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HAS STOCK MARKETS' REACTION TO TERRORIST ATTACKS CHANGED THROUGH TIME? COMPARATIVE EVIDENCE FROM A LARGE AND A SMALL CAPITALIZATION MARKET

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Abstract: An expanding body of literature has addressed the question of the economic impact terrorist attacks have. A part of this literature has focused on the impact recent major terrorist hits had on financial markets. The question addressed by this paper is to what extent markets' reaction to major terrorist hits has changed over time. A large - the London stock exchange - and a small - the Athens stock exchange - capitalization market are used as the vehicles for the empirical investigation. Results from event study methodology as well as from conditional volatility models used here do no seem to point to any clear and unequivocal picture. Both markets appear to react selectively to terrorist events with no evidence of a noticeable change through time. Generally the effects appear to be transitory in both markets and seem to depend on the political and symbolic significance of the target hit. Market size and maturity also seem to influence the degree of the effects.

JEL Classification: G14, G21, C22
Key Words: terrorism, financial markets, volatility, event study

1. INTRODUCTION

With the predominance over the past decade or so of terrorism as the main international security threat, the number of papers that take up the issue of the economic effects of terrorist actions, and more broadly of the costs of thwarting terrorism, has steadily grown. In particular, recent terrorist mega-attacks such as 9/11; the March 2004 Madrid and July 2005 London bombings by transnational terrorist organisations and their local operatives, have spurred research on the direct and indirect economic consequences of terrorist hits. From early pioneering works such as Enders *et al*. (1992), Enders and Sandler (1991, 1996) to more recent studies such as Drakos and Kutan (2003), Blomberg *et al* (2004), Eckstein and Tsiddon (2004), Enders *et al.* (2006), Llorca-Vivero (2008), Abadie and Gardeazabal (2008), Larocque *et al*. (2010); the economic repercussions of terrorist actions have been studied for a number of countries and different economic sectors and activities such as for example tourism, FDI flows, macroeconomic performance.

A part this growing literature has focused its attention to the possible effects terrorist incidents can have on stock markets. As, among others, Carter and Simkins (2004), Chen and Siems (2004) note, from the markets' perspective, terrorist hits are important and momentous unforeseen events that can and do severely disrupt the normal, daily routine of economic life due to the havoc they generate since they destroy capital and infrastructure and cause widespread damages as well as losses of life. Among others, Asteriou and Siriopoulos (2003) point out that markets often reverberate and

echo major events that act as exogenous shocks the impact of which is not limited to the sphere of politics but has direct economic effects. Indeed, the agenda of terrorist organisations such as Al-Qaeda is to disrupt and destroy the daily economic and social routine of the targeted metropolitan centres that offer a target rich environment. Financial markets react both in terms of returns as well as volatility to external mega events such as a major terrorist attack. Empirical studies such as for example Nikkinen *et al*, (2008), Barros and Gil-Alana (2008), Eldor and Melnick (2004), Drakos (2004), Hon *et al* (2004), have set out to investigate the impact major terrorist incidents have on capital markets. For instance, Nikkinen *et al*, (2008) examine the effects of 9/11 on 53 markets world wide with results indicating increased volatility as well as short-run negative effects that varied across regions depending on the degree of their integration in the global economy. From a different angle, Hon *et al*. (2004) focus on how the cross-country correlation of assets was affected from this terrorist mega event. The 9/11 effects on the shares of the airline industry is the issue addressed by the studies of Drakos (2004) and Carter and Simkins (2004). Two other major terrorist hits, the March 2004 Madrid and July 2005 London bombings, and the reaction of the Spanish and London markets, is the theme of Kollias *et al*. (2010). Other studies, instead of focusing on the consequences of a single major terrorist incident have looked at how ongoing terrorist activity has affected financial markets. For instance, in the case of Israel, a country that over the years has fallen victim to numerous and frequent terrorist attacks that have caused thousands of casualties, a high

death toll and extensive damages, Eldor and Melnick (2004) investigate the impact that such hits had on Israel's foreign exchange and stock markets with findings indicating a permanent effect on both markets. The effects on global capital markets of major terrorist/military incidents dating back to 1915 is the theme of Chen and Siems (2004) using an event study methodology. They report a growing resilience of markets to major, unanticipated incidents. Evidence reported by Arin *et al*. (2008) in the case of six different financial markets shows that terrorist attacks have a significant impact on market volatility and returns with more pronounced effects in emerging markets. Adverse effects are also reported by Barros and Gil-Alana (2008) that investigate the effects that ETA terrorist actions had on the Basque country stock market.

Broadly in line with the latter studies, the question investigated here is not the effects on financial markets of a single terrorist mega attack but rather whether or not stock exchanges' reaction to terrorist activity has changed over time. To this effect, a number of different terrorist hits over the last twenty-five years are examined in the case of a large and a small capitalisation European market. The London and Athens stock markets are used as the vehicles for the purposes of this empirical investigation. A total of nineteen terrorist attacks, selected in terms of importance and magnitude, perpetrated both by domestic as well as transnational terrorist organisations, are used in order to address the issue at hand.

2. THE MARKETS AND THE TERRORIST INCIDENTS

Neither the UK nor Greece are strangers to terrorism. Over the years both countries have been the venue of terrorist activity both by domestic terrorist groups but also by transnational terrorist organisations such as Al-Qaeda in the case of the UK. Of the two countries it is the UK that has a much longer and bloodier history of terrorist activity both domestic as well as transnational. Over the years the UK has been the venue of some of the biggest terrorist hits worldwide both in terms of victims but also in terms of the symbolic significance of the targets that were chosen by the perpetrators. The Provisional Irish Republican Army (IRA), a paramilitary organisation aiming at removing Northern Ireland from the UK and bring about a united Ireland was the terrorist group that conducted a bloody campaign for around three decades both in the Northern Ireland and in England. It is estimated that IRA's terrorist attacks have caused the deaths of almost two thousand people both civilians and members various security forces. Perhaps the most significant attack in terms of symbolism was the Brighton Hotel bombing in October 1984 when the IRA attempted to assassinate Prime Minister Margaret Thatcher (Table 1). She narrowly escaped death but five people did loose their lives. Other IRA attacks have claimed the lives of military personnel, such as the September 1989 with eleven marines killed; politicians as in the case of the July 1990 assassination of a conservative MP; or civilians in a number of other cases as it can be seen in Table 1. Apart from domestic terrorism the UK has also been the venue of attacks by international terrorists with the most

prominent and heinous, that left scores of people dead, the 1988 and 2005 bombings. The first was a suitcase bomb aboard Pan Am Flight 103 over Scotland (town of Lockerbie) by Libyan state backed terrorists that caused the death of the 270 passengers and crew of the airplane. The more recent one, the July 7, 2005 conducted by Islamist extremists with Al Qaeda affiliations, targeted London's transportation system during the morning rush hour and left 56 dead and more than 700 injured (Table 1).

Table 1: Targets, casualties and perpetrators of the terrorist incidents

Date	Perpetrator	Target	Fatalities	Injuries
UNITED KINGDOM				
12/10/1984	IRA	Brighton Hotel bombing – attempted assassination of Prime Minister	5	5
21/12/1988	Libyan backed terrorists	Bomb onboard Pan-Am flight 103- Lockerbie Scotland	270	0
22/09/1989	IRA	Army barracks bombed	11	22
30/07/1990	IRA	Assassination of MP	1	0
10/04/1992	IRA	Bombing in St. Mary Axe in London	3	90
24/04/1993	IRA	Bombing in Bishopsgate, City of London	0	40
30/04/1999	White Wolves	Nail bomb in pub	2	30
03/08/2001	IRA	Central Criminal Court & Army recruitment office	1	238
07/07/2005	Al-Qaeda cells	London transportation system bombings	56	700
GREECE				
26/11/1985	N17	Police bus bombing	1	13
02/04/1986	Arab Revolutionary Cells	Bomb onboard TWA flight 840 en route from Rome to Athens	4	9
28/06/1988	N17	Car bomb kills US Defence Attaché	1	0
26/09/1989	N17	Assassination of MP	1	0
12/03/1991	N17	Bomb kills American serviceman	1	0
07/10/1991	N17	Assassination of Turkish Embassy employee	1	0
04/07/1994	N17	Assassination of Turkish diplomat	1	0
19/09/1994	ELA	Bombing of police bus	1	9
28/05/1997	N17	Prominent businessperson assassinated	1	0
08/06/2000	N17	British Defence Attaché assassinated	1	0

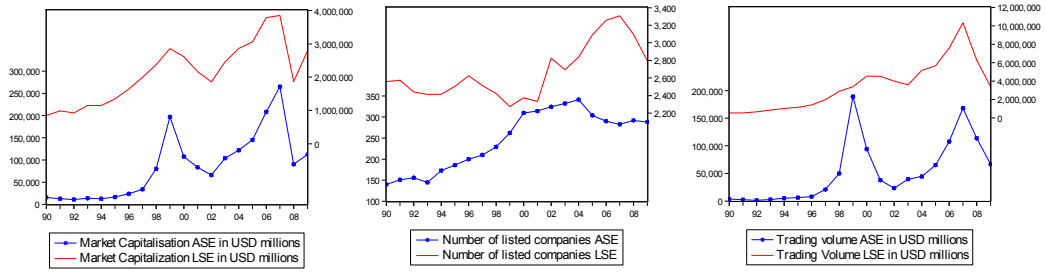
In comparison, the terrorist hits in Greece have not been as bloody in terms of victims. The choice of targets, however, has often been quite significant since it involved the assassination of diplomatic emissaries such as for example the US and British Defence Attachés in June 28, 1988 and June 8, 2000 respectively; US military personnel in March 1991; personnel of the Turkish Embassy in October 1991 and July 1994; or politicians as in the case of the September 1989 assassination of a member of Parliament; prominent businesspeople as in the case of the May 1997 assassination. With the exception of a hit by international terrorists with a bomb aboard a TWA flight that killed four US citizens in April 1986; all other terrorist incidents had domestic perpetrators (Table 1). November 17th (N17) and the Revolutionary People's Struggle (ELA) are the two main domestic terrorist groups that operated in Greece in the last three decades or so with the former being the most active and responsible for the death of twenty three people. The latter was considered to be an ideological and operational off-spring of N17 and has generally been less active and lethal.

Table 2: Main stock market indicators: Average annual values for the period 1990-2009

	ASE	LSE
Total Value of Share Trading (Domestic & Foreign, including Investment Funds, in USD millions)	52.585,45	3.480.173,25
Total Number of Listed Companies (Domestic & Foreign, Main & Parallel Markets)	247	2667
Domestic Market Capitalization (Main & Parallel Markets, in USD millions)	86.004,59	2.130.057,03

In the section that follows, the effects of the terrorist attacks presented in Table 1 will be investigated in the case of the London and Athens stock exchanges (henceforth LSE and ASE). The former is a large capitalisation mature market, one of the three most important stock exchanges internationally, with a current capitalisation over $3,500 billion and approximately 1,800 listed companies. By comparison, as it can be seen in Table 2, the ASE is a midget both in terms of capitalisation as well as the number of listed companies. It has around 4% of the capitalization of the LSE and presents a much lower trading activity, for the period 1990-2009. Thus, the sheer difference in size adds a further interesting twist since, apart from examining possible changes in how markets reacted overtime to the exogenous shocks of terrorist hits; we will also look at whether size and maturity are also factors that affect markets' reaction. The evolution of the main indices that describe and encapsulate the two markets' differences is graphically presented in Figure 1.

Figure 1: Trading volume, Capitalization and number of listed companies in LSE and ASE for the period 1990-2009.



3. METHODOLOGY, EMPIRICAL FINDINGS AND DISCUSSION

A two step methodology is used to address the issue at hand. First, in line with other studies such as for instance Chen and Siems (2004), we employ event study analysis to investigate the effect of the terrorist events on the two stock markets. Following this, conditional volatility models are estimated in order to see their effect on stock market volatility.

The event study methodology is based on the effective markets hypothesis (Fama *et al.*, 1969). Essentially, it assumes that as new information becomes available as a result of an important unpredictable event, market agents will take it into consideration and will re-evaluate the individual firms and their ability to operate efficiently given the economic, environmental, political, social and demographic changes that an exogenous event may bring about. The power of this methodology is based on its ability to trace such "abnormal" changes, because it follows the general valuation of many investors that (re)examine quickly all the available data for the estimation of the market value of each traded stock (Schwert, 1981). The daily excess

returns (abnormal returns) are measured by the mean-adjusted-returns approach (MacKinlay, 1997); that is for each day at, and following, the event, we computed:

$$AR_t = R_t - \overline{R} \quad (1)$$

Where AR_t is the abnormal return for the stock index at time t, R_t is the actual observed rate of return for this index, and $\overline{R}$ is the mean of this index daily returns in the (-30,-11) estimation period.

$$\overline{R} = \frac{1}{20}\sum_{t=-30}^{11} R_t \quad (2)$$

Initially, the event-day abnormal returns are calculated. Given that the event date is at t=0, and following Chen and Siems (2004), the mean adjusted returns model is estimated over 20 days, from t=-30 to t=-11. Moreover, we examine two longer event windows to see how quickly the market absorbs the consequences from the events considered here. The two longer event windows are examined by estimating the cumulative average abnormal returns (CARs) 5 days (t=5) and 10 days following the event (t=10). The cumulative abnormal returns (CARs) were estimated as follows:

$$CAR_t = \sum_{t=T_1}^{T_2} AR_t \quad (3)$$

Where T_1 is the event day and T_2 is consequently 5 and 10 days after the event. The statistical importance of the abnormal returns for the period examined here was estimated for each sample, using the statistics described by Brown and Warner (1985).

Table 3: Event study results for LSE and ASE

Event Date	Event-day AR	6-day CAR	11-day CAR	Event description
London Stock Exchange				
12/10/1984	0,02%	-3,61%	-2,71%	Attempted assassination of Prime Minister
	(0.03)	(-4.60)*	(-3.45)*	
21/12/1988	-0,07%	1,72%	5,68%	Pan Am flight 103- Lockerbie Scotland
	(-0.10)	(2.64)*	(8.68)*	
22/9/1989	-0,57%	-4,74%	-7,18%	Army barracks bombed
	(-0.62)	(-5.15)*	(-7.81)*	
30/7/1990	-0,56%	-3,98%	-3,96%	Assassination of MP
	(-0.58)	(-4.09)*	(-4.07)*	
10/4/1992	5,62%	8,05%	11,10%	Bombing in St. Mary Axe in London
	(5.10)*	(7.30)*	(10.08)*	
24/4/1993	-0,53%	-0,05%	3,39%	Bombing in Bishopsgate, City of London
	(-0.88)	(-0.08)	(5.65)*	
30/4/1999	0,63%	-3,31%	-7,09%	Nail bomb in pub
	(0.55)	(-2.91)*	(-6.22)*	
8/3/2001	0,26%	-5,92%	-7,66%	Criminal Court & Army recruitment offices
	(0.17)	(-3.81)*	(-4.93)*	
7/7/2005	-1,49%	-0,84	-1,27	London transportation system bombings
	(-2.89)*	(-1.64)	(-2.47)*	
Athens Stock Exchange				
26/11/1985	0,57%	0,54%	-0,58%	Police bus bombing
	(1.33)	(1.26)	(-1.37)	
2/4/1986	0,47%	0,07%	0,84%	TWA flight 840 en route from Rome to Athens
	(1.37)	(0.20)	(2.46)*	
28/6/1988	-0,89%	-2,38%	-2,21%	Car bomb kills US Defence Attaché
	(-0.91)	(-2.42)*	(-2.25)*	
26/9/1989	-1,59%	6,45%	1,37%	Assassination of prominent MP
	(-0.51)	(2.07)*	(0.44)	
12/3/1991	-3,85%	-14,52%	-18,14%	Bomb kills American serviceman
	(-1.70)	(-6.41)*	(-8.01)*	
7/10/1991	2,00%	1,06%	1,98%	Assassination of Turkish Embassy employee
	(1.70)	(0.90)	(1.67)	
4/7/1994	-0,14%	1,89%	3,01%	Assassination of Turkish diplomat
	(-0.14)	(1.88)	(2.99)*	
19/9/1994	1,44%	1,15%	4,77%	Bombing of police bus
	(2.03)*	(1.63)	(6.74)*	
28/5/1997	-0,45%	-7,98%	-11,51%	Prominent businessperson assassinated
	(-0.25)	(-4.55)*	(-6.57)*	
8/6/2000	0,67%	-1,01%	-9,87%	British Defence Attaché assassinated
	(0.50)	(-0.75)	(-7.34)*	

Broadly speaking, from the event study findings presented in Table 3, it appears that no unequivocal picture and clear pattern emerge as to the markets' reaction to the events. In the case of the LSE in five out of the nine events - 12/10/1984, 22/09/1989, 30/07/1990, 30/04/1999, 08/03/2001 – the reaction is found to be negative and significant but not on the same day of the occurrence of the event. The 6-day CARs for these five incidents are negative and significant and only in the case of the recent terrorist bombings in July 2005 does the market record a same day significant negative reaction. Strikes at targets with strong political symbolism, as in the case of the 1984 Brighton Hotel bombing that threatened the life of the British Prime Minister and the 1990 assassination of a Conservative MP cause, as one would intuitively expect, a strong negative reaction. It is also quite possible that such attacks on targets that can hardly be considered as soft are regarded as indications of increased operational capability by the terrorists and thus they further augment markets' reaction. The number of fatalities may explain the reaction in the case of the 1989 event as well as the type of the target – military barracks – that again be seen as revealing increased and effective operational capabilities. An explanation along the same lines may also be advanced in the case of the 2001 incident. But this leaves the findings for the 1992 and 1993 attacks a bit difficult to explain given the similarities in terms of symbolism of the targets. The negative and significant CARs for the 1999 attack, which is not an IRA operation, are also difficult to explain given that it neither had a strong symbolism in terms of the target nor did it cause many fatalities.

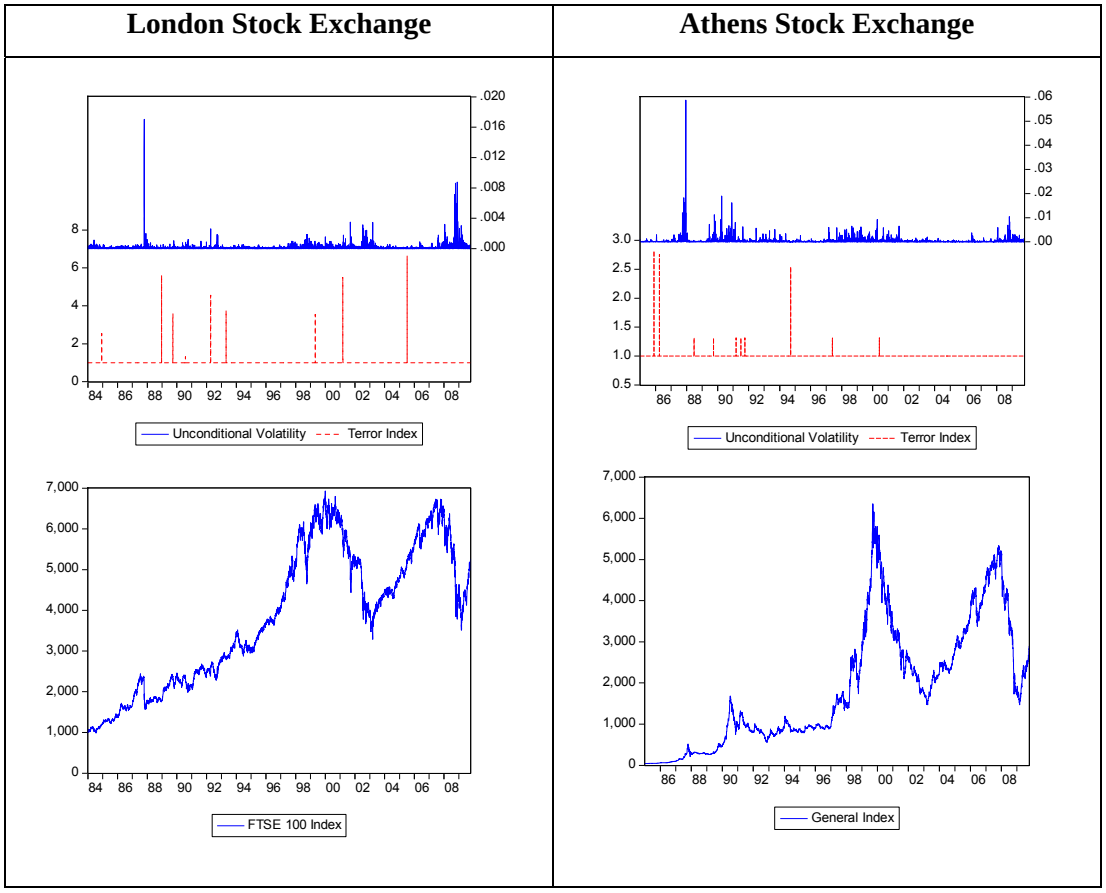
Counterintuitive are also the findings in the case of the Pan-Am flight 103 that was brought down near the Scottish town of Lockerbie by a suitcase bomb aboard the aircraft killing 270 people including eleven people on the ground. It was by far the bloodiest in terms of victims attack in the UK. A tentative explanation is that this hit took place just before Christmas and thus the vacation lull did not offer ample time for market agents to react. By the time markets fully reopened the immediate fallout of the incident probably had already been absorbed.

Turning to the findings for the ASE a broadly similar hazy picture seems to emerge on the basis of the event study results (Table 1). On three occasions – the terrorist hits of 28/6/1988, 12/3/1991 and 28/5/1997 – does the market present a significant negative reaction in terms of the 6-day CARs. The fact that the victim of the 1997 assassination attack was a prominent businessperson probably adequately explains the strong negative 6- and 11-day CARs. The other two events involved the death of an American citizen: the US Defence Attaché in 1988 and a serviceman in 1991. The fact that US citizens were the victims of the attacks probably offers an adequate explanation for the market's reaction as this is recorded by both the 6- and 11-day CARs. Oddly enough, this is not the case of the 2000 assassination by N17 of the British Defence Attaché in Athens although, in this case, the 11-day CARs are also found negative and significant. One may tentatively interpret this finding as a reaction by the market to the stern international political pressure that gradually built demanding more effective antiterrorist measures

and policy by the Greek authorities given the fact that N17 had operated for all the previous years with complete impunity. Worth noting is also the fact that no significant reaction is found for two other incidents where foreign diplomats were the victims. In October 1991, a few months after the US serviceman was killed, a Turkish embassy employee is assassinated and in July 1994 a Turkish diplomat is the victim of N17's operation. On both occasions, no significant negative reaction is found. Similar is the finding in the case of the assassination of the prominent MP in 1989 with no negative reaction recorded in the ASE although the attack strongly stirred the political scene at the time. No strong reaction is also the case when the police are the target of the attacks as in the case of the November 1985 and September 1994 bombings that each killed a policeman. On the whole, it would appear that, in the case of the ASE, a strong negative reaction is recorded whenever the targets of the terrorist attacks are foreign nationals and in particular US citizens given the importance of the Greek-US bilateral relations. Perhaps, a noteworthy difference with the LSE is that the reaction of the ASE, when present, is much more pronounced and strong as this is reflected in the 6- and 11-day CARs. The political and economic significance of the targets that trigger a reaction as well as the maturity and size of the market in terms of trading and capitalisation vis-à-vis LSE probably explain this difference in our findings. This is broadly line with the results reported by Arin *et al*. (2008) where they conclude that the impact of terrorist incidents seems to be larger in emerging markets.

We now proceed with the second stage of our investigation since the event study methodology employed thus far does not offer any insights on the volatility of the markets on the days of the events. Thus conditional volatility models were used. To start with, the unconditional stock return volatility, the terror index and the two general indices are shown in Figure 2. The terror index is constructed following the methodology of Eckstein and Tsiddon (2004) whereby the daily index is defined as the natural logarithm of (e + number of fatalities +number of injuries) that occurred each day. The terror events that took place during the weekend are summed up to the previous Friday's figure. This will be introduced in the conditional volatility analysis that follows.

Figure 2: Unconditional volatilities, terrorist events and stock prices in LSE and ASE



Observing high frequency financial series we often see that their volatility is time varying and that volatility clustering is also a frequent phenomenon. This roughly suggests that big changes tend to be followed by big changes and small changes are followed by small ones. Therefore there exists a time dependence on the variance of the series. Over the last two decades, ARCH and GARCH models, developed by Engle (1982) and Bollerslev (1986) respectively, became the dominant tools in modelling time varying volatilities in stock markets. Given the difficulty in optimal lag length selection in ARCH models, and ensuring the non-negativity of the coefficients on the conditional variance equation, Bollerslev's (1986) GARCH model is more frequently used in empirical finance. Thus, in our study in order to investigate the effect of the terror events on the stock markets' volatility a model of the following form for the mean and the variance is estimated:

$$R_t = b_0 + b_1 R_{t-1} + b_2 D_t^{19101987} + \varepsilon_t,\ \varepsilon_t \sim N(0, h_t) \tag{4}$$

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \sum_{i=1}^{n} \delta_i D_{i,t} \tag{5}$$

Where R_t, is the daily return for the stock index and R_{t-1} its one period lag value, and $D_t^{19101987}$ a dummy for the "black Monday" of October 1987, and ε_t is the error term with conditional mean zero and conditional variance h_t.

In line with previous studies, (*inter allia*: Athanassiou *et al*., 2006; Shawkat and Huimin, 2008; Kollias *et al*., 2010) equation (5), is a GARCH(1,1)

model, augmented with the dummies for the exogenous shocks. The variable $D_{i,t}$ takes the values of 1 on the event day *i*, in order to quantify any possible effect of the terrorist event on conditional volatility. However, by just including such dummies, all the events are treated equally. Thus, in order to allow for the significance of the incident as this is reflected in the number of victims and following Eckstein and Tsiddon (2004), the terror index referred to earlier was included in the variance equation:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \lambda_1 Ter_t \quad (6)$$

Where, $\alpha_0 > 0$, $\alpha_1 > 0$, $\beta_1 > 0$ are the required conditions for the variance to be positive while the stability condition is $\alpha_1 + \beta_1 \leq 1$. This sum is also called persistence, and the long-term prediction of the variance is α_0.

However, the GARCH model imposes symmetry on the conditional variance that might not be appropriate for the prediction of return volatility. Therefore, Nelson (1991) introduced the exponential GARCH model and proposed a way to examine the asymmetry, allowing negative and positive shocks to have different results. The logarithmic construction of variance equation ensures that the evaluated conditional variance is strictly positive and therefore the non-negativity constrains used in the estimation of the GARCH models, are not necessary. Under the standard EGARCH(1,1) the conditional variance is given by:

$$h_t = \alpha_0 + \alpha_1 \cdot \left[\frac{|\varepsilon_t|}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}} \right] + \beta_1 \cdot \log(h_{t-1}) + \gamma_1 \cdot \left[\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \right] \qquad (7)$$

Where $\alpha_0, \alpha_1, \beta_1, \gamma_1$ are constant parameters. Since the parameter γ_1 typically enters equation (7) with a negative sign, bad news ε_{t-1} generates more volatility than good news. In our study, equation (7) is augmented by including the dummy variables in one case, and the terror index in the other case, as we did before with the symmetric GARCH(1,1), in order to take into account the terror exogenous shocks. The estimated results for the alternative conditional volatility models, including the GARCH and EGARCH versions with and without exogenous shocks, are presented in Tables 4 and 5. The left-hand panel of theses tables displays the results of estimating the standard GARCH(1,1) model without taking into account the exogenous shocks, while the next columns refers to the GARCH model augmented with the terror index and the dummies respectively. The same is followed for the EGARCH model for each of the two markets.

Looking at Table 4 where the LSE findings are presented it appears that the impact of the constructed terror index is statistically significant in the symmetric GARCH model. The estimation broadly yields similar results when the dummy variables are introduced instead of the terror index. However, as it can be observed, not all the dummies are significant. In particular, the GARCH results indicate that the April 1992 and April 19993 bombings in St. Mary Axe and Bishopsgate respectively do not seem to have impacted the market's volatility. No effect on returns was also the finding for

these two incidents in the event study results reported in Table 3 earlier. No effect on volatility is also the finding for the 2005 attacks on the London transportation system as the GARCH results show. These findings suggest that not all the events have an equal impact on the stock market's volatility. A further interesting finding is that, when the EGARCH model is estimated, the factor responsible for asymmetric behaviour is found statistically significant, but the terrorist incidents variables are not. This means that the exogenous security shocks variable in this model captures the asymmetric effects on stock market volatility caused by the terrorist incidents.

Table 4: Conditional Volatility with & without exogenous shocks for LSE

Model	GARCH(1,1)						EGARCH(1,1)					
	Without Exogenous Shocks		With Terror Index		With Dummies		Without Exogenous Shocks		With Terror Index		With Dummies	
The conditional mean model												
b_0	0.0005	(0.00)	-0.0003	(0.10)	0.0004	(0.00)	0.0003	(0.00)	0.0003	(0.00)	0.0003	(0.00)
b_1	0.0144	(0.38)	-0.0163	(0.65)	-0.0182	(0.50)	0.0178	(0.24)	0.0178	(0.24)	0.0164	(0.28)
b_2	-0.0884	(0.00)	-0.1216	(0.00)	-0.1184	(0.00)	-0.0872	(0.00)	-0.0872	(0.00)	-0.0873	(0.00)
The conditional variance model												
α_0	1.43E-06	(0.00)	0.0001	(0.00)	7.61E-05	(0.00)	-0.2443	(0.00)	-0.3739	(0.00)	-0.2461	(0.00)
α_1	0.0875	(0.00)	0.1465	(0.00)	0.1300	(0.00)	0.1427	(0.00)	0.1416	(0.00)	0.1415	(0.00)
β_1	0.8999	(0.00)	0.5779	(0.00)	0.5047	(0.00)	0.9858	(0.00)	0.9862	(0.00)	0.9858	(0.00)
γ							-0.0574	(0.00)	-0.0572	(0.00)	-0.0550	(0.00)
λ_1			-2.40E-05	(0.00)					0.1337	(0.16)		
δ_1 - 12/10/1984					-1.36E-04	(0.00)					0.9061	(0.18)
δ_2 - 21/12/1988					-1.54E-04	(0.00)					0.3367	(0.40)
δ_3 - 22/09/1989					-1.35E-04	(0.00)					0.6096	(0.26)
δ_4 - 30/07/1990					-1.54E-04	(0.00)					0.5074	(0.43)
δ_5 - 10/04/1992					4.39E-05	(0.98)					1.0644	(0.35)
δ_6 - 24/04/1993					-1.16E-04	(0.37)					0.1734	(0.81)
δ_7 - 30/04/1999					-1.93E-04	(0.00)					0.0507	(0.93)
δ_8 - 03/08/2001					-1.29E-04	(0.00)					1.2096	(0.00)
δ_9 - 07/07/2005					-6.52E-05	(0.46)					0.1901	(0.83)
Akaike info criterion	-6.544486		-6.28442		-6.216468		-6.550248		-6.55136		-6.550991	
Schwarz criterion	-6.538408		-6.27733		-6.201272		-6.543157		-6.54325		-6.534782	

Note: Figures in parentheses are the probability values of the t-statistics

Turning to the results in the case of the ASE in Table 5, it can be seen that the terrorist variables significantly affect stock market volatility. Again, as one would expect, not all incidents have the same effect on the conditional

volatility of the market. The assassination of the US and British Defence Attachés in June 1986 and June 2000 seem to have a strong impact on volatility both in the GARCH and EGARCH results offering further evidence in support of the argument that the political importance of the targets hit is a factor that has strongly impacted ASE's reaction to such exogenous shocks. The TWA event in April 1986 also seems to have had a noteworthy effect on ASE's volatility as the results of both the GARCH and EGARCH models indicate. Finally, an interesting observation from the reported results in Table 5 is that, in the case of ASE, bad news do not seem to have a greater impact on stock market volatility compared to the good news.

Table 5: Conditional Volatility with & without exogenous shocks for ASE

Model	GARCH(1,1)						EGARCH(1,1)					
	Without Exogenous Shocks		With Terror Index		With Dummies		Without Exogenous Shocks		With Terror Index		With Dummies	
The conditional mean model												
b_0	0.0005	(0.00)	0.0004	(0.11)	0.0009	(0.00)	0.0005	(0.00)	0.0005	(0.00)	0.0006	(0.00)
b_1	0.1937	(0.00)	0.1867	(0.00)	0.1820	(0.00)	0.1986	(0.00)	0.2005	(0.00)	0.2342	(0.00)
b_2	0.0626	(0.32)	-0.0279	(0.83)	-0.0081	(0.30)	-0.0771	(0.25)	0.0663	(0.37)	-0.0608	(0.23)
The conditional variance model												
α_0	3.78E-06	(0.00)	0.0002	(0.00)	2.46E-04	(0.00)	-0.4409	(0.00)	0.1964	(0.51)	-4.9222	(0.00)
α_1	0.1614	(0.00)	0.2046	(0.00)	0.1358	(0.00)	0.2862	(0.00)	0.2850	(0.00)	0.6041	(0.00)
β_1	0.8405	(0.00)	0.5856	(0.00)	0.5494	(0.00)	0.9729	(0.00)	0.9722	(0.00)	0.4618	(0.00)
γ							-0.0045	(0.77)	-0.0068	(0.67)	-0.0191	(0.51)
λ_1			-8.98E-05	(0.00)					-0.6419	(0.03)		
δ_1 - 26/11/1985					-0.000549	(0.90)					-3.1802	(0.00)
δ_2 - 02/04/1986					-0.000548	(0.00)					-4.7124	(0.00)
δ_3 - 28/06/1988					-0.000529	(0.00)					-1.4572	(0.00)
δ_4 - 26/09/1989					0.000292	(0.70)					0.3735	(0.67)
δ_5 - 12/03/1991					-0.000613	(0.12)					-0.2161	(0.40)
δ_6 - 07/10/1991					-0.000398	(0.00)					-0.1643	(0.57)
δ_7 - 04/07/1994					-0.000522	(0.00)					-0.1753	(0.47)
δ_8 - 19/09/1994					-0.000552	(0.00)					-4.9946	(0.00)
δ_9 - 28/05/1997					-0.00058	(0.00)					-0.7838	(0.50)
δ_{10} - 08/06/2000					-0.000528	(0.00)					-1.1229	(0.00)
Akaike info criterion	-5.762291		-5.60628		-5.144777		-5.752749		-5.75378		-6.550991	
Schwarz criterion	-5.756004		-5.59894		-5.128009		-5.745413		-5.7454		-6.534782	

Note: Figures in parentheses are the probability values of the t-statistics

Comparing the results for UK and Greece, it appears that the latter presents evidence of a lower degree of market efficiency due to the significance of past returns in the mean equation as well as the fact that the information concerning volatility observed in the previous period (the ARCH term, *a*) has a higher effect on volatility. Nevertheless, when it comes to volatility persistence the two stock exchanges present a fairly similar behaviour. As demonstrated by Aggarwal *et al.* (1999) and Malik (2003) persistence of volatility decreases dramatically when regime shifts are included in a GARCH model. Our results, indicates that the inclusion of the terror index or dummies for capturing the impact of exogenous shocks, have also significantly reduced the persistence of volatility, implying that these events are responsible for a significant part of volatility persistence.

4. CONCLUDING REMARKS

This paper set out to examine the extent to which stock markets' reaction to terrorist violence has changed over time. A large (the London stock exchange) and a small (the Athens stock exchange) capitalization market were used as the vehicles for the empirical investigation. Findings of both the event study methodology, as well as the conditional volatility models used here, do no seem to point to any clear and unequivocal picture or pattern. Both markets appear to react selectively, either in terms of returns or in terms of volatility, to terrorist incidents and this reaction does not

present any noteworthy change over time. The political significance of the target hit, such as for example the attempted assassination of the UK's Prime Minister in the 1984 Brighton Hotel bombing or the 1990 assassination of a conservative MP, seem to be the terrorist incidents that mostly rattled the LSE and so did successful attacks on hard targets such as courts and military buildings. But the effect was generally transitory and it would appear that overtime resilience to such incidents has grown judging from the findings in the case of the 2005 bombings by muslim extremists. Perhaps, a clearer pattern is the case for the ASE and pointing to a similar conclusion when it comes to the political significance of the targets hit. Targets with a key political importance, such as the assassination of foreign citizens and in particular US and European diplomatic and military personnel seem to have been the events that mostly affected ASE but interestingly not so when Turkish Embassy personnel was the target despite the tense bilateral relations between the two countries. The same strong negative reaction was the case when a prominent businessperson was the victim but not when a prominent politician and serving MP was killed. Again, there is no evidence of any significant or noteworthy change in ASE's reaction over time.

Therefore, it appears, that a common feature in the results for both markets is that the political significance of the targets and/or the victims of the terrorist attacks is the factor that triggers the greatest reaction. A further finding of the results reported herein worth mentioning is that the smaller of the two markets, i.e. ASE, was the one that exhibited a greater reaction,

whenever affected, to terrorist events. As other studies have also reported, size and maturity appear to emerge as two possible determinants of markets' reaction to terrorist attacks.

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