**Market Efficiency and the Euro:
The case of the Athens Stock Exchange**

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Abstract

The efficient market hypothesis (EMH) is tested in the case of the Athens Stock Exchange (ASE) after the introduction of the euro. The underlying assumption is that stock prices would be more transparent; their performance easier to compare; the exchange rate risk eliminated and as a result we expect the new currency to strengthen argument in favour of the EMH. The General ASE Composite Index and the FTSE/ASE 20, which consists of "high capitalisation" companies, are used. Five statistical tests are employed to test the residuals of the random walk model: the BDS, McLeod-Li, Engle LM, Tsay and Bicovariance test. Bootstrap as well as asymptotic values of these tests are estimated. Alternative models from the GARCH family (GARCH, EGARCH and TGARCH) are also presented in order to investigate the behaviour of the series. Lastly, linear, asymmetric and non-linear error correction models are estimated and compared.

Keywords: Non-Linearity, Market Efficiency, Random Walk, GARCH, non-linear error correction
JEL Classification: C22, C52, G10

1. INTRODUCTION

A large body of literature has accumulated over the past three decades concerning the validity of the weak-form efficient market hypothesis (EMH) with respect to stock markets. The weak form of the EMH postulates that successive one-period stock returns are independent and identically distributed (*iid*) , i.e. they resemble a random walk. In the same time it is well known that stock returns are characterised by volatility clustering, where large returns are followed by large returns and small returns tend to be followed by small returns, leading to contiguous periods of volatility and stability. In this paper we are going to examine both hypotheses in the case of an emerging capital market which has recently joined the euro zone. We would examine how the introduction of the single European currency has affected the efficiency of a stock market in the process of becoming a developed capital market.

Limited number of studies has appeared in the literature providing with empirical application to the ASE and none has investigated the introduction of the common currency. Siriopoulos (1996) used monthly observations of the ASE General Index from 1974:1 to 1994:6. Using the BDS test statistic and the correlation dimension, it was concluded that a GARCH model could not explain the non-linearities of the series which might be generated by a "semi-chaotic behaviour". Barkoulas & Travlos (1998) used daily observations of the ASE30, the 30 most marketable stocks, from January 1981 to December 1990. Models like an AR(p) and a GARCH (1,1) were employed and diagnostic tools like BDS, correlation dimension and Kolmogorov entropy were estimated. They concluded that "*the BDS test detects remaining unspecified hidden structure in the Greek stock returns*" but " *do not find evidence in support of a chaotic structure in the Athens Stock Exchange*". Niarchos & Alexakis (1998) followed a different methodology to test the EMH in the Athens Stock exchange. They used error correction models and compared the speed of adjustment. Their evidence contradicted the EMH. More recently, Apergis & Eleptheriou (2001) examined the market volatility using daily observations of the ASE General Index for the period January 1990 to July 1999. They have compared different GARCH models based on the log likelihood and concluded that "the presence of persistence in volatility clustering implies inefficiency of the ASE market".

These studies, amongst other, underline the fact that there is strong evidence against the EMH. The goal of this paper is twofold. Firstly, to review the weak form efficiency in the light of the introduction of the euro. Our prior is that the new currency will strengthen the case for the EMH: costs and functions are more transparent to investors (domestic and non), the disappearance of the risks associated with exchange rates fluctuations, vanished capital control regulations, easy and straightforward comparison of prices and evaluation of performances (to name a few). Secondly, to nest and extend the methodologies used. The models are going to be used include linear and non-linear models. The assumption of randomness, which is closely associated with the EMH, is investigated using a powerful battery of tests.

The outline of the paper is as follows: Section 2 discusses the econometric methodology followed, the models and the tests for non-linearity that are employed. Sections 3 presents the statistical properties of the data. The empirical results are discussed in Section 4 and Section 5 concludes.

2. METHODOLOGY

We start our analysis with the naive random walk

$$x_t = x_{t-1} + e_t \qquad (1)$$

where $x_t = \ln(E_t)$ represents the natural log of the original time series, E_t, and e_t is a zero-mean pure white noise random variable. If the random walk hypothesis holds, then the series x_t will have a single unit root (i.e. will be $I(1)$) and the series Dx_t ($= x_t - x_{t-1} = \ln(E_t / E_{t-1})$) will be purely random. The series Dx_t may be examined further by estimating the equation:

$$Dx_t = constant + e_t \qquad (2)$$

using ordinary least squares. Under the random walk hypothesis the constant term should be insignificantly different from zero and the resultant residuals should be uncorrelated.

Secondly, an autoregressive processes (AR) is employed. The **general autoregressive model of order *p*** can be written as:

$$\Delta x_t = constant + \Delta x_{t-1} + \Delta x_{t-2} + ... + \Delta x_{t-p} + e_t \qquad (3)$$

Thirdly, three models from the GARCH family are considered:

The GARCH(1,1) specification is

$$\Delta x_t = a_0 + \sum_{i=1}^{k} a_i \Delta x_{t-i} + u_t \,; u_t / \Omega_{t-1} \sim N(0, h_t^2) \qquad (4)$$

$$h_t^2 = b_0 + b_1 u_{t-1}^2 + b_2 h_{t-1}^2 \qquad (5)$$

Two models that allow for asymmetric shocks to volatility, TARCH and EGARCH, are also considered.

In the exponential GARCH (EGARCH) model of Nelson (1991), h_t^2 depends on both size and the sign of lagged residuals. The specification is:

$$\ln(h_t^2) = b_0 + b_1 \ln(h_{t-1}^2) + b_2 \left| \frac{u_{t-1}}{h_{t-1}} \right| + g \, \frac{u_{t-1}}{h_{t-1}} \qquad (6)$$

This implies that the leverage effect is exponential and its presence can be tested by the hypothesis that $\gamma > 0$. The news impact is asymmetric if $\gamma \neq 0$.

The TGARCH or Threshold GARCH (also known as GJR model) was introduced by Zakoian (1994) and Glosten, Jaganathan, and Runkle (1993). The specification for the conditional variance is given by

$$h_t^2 = w + a\, e_{t-1}^2 + g e_{t-1}^2 d_{t-1} + b\, h_{t-1}^2 \qquad (7)$$

where $d_t = 1$ if $e > 0$, and 0 otherwise. If $\gamma > 0$ the leverage effect exists and again the news impact is asymmetric if $\gamma \neq 0$.

Lastly, error correction models (ECM), asymmetric (AECM) and non-linear error correction models (NECM) are considered. If x_t, y_t are both $I(1)$ then it is typically true that any linear combination x_t+by_t will also be $I(1)$. However, for some pairs of $I(1)$ series there does exist a linear combination $z_t=x_t-Ay_t$ that is $I(0)$. When this occurs, x_t, y_t are said to be cointegrated. If x_t, y_t are cointegrated they may be considered to be generated by an error-correcting model of the form

$$\Delta x_t = r_1 z_{t-1} + lagged(\Delta x_t, \Delta y_t) + e_{xt} \qquad (8)$$

where at least one of r_1, r_2 is non-zero and e_{xt}, e_{yt} are jointly white noise.
The error corrections in the models considered above are symmetric so that the extend of the effect $|z_{t-1}|$ is the same regardless of the sing of z_{t-1}. However, when the current level of shares (or indices) is determined, it may well matter whether z_{t-1} (the level of the index/share in the previous day / week) was positive or negative. To investigate these probabilities further sets of error correction models (*asymmetric error correction models*) were conducted, using the notation (proposed by Granger & Lee, 1989) $z = z^+ + z^-, z^+ = \max(z,0)$ and $z^- = \min(z,0)$.

$$\Delta x_t = r_{11} z^+_{t-1} + r_{12} z^-_{t-1} + lagged(\Delta x_t, \Delta y_t) + e_{xt} \qquad (9)$$

Lastly, we are going to briefly discuss, the non-linear error correction model. This basically, refers to non-linear adjustment to long-run equilibrium economic relationships. This type of non-linear adjustment allows for faster adjustment when deviations from the equilibrium level get larger. Further, it allows for the possibility of more than one equilibrium points when the additional regressors, that is z^2_{t-1} and z^3_{t-1}, are statistically significant. In that sense, the cubic error correction model is more flexible than the Granger & Lee (1989) type of asymmetric adjustment.

Following Escribano & Granger 1998, the non-linear error correction model could be written as:

$$\Delta x_t = r_{11} z_{t-1} + r_{12} z^2_{t-1} + r_{13} z^3_{t-1} + lagged(\Delta x_t, \Delta y_t) + e_{xt} \qquad (10)$$

Escribano & Granger (1998) point out that *"The non-linear error correction terms should be considered as local approximations to the true non-linear specifications oif it occurs. In particular, if z_{t-1} enters a cubic it would produce a non-stable difference equation for x_t, since for large values z_{t-1} the cubic polynomial is unbounded, and so would not be appropriate as this series is supposed to be I(0)".*

Many tests have been proposed in the literature for detecting non-linearity in the residuals. Instead of using a single statistical test, for the purposes of this paper five different tests are considered; McLeod & Li (1983), Engle LM (1982), BDS (1996), Tsay (1986), and Hinich & Patterson (bicovariance) (1995). All these tests share the principle that once any (linear or non-linear) structure is removed from the data, any remaining structure should be due to an (unknown) non-linear data generating mechanism. All the procedures embody the null hypothesis that the series under consideration is an *i.i.d.* process.

The McLeod & Li test looks at the autocorrelation function of the squares of the prewhitened data and tests whether corr (e_t^2, e_{t-k}^2) is non-zero for some k and can be considered as an LM statistic against ARCH effects (see Granger & Terasvirta, GT , 1993; Patterson & Ashley 2000). The test suggested by Engle (1982) is an LM test, which should have considerable power against GARCH alternatives (see GT 1993; Bollerslev, 1986). The Tsay (1986) test explicitly looks for quadratic serial dependence in the data and has proven to be powerful against a TAR process. The BDS test is a nonparametric test for serial independence based on the correlation integral of the scalar series, $\{e_t\}$ (see Brock, Hsieh & LeBaron 1991 and GT 1993). The Hinich Bicovariance test assumes that $\{e_t\}$ is a realisation from a third-order stationary stochastic process and tests for serial independence using the sample bicovariances of the data. The last two tests are general linearity tests and in the case of the BDS test the alternative to linearity can be considered to be a stochastic non-linear model (GT 1993). The reader is also referred to the detailed discussion of these tests in Patterson & Ashley (2000) and Panagiotidis (2002).

3. DATA & UNIT ROOT TESTS

After years of adopting stabilisation policies in order to reduce inflation and achieve the other convergence criterion, Greece joined the Economic and Monetary Union. The official announcement was made on 19/6/2000 from the European Council although the decision was known in advance. The data employed in this exercise consist of two indices: the General Index (ASE Composite Share Index) and the FTSE/ASE20. The last is a joint venture between FTSE and the ASE and is a capitalisation weighted index. It consists of the top 20 companies by market capitalisation (mainly the banking sector and telecommunications[1].)

The data statistics of the logarithmic transformation and the first differences of the series are given in Table 1. Table 2 presents the results of the unit root test. Clear evidence emerges that both series are $I(1)$.

4. RESULTS

In this section a number of alternative models are considered with the ASE General Index as the dependent variable (*DLGeneral*), where *D* denotes first difference. Starting with the simplest form, with no explanatory variables, Model 1 corresponds to the random walk. Secondly, an AR(p) model was considered for values from $p = 0$ to $p = 10$. The optimal lag length is chosen to minimise the Schwartz criterion (SC). Model 3 is the standard linear error correction model. The simple GARCH (1,1) and two asymmetric GARCH models (EGARCH and TGARCH) are models 4, 5 and 6 respectively. Model 7 is the simple error correction model, model 8 is the asymmetric error correction model used by Granger & Lee (1989). Model 9 introduces the non-linear adjustment used previously by Escribano & Granger (1998) and

[1] For more information on the indices and their composition http://www.ase.gr and http://www.ftse.com. The data are available free from http://www.enet.gr/finance/finance.jsp .

Escribano & Pfann (1998) amongst others. The FTSE 20 is used as it consists of the high capitalisation companies which usually "drives" the General Index. A dummy variable is introduced in the long-run relationship (see Table 3).
The general-to-specific approached was followed. In particular, in the case of the asymmetric GARCH models (EGARCH & TGARCH), we started with lagged values of Dl*General* and Dl*FTSE20*. The preferred model was the one that minimised the SC. The same methodology was followed for the determination of the number of independent variables in the case of the ECM, AECM and NECM.
Table 4 summarises the results from all the models. The RW outperformed the AR, producing lower SC and is the preferred "linear " univariate model. The results of the AR are not reported here but are available from the author. The constant term is negative and significant in all cases but the ECM, AECM and NECM. EGARCH has the lowest SC and the NECM the lowest standard error of regression.
The diagnostic tests for all models are presented in Tables 5 and 6. Under investigation are the ordinary residuals of the RW, ECM, ACM, NECM and the standardised residuals of the GARCH, EGARCH and TGRACH. The employed tests are, like most econometric procedures, only asymptotically justified. Given the limited sample available, the tests are estimated using both the asymptotic theory and the bootstrap. The values under "asymptotic theory" are based on the large sample distributions of the relevant test statistics. For the "Bootstrap" results, 1000 new samples are independently drawn from the empirical distribution of the pre-whitened data. Each new sample is used to calculate a value for the test statistic under the null hypothesis of serial independence. The obtained fraction of the 1000 test statistics, which exceeds the sample value of the test statistic from the original data, is then reported as the significance level at which the null hypothesis can be rejected (for a detailed discussion on the sample size, the asymptotic theory and the bootstrap see Patterson & Ashley 2000).
Firstly, we are able to reject the hypothesis that the ASE General Index follows a random walk. The *p*-values across the battery of tests employed are 0 (or very close to 0). The same conclusion can be drawn for the ECM, the AECM and NECM models suggesting that some kind of hidden structure is contained in the residuals. To obtain an idea of the contribution of the error correction term to the dependent variable, we have graphed the values of the error correction component over time (see Figure 2). It is seen that in the beginning of the observation period NECM error corrects more than the other two models.
On the other hand, we can accept the *iid* assumption in some cases for the residuals of the GARCH models. A thorough investigation of the results reveals that only in the case of the standardised residuals of the TGARCH model there is a "unanimous" acceptance of the randomness hypothesis (low *p*-values in the Engle and the Tsay test in the case of GARCH and Engle in the case of EGARCH). The estimated coefficient of g in the case of the TGATCH

model is positive and statistically significant suggesting that the leverage effects exist and the news impact is asymmetric (see Figure 3).

What is the implication of our results for the weak-form efficiency? Firstly, we can reject the hypothesis that the series follows a random walk. Evidence was found in favour of the TGARCH model. However, the neither the variance nor the standard deviation were found statistically significant predictors of the mean equation. As a result, the conclusion we draw is that persistence volatility clustering is present in the series but this does not imply inefficiency.

5. CONCLUSIONS

The weak form EMH was tested in the Athens Stock Exchange after the introduction of the common European currency. Alternative linear and non-linear models are used to model the General Index. Simple univariate linear models (RW and AR), various conditional volatility models (GARCH, EGARCH and TGARCH) and multivariate models (ECM, ACM, NECM) are estimated. A battery of tests for randomness are estimated in each case. Bootstrap values as well as asymptotic are generated. The preferred model (TGARCH) is the one that produced a unanimous verdict of iid residuals. The evidence suggests that the leverage effects exist and the news impact is asymmetric The argument in favour of time varying variance does not challenge though the weak form efficiency. Overall, strong efficiency gains are found to exist on the period after the introduction of the common currency.

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FIGURE 1

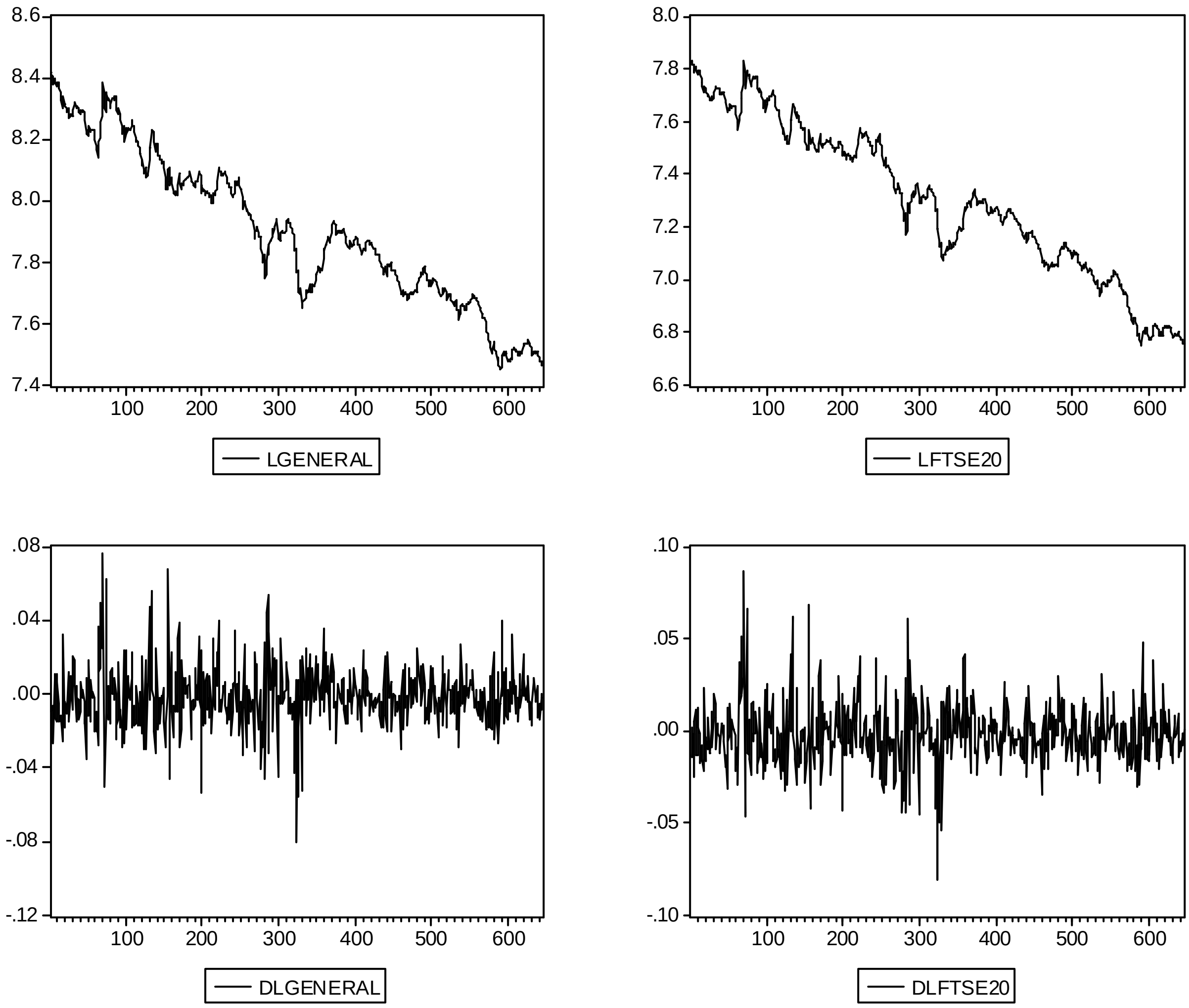

8.6
8.4
8.2
8.0
7.8
7.6
7.4
100 200 300 400 500 600
LGENERAL
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
100 200 300 400 500 600
LFTSE20
.08
.04
.00
-.04
-.08
-.12
100 200 300 400 500 600
DLGENERAL
.10
.05
.00
-.05
-.10
100 200 300 400 500 600
DLFTSE20

FIGURE 2: Error Correction Components, where ec=-0.025461*z, aec=-0.042425*z^++0.00649*z^-, and nec=0.018387*z-0.37277*z^2-21.22782*z^3

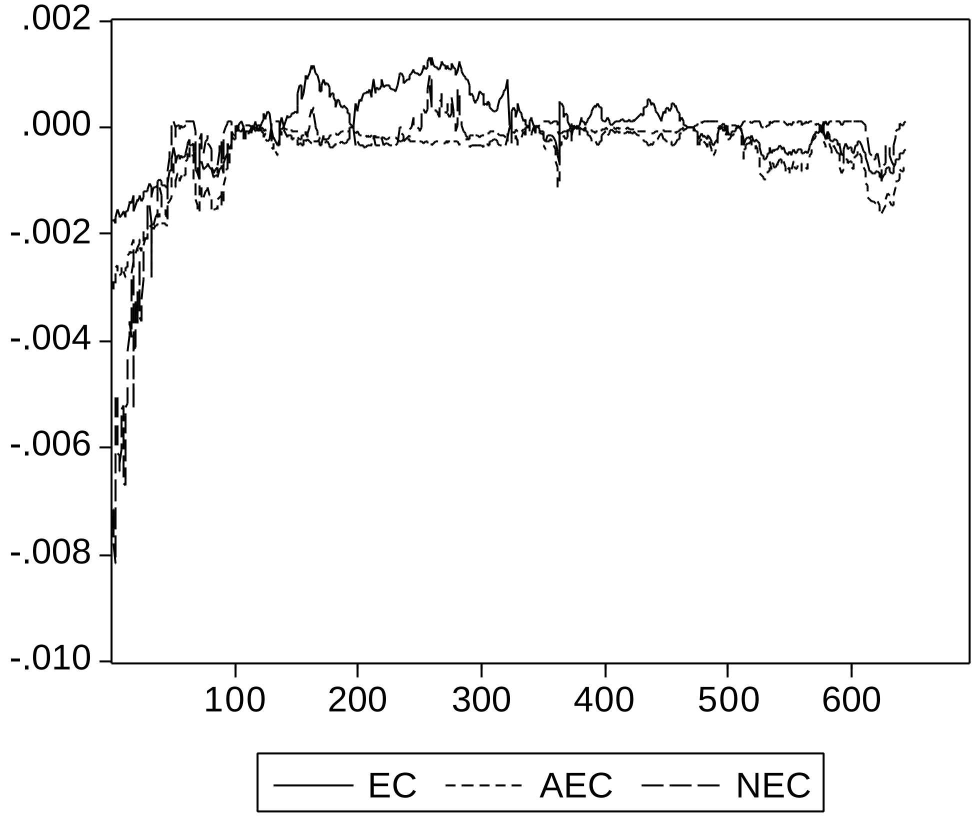
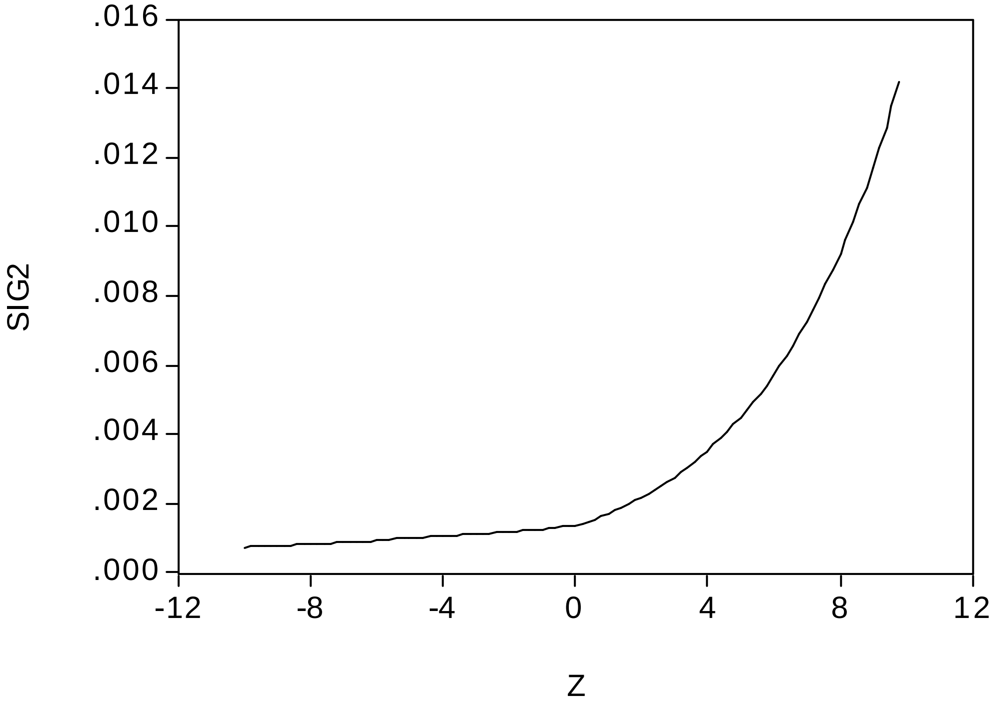


FIGURE 3: Estimated News Impact Curve from TGARCH



APPENDIX 1

Table 1: Data Statistics

The levels and the first difference of the series (period from 1/6/00 to 31/12/02)

	LGENERAL	LFTSE20	DLFTSE20	DLGENERAL
Mean	7.906188	7.305408	-0.001656	-0.00148
Median	7.880948	7.295308	-0.002394	-0.00207
Maximum	8.419543	7.829463	0.086787	0.076205
Minimum	7.454193	6.75338	-0.080191	-0.08059
Std. Dev.	0.250363	0.293077	0.016475	0.015995
Skewness	0.126852	-0.124461	0.528173	0.330906
Kurtosis	2.047701	1.969053	6.592779	6.250502
Jarque-Bera	26.10202	30.22939	376.3088	295.2675
Probability	0.000002	0	0	0
Sum	5099.491	4711.988	-1.066442	-0.95289
Sum Sq. Dev.	40.36686	55.31572	0.174521	0.16451
Observations	645	645	644	644

L GENERAL is the log of the General Index; LFTSE20 is the log of the FTSE20 and LFTSE Mid 40 is the log of FTSE Mid 40 and D denotes the first difference of the series.

Table 2: Unit Root Tests

	Levels	First Differences	Critical Values 1%
		ADF with intercept	
LGeneral	-1.157375	-23.23483	-3.44
LFTSE20	-0.718135	-22.96417	-3.44
		PP	
LGeneral	-1.221341	-23.33435	-3.44
LFTSE20	-0.729186	-23.03782	-3.44

ADF is the Augmented Dickey-Fuller Unit Root Test and PP is the Phillips-Perron Unit Root Test.

Table 3. Long-run relationship and cointegration

LGeneral=1.74+0.84*LFTSE20-0.044*D
Unit root test on the residuals of the LR relationship
ADF 2.84 (Critical Value 1% 2.56)
PP 2.79

D is a dummy variable introduced in the long run relationship and takes the value of 1 between 14/9/901 and 2/11/01

Table 4: Estimated Models

Sample 1/6/00-31/12/02- Dependent Variable D(LGeneral) Models	1. RW	2. GARCH(1,1)	3. EGARCH	4. TGARCH	5. ECM	6. AECM	7. NECM	
Constant	-0.00148	-0.001449	-0.00184	-0.00184	-0.001222	-0.000745	-0.000938	Constant
	(2.34)	(2.69)	(3.32)	(3.21)	(1.95)	(0.721)	(1.16)	
					0.274319	0.270364	0.263128	DLGENERAL(-5)
					(1.23)	(1.22)	(1.18)	
					0.092641	0.091901	0.091748	DLFTSE20(-1)
					(2.41)	(2.39)	(2.38)	
Variance Equation					0.126621	0.126236	0.123888	DLFTSE20(-4)
C		3.07E-05	-0.091643	1.89E-05	(3.13)	(3.305)	(3.23)	
		(3.52)	(2.64)	(3.45)	-0.323218	-0.319905	-0.314440	DLFTSE20(-5)
ARCH(1)		0.175279		0.089290	(1.5)	(1.485)	(1.45)	
		(5.66)		(4.46)		-0.042425		$z^{+}(-1)$
GARCH(1)		0.704630		0.772211		(0.888)		
		(12.87)		(19.76)		0.006490		$z^{-}(-1)$
|RES|/ SQR[GARCH](1)			0.105045			(0.129)		
			(8.33)		-0.018762		0.018387	z(-1)
RES/ SQR[GARCH](1)			-0.083038		(0.73)		(0.37)	
			(6.05)				-0.372770	$z(-1)^2$
EGARCH(1)			0.998425				(0.42)	
			(229.98)				-21.22782	$z(-1)^3$
(RESID<0)* ARCH(1)				0.151283			0.808)	
				(3.93)				
Adjusted R^2	0.0	-0.004691	-0.006772	-0.006770	0.023003	0.021988	0.022070	
SE of regression	0.01599	0.016033	0.016049	0.016049	0.015833	0.015841	0.015840	
Pr (J-B stat)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
SC	-5.42456	-5.548427	-5.557009	-5.554214	-5.402270	-5.392703	-5.384262	

Note: Numbers in ( ) are the corresponding *t* statistics, SC is the Schwartz criterion and SE is the Standard Error, z is the cointegration vector, RW is the random walk model, ECM is the linear Error Correction model, ACM is the asymmetric Error Correction Model and NECM is the non-linear error correction model. The "general-to-specific" approach was followed. The preferred model in each case was the one that min the SC. The sum of the GARCH coefficients (0.17+0.70) is less but close to one, suggesting that the GARCH process is stationary.

Table 5: Diagnostic Tests

	RW		GARCH		EGARCH		TGARCH	
	BOOTSTRAP	ASYMPTOTIC THEORY	BOOTSTRAP	ASYMPTOTIC THEORY	BOOTSTRAP	ASYMPTOTIC THEORY	BOOTSTRAP	ASYMPTOTIC THEORY
MCLEOD-LI TEST								
USING UP TO LAG 20	0.000	0.000	0.376	0.477	0.122	0.141	0.323	0.388
USING UP TO LAG 24	0.000	0.000	0.524	0.654	0.159	0.197	0.367	0.447
BICOVARIANCE TEST								
UP TO LAG 11	0.001	0.000	0.710	0.803	0.584	0.680	0.802	0.882
ENGLE TEST								
USING UP TO LAG 1	0.024	0.009	0.174	0.194	0.119	0.137	0.303	0.304
USING UP TO LAG 2	0.000	0.000	0.066	0.073	0.004	0.000	0.116	0.134
USING UP TO LAG 3	0.000	0.000	0.105	0.137	0.007	0.001	0.196	0.222
USING UP TO LAG 4	0.000	0.000	0.058	0.050	0.009	0.002	0.065	0.061
TSAY TEST	0.000	0.000	0.085	0.083	0.479	0.494	0.289	0.28

BDS		BOOTSTRAP											
Dimension		EPS=0.50	EPS=1.00	EPS=2.00	EPS=0.50	EPS=1.00	EPS=2.00	EPS=0.50	EPS=1.00	EPS=2.00	EPS=0.50	EPS=1.00	EPS=2.00
	2	0.001	0.001	0.001	0.717	0.829	0.854	0.604	0.747	0.907	0.858	0.856	0.781
	3	0.000	0.000	0.000	0.489	0.572	0.686	0.241	0.239	0.346	0.713	0.622	0.549
	4	0.000	0.000	0.000	0.372	0.472	0.547	0.072	0.107	0.241	0.645	0.531	0.438
		ASYMPTOTIC THEORY											
	2	0.000	0.000	0.000	0.959	0.956	0.828	0.655	0.788	0.914	0.865	0.861	0.802
	3	0.000	0.000	0.000	0.927	0.766	0.443	0.253	0.267	0.380	0.747	0.644	0.58
	4	0.000	0.000	0.000	0.853	0.676	0.449	0.045	0.100	0.259	0.687	0.57	0.483

Note: The standardised residuals of the GARCH, EGARCH and TGARCH are under investigation in this part. Following de Lima (1996), the BDS test was also calculated for the squared standardised residuals. The results were not altered and are available for the author. Only *p*-values are reported.

Table 6: Diagnostic Tests

		ECM			Asymmetric ECM			Non-Linear ECM		
		BOOTSTRAP	ASYMPTOTIC THEORY		BOOTSTRAP	ASYMPTOTIC THEORY		BOOTSTRAP	ASYMPTOTIC THEORY	
MCLEOD-LI TEST										
USING UP TO LAG 20		0.000	0.000		0.000	0.000		0.000	0.000	
USING UP TO LAG 24		0.000	0.000		0.000	0.000		0.000	0.000	
BICOVARIANCE TEST										
UP TO LAG 11		0.002	0.000		0.002	0.000		0.003	0.000	
ENGLE TEST										
USING UP TO LAG 1		0.006	0.001		0.006	0.001		0.005	0.001	
USING UP TO LAG 2		0.000	0.000		0.000	0.000		0.000	0.000	
USING UP TO LAG 3		0.000	0.000		0.000	0.000		0.000	0.000	
USING UP TO LAG 4		0.000	0.000		0.000	0.000		0.000	0.000	
TSAY TEST		0.000	0.000		0.000	0.000		0.000	0.000	
BDS		BOOTSTRAP								
Dimension		EPS=0.50	EPS=1.00	EPS=2.00	EPS=0.50	EPS=1.00	EPS=2.00	EPS=0.50	EPS=1.00	EPS=2.00
	2	0.012	0.000	0.000	0.014	0.000	0.000	0.010	0.000	0.000
	3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		ASYMPTOTIC THEORY								
	2	0.009	0.000	0.000	0.012	0.000	0.000	0.007	0.000	0.000
	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000