles	0.000777 (0.1817)	5.38E-06 (0.0001)	0.094459 (0.0000)	0.880282 (0.0000)	0.050004 (0.0073)	0.974741
Personal & Household Products *	4.06E-05 (0.9272)	1.64E-06 (0.0052)	0.063673 (0.0000)	0.921309 (0.0000)	0.037070 (0.0013)	0.984982
Real Estate	0.001192 (0.0569)	1.08E-05 (0.0002)	0.099695 (0.0000)	0.851096 (0.0000)	0.077805 (0.0023)	0.950791
Telecom	-0.00059 (0.3171)	8.31E-06 (0.0026)	0.026043 (0.0168)	0.898602 (0.0000)	0.118978 (0.0000)	0.924645
Travel & Leisure	0.000364 (0.5737)	6.77E-06 (0.0049)	0.075727 (0.0000)	0.904441 (0.0000)	0.020611 (0.2928)	0.980168

Table 7: continued

PANEL B: TGARCH (1,1) During the Revolution						
	Mean Equation	**Variance Equation**				
Index	**C**	**ω (Constant)**	**α (Arch Effect)**	**β (Garch Effect)**	**γ (Leverage Effect)**	**α + β (Persistence)**
Banks	-0.001211 (0.2869)	0.000130 (0.0000)	0.071533 (0.3344)	0.469854 (0.0000)	0.339102 (0.0070)	0.541387
Basic Resources	-0.002868 (0.0872)	0.000290 (0.0043)	0.230821 (0.0115)	0.407024 (0.0011)	0.107505 (0.3675)	0.637845
Chemicals	-0.000633 (0.4595)	5.88E-05 (0.0065)	-0.05233 (0.0499)	0.692057 (0.0000)	0.270294 (0.0021)	0.639727
Construction & Materials	-0.000749 (0.4556)	7.80E-05 (0.0006)	-0.02219 (0.5093)	0.646870 (0.0000)	0.294260 (0.0006)	0.62468
Financial Services excluding Banks	-0.001920 (0.1322)	0.000201 (0.0000)	0.142220 (0.0259)	0.355974 (0.0005)	0.180597 (0.0931)	0.498194
Food & Beverage	-0.001487 (0.0926)	7.70E-05 (0.0000)	0.092345 (0.0795)	0.503495 (0.0000)	0.427082 (0.0018)	0.59584
Healthcare & Pharmaceuticals *	-0.000764 (0.4626)	5.86E-05 (0.0003)	0.116776 (0.0331)	0.688005 (0.0000)	-0.007020 (0.9102)	0.804781
Industrial Goods & Services and Automobiles	-0.001988 (0.0326)	0.000134 (0.0000)	0.280684 (0.0004)	0.262562 (0.0025)	0.188870 (0.1481)	0.543246
Personal & Household Products	-0.001108 (0.0973)	3.63E-05 (0.0003)	0.049429 (0.2656)	0.604954 (0.0000)	0.307415 (0.0002)	0.654383
Real Estate	-0.002405 (0.0938)	0.000314 (0.0050)	0.254223 (0.0102)	0.264564 (0.1345)	0.103882 (0.4103)	0.518787
Telecom	-0.001173 (0.2743)	9.15E-05 (0.0001)	0.219256 (0.0098)	0.506071 (0.0000)	0.152860 (0.2467)	0.725327
Travel & Leisure	-0.002291 (0.1222)	0.000325 (0.0023)	0.148732 (0.0429)	0.315505 (0.0539)	0.260234 (0.0214)	0.464237

P- values are given in parenthesis
Italics indicate failure to improve likelihood
* Signifies no ARCH effect indicated by the heteroskedasticity test

Table 8 displays statistics for the parameters α, β, and γ for EGARCH(1,1) and TGARCH(1,1). The average value and the standard deviation for each parameter for each model for both periods are presented. Only parameters with statistically significant values were used in calculating the average and the standard deviation. For the EGARCH model, the average value of α almost doubled during the revolution period. The average value of β decreased from 0.97384 to 0.73917 indicating decreased persistence of the volatility between the two periods. The average value of γ decreased almost three times between the two periods indicating a much greater impact of the leverage effect during the revolution period. The standard deviation of α almost tripled during the revolution period. The standard deviation of β increased almost 5 times during the revolution period. The standard deviation of γ was almost unchanged. The changes in the standard deviations strongly indicate that the impact of the exogenous shocks during the revolution had a heterogeneous effect on the persistence of volatility of the sectors with great variation among the indices. However, for the leverage effect, the exogenous shocks of the revolution had a homogenous effect on the sectors since the standard deviation of γ was almost unchanged between the two periods.

For the TGARCH model, the average value of α between the two periods increased from 0.09079 to 0.15919. The average value of β decreased almost by half indicating decreased persistence of the volatility between the two periods. The average value of γ increased almost four times between the two periods indicating a much greater impact of the leverage effect during the revolution period. The standard deviation of α more than tripled in value during the revolution period and the standard deviation of β increased more than 4 times. The standard deviation of γ increased from 0.04006 to 0.07575. The changes in the standard deviations of the TGARCH parameters strongly indicate that the effect of the exogenous shocks during the revolution had a heterogeneous effect on the persistence of volatility of the indices as well as the leverage effect with great variation among the indices. Therefore, for the leverage effect, the TGARCH model indicated a heterogeneous impact for the exogenous shocks of the revolution on the sector indices while the EGARCH model indicated a homogenous impact on the indices.

Table 8: Statistics for EGARCH and TGARCH Parameters for both Periods

EGARCH Pre-Revolution	**α**	**β**	**γ**
Average	0.21970	0.97384	-0.04921
Standard Deviation	0.03477	0.01473	0.02579
EGARCH During Revolution			
Average	0.45039	0.73917	-0.15177
Standard Deviation	0.09324	0.07584	0.02383
TGARCH Pre-Revolution			
Average	0.09079	0.86974	0.07488
Standard Deviation	0.03056	0.03408	0.04006
TGARCH During Revolution			
Average	0.15919	0.49567	0.29700
Standard Deviation	0.10243	0.15012	0.07575

6. Summary and Conclusion

This research examined the time-varying volatility of 12 industrial sectors in the EGX using GARCH, EGARCH, and TGRACH models. The data was divided into two periods. The first period was the pre-revolution period characterized by relative tranquility. The second period was the period during the revolution and was characterized by turbulent volatility. The temporal volatility dynamics during the two periods were compared for each of the 12 sector indices. The idiosyncratic behavior of each sector to the exogenous shocks associated with the political, social, and economic instability during the revolution period were investigated. The GARCH(1,1) correctly specified 7 out of the 12 sector indices during the pre-revolution period and 4 out of the 12 sector indices during the revolution period. For the sector indices, the volatility persistence was clearly lower during the revolution period with shocks having a faster decay than the pre-revolution period.

The EGARCH(1,1) specification was successful in modeling 10 out of the 12 sector indices for the pre-revolution period and 10 of the 12 sector indices for the period during the revolution. For the pre-revolution period, the leverage effect was apparent in 8 sector indices with γ having a negative and statistically significant value. For the period during the revolution, the leverage effect was apparent in 7 sector indices with γ having a negative and statistically significant value. For the 10 indices during the pre-revolution period that were successfully modeled, all showed high β values indicating high persistence of the volatility shocks. For the period during the revolution, β values were considerably lower indicating a faster decay and mean reversion.

The TGARCH(1,1) specification was successful in modeling all 10 sector indices for the pre-revolution period and all 11sector indices for the period during the revolution. For the pre-revolution period, the leverage effect was apparent in 6 sector indices with γ having a positive and statistically significant value. For the period during the revolution, the leverage effect was apparent in 7 sector indices with γ having a positive and statistically significant values. For indices during the pre-revolution period, all showed high $(\alpha + \beta)$ values indicating high persistence of the volatility shocks. For the period during the revolution, $(\alpha + \beta)$ values were considerably lower indicating a faster decay and reversion to the mean.

Examination of the mean and standard deviation for the EGARCH and TGARCH parameters α, β, and γ for both periods indicated that sector indices responded differently to the exogenous shocks of the revolution. For the EGARCH model, the average value of β during the revolution was lower but the standard deviation was almost 5 times higher indicating a heterogeneous response among the indices to the persistence of the volatility shocks. The average value of γ was much lower during the revolution period indicating a much stronger leverage effect but the standard deviation was almost unchanged between the two periods indicating that the leverage effect was homogeneous during the revolution period. For the TGARCH model, again the average value of β during the revolution was lower and the standard deviation was almost 4 times higher indicating a heterogeneous response among the indices to the persistence of the volatility shocks. The average value of γ increased alsmost 4 times during the revolution period indicating a much stronger leverage effect and the standard deviation also increased between the two periods indicating that the leverage effect was heterogeneous during the revolution period.

The findings of this research are in line with findings of the study by Bakri and Ham (2009) showing that significant differences exist between the volatility structures across different sectors in the Egyptian equity market. The findings are also in agreement with the study by Ismail (2011) who reported a difference between firm-level and aggregate level volatility of returns among stocks in the EGX 30 index. The findings of decreased persistence of volatility during the revolution period indicated by a lower β is in contrast with Veredas and Lucianni (2012) who suggest that the degree of long memory concentrates during periods of turmoil. However, Bollerslev, Chou and Kroner (1992) mention that markedly lower persistence is reported after the October 1987 crash in the US market which is in line with the results in this research. Finally, the most striking finding of this research is the strong evidence of a heterogeneous response by different sectors to volatility shocks which may help investors in the diversification of their portfolios by allocating assets according to the volatility characteristics of each sector.

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