THE EFFECTS
OF DERIVATIVES TRADING
ON STOCK MARKET VOLATILITY:
THE CASE OF THE
ATHENS STOCK EXCHANGE
(This is the final draft. We sent our first draft on 31/12/2007)

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1. Abstract
One of the most important issues that have occupied the financial managers and the academicians in Finance all over the world is the financial markets volatility and the need to forecast it accurately. The stock prices depend on the investment behavior which, in turn, is affected by the efficiency of volatility forecasting. The purpose of this paper is to examine the volatility in the Greek stock market after the introduction of futures contracts on the FTSE/ASE-20 index. Various volatility forecasting approaches are used such as GARCH and EGARCH models and the GJR model using the data for a sample period of 10 years. There are controversial results in existing literature. Some studies concluded that there was an increase on the underlying spot market volatility of the examined asset after the introduction of futures while other studies concluded that there was a decrease. Most of the previous studies break the sample period into two sub-periods, one period before the introduction of futures trading and one after that introduction. In this paper, we are going to use the same approach. In order to capture the volatility, we apply at the same time the EGARCH(1,1), GARCH(1,1) and the TGARCH(1,1) models for the pre-futures period and the post-futures period as well, with and without a dummy variable. The results of this study indicate that the introduction of futures leads to a significant change in the spot market volatility of the FTSE/ASE-20 index.

Keywords: Volatility; GARCH-family models; Information; Futures; Leverage Effect

JEL classification: G10; G14

1.1. Introduction
The need for market completeness has generated the need to create some financial instruments that will allow investors to hedge and thus, to be secured from price fluctua-
tions. The introduction of derivatives such as futures and options gave the financial managers the ability to create efficient portfolios in order to benefit from prices’ upwards or downwards movements. For that reason, the demand for options and futures has increased since 1970’s (Alexander, 2001) significantly. The first official Derivatives Markets was the Chicago Boards of Trade and the Chicago Mercantile Exchange (1973), while futures trading began in 1865 at the Chicago Board of Trade (Hull, 2006). However, it should be noted, the possibility that the October’s 1987 market crash, known as Black Monday, was exacerbated by the trading of futures and options contracts (Fabozzi and Modigliani, 1992).

The concept of volatility in the stock market is defined as a measure for the size and the frequency of fluctuations of the underlying asset’s price for a time period (Maris, Pantou, Nikolopoulos, Pagourtzi and Assimakopoulos, 2004). According to Alexander (2001), “implied volatility is the volatility forecast over the life of an option or future that equates an observed market price with the model price of an option while statistical volatility depends on the choice of statistical model, such as GARCH models, that is applied to historical asset returns data”. Thus, the uncertainty about future stock price movements is measured by the volatility. Therefore, the need to estimate and forecast volatility is one of the greatest issues for financial markets.

In recent years, the volatility of many financial assets has increased and this issue has attracted the interest of many financial managers and academicians. For example, derivatives markets use to attract more and more uninformed investors because of the higher degree of leverage. Thus, the lower the information received by the traders in the cash markets, the higher the volatility of the price fluctuations (Alexander, 2001). This is usually referred as the “destabilization hypothesis” and there are two variants of the “destabilization hypothesis”: 1) the populist variant, which suggests that the cash market in-
strument does not reflect any fundamental economic value, and 2) the liquidity variant which suggests that there is no effect on the underlying volatility in the long-term (Fabozzi and Modigliani, 1992).

Many studies have focused on the analysis of the US market volatility and a small number of studies refer to the UK market. The objective of this study is to examine and analyze the Greek Stock Market’s volatility after the introduction of futures contracts on the FTSE/ASE-20 and it focuses on the behavior of the volatility for years after the introduction of derivatives trading. Floros and Vougas (2006) also examined the impact of futures trading on FTSE/ASE-20 and FTSE/ASE-Mid40 indices for two years after the beginning of futures trading. This paper is divided into six sections, including introduction and conclusions. The next section presents the general condition and the main characteristics of the Greek Stock Market. The third section discusses previous studies and their empirical results. The fourth section describes data and the methodology used and makes a brief presentation of the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) family models applied. These models are able to link information and volatility and they avoid some methodological problems that appeared in other studies. The fifth section presents and analyzes the results and the last section contains a summary and concluding remarks.

2. The Greek Stock Market

The economy of Greece is characterized by a great wave of economic growth during the period 1996-1999, which followed by the great financial crisis of 1999. Since 1996, the basic financial policy of the Greek government was to achieve an economic development by keeping stable the inflation rate, the fiscal expenses and by giving motivations to
the international investors to invest their funds into the emerging Greek stock market\(^1\). On the second half of 1999 the great rise of the ASE was interrupted and the General Index followed a great downward movement. From 6400 points it dropped to 3000 points. This is widely known as the *Great Crash of 1999* for the Greek Stock Market. It is estimated that small investors lost almost 100 billion of Euros lost for small investors. After that shock, the ASE has known an increase which was related to the participation of Greece to the European Monetary Union, the adoption of the single currency\(^2\) of euro in 2001 and the Olympic Games of 2004. The General Index was almost stabilized at the level of 3500 points and nowadays it has reached 4800 points.

The Athens Stock Exchange (ASE) since the late 80’s plays a major role in the economic development of Greece. It is the official institution organized by the Greek government to trade shares and financial securities in Greece. The investors can trade on various financial instruments such as the basic indices by participating in the derivatives market of the Athens Derivative Exchange (ADEX). Some of the main indices of the ASE are the FTSE/ASE-20, the FTSE/ASE-Mid40, the ASE Composite Index of the Main Market, the ASE Composite Index of the Parallel Market, the ASE sector indices, the All-Share Index and the two (Main-Parallel) total return indices. The FTSE/ASE-Mid40 was established on December 1999 and it contains 40 stocks of companies of middle capitalization while the ASE Composite Index of the Parallel Market contains the 40 main stocks of the companies of the Parallel, or Secondary Market.

This study focuses on the most important index of the ASE, the FTSE/ASE-20 Index. The FTSE/ASE-20 index is the product of the cooperation of the ASE and FTSE International and was established on September 1997. It includes the 20 stocks with the highest capitalization traded in the ASSE/ASE-20 which is the first index that has been

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\(^1\) Bank of Greece (http://www.bankofgreece.gr/en/euro/Changeover.htm), 2002

used by the Athens Derivative Exchange (ADEX) as the underlying asset for futures’ contracts. The capitalization of the 20 companies of the FTSE/ASE-20 is equal to more than half of the total capitalization of the ASE companies.

Many specialists of the market suggest that the introduction of financial derivatives, constitute the most important innovation in the last 25 years for the financial markets, because of their characteristic to supply investors with a great instrument for the management of risk. To support this statement, on September 30th, 2002 Allan Greenspan, the former President of the U.S. Federal Reserve stressed the great importance of the derivatives markets by saying that the great flush of derivatives was the main factor that helped the US economy absorb many last year’s great shocks. However, there is another group of economists, disagreed with this view, suggesting that derivatives are the main factor that caused the crash of the US financial market in 1985 and the financial crisis of 1998.

The development of the Greek stock market is highly related to the progress of the most important financial markets and Stock Exchange Markets all over the world. Furthermore, there is a great degree of correlation between the Greek Stock Exchange and the financial variables on the international markets. For example, a possible increase of the US interest rates or a crisis in the South East Asian Stock Markets would possibly affect the prices on the Greek Stock Market (Dritsaki, 2005). However, during the last years, the Greek financial market is characterized by an increasing trend. Furthermore, since 2001 it has become a mature market and is highly internationalized. It is estimated that 54.11% of the total capitalization of the FTSE/ASE-20 and 50.35% of the total capitalization of the ASE belongs to foreign investors. Nowadays, the main goal of the Greek

Stock Exchange is to be the main “player” in the region of the South-East Europe. To achieve this, the ASE has built strong relationships and agreements with other stock exchanges of the South-East European region.

3. Literature Review

Most of the evidence for the measure of volatility related to the introduction of futures trading is coming from different studies for different countries and in various time periods. Plus, most studies examine the commodities rather than financial futures or options. During the last years, the empirical studies have focused on the financial futures trading. The results obtained don’t give any clear view because of the differences in the nature of the stock markets, the different time periods and the fact that the introduction of derivatives can stabilize or destabilize the spot markets, as well. The destabilization of the stock markets refers to the increase of its volatility, while the stabilization refers to the decrease, or at least no change, of the underlying volatility. One possible reason leading to these different results is the speed that the new information is arriving because of the derivatives’ trading and the speed that this information is transmitted (Perold and Gammill, 1989). The main characteristics of the derivative markets are their higher liquidity, lower transaction costs and lower margins. For those reasons, the investors are able to act faster and more efficiently compared to their action in the cash markets. That means that the cash market volatility depends on the proportion of informed to uninformed investors (noise traders) migrating from the cash markets to the derivatives markets (Vipul, 2006). Most of the studies in the pertinent literature have used GARCH-family models to examine the volatility change after the introduction of derivatives trading in a market. There are studies covering mainly the U.S. market as well as other developed markets in the USA, in Asia and in Europe.
It is evident from this extensive literature that the country, the time period and the economic conditions, as well as the various models used for the analysis play a significant role for the controversial results that exist regarding the effect of the introduction of derivatives’s trading on the spot market’s volatility.

Various studies have given different results with respect to the effect of futures on the spot market volatility. Several theoretical arguments have been used to explain the consequences of the futures’ introduction of futures in the spot market. A variety of models such as those in the GARCH family models try to explain whether the introduction of a futures’ market stabilizes or destabilizes the volatility of the spot market.

Cox (1976) found that the uninformed speculators participating in the derivatives markets increase the volatility of the spot market prices. According to Hellwig (1980), futures’ markets tend to destabilize the cash markets because of their higher degree of leverage. For that reason more and more investors without perfect information, actually sometimes uninformed, enter the futures markets and thus the volatility is increased. Finglewski (1981) concluded that the volatility of the underlying asset is increased after the introduction of futures markets. Finglewski (1981) examining the impact of futures trading in the Government National Mortgage Association (GNMA) by using the standard deviations of the returns. Stein (1987) also concluded that the derivatives are responsible for the destabilization of the underlying spot market. Aggarwal (1988) and Harris (1989) supported that the volatility of the period after the introduction of futures was higher. Maberly et al. (1989) found that the volatility of the S&P500 index was higher for the period after the introduction of futures. Lockwood and Lim (1990) found that the volatility in the spot market increased because of the introduction of futures trading. Brorsen (1991) reached the same result and he found that volatility was higher after the futures entered the stock markets.
Lee and Ohk (1992) examined the effect of the introduction of the futures trading on the volatility of the market in Japan, Hong Kong, the UK, the USA and Australia. Except for the markets of Australia and Hong Kong, they concluded that the volatility of the stock market increased after the introduction of futures trading. Kamara et al. (1992) supported the proposition that the beginning of futures market trading destabilizes the spot market by increasing the volatility by examining the S&P500 index in the US market. Chang et al. (1995) used the same methods and concluded that there is an increase in volatility only at the close of the futures market and especially in the last 15 minutes. Butterworth (1998), found also that derivatives can cause destabilization of the spot market and that volatility increased for the FTSE Mid 250 index in the UK market. Gulen and Mayhew (2000) reached the same results. Yu (2001), by using a switching GARCH(1,1)-MA(1) model, for the US, French, Japanese, Australian, the UK and Hong Kong markets, found slightly different results. For the markets of the USA, Japan, Australia and France, he found that the underlying spot market volatility increased, similarly with the previously mentioned studies. However, for the markets of Hong Kong and the UK, he found no significant relationship between change in volatility and futures. Chiang and Wang (2002), for the TAIEX futures in Taiwan supported all the previous propositions. In more recent studies, Pok and Poshakwale (2004) and Ryoo and Smith (2004), after examination of the Malaysian and the Korean markets respectively, found that the increased volatility of the underlying spot market was due to the introduction of futures market.

In contrast to the above studies that suggested that the futures markets are responsible for the increased volatility of the underlying spot markets, other studies reached the conclusion that the volatility in the post-introduction period, the period after the introduction of derivatives, is decreased relatively to the volatility of the pre-introduction period. Edwards (1988) after examining the introduction of S&P500 futures contracts, he found
that this is responsible for the reduced volatility in the post-introduction period. Freris (1990) examined the Hang Seng index of the Hong Kong market and found also that the stock market volatility was decreased after the introduction of futures. Brown-Hruska and Kuserk (1995) studied the volatility of the S&P500 index after the introduction of stock index futures markets and found that futures markets decrease the stock market volatility. The future markets may increase the market’s depth and liquidity and so, the volatility may decrease. Antoniou and Holmes (1995) support that the arrival of futures trading depends on the information of the market speculators. More precisely, if the speculators have perfect information, the futures’ introduction stabilizes the spot prices. Otherwise, there is a destabilizing effect. Antoniou et al. (1998) suggested that the futures trading have a significant negative effect on the volatility of the spot market in Germany and Switzerland. Chatrath et al. (1995) using the S&P100 US index and Pericli and Koutmos (1997), using the S&P500 index concluded the same. Galloway and Miller (1997) found similar results after the examination of the Mid-cap 400 index and Cohen (1999) for the US, the Japanese and the British market reinforced this outcome. In their research for the Spanish market, Pilar and Rafael (2002) used the GJR model with a dummy variable and they concluded that the derivatives markets decrease the volatility of the underlying market based on the Spanish Ibex35 index. Bologna and Cavallo (2002), studied the Italian market’s volatility and found that the stock market volatility was lower after the establishment of the futures contracts trading markets. Their research is based on the examination of the Italian MIB30 index and on the basic GARCH equation with and without a dummy variable. Finally, Floros and Vougas (2006), regarding the spot market volatility of the FTSE/ASE-20 and the FTSE/ASE-Mid40 indices of the Greek stock market for the period 1997-2001, found that it decreased by the introduction of derivatives trading.

There are many other studies suggesting that there is no significant effect of the in-
troduction of futures trading on the spot market volatility of the underlying index. Santoni (1987) for the S&P500, Davis and White (1987) as well as Edwards (1988a,b) reached the same conclusion. Hodgson and Nicholls (1991) for the Australian stock market, Baldauf and Santoni (1991) and Seguin (1992), said that there is no significant relationship between the futures trading and the volatility of the S&P500 index. Antoniou et al. (1998) found that the futures’ markets have no effect on the underlying volatility for the Japanese, Spanish, British and American markets.

Dennis and Slim (1999) used an exponential asymmetric ARCH model for the Australian market and found that the impact of the introduction of futures trading on the underlying spot market volatility was not significant. Kan (1999) studied a different market, namely that of Hong Kong, over the period 1982-1992 and he also reached similar conclusions in his research on the stocks’ volatility of the HIS index. Becchetti and Caggese (2000) suggested that the introduction of futures trading market increased the volatility in the German market, had no effect in the UK, Swiss, French and Austrian markets and decreased the volatility in the Dutch market. Rahman (2001) found no significant correlation between the conditional volatility of the Dow Jones Industrial Average stocks index and the futures’ trading on this index. Darrat et al. (2002) having embodied more macroeconomic variables and employing a different methodology, reached no different conclusions. Finally, Illeca and Lafuente (2003) found the same results for the Spanish market efficiency by applying a bivariate error correction GARCH model with a dummy variable.

The evidence from the different markets on the volatility change is still contradictory and controversial. In other words, the issue of the relationship between the introduction of futures’ markets and the spot market volatility is not clear yet. Some results suggest that spot market volatility is increased because of the futures trading. The futures
markets react more quickly to new information and thus, the volatility increases because of the more rapid rate at which information is incorporated into prices. This can be interpreted as an increase in the informational efficiency in the spot market (Antoniou and Foster, 1992). Other studies support that the volatility does not change as a result of futures’ trading. Most of these studies use econometric models and they try to compare the volatility of the spot market before and after the introduction of derivatives.

In the academic literature, many authors have used different countries with different economic variables and financial environment, for different time periods and applied a variety of models to reach their results. The analysis of the introduction of futures markets depends on the comparison of the relevant period to the pro-period and the post-period. Thus, most studies researched the impact of futures markets after examining of the unconditional variance of returns before and after the introduction of futures. To achieve this, most of the authors have used different GARCH-family models (Engle, 1982; Bollerslev, 1986) with or without a dummy variable. Most of the studies concluded that the GARCH models are very efficient in capturing the volatility of the spot market index.

4. Data and Methodology

In order to analyze the impact of futures trading on the underlying spot market volatility of the FTSE/ASE-20 index, we use several GARCH-family models and we divide the sample period into the pre-introduction and the post-introduction period. The pre-introduction period covers the period before the introduction of futures contracts on the Greek FTSE/ASE-20 index, that means from April 10th 1998 to August 20th 1999 and the post-introduction period which covers the period after the introduction of futures contracts, from 27 August 27th 1999 to June 15th 2007.

The data used is weekly closing prices of the FTSE/ASE-20 index. The FTSE/ASE-20 index is one of the most important and high traded indices in the Greek
Stock Exchange and includes the 20 stocks of the Greek Market with the highest capitalization. It is the first index that has been used as an underlying asset for the derivatives traded in the Athens Stock Exchange. The data was obtained in an official way from the Athens Stock Exchange. The results were obtained on the basis of the rate of return $R_t$ in period $t$, $R_t$, computed in the logarithmic first difference, which means:

$$R_t = \log(\text{FTSE/ASE}-20_t / \text{FTSE/ASE}-20_{t+1})$$

where FTSE/ASE-20$_t$ is the weekly spot price of the FTSE/ASE-20 index at the period $t$.

In this paper, we are going to use three different methods to capture the volatility of the FTSE/ASE-20 index. The first step is to model the conditional volatility by separating the sample period into two sub-periods: the period before and the period after the introduction of futures contracts on the underlying index. Then, we apply different GARCH-family models such as GARCH(1,1) according to Rahman (2001), EGARCH(1,1) and TGARCH(1,1) according to Gulen and Mayhew (2000) and we measure the volatility of the pre-introduction period and the post-introduction period. However, we also compare the ARCH and GARCH parameters as well. The last two models are used in order to capture the volatility asymmetry. The conditional mean of the sample is estimated using ARMA (p,q) models and using AIC and BIC criterions. The GARCH (p,q) model has the characteristic to capture better the volatility of returns to perform volatility clustering, incorporating heteroscedasticity into the estimation procedure [Tsay, (2005)]. Volatility clustering is the phenomenon when big shocks tend to be followed by big shocks in either direction and small shocks tend to be followed by small shocks [Verbeek, (2004)]. This phenomenon is very usual for weekly or daily data. A study from Floros and Vougas (2006) was the first study that examined the effect of derivatives trading in Greek stock market by using GARCH-family models and our examination will be based on the same GARCH models.
4.1 GARCH – Family Models

4.1.1 GARCH(1,1)

Developed by Bollerslev and Taylor (1986), GARCH models have the ability to allow the conditional variance to depend on its previous lags. In this way, we interpret the current fitted variance, $\sigma^2_t$, as a weighted function of an average value $\alpha_0$, information for the previous period’s volatility, $\alpha_1 \epsilon_{t-1}^2$, and the fitted variance of the model in the previous period, $\beta_1 \sigma^2_{t-1}$. According to Campbell et al. (1997), “in the standard GARCH model, forecasts of future variance are linear in current and past variances and squared returns drive revisions in the forecasts.” Furthermore, according to Verbeek (2004), “GARCH models are better and more fitted than ARCH models because GARCH models are more parsimonious while they contain only three parameters and it is likely to hold the non-negativity constraints.” A GARCH (1,1) model can be extended to a more generalized GARCH (p,q) model but generally, and according to Verbeek (2004), a GARCH(1,1) model captures sufficiently the volatility clustering of financial time series, performing hence, very well. According to Bollerslev and Taylor (1986), the standard GARCH (1,1) model is expressed as follows:

$$\sigma^2_t = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma^2_{t-1} + u,$$

(1)

where $\sigma^2_t$ is the conditional variance of the period $t$, $\epsilon_{t-1}^2$ is the squared error term of the previous period, $\alpha_1$ (ARCH parameter) and $\beta_1$ (GARCH parameter) are the regression coefficients and $u$ is the unexplained error term. If the conditional variance $\sigma^2_t$ is non-negative, it implies that the coefficients $\alpha_0$, $\alpha_1$ and $\beta_1$ are positive numbers. In addition, the coefficient $\alpha_1$ can be viewed as the “news” coefficient. So, an increase (decrease) in the ARCH parameter means that news is reflected in prices more rapidly (slowly) [Buttersworth, (1998)]. The $\alpha_1$ parameter refers to the effect of yesterday’s market price changes on price changes today and higher value implies that recent news has a greater impact on
price changes [Antoniou and Holmes, (1995)]. The $\beta_1$ coefficient is the ‘old news’ coefficient or the persistence coefficient. An increase (decrease) in $\beta_1$ means that old news has a greater (lower) persistence effect on price changes while when the sum of those two coefficients is close to unity that means that the volatility shocks are persistent [Antoniou and Holmes, (1995); Floros and Vougas, (2006)].

GARCH models reinforce the symmetric response of volatility to positive and negative shocks. However, it has been supported, and found empirically, negative shocks are likely to affect the volatility of financial time series more than a positive shock of the same magnitude. Why is this important? In cases of returns, a fall in the value of the stock of a firm causes the firm’s debt to equity ratio to rise and for that reason shareholders prefer to perceive their future cash-flow stream as being more uncertain [Alexander, (2001)].

Plus, in the GARCH-family models, the non-negativity constraints may sometimes be violated. Furthermore, the GARCH models, despite the fact they are able to explain the volatility clustering in the data, they cannot explain the leverage effects and finally, this model does not allow for any direct feedback between the conditional mean and the conditional variance [Alexander, (2001)].

Symmetric GARCH models have limited practical use. Therefore, it is necessary to include the possibility of asymmetries in order to capture the leverage effect. Thus, asymmetric GARCH models are used. A useful distinction between symmetric and asymmetric GARCH models is that in symmetric GARCH models the conditional variance and the conditional mean equations can be estimated separately [Alexander, (2001)]. In this way, some constraints for the parameters can be put so that they can be determined.
4.1.2. **EGARCH(1,1)**

Nelson (1991) proposed a useful extension of the GARCH model. It is the exponential GARCH or the EGARCH model and it is given by the equation:

\[
\log (\sigma^2_t) = \alpha_0 + \alpha_1 |\epsilon_{t-1}/\sigma_{t-1}| + \alpha_2 (\epsilon_{t-1}/\sigma_{t-1}) + \alpha_3 \log(\sigma^2_{t-1}) + u
\]  

(2)

Since we use the log of the variance, we verify that the conditional variance will be positive even if the parameters are negative. The \(\alpha_2\) coefficient can be viewed as the ‘leverage effect’ and refers to the presence of asymmetries. EGARCH model is mainly used in order to capture asymmetries like an unexpected drop in price which has a larger impact on volatility than an unexpected increase in price of similar magnitude and thus, we can test for the presence of asymmetries from the value of \(\alpha_2\). If \(\alpha_2\) is negative, then positive shocks generate less volatility than negative shocks (‘bad news’) [Verbeek, (2004)]. In many cases, the EGARCH model performs better than other GARCH models. ‘Compared to GARCH(1,1) model, the EGARCH(1,1) model has an asymmetric news impact curve (larger impact for negative shocks)’ [Verbeek, (2004)]. Plus, the effect upon the conditional variance is exponential, the news impact curve for the EGARCH model has larger slopes [Engle and Ng, (1993)].

4.1.3. **TGARCH(1,1)**

The third model of the GARCH family that we are going to apply is the TGARCH (1,1) model. It was expressed by Glosten, Jagannathan and Runkle (1993) and the equation of the conditional variance is given by the formula:

\[
\sigma^2_t = \sigma^2_0 + \alpha_1 \epsilon^2_{t-1} + \alpha_2 \epsilon^2_{t-1} \Delta_{t-1} + \alpha_3 \sigma^2_{t-1} + u,
\]  

(3)

where the \(\alpha_3\) coefficient is the leverage effect and it is significant when \(\alpha_3>0\) and where \(\Delta_{t-1} = 1\) if \(\sigma^2_{t-1} < 0\) and \(\Delta_{t-1} = 0\) otherwise. The non-negativity constraints suppose that \(\sigma^2_0 \geq 0, \alpha_1 \geq 0, \alpha_2 \geq 0\) and \(\alpha_1 + \alpha_2 \geq 0\). If \(\alpha_2 \neq 0\), the news impact is asymmetric [Verbeek, 2004].
The question is which GARCH model is better to use? To answer that question we have to find which model captures the conditional volatility of the time series better than others. According to Alexander (2001), ‘‘if the returns have no significant autoregressive conditional heteroscedasticity once they have been standardized by their conditional volatility, then the GARCH model is a well-fitted model or it well-captures the volatility’’.

4.2. Models with dummy variable

The second method we are going to use is to include a dummy variable into the GARCH models mentioned above. In this way, we can test for the significance of the dummy variable. If the dummy is statistically significant then the introduction of futures trading has changed the spot market volatility of the FTSE/ASE-20 index. It should be noted that the dummy takes the value 0 for the period before the introduction of futures contracts on FTSE/ASE-20 and 1 for the period after. The GARCH models with a dummy variable take the following expression:

- **GARCH(1,1)**
  \[ \sigma^2_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \beta_1 \sigma^2_{t-1} + \gamma dv + u, \quad \text{where } dv \text{ is the dummy variable} \]

- **EGARCH(1,1)**
  \[ \log(\sigma^2_t) = \alpha_0 + \alpha_1 \frac{\varepsilon_t}{\sigma_{t-1}} + \alpha_2 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \alpha_3 \log(\sigma^2_{t-1}) + \gamma dv + u \]

- **TGARCH(1,1)**
  \[ \sigma^2_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \alpha_2 \varepsilon^2_{t-1} \Delta_t + \alpha_3 \sigma^2_{t-1} + \gamma dv + u \]

As long as the coefficient \( \gamma \) of the dummy variable is positive then we suggest that there is a positive effect of futures contracts trading on volatility of the underlying index. On the other hand, when the coefficient \( \gamma \) is negative there is a negative effect on volatility.
4.3 Unconditional Variance

Finally, the last method used for capturing the change on the volatility of the FTSE/ASE-20 index is the simplest of all the above and is the unconditional variance method. As Floros and Vougas (2006), first, we find the unconditional variance for GARCH(1,1) model for the pre-introduction period and the post-introduction period and then we compare the variance between the two periods.

Under stationarity, \( E(\varepsilon^2_{t-1}) = E(\sigma^2_{t-1}) \), the unconditional variance of \( \varepsilon_t \) for the basic GARCH(1,1) model can be expressed as following:

\[
\sigma^2 = \alpha_0 / (1 - \alpha_1 - \beta_1)
\]

where \( \alpha_0, \alpha_1 \) and \( \beta_1 \) are non-negative numbers. The stationarity also requires that \( \alpha_1 + \beta_1 < 1 \). Plus, the values of \( \alpha+\beta \) close to unity means that the persistence in volatility is high [Verbeek, (2004)].

5. Empirical Results and Analysis

5.1. Modelling the FTSE/ASE-20 series

In this section, we consider weekly data of the closing prices of the FTSE/ASE-20 index before and after the introduction of futures trading. The issue whether the series are mean reverting has attracted considerable attention in the academic literature. From the graph of the series (Graph 1), it is evident that the series does not fluctuate around a mean or, in other words, the series is not mean reverting. Furthermore, there is clearly a break until 2003 where the FTSE/ASE-20 follows a downward movement since 1999. On the other hand, the index follows an upward movement after 2003. This is due to the general conditions of the Greek Stock Market after the financial crisis of 1999. More precisely, the great rise of the Greek Stock Market during the 1999 has driven the stock prices to be overpriced and thus, to follow a “‘strong’” downward movement during the next years. As
a consequence, the Greek investors were extremely ‘’nervous’’ for years after.

After applying the appropriate tests, we concluded that the series for both post-futures introduction and pre-futures introduction periods are stationary in first difference which means that they fluctuate around a mean, which is close to zero. Furthermore, the first differenced series are not normally distributed for both sub-periods while the FTSE/ASE-20 series follow the AR(1) process for both sub-periods (all the test details are available upon request). Floros and Vougas (2006) also used two benchmark models, AR(1) and MA(1) models, for capturing the volatility of the FTSE/ASE-20 and FTSE/ASE-Mid40 indices.

5.2. Testing for ARCH effects

Statistical tests can be used to test for the existence of heterocadesticity for the whole sample period. For example we can examine the correlograms of the fitted OLS regression errors,  e^2_i. [(Verbeek, (2004)]. From the inspection of the correlogram of the squared residuals  e^2_i, we conclude that there is heteroscedasticity. Plus, close to zero P-values for the Ljung-Box Q-statistics for all lags after the 4th also lead us to reject the null hypothesis of no ARCH effects. The formal test for the presence of ARCH effects is the ARCH-Lagrange multiplier test or ARCH-LM test. In this way, we run a regression of  e^2_i upon a constant and p of its lags. We get the t-statistic for 6 lags and we conclude that the second and the fifth lag have P-values close to zero which is evidence for the rejection of the homoscedasticity hypothesis.

5.3. GARCH(1,1) model

Then, we examined the volatility of the FTSE/ASE-20 across two periods. One period before the introduction of futures and one period after the introduction. Then, we compare the test parameters. Three GARCH family models are used such as the
GARCH(1,1), the EGARCH(1,1) and the T-GARCH(1,1) (GJR model). Then we compare the results taken before and after the introduction of futures trading. After that, we include a dummy variable in the basic GARCH equations for the whole sample period and we test for the value of the dummy variable. If the coefficient of the dummy variable is positive then we conclude that there is a positive effect of futures trading on the underlying volatility of the FTSE/ASE-20 index. To begin with, we apply the basic GARCH (1,1) model using the Eviews program.

For the post-introduction period, we have the ARCH parameter equal to $\alpha_1 = -0.012309$ and the GARCH coefficient, $\beta_1 = 1.000708$ with the standard errors being 0.000658 and 0.000161 respectively. Thus, the sum of $\alpha_1$ and $\beta_1$ equals 0.988399 which approaches unity. This implies that shocks to the conditional variance will be highly persistent. Both ARCH and GARCH parameters are statistically significant at the 5% significance level which means that the ‘news’ parameter and the persistence coefficient are significant. Thus, the volatility of the FTSE/ASE-20 index will change after the introduction of futures trading significantly. Next, we examine the AR(1)-GARCH(1,1) model and we reach the same results as in the GARCH(1,1) analysis for ARCH and GARCH parameters. The ARCH parameter, $\alpha_1 = -0.021803$ and the GARCH coefficient, $\beta_1 = 1.004129$ with their sum being 0.982326 which approaches unity. Thus, like in the GARCH(1,1) analysis, the AR(1)-EGARCH(1,1) analysis implies that shocks to the variance will be persistent too. The ‘news’ parameter and the persistence coefficient are significant at the 5% significance level because of the P-value of the ARCH and GARCH parameters.

From the analysis of the results for the pre-introduction period we conclude the same inferences. The ARCH parameter is -0.071447 and the GARCH coefficient is 0.536151, while for the AR(1)-EGARCH analysis, the ARCH parameter is -0.076439.
and the GARCH coefficient is 0.471613. The sum of those two coefficients is 0.462704 for the GARCH(1,1) model and 0.395174 for the AR(1)-GARCH(1,1). Both are being far away from the value of 1. The ARCH and GARCH coefficients are not statistically significant at the 5% significance level for both GARCH(1,1) and AR(1)-GARCH(1,1). Thus, the ‘news’ parameter is not statistically significant during the pre-introduction period.

Tables 1 and 2 summarize the above results and we can see the parameters’ values for the pre-introduction period and the post-introduction period. We conclude that the ARCH parameter, $\alpha_1$, is higher for the post-introduction period suggesting that ‘news’ is reflected in prices more rapidly. Plus, the GARCH parameter is higher in the post-introduction period and thus, the old news has a greater persistent effect on price changes or there is a greater persistence [Antoniou and Holmes, (1995)]. The sum of ARCH and GARCH parameters is 0.464704 in the pre-introduction period and 0.988399 in the post-introduction period, for the GARCH(1,1) model, and 0.395174 in the pre-introduction period and 0.982326 in the post-introduction period for the AR(1)-GARCH(1,1) model. The results imply that the introduction of futures contracts has generated significant positive effects on the spot market volatility of the FTSE/ASE-20 index and the persistence of shocks in the post-introduction period increased, while the news is reflected in prices more rapidly.

5.4. **EGARCH(1,1) model**

Another way to capture the volatility of the FTSE/ASE-20 index is by applying the EGARCH model. We will apply the EGARCH(1,1) and AR(1)-EGARCH(1,1) models for both the pre-introduction period and post-introduction period in the same way as in the GARCH(1,1) and the AR(1)-GARCH(1,1) analysis above.
All the parameters of the EGARCH model are highly significant. Thus, the ‘news’ parameter and the ‘persistence’ coefficient are significant in the post-introduction period. The leverage effect coefficient, C(4), is also significant, different from zero and negative which means that there is leverage in the returns for our sample-period and the news impact is asymmetric. Negative shocks imply a higher conditional variance for the post-introduction period than positive shocks of the same magnitude do. For the AR(1)-EGARCH(1,1) analysis we conclude the same. The ‘news’ parameter, C(4), and the ‘persistence’ coefficient, C(6) are significant in the post-introduction period. The leverage effect coefficient, C(5), is insignificant at the 5% significance level and negative. Thus, there are no asymmetric effects in the post-introduction period.

For the pre-introduction period, we note again the significance of both ARCH and GARCH parameters and the existence of a leverage effect with the EGARCH(1,1) analysis. In contrast to the results of the EGARCH(1,1) analysis, the AR(1)-EGARCH(1,1) analysis proves that the ARCH and GARCH parameters are insignificant at the 5% significance level and the leverage effect is negative and insignificant too.

The next step is to check whether the coefficients have increased or decreased from the pre-introduction period to the post-introduction period. For the EGARCH(1,1) analysis, Tables 1 and 2 show that there is an increase in the ARCH parameter, C(3). Plus, there is an increase in C(5) which is the GARCH parameter and implies that old news has a greater persistent effect on price changes.

Comparing the results from Tables 1 and 2, we conclude that for the EGARCH(1,1), both ARCH and GARCH parameters have increased in the post-introduction period and their sum too. Thus, the ‘‘news’’ is reflected in prices more rapidly and old news have higher impact on today’s prices. Thus, the introduction of futures trading has a significant positive impact on the spot market volatility of the FTSE/ASE-
20 index. The leverage effect coefficient \((a_2)\) is negative for both the EGARCH(1,1) and the AR(1)-EGARCH(1,1) analysis. However it is significant only for the EGARCH(1,1) model analysis and not for the AR(1)-EGARCH(1,1) model. Thus, the leverage effect is significant in the post-introduction period with the EGARCH(1,1) analysis. However, with the AR(1)-EGARCH(1,1) analysis, we observe a decrease in the sum of ARCH and GARCH parameters which indicates that the new information is reflected in prices more slowly and the persistence of shocks from the pre-introduction period to the post-introduction period is lower.

5.5. **TGARCH (GJR) model**

The final step is to examine the volatility of the underlying spot index with the GJR model. By following the same procedure, we have the following results for the TGARCH(1,1): ARCH and GARCH parameters are highly significant indicating that there is a significant positive change in the volatility of the FTSE/ASE-20 spot index after the introduction of futures markets. The leverage effect is insignificant indicating the absence of asymmetric effects in the post-introduction period.

For the pre-introduction period, ARCH and GARCH parameters are statistically significant at the 5% significance level and the leverage effect coefficient is marginally significant indicating that there is an asymmetric effect in the pre-introduction period. If we compare the results between the two sub-periods, we observe that there is an increase in the ARCH and GARCH parameters again and there is a decrease in the leverage effect coefficient which supports the previous conclusion that the leverage effect is insignificant in the post-introduction period. As we can see the ARCH parameters are negative for both periods. The increase in the ARCH parameter implies that there is a greater impact of the ‘good news’ on the volatility and that the rate at which news is reflected in prices is high-
An increase in the GARCH coefficient suggests that old news has a higher persistent effect.

For the AR(1)-TGARCH(1,1) analysis, we reach the same inference for the ARCH parameter which has increased in the post-introduction period and for the GARCH parameter whose value in the post-introduction period is higher than in the period before. The leverage effect is lower as in the TGARCH(1,1) analysis and insignificant, indicating no asymmetric effects. In both TGARCH(1,1) and AR(3)-TGARCH(1,1) models, the GARCH coefficient is higher in the post-introduction period indicating that old news has a greater persistent effect on prices with TGARCH models. Tables 1 and 2 give the overall results for all GARCH family models and for both sample periods with the value of t-statistics in the parenthesis.

5.6. **Modeling with a dummy variable**

An alternative modeling methodology to examine the spot market volatility after the introduction of futures contracts on the FTSE/ASE-20 index is the inclusion of a dummy variable, \( dv \), in the previously examined GARCH-family models. This variable takes the value zero for the period before the introduction of derivatives and the value one for the period after. If the dummy variable is significant then we conclude that the introduction of futures has influenced the volatility of the FTSE/ASE-20. If the coefficient of the dummy is negative then, the volatility has decreased and if it is positive then the volatility has increased.

5.6.1 **GARCH(1,1) with a dummy variable**

We begin with the results given by the GARCH(1,1) model. The dummy variable is statistically significant at the 5% significance level with a t-statistic of -20.17090 exceeding the critical value for the 5% significance level. That means that the existence of
futures markets has a very strong impact on the volatility of the FTSE/ASE-20 spot closing prices. The coefficient of the dummy variable is negative (-2.13E-0.5) which means that there is a negative effect of futures on stock market volatility. The negative effect is statistically significant, as mentioned above. Thus, the introduction of futures has decreased the volatility of the underlying spot prices of the FTSE/ASE-20. Plus, the ARCH and GARCH coefficients are significant too, at the 5% significance level. That means that the ‘news’ parameter and the ‘persistence’ coefficient are also significant by applying this method.

The results for the AR(1)-GARCH(1,1) are similar to the ones obtained above, with the dummy variable being significant and negative and equal to -1.57E-05, while the ARCH and GARCH parameters are significant also at the 5% significance level.

### 5.6.2 EGARCH(1,1) with a dummy variable

The EGARCH (1,1) model with a dummy variable is another way to capture the volatility of the spot index. The results are similar to those above with the GARCH analysis because the dummy variable coefficient is statistically significant and negative for both approaches. The dummy variable takes the value -0.036840 for the EGARCH(1,1) method and the value -0.035233 for the AR(1)-EGARCH(1,1) method. Thus, the futures trading have a strong impact and a negative effect on the volatility of the underlying index. ARCH and GARCH coefficients are also significant for both methods and the leverage effect is statistically significant.

### 5.6.3 THARCH(1,1) with a dummy variable

Another parsimonious model for capturing asymmetries is the GJR model with a dummy variable. The analysis of the data with the GJR model suggests and gives the same results as with the GARCH(1,1) and the EGARCH(1,1) models. The coefficient of
the dummy variable is highly significant for both the TGARCH(1,1) and AR(1)-TGARCH methods, which implies that the introduction of futures had a great impact on the volatility of the FTSE/ASE-20 index. The negative sign of the coefficients testify the negative effect of futures trading on the volatility of the index. Thus, the introduction of futures contracts on FTSE/ASE-20 has decreased the spot market volatility of the underlying index. ARCH and GARCH parameters are statistically significant and the leverage effect exists in both methods because of the positive value of the leverage effect coefficients. Table 3 depicts the overall results of analyzing the volatility of the FTSE/ASE-20 with GARCH family models including a dummy variable. The results reinforce the previous conclusions. The t-statistic of the dummy variable is highly significant at the 5% significance level for all GARCH family models. Furthermore, the coefficient of the dummy variable is negative which means that the introduction of futures trading has decreased the spot underlying volatility of the FTSE/ASE-20 index or it has a negative effect. All effects are statistically significant.

5.7. Unconditional Variance

In this section, we are going to measure the unconditional variance across the two sub-periods. It was mentioned above that the sum of the ARCH and GARCH parameters, $\alpha_1+\beta_1$, should be less than one. Thus, we are going to find the unconditional variance for the GARCH(1,1) and the AR(1)-GARCH(1,1) models by using Equation 7 mentioned previously. Table 4 summarizes the results for the unconditional variances: we observe that the unconditional variance is lower in the post-introduction period for both the GARCH(1,1) and the AR(1)-GARCH(1,1) models. This is evidence of lower volatility of the FTSE/ASE-20 index in the post-introduction period which implies that the introduction of futures trading has decreased the spot market volatility of the FTSE/ASE-20 index.
7. Summary and Conclusion

The operation of futures markets and the introduction of futures contracts trading in stock markets have produced many important changes in the volatility of the markets and more particularly, in the volatility of the underlying asset. Many studies have shown that the introduction of futures markets leads to a decrease in the volatility of the underlying index. They support that this is because of the increase in the market liquidity. The investors could hedge their positions due to the increased market liquidity and thus, reduce their risk. In contrast, many studies concluded that the underlying volatility has not changed after the introduction of futures while other studies suggested that the volatility increased.

This study examined the effect of the introduction of the futures markets in the Greek Stock Market on the volatility of an underlying index, the FTSE/ASE-20. The data used is weekly closing prices of the FTSE/ASE-20 for the period between 10/4/1998 and 21/6/2007. For the analysis, the period of examination is separated into two sub-periods: the pre-introduction period and the post-introduction period. The first sub-period contains the weekly closing prices of the FTSE/ASE-20 from April 10th, 1998 to August 20th, 1999. The introduction of the derivatives market was established on August 27th, 1999. The post-introduction period refers to the weekly closing prices after the introduction of futures trading on FTSE/ASE-20, which means the period from August 27th, 1999 to June 21st, 2007. We have to mention here that we have 72 observations for the pre-introduction period and 408 observations for the post-introduction period. However, similar tests have been applied with 72 observations after the introduction of derivatives but the results obtained were similar to Floros and Vougas (2006) suggestions.

The main idea behind this analysis is to compare the volatility of the spot market volatility of the FTSE/ASE-20 before and after the introduction of futures trading. For this
purpose, in order to capture the underlying volatility, several GARCH-family models were used such as the GARCH(1,1), the EGARCH(1,1) and the TGARCH(1,1) for the periods before and after the futures trading establishment. The results from all the above GARCH models were different for the weekly return series of the FTSE/ASE-20. In addition, we have included a dummy variable which takes the value 0 for the pre-introduction period and the value 1 for the period after the introduction of futures and we tested the significance and the value of this dummy. The results indicate that there is a great impact in the spot market volatility of the FTSE/ASE-20 index after the introduction of futures contracts because of the significance of the coefficient of the dummy with all GARCH-family models. In addition, this impact is negative because the coefficient of the dummy is negative. Thus, there is a decrease on the volatility of the FTSE/ASE-20 after the introduction of futures. The unconditional variance method supported the previous conclusion while we found that the value of the unconditional variance was lower in the post-introduction period which means that there was a decrease on the market volatility for the FTSE/ASE-20 index.

However, the different GARCH-family models gave different results for the spot market volatility. For example, both GARCH(1,1) and AR(1)-GARCH(1,1) models suggest that ‘news’ is reflected in prices more rapidly and the ‘old news’ has a greater persistent effect on price changes implying that volatility increases in the post-introduction period.

The unconditional variance method, the dummy variable method and the AR(1)-EGARCH(1,1) model as well, depicted a decrease in the spot market volatility after the introduction of futures trading implying increasing market efficiency. On the other hand, the GARCH, TGARCH and EGARCH(1,1) models supported the positive effect (increased volatility) that the introduction of futures has brought on the spot market.
Floros and Vougas (2006) have concluded to a reduced spot market volatility for the FTSE/ASE-20 index for the period between 1997-2001. It was the first study for the Greek stock market. However, the results of this study indicate that there is not a very clear view of the spot market volatility of the FTSE/ASE-20 index for the period until 2007 despite the fact that the FTSE/ASE-20 is a very high-traded index on the ADEX and there is a quite high liquidity on the market for this index. Plus, we should not ignore that the sample period of this study is quite large. As a result, we can suggest that this study focuses mainly on the long-term volatility of the FTSE/ASE-20 index after the introduction of futures trading. Floros and Vougas (2006) examined the spot market volatility for almost two years after the introduction of futures.

In summary, we can suggest a negative effect of the introduction of futures trading on the underlying volatility of the FTSE/ASE-20 index but the evidence is not consistent and strong enough for our sample period due to the different results from different GARCH-family models applications. The ability to predict the direction of spot market volatility is very important for academicians and practitioners in the field. It is a crucial factor for the formation of optimal asset allocation decisions and for the determination of dynamic hedging strategies for derivative products such as options and futures (Baillie and Myers, 1991). Thus, further research needs to be done in order to get conclusive results for the impact of the introduction of futures contracts trading on spot market volatility of the FTSE/ASE-20 index and other indices of the Greek stock market.

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ECOFIN available at:
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Table 1  
Results for all GARCH models for FTSE/ASE-20 index for the Post-Introduction Period

<table>
<thead>
<tr>
<th>Models</th>
<th>$\Omega$</th>
<th>$\alpha_1$</th>
<th>$\alpha_2$</th>
<th>$\alpha_3$</th>
<th>$\beta_1$</th>
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</thead>
<tbody>
<tr>
<td>GARCH(1,1)</td>
<td>5.75E-06</td>
<td>-0.012309</td>
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<td></td>
<td>1.000708</td>
</tr>
<tr>
<td></td>
<td>(10.93537*)</td>
<td>(-18.69977*)</td>
<td>(6224.086*)</td>
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<tr>
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<td></td>
<td>(-478.5815*)</td>
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<td>(7261.960)</td>
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<td>(7.502933*)</td>
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<td>(5.042690*)</td>
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<td>(303.7574*)</td>
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Table 2
Results for all GARCH models for FTSE/ASE-20 index for the Pre-Introduction Period

<table>
<thead>
<tr>
<th>Models</th>
<th>$\omega$</th>
<th>$\alpha_1$</th>
<th>$\alpha_2$</th>
<th>$\alpha_3$</th>
<th>$\beta_1$</th>
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<tbody>
<tr>
<td>GARCH(1,1)</td>
<td>0.001936</td>
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<td></td>
<td>(0.598138)</td>
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<td>(0.651216)</td>
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<td>EGARCH(1,1)</td>
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<td></td>
<td>(-699.9364*)</td>
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<td>TGARCH(1,1)</td>
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<td></td>
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<td>(1.956436*)</td>
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<td>AR(1)-GARCH(1,1)</td>
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<td></td>
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<td>(0.603412)</td>
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<td></td>
<td>(-1.019687)</td>
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<td>AR(1)-TGARCH(1,1)</td>
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<td>(0.960055)</td>
<td>(-3.412651*)</td>
<td>(1.403864)</td>
<td>(1.079181)</td>
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Table 3
Results for all GARCH models including a dummy variable for the FTSE/ASE-20 index

<table>
<thead>
<tr>
<th>Model</th>
<th>Coefficient on dummy variable</th>
<th>t-ratio</th>
<th>P-value</th>
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<tbody>
<tr>
<td>GARCH(1,1)</td>
<td>-2.13E-05</td>
<td>-20.17090</td>
<td>0.0000</td>
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<td>EGARCH(1,1)</td>
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<tr>
<td>TGARCH(1,1)</td>
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<td>-2.962857</td>
<td>0.0030</td>
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<td>AR(1)-GARCH(1,1)</td>
<td>-1.57E-05</td>
<td>-4.804646</td>
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<td>AR(1)-EGARCH(1,1)</td>
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<td>-3.014708</td>
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<td>AR(1)-TGARCH(1,1)</td>
<td>-1.97E-05</td>
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<td>0.0032</td>
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Table 4
Results for unconditional variances for both GARCH(1,1) and AR(1)-GARCH(1,1) models for both sub-periods

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<th>Periods</th>
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<th>AR(1)-GARCH(1,1)</th>
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<td>Post-Introduction Period</td>
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<td>0.00056127</td>
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<tr>
<td>Pre-Introduction Period</td>
<td>0.00361669</td>
<td>0.00353159</td>
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Table 5
ARCH and GARCH coefficients for the Pre-Period with the GARCH(1,1) and AR(1)-GARCH(1,1) models

<table>
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<th>Model</th>
<th>GARCH (1,1)</th>
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<td>ARCH</td>
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<td>SUM</td>
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<td>0.395174</td>
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### Table 6
**ARCH and GARCH coefficients for the Post-Period with the GARCH(1,1) and AR(1)-GARCH(1,1) models**

<table>
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<th>GARCH (1,1)</th>
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<td>ARCH</td>
<td>-0.012309</td>
<td>-0.021803</td>
</tr>
<tr>
<td>GARCH</td>
<td>1.000708</td>
<td>1.004129</td>
</tr>
<tr>
<td>SUM</td>
<td>0.988399</td>
<td>0.982326</td>
</tr>
</tbody>
</table>

### Table 7
**ARCH and GARCH coefficients for the Pre-Period with the EGARCH(1,1) and AR(1)-EGARCH(1,1) models**

<table>
<thead>
<tr>
<th></th>
<th>EGARCH (1,1)</th>
<th>AR(1)-EGARCH(1,1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH</td>
<td>-0.429111</td>
<td>-0.334595</td>
</tr>
<tr>
<td>GARCH</td>
<td>0.897474</td>
<td>0.615652</td>
</tr>
<tr>
<td>SUM</td>
<td>0.468363</td>
<td>0.281057</td>
</tr>
</tbody>
</table>

### Table 8
**ARCH and GARCH coefficients for the Post-Period with the EGARCH(1,1) and AR(1)-GARCH(1,1) models**

<table>
<thead>
<tr>
<th></th>
<th>EGARCH (1,1)</th>
<th>AR(1)-EGARCH(1,1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH</td>
<td>-0.044967</td>
<td>-0.052752</td>
</tr>
<tr>
<td>GARCH</td>
<td>0.987078</td>
<td>-0.019013</td>
</tr>
<tr>
<td>SUM</td>
<td>0.942111</td>
<td>-0.071765</td>
</tr>
</tbody>
</table>
Graph 1

Graph of the Log(FTSE/ASE-20) series in the Post-Introduction Period