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Investigation of the Greek Stock Exchange volatility and the impact of foreign markets from 2007 to 2012

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Abstract

Purpose of this paper - *The current paper aims to analyze the impact of the debt crisis on the FTSE / ASE 20 index volatility. The research also examines the impact of powerful foreign capital markets on the Greek Stock Exchange market, the seasonality returns (Day-of-the-Week effect) and the volatility structure.*

Design/methodology/approach - *The analysis of data is made by employing the GARCH models, and more specifically the GJR-GARCH model.*

Findings - *The results of the GJR-GARCH model demonstrate that the debt crisis and, therefore, its consequences increase the FTSE / ASE 20 index volatility and the Greek market does not react asymmetrically to negative information. In addition, the results indicate the importance of foreign markets in shaping the first moment of the FTSE / ASE 20 index and the presence of the Reverse Day of the Week effect.*

Research limitations/implications - *The implication of volatility measurement is vital in determining the cost for investment, security pricing markets, hedging and other trading strategies, and also for regulatory policies conducted within financial markets.*

Originality/value - *The paper may prove helpful to regulatory authorities, investors and financial analysts to understand the structure and behavior of volatility in a small stock exchange market under crisis.*

Keywords: *Greek market, volatility, GARCH models, Day-of-the-Week effect*

JEL Classification: *G10, G14, G15, C22*

1. Introduction

Stock Exchange volatility and the Day-of-the-Week patterns have been researched extensively in the framework of the financial literature, and great attention has been given to their association with stock returns. Although there is a large number of studies focusing on volatility in developed and mature markets, such as the U.S., British and Japanese markets, small but emerging markets, such as the Greek market, have been less frequently researched in terms of their Stock Exchange volatility, which appears to be crucial in the period of the sovereign debt crisis in Greece.

In this context, the present research aims at investigating the impact of major stock market indices on the FTSE / ASE 20 index, which will enable a better understanding and more accurate interpretation of its performance and volatility. In detail, the research examines:

- the effect of large foreign capital markets on the performance of the Greek Stock Exchange market
- seasonality returns (Day-of-the-Week effect)
- volatility structure
- the impact of the debt crisis on the Greek Stock Exchange volatility

It is worth noting that the Greek debt crisis was announced on April 23, 2010, by the former Prime Minister, George Papandreou, who made a declaration about the Greek appeal to the International Monetary Fund.

2. Literature Review

The present research discusses the results of previous work concerning the Athens Stock Exchange seasonality, and, in particular, the Day-of-the-Week effect as well as the Greek sovereign debt crisis. More specific the Day-of-the-Week effect, which in addition to research on the existence or not in many stock markets, tested for the strength and its correlation with other anomalies. Thus, it turned out that this phenomenon was strongest for companies with low capitalization Lakonishok and Smidt (1988).

Mills et al. (2000) evaluated the daily data of sixty stock returns and the market index for the period between 1986 and 1997. They claimed that the Greek Stock Exchange market cannot be considered efficient and provided evidence of the Day-of-the-Week effect (DOW effect) in the Greek market. In detail, Friday returns were tested positive, despite the analysis of individual stocks which showed that less than 50% of the Athens Exchange stocks tend to exhibit significant returns on Friday, whereas on the other weekdays they were lower than 20%. In addition, they suggested that market concentration is crucial to determine the DOW effect impact on the Athens Stock Exchange and they concluded that the intensity of seasonality effects is probably contingent on specific stock features, such as market capitalization, which is related to the case of heterogeneous investors focused on different stock types.

In the same framework, Alexakis and Xanthakis (1995) investigated the Athens Stock Exchange in the period between 1985 and 1994, namely, after the Greek accession to the European Union and before the Euro zone and demonstrated that the Athens Stock Exchange composite index generates the DOW effect. In detail, they provided evidence of Monday positive returns and Tuesday negative returns for the period earlier than 1990, which corroborates Coutts' et al. (2000) findings for the period from 1986 to 1996, who demonstrated that the DOW effect is largely associated with Market concentration and also that Friday returns were higher.

Later during that time, Kenourgios and Samitas (2008) compared the periods before and after the Euro zone and identified a "weakened" anomaly for the subsequent period, thus, indicating the significant progress of the Athens Stock Exchange since 1995. They argue that in the period between 1995 and 1999, there was a "massive entrance of individual and institutional investors in the capital market", which led to the growth of the Athens Stock Exchange as regards the number of transactions and market capitalization. A similar tendency is observed for the period between 2003 and 2005. Thus, the "weakened" anomalies in concurrence with the Athens Stock Exchange growth imply that the Greek market is becoming more efficient because of its own growth.

Apergis and Eleptheriou (2001) investigates the volatility of the ASE stock returns over the period 1990-1999 through the comparison of various conditional hetero-skedasticity models with GARCH Models such as GARCH-M, EGARCH, GJR and GQARCH. The results for the day-of-the-week effects are similar to those reached by Alexakis and Xanthakis (1995) for the case of the ASE. Also the mean equation results show negative returns on Mondays and Tuesdays and positive returns for the remaining days.

In addition, Al-Khazali et al (2008) studied the General Index of the Athens Stock Exchange for the period 1/1985-12/2004 and concluded that the daily, weekly and monthly returns are positive and significantly different from zero. The highest daily returns were observed on Friday, whereas the lowest ones on Tuesday. Notably, the average daily returns are positive for every day of the week, and, apart from Tuesday, they are significantly different from zero. The results do not only contradict Alexakis and Xanthakis' (1995) survey, which demonstrated negative returns on Tuesday, but also the conclusions made by Coutts et al. (2000) and Mills et al. (2000), who indicated negative returns both on Tuesdays and Wednesdays.

Dicle and Levendis (2011), who studied the Athens Stock Exchange and market efficiency as determinants of development, examined the impact of 50 stock returns of foreign markets on the Athens Exchange in the period from 01/2000 to 12/2007. Based on an analysis of returns, the results demonstrated inefficiency and also the presence of the DOW effect resulting from the impact of other markets and from liquidity. Monday and Tuesday returns were negative whereas Friday returns were positive.

In relation to the market, the DOW effect in the Athens Stock Exchange was observed on Monday and Tuesday, whereas it was also noticed that on Monday and Thursday it affected 10% of the stocks. Thus, Monday negative returns can be explained by the "trading time" hypothesis. The DOW effect is higher in smaller firms, although it also affects larger ones; Monday is observed to be the day of the week to exhibit the lowest returns, and next comes Tuesday. In contrast, Friday is the day of the week with the highest returns. It is also worth noting that the DOW effect is not observed on Friday returns and in larger firms, which implies that on Friday the effect is explained by the "trading time" hypothesis.

Drimbetas et al. (2007), based on data during the period from 23/08/1997 to 05/04/2005, demonstrated that during the preliminary examination of the time series of returns of the FTSE / ASE 20 index, a daily seasonality was identified, which is consistent with previous research work on the ASE.

In contrast, Tsangarakis (2007) demonstrated the non-dominance of the DOW effect from 1981 to 2002 and emphasized that there is no systemicity in the Day-of-the-Week effect. More specifically, different results were derived concerning the daily seasonality in different sub-periods. Monday effect was observed only in 2001 whereas in 1986 and 1990 the "reverse" Monday effect was identified.

Among the studies focusing on the Reverse DOW effect, the research made by Brusa et al. (2000), who analyzed data from the U.S. Stock Exchange markets from 1/1990 to 12/1994, identified the "reverse" Monday effect, which implies positive returns on Monday compared with other weekdays. Later, Brusa et al. (2003) investigated the'' reverse'' weekend effect in the U.S. market by analyzing the returns of DJIA in the period 1963-1995. They suggest that in the last few years Monday returns tend to be positive and higher than the returns derived on other weekdays. They also discussed the reason for the specific "anomaly" and its relationship to the impact of industry.

To compare their results with previous research work in the field, they examined the presence of the 'conventional' and 'reverse' DOW effects on two major indices: Dow Jones Industrial Average (DJIA) and New York Stock Exchange (NYSE) composite index for the period 1966-1996. The results corroborate the fact that although there is a 'conventional' DOW effect during the period before1988, the effect is reversed in the period after 1988. The specific research, subsequently, provides evidence for the Reverse DOW effect in general indices, and, in addition, it examines whether the effect has affected industries or whether only a small number of industries has remained unaffected.

Four major industry indices were subsequently examined, which were readily available in the market (NYSE Industrial index, the NYSE Transportation index, the NYSE Utility index, and the NYSE Financial index). The results suggest that the DOW and the Reverse DOW effects are present not only in general indices, but in most industry indices in the period 1966-1996. The similarities on Monday returns between general and market sector indices may suggest that the sources of the DOW effect are financial incidents which affect all sectors of the economy rather than factors affecting only a few industries. It was also demonstrated that Monday performance standards are different between pre-and post-1988 periods.

In a later research, Brusa et al (2005) document the presence of the DOW Effect over an extended period of eleven years (1988-1998) and argue that Monday returns are very positive and higher than the returns on other weekdays. They also report that the 'conventional' DOW and Reverse DOW effects are associated with firm size. In addition, the 'conventional' DOW effect tends to be associated with small firms, whereas the Reverse DOW effect tends to be associated with large ones.

As regards market efficiency, Alexakis et al (2010) examined the predictability of stock returns (47 firms) on the Athens Stock Exchange (ASE) in the period 1993-2006. The results suggest that the portfolios selected on the basis of financial indices generate higher than mean returns, which implies that the emerging Greek market does not fully assimilate market information in stock prices and, thus, it is not efficient. The empirical results demonstrate that there are financial indices which include important information on anticipating a cross-section in the Athens Stock Exchange stock returns.

Similarly, Dicle & Levendis (2010) investigate the efficiency of the Athens Stock Exchange in relation to market tests and individual stock returns. Both at market and stock return level, the research provides evidence of inefficiency. In an earlier study Mollah and Mobarek (2009), noted that there is a long-term persistence shock in emerging markets compared to developed markets. That also indicates efficiency. Moreover, Dicle & Levendis (2010) based on the premise that approximately 94% of the Greek stock returns are Granger-caused by at least one foreign market, it is concluded that the Greek market does not provide evidence of international diversification. Considering the importance of liquidity for emerging markets, its impact on Greek stocks is assessed as part of the analysis of market efficiency. Hence, liquidity is found to be a statistically significant cause for the returns of less than 10% of the Greek market, which implies that despite being significant, liquidity it is not accountable for the returns of about 90% of Greek stocks.

Finally, and as regards the Greek sovereign debt crisis, Mink Haan (2013) examined the impact of the information about Greece and the Greek bailout plan on bank stock prices in 2010 using data from 48 European banks and identified twenty days exhibiting extreme returns for Greek government securities, which they ranked by relevance to current affairs in Greece and the information about the Greek bailout prospects. It was demonstrated that, with the exception of Greek banks, the relevant information did not generate irregular returns. Finally, it was suggested that the price of sovereign debt in Portugal, Ireland and Spain comply both with the information about Greece and the information about the Greek bailout.

3. Data

The corpus of data is comprised of the daily FTSE / ASE 20 index prices of the Athens Stock Exchange, Hang Seng, China (Hong Kong) and DAX30, Germany, and it applies to a period from 4 January 2007 to 20 December 2012. Totally, 1318 prices were obtained from each index.

FTSE / ASE 20 index has been chosen on the basis of being representative of the Greek Stock Exchange progress, as the market capitalization of its 20 listed companies exceeds 60% of the ASE total capitalization.

DAX30 index was employed with a view to studying and isolating the systematic factors related to the European Union, whereas the Hang Seng Index was similarly employed for the factors related to Asia.

4. Methodology

The analysis of data was based on the null hypothesis of the mean returns of the researched Stock Exchange markets.

Table 1: Testing null hypothesis for the FTSE/ASE20, DAX30, HANG SENG stock market indices

	Sample (adjusted):	Sample Mean	t-statistic	Probability
Hypothesis Testing for FTSE/ASE20	1317	-0.001245	-1.936365	0.0530
Hypothesis Testing for DAX30	1317	0.000106	0.224238	0.8226
Hypothesis Testing for HANG SENG	1317	0.000009	0.165060	0.8689

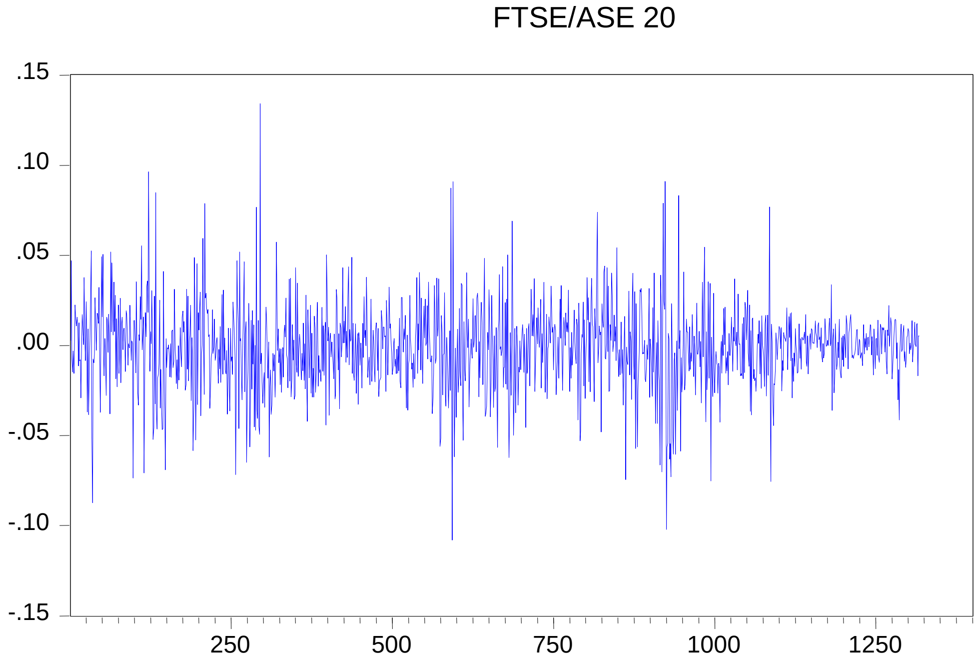
Table 1 shows that at a significance level of 5% and 1% the null hypothesis of the mean returns of the FTSE/ASE20 indices (p-value = 0.0530), DAX30 (p-value = and HANG SENG (p value) is not rejected.

In addition, more data about the type of distributions can be derived. Table 2 demonstrates that all series are leptokurtic. The highest value of kurtosis is exhibited in HANG SENG index (10.8), whereas the lowest in FTSE / ASE 20 index (5.8), much higher than the kurtosis of the normal distribution, which is equal to 3. The Jarque-Bera statistic values are high, indicating the rejection of the normal distribution for all series. In addition, a positive asymmetry (skewness) was observed in the series of FTSE/ASE20 and DAX30 indices and a negative symmetry in HANG SENG index.

Table 2: Descriptive measures of the distributions of stock returns of the FTSE/ASE20, DAX30 and HANG SENG indices

	FTSE/ASE20	DAX30	HANG SENG
Mean	-0.001	0.000	0.000
Median	-0.000	0.000	0.000
Maximum	0.134	0.103	0.142
Minimum	-0.108	-0.077	-0.146
Std. Dev.	0.023	0.017	0.020
Skewness	0.089	0.033	-0.069
Kurtosis	5.822	7.374	10.812
Jarque-Bera	438.830	1050.211	3350.432
Probability	0.000	0.000	0.000
Sum	-1.639	0.139	0.123
Sum Sq. Dev.	0.716	0.385	0.560
Observations	1317	1317	1317

Figure 1: Returns of FTSE / ASE 20 index
Data numbered from the most to least recent



In Fig. 1 return volatility is very high at points 900-1000, which is explained by the market shocks caused by the bank crisis (June-December 2008) (Mazumder and Ahmad 2010), and also at points 575-600 (June-April 2010), indicating the period during which Greece appealed to the International Monetary Fund.

Table 3: Testing for unit root for the FTSE/ASE20, DAX30, HANG SENG indices

		FTSE/ASE20		DAX30		HANG SENG	
		t-Statistic	**Prob.***	**t-Statistic**	**Prob.***	**t-Statistic**	**Prob.***
Augmented Dickey-Fuller test statistic		-20.193	0.000	-27.238	0.000	-36.909	0.000
Test critical values:	**1% level**	-3.965		-3.965		-3.965	
	5% level	-3.413		-3.413		-3.413	
	10% level	-3.128		-3.128		-3.128	

Table 3 shows the test results for the presence of unit root. Dickey-Fuller statistic demonstrated that the time series of stock returns of the FTSE/ASE20, DAX30 and

HANG SENG indices have been produced by stationary series, deriving from the t statistic values, which are much higher in absolute rates than the critical values at the conventional significance levels 1%, 5%, 10%.
Finally, Table 4 shows the autocorrelation tests of first and second moment controls for the FTSE/ASE20 index. As regards the first moment, p (probability) values are lower than the significance level of 5%, indicating autocorrelation.
With regard to squared returns (2nd moment), it is worth noting that these are value fluctuations as the mean has been proven to be zero ($\sigma^2 = \frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n}$). It is, thus, suggested that the squared returns (GARCH effect) are auto-correlated, as p-values are lower than 5%.

Table 4: Testing serial dependence for first and second moment

Returns				**Squared Returns**			
Lags	**Auto-correlation**	**Partial Correlation**	**LB(n)**	**Lags**	**Auto-correlation**	**Partial Correlation**	**LB(n)**
1	0.035	0.035	15.916	**1**	0.142	0.142	26.649
2	-0.091	-0.093	12.625	**2**	0.199	0.183	79.033
3	0.076	0.083	20.203	**3**	0.155	0.112	110.83
4	0.018	0.003	20.640	**4**	0.090	0.027	121.49
5	-0.055	-0.042	24.686	**5**	0.178	0.127	163.37
6	0.063	0.065	29.990	**6**	0.108	0.047	178.77
12	0.056	0.059	37.696	**12**	0.087	0.024	251.60
22	0.036	0.042	50.501	**22**	0.037	-0.006	326.11
36	0.026	0.040	64.921	**36**	0.006	0.008	336.10

LB (n) is the Ljung-Box statistic for the n-lag of R_t and R_t^2 respectively. LB (n) follows X^2 (chi-square) distribution with n degrees of freedom. The sample is comprised of 1317 daily returns.

Results of the GJR-GARCH Model

In the above analysis, the mean is zero and the squared returns are related to the previous days; thus, mean and variance are modelled on the basis of the GARCH model.

Notably, a major weakness in ARCH and GARCH models is the fact that they assume the volatility reactions to positive and negative variation (shocks) in a symmetrical manner. The specific weakness is encountered by employing asymmetric models, which assume the asymmetric aspects of returns.

Within this framework, volatility will be discussed in terms of:

- The application of GJR-GARCH model, which involves fewer parameters than other GARCH models; thus, it saves degrees of freedom in assessing the model.
- The introduction of a bivariate model of analysis, related to the periods before and after the debt crisis. Thereby, a further identification of and approach to volatility is possible in the framework of the relationship

between the FTSE / ASE 20 index and DAX30 and HANG SENG indices before and after receiving a statement of the debt crisis.

- The introduction of a bivariate to examine daily seasonal patterns.

The proposed mean equation of the time series of stock returns of FTSE / ASE 20 index is:

$FTSE_t = b_1 D_{FRt} + b_2 D_{Mt} + b_3 D_{TUt} + b_4 D_{Wt} + b_5 D_{THt} + b_6 DAX_t + b_7 Hang_t + b_8 FTSE_{t-1} + b_9 FTSE_{t-2} + b_{10} FTSE_{t-3} + u_t$

In detail:

- FTSEt is the dependent variable of the equation and displays the value of the returns index at time t.
- D_{Mt}, D_{TUt}, D_{wt}, D_{THt} and D_{FRt} are bivariate dummies to control daily seasonal patterns in the mean equation[1].
- DAX_t and $Hang_t$ are the variables reflecting the returns of German and Chinese markets respectively; in addition, they implicitly reflect the international systematic factors.
- Variables $FTSE_{t-1}$, $FTSE_{t-2}$ and $FTSE_{t-3}$, represent the previous to t-day FTSE/ASE20 index returns.
- The disruptive conditions u_t are assumed to follow the generalized normal distribution[2].
- bi are constant parameters.

Variance equation, according to the GJR-Garch model, is:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 + \alpha_2 u_{t-1}^2 + \alpha_3 S_{t-1}^- u_{t-1}^2 + \alpha_4 K$$

The estimate of the conditional variance σ_t^2 is based on the following:

- σ_{t-1}^2 is the variance of the previous to the GJR-Garch model period. It reflects how the shocks of the previous period (t-1) are lasting and affect the next period (t).
- u_{t-1}^2 is information on the volatility of the previous period.
- Variable $S_{t-1}^- u_{t-1}^2$ involves information on the model asymmetry.
- K is the bivariate representing the period before and after the crisis. At the time there is no impact of the Greek crisis, the variable value is 0, whereas after the crisis announcement, it is 1.
- α_i are constant parameters.

It is worth noting that the selection criteria of the set of lags in the model (Akaike and Schwartz criteria in Table 5), provides evidence that adding extra lags or removing some of them in the model does not increase model significance, according to the Akaike and Schwarz criteria values, which are required to be as low as possible.

Table 5: Akaike and Schwarz Criteria for the selection of lags for the dependent variable FTSE / ASE 20

Lags	Akaike	Schwartz
1	-5.317.662	-5.262.531
2	-5.324.724	-5.265.618
3	-5.328.236	-5.265.151
4	-5.326.891	-5.259.823

[1] factor $b_1 D_{FR}t$, estimated with the constant factor of the regression; otherwise, the bivariates will show perfect linear relationship ie DM + DTU + Dw + DTH + DFR = 1 (high multicollinearity).

[2] In terms of Taylor (1994), to maximize the function of maximum probability, it is assumed that the residuals follow the generalized error distribution (GED), a special type of which is normal distribution. The generalized error distribution function includes the variable which adjusts heavy tails; thus, it can capture leptokurtosis usually exhibited in the distributions of stock returns.

Table 6: Mean equation

$$FTSE_t = b_1D_{FRt} + b_2D_{Mt} + b_3D_{TUt} + b_4D_{Wt} + b_5D_{THt} + b_6DAX_t + b_7Hang_t + b_8FTSE_{t-1} + b_9FTSE_{t-2} + b_{10}FTSE_{t-3} + u_t$$

b_1	b_2	b_3	b_4	b_5
-0.002217***	0.002225**	0.001205	0.001910	0.002526**
(-2.613166)	(1.985955)	(0.995462)	(1.643064)	(2.095298)
b_6	**b_7**	**b_8**	**b_9**	**b_{10}**
0.598401***	0.190847***	0.004166	-0.042901**	0.059631***
(24.92721)	(10.94410)	(0.199901)	(-2.024278)	(2.751660)

*t-statistics is shown in brackets. *** It indicates the statistical significance at 1% ** It indicates the statistical significance at 5%. * It indicates the statistical significance at 10%.*

Table 6, which shows mean equation, demonstrates that on average, Friday returns (b_1 = -0.002217) are lower than Monday (b_2 = 0.002225) and Thursday returns (b_5 = 0.002526) (Reverse DOW Effect).

In addition, the specific table demonstrates a statistically significant autocorrelation in the second and third lags of the historic series of returns of the FTSE / ASE 20 index at the significance level (b_9 = -0.042901) 5% and (b_{10} = 0.059631) 1%, respectively.

It also indicates that the influence of the German and Chinese markets on Greece is substantial; however, the influence of the Chinese market is considered less significant. DAX30 index (24.92721) with b_6 = 0.598401 and HANG SENG index (10.94410) with b_7 = 0.190847, are statistically significant at a significance level of 5% and 1%, respectively.

Table 7: Variance equation

$$\sigma_t^2 = \alpha_0 + \alpha_1\sigma_{t-1}^2 + \alpha_2 u_{t-1}^2 + \alpha_3 S_{t-1}^- u_{t-1}^2 + \alpha_4 K$$

α_0	α_1	α_2	α_3	α_4
0.00000243**	0.888708***	0.10401***	-0.013387	0.0000106**
(2.216534)	(48.89835	(4.377327)	(-0.402476)	(2.428554)

*t-statistics is shown in brackets. *** It indicates the statistical significance at 1% ** It indicates the statistical significance at 5%. * It indicates the statistical significance at 10%.*

Table 7, which shows variance parameters, demonstrates that the coefficient reflecting α_3 asymmetry (-0.013387) is not statistically significant at a significance level of 10%, which implies that the impact of negative information does not seem to be stronger than the impact of positive information.

The variance dependence on past volatility α_1 (0.888708) is statistically significant at 1%, implying that past shocks have been present for a long time. In addition, the statistical significance of α_4 coefficient (0.0000106) at a significance level of 5% indicates that the debt crisis has increased volatility in the Greek Stock Exchange market.

The application of the GJR-GARCH model followed the assumption that the residuals exhibit a generalized distribution, as this may allow for heavy tails usually present in financial time series.

In Table 8, the diagnostic tests and quadratic residuals demonstrate that the GJR-GARCH model can satisfactorily describe the first and second moment of returns of the FTSE / ASE 20 index.

In addition in Table 9, the ARCH-LM TEST at a significance level of 5% confirms the deletion of ARCH effect at the residuals squared (lack of autocorrelation of square deviations).

Table 8: Autocorrelation function of residuals and squared residuals with respect to the regression

Residuals				**Squared Residuals**			
Lags	**Auto-correlation**	**Partial Correlation**	**LB(n)**	**Lags**	**Auto-correlation**	**Partial Correlation**	**LB(n)**
1	-0.046	-0.046	28.302	**1**	0.032	0.032	13.356
2	-0.049	-0.051	60.084	**2**	-0.017	-0.018	17.347
3	-0.027	-0.032	70.022	**3**	-0.046	-0.045	44.866
4	-0.013	-0.018	72.101	**4**	0.002	0.005	44.929
5	-0.048	-0.053	10.210	**5**	0.022	0.021	51.597
6	0.018	0.010	10.630	**6**	0.012	0.009	53.447
12	0.058	0.058	17.815	**12**	-0.016	-0.018	70.130
22	-0.003	-0.002	25.544	**22**	-0.012	-0.011	11.239
36	0.051	0.051	44.798	**36**	0.021	0.024	19.938

Table 9: ARCH LM Test

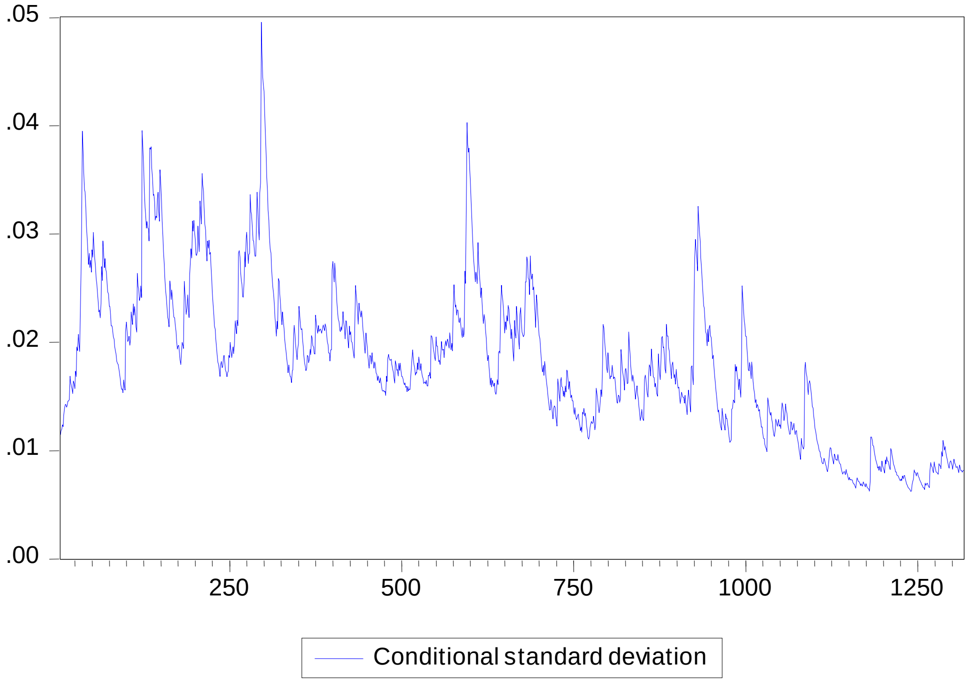
Lags	**T*R²**
1	1.331.560
2	1.774.668
3	4.375.578
4	4.411.565

TR^2statistic (Observations on R^2) follows X^2 distribution with n degrees of freedom, where n is the number of the regression parameters.

Finally, below are the Figures showing standard deviations and residuals.

Figure 2 demonstrates that the points exhibiting the greatest volatility involve periods of crucial incidents. Points 900-1000 (June-December 2008), 600 (April 2010) and 250 to 0 (November 2011-December 2012) exhibit high volatility due to the U.S. bank collapse, the declaration made by G. A. Papandreou about Greece's appeal to the International Monetary Fund, and the early outcomes of the appeal.

Figure 2: Conditional volatility of the GJR-GARCH model
Data are numbered from the most to the least recent.



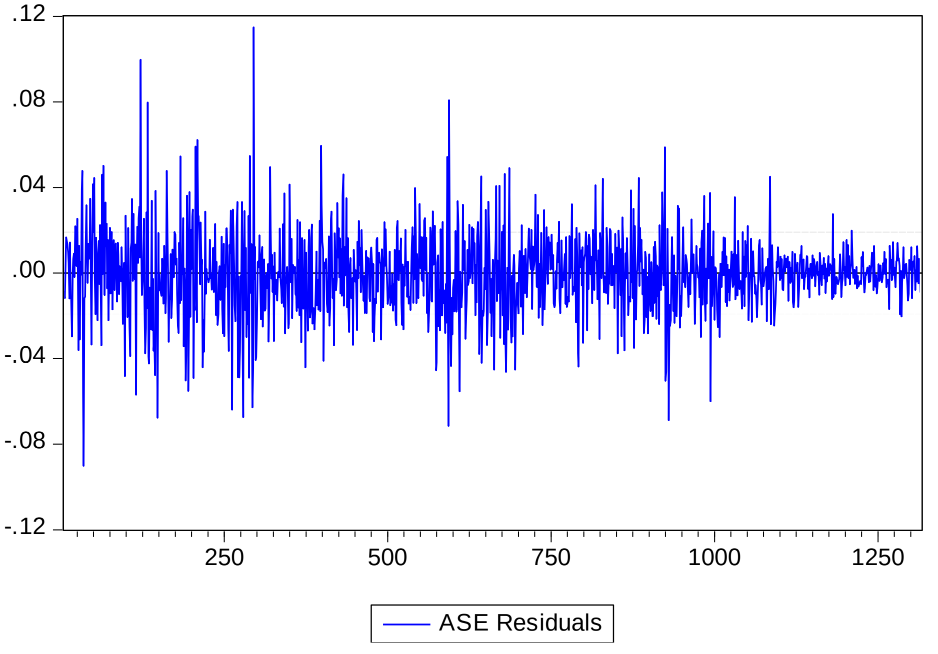
5. Conclusions

Volatility is one of the major concepts in modern Stock Exchange markets, as it plays a crucial role concerning their function, fund management, assessment of financial products and forecast accuracy. It has received considerable attention both from researchers and also practitioners; however, the vast majority of studies are focused on developed and mature markets, such as the U.S., British and Japanese markets. The present research, attempting to fill a part of this gap, focuses on volatility in the small but also developed Stock Exchange market in Greece.

Variance analysis of the FTSE / ASE 20 index of the Athens Stock Exchange was carried out on the basis of the GARCH model. In this context, the discussion was focused on daily seasonality, the role of foreign markets and the importance of the debt crisis in shaping volatility.

The results demonstrated the presence of the Reverse Day of the Week effect. In detail, it was demonstrated that Friday returns were lower than the corresponding Monday and Thursday returns, which contradicts other researchers' findings about the Greek market (higher returns on Friday, lower on Monday). It is likely that the accumulated uncertainty in the recent years (mortgage crisis in the U.S. and debt crisis in Greece), has forced investors to expect negative information on weekends, to sell on Friday and buy on Monday.

Figure 3: Residuals of the FTSE/ASE20 index
Data are numbered from the most to the least recent.



In addition, the importance of foreign markets in shaping the first moment of the FTSE / ASE 20 index was confirmed by the statistical significance of the German and Hong Kong markets. There are major international systematic factors in the German market returns which affect the Greek market, as the German market 'wakes up' before the Greek market and absorbs the most important information, such as the progress of the U.S. market as well as oil, currency and other financial product pricing of the previous evening close. In addition, owing to the political and socio-economic relationships between Greece and Germany, the German market appears to affect financial progress in Greece. Vortelinos (2010) also showed a strong correlation between the markets of Greece and Germany, while noting that the introduction of the euro highly upgraded its geopolitical role of Germany. Thus the determinant role of Germany is expected not only at European level but also internationally.

Similarly, the Hong Kong market is also considered significant as it reflects all developments in Asia, particularly China, which plays an important role in the world economy.

In addition, the application of the GJR-GARCH model demonstrated that the Greek market does not react asymmetrically to negative information. A thorough analysis of volatility demonstrated that, overall, market volatility in Greece depends more on older-than-one-day information, which indicates it is an inefficient market; this is confirmed by the impact of the autocorrelation of the FTSE / ASE 20 index on current returns and on the Day of the Week effect.

Finally, the present research examined the impact of the debt crisis on the Greek market volatility. The results of the GJR-GARCH model demonstrated that the debt crisis and its consequences increased the FTSE / ASE 20 index volatility.

ASE had a similar reaction when he was heavily influenced in 1987 by the crisis in international stock markets Siourounis (2002). The market did not manage to overcome the negative impact of the crisis in October 1987 until mid-1989, despite the positive developments in the EU countries.

It is most likely that the adverse incidents affecting key sectors in the Greek economy have also affected the returns of Greek firms, and significantly increased uncertainty; apparently, this had a catalytic impact on volatility. Overall, the progress of capital assets and the deterioration of the Greek capital market, the labour market and also of the returns of Greek firms have produced a rather less dependable financial environment involving greater risks and, thus, fluctuations.

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