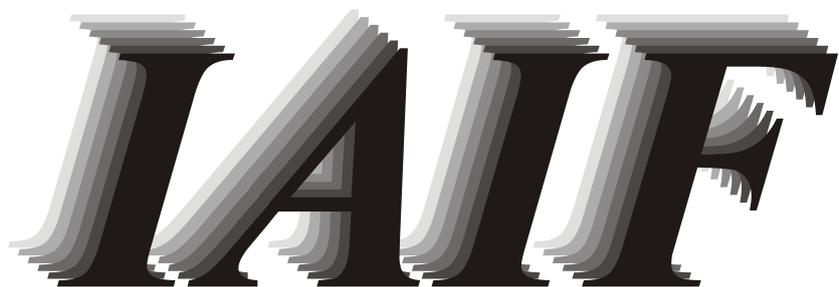


THE IMPACT OF TERRORISM ON STOCK MARKETS: THE BOSTON BOMBING EXPERIENCE IN COMPARISON WITH PREVIOUS TERRORIST EVENTS

THOMAS BAUMERT, MIKEL BUESA AND TIMOTHY LYNCH

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Facultad de Ciencias Económicas y Empresariales. Campus de Somosaguas. 28223 Madrid.
Fax: 91 3942457
Tel: 91 3942456
Director: Joost Heijs
e-mail: joost@ccee.ucm.es
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* Universidad Católica de Valencia; ** Universidad Complutense de Madrid;
*** Siena College

ABSTRACT

The present paper studies the impact of the Boston bombings on the main international stock markets, comparing it with that of previous terrorist attacks (9/11, 3/11 and 7/7). In order to properly embed our analysis in the theoretical framework, first we present an overview of earlier studies centered on the repercussion of terrorism on financial markets. The empirical part consists in measuring whether the return of the main index of New York stock Markets resulting from the attacks differ statistically regarding the variations of the 30 trading days before the attack. In addition, we also study the intraday data, contrasting the direct impact of news spread through social media affected the index of the New York stock market. Finally we also take into consideration the repercussion of the fake tweet about an alleged terrorist attack on the White House hurting president Obama and compare its impact with that of the Boston bombing. The analysis of the results offers some interesting interpretative hypotheses involving an evolution in the behavior of the stock markets in response to the terrorist attacks.

KEY WORDS

Terrorism, stock markets, financial markets.

RESUMEN

El presente documento estudia el impacto de los atentados de Boston sobre los principales mercados financieros internacionales, comparándolo con el de sucesos terroristas anteriores (11-S, 11-M y 7-J). A fin de enmarcar nuestro análisis en un marco teórico adecuado, revisamos, en primer lugar, aquellos otros trabajos que han estudiado la repercusión de los ataques terroristas sobre los mercados de valores. La parte empírica consiste en medir si la variación de los principales valores de la bolsa de Nueva York difiere de forma estadísticamente significativa de la de las treinta sesiones anteriores a los ataques. A su vez, estudiamos los datos intradía, contrastando el impacto directo de las noticias que fueron difundidas por medio de las redes sociales, también comparamos el fenómeno con el impacto del falso tweet anunciando un supuesto atentado contra la Casa Blanca en el que resultó herido el presidente Obama.

Del análisis de los resultados podemos avanzar algunas hipótesis interpretativas interesantes que involucran una evolución en el comportamiento de los mercados de valores en respuesta a los atentados terroristas.

PALABRAS CLAVE

Terrorismo, mercados de valores, mercados de financieros.

INTRODUCTION

In the morning of that picturesque Boston spring day, with blue skies, the sun shining, and a slight spring breeze, no one could have predicted how different the city's mood would change just a few hours later. As every year, on the third Monday of April, the state of Massachusetts (along with Wisconsin and Maine) celebrated Patriots' Day, commemorating the anniversary of the first battles of the American Revolution.¹ Behind the Fourth of July, it is essentially the most patriotic holiday in America, hence its name. At the same time, for Bostonians the day symbolizes the unofficial beginning of spring — even though spring officially begins three weeks before. Added to that, it is also the day of the Boston Marathon, the oldest and most popular marathon in the United States. People come from all parts of the country and the world to take part in the great tradition of the Marathon and to see the city of Boston. And along with the participants, thousands of people line the streets to cheer on their friends, family, and other runners, as well as to take part in the Patriots' Day festivities.

* * *

However, on April 15, 2013, a pair of terrorists decided to take this staple in Massachusetts tradition and turn it into nightmare. At approximately 2:50 p.m. (around 4 hours and 15 minutes into the race) a large explosion went off near the finish line on Boylston Street, followed by another, seconds later on that very street.² Runners and spectators ran in terror and shock. Those who were able made their way to the nearest hospital to begin donating blood, including runners who had just finished the race. At this point the extent of the attack was not known, thus spreading fear and worry in the hearts of Bostonians and people all over the world.

The following hours were incredibly hectic in the city: other explosive devices were being reported to be found in the surrounding areas, a third explosion — which later turned out to be unrelated to the attack — went off at the JFK Library, and the cellphone services were inhibited in order to avoid the use of another detonation device. Suddenly, the attack brought back memories of 9/11 and people began to question if this was an Al-Qaeda related attack, evoking fears that the citizens of the U.S. had been able to overcome.

¹ The Battles of Concord and Lexington which occurred on April 19, 1775. It is a day to look back on the success and the freedom the United States gained from their fight with the British, which led to the creation of the United States we know today.

² Sporting events have been a common place for terrorist attacks to occur. With thousands of people watching and being such a popular escape from every-day life, terrorist have used them in order to send their message. Prominent attacks on sporting events include: the 1972 Munich Olympics (where members of the Palestinian organization Black September held members of the Israeli national team hostage, eventually killing 11 athletes and coaches, along with one German police officer); the 1996 Atlanta Olympics bombing (carried out by Eric Rudolph who killed 2 and injured another 100-plus people with his bomb); the car bomb detonated by ETA on May 1, 2002 at Bernabeu Stadium in Madrid before Real Madrid's semi-final Champions League game against Barcelona; the reschedule of the Paris-Dakar Rally in 2008 —for the first time after 30 years— due to the threat of an Al Qaeda attack (causing a major economic loss); and the suicide bomber attack, on April 8, 2006, of the Sinhala and Tamil New Year Marathon in Sri Lanka (killing 15 and injuring another 90 people). For a more detailed analysis regarding the relation between sports and terrorism, see, among others, Giulianotti and Klauser (2012) and Hassan (2012).

The fright and uncertainty caused by the attack was not just injected into the general public, but also into the stock markets. This can be seen by the 1.97 per cent point drop that occurred in the Dow Jones Industrial Average on the that day — of which, more specifically, 120 points or 0.82 per cent were due to the attacks —, as well as on the losses in the European and Japanese indices. While there are probably other factors that caused these point losses, it is undoubtable that the fear and questions regarding the perpetrators of the attack and what would follow (Was it Al-Qaeda? Will there be another attack? If so when?) caused uncertainty and volatility in the world stock markets (for a detailed time-line of the events, see table 1).

What makes this recent attack particularly interesting was not just how it initially reacted to the news, but also how it was affected by the real time information given by social media websites like Twitter. In recent terrorist attacks like 9/11 or the Madrid Train Bombings (3/11) or the London Bombings (7/7), social media was nowhere near as prominent in society as it is today. And because of this, in the past the stock markets were blind to emerging details about the attacks for some time. However now, with the number of people using social media websites, the Boston Police Department utilized Twitter to communicate to the public, including the stock markets, real time details of the attack. This includes information regarding the number of injuries and deaths, and who may or may not have committed the crime. As mentioned in a previous study about the Madrid March 11 attacks, “there were two factors which had a significant influence on [market movements]: the number of victims — the only objective measurement available to investors when quantifying the magnitude of the attacks — and who was being accused of perpetrating them” (Baumert, 2009:125-126). With that information now readily available to the general public and the stock markets through the use of social media, it can be seen when drops occur in the markets and what news corresponds with those decreases, a study previously only applied to the case of the Madrid bombings (Baumert, 2009). Thus, this paper will examine both the overall effect that the Boston bombings had on the international markets and, more specifically, the way in which the real time flow of information through forums like social media was reflected in the (intraday data) index of the New York Stock Exchange.

HOW STOCK MARKETS REACT TO TERRORIST ATTACKS

Financial markets are the first — after a period of initial shock, when there is a predominance of exaggerated reactions as a result of uncertainty (Chen and Siems 2004:39) — to absorb and transform the news of a terrorist attack — or any similar “disastrous” event³ — into economic information, efficiently incorporating it into share prices, so that these reflect almost immediately the expectations as to future performances of these shares (Johnston and Nedelescu 2005: 4).⁴

³ From an economic viewpoint, terrorist attacks are not different from other “extreme events” (such as natural or similar catastrophes), characterised by giving rise to non-linear responses, low likelihood, grave consequences and high probability of triggering systemic reactions which can lead to heavy losses. See for this, Richardson, Gordon and Moore (2005:1) and Chesney *et al.* (2011:267).

⁴ Thus, stock markets act as a sort of seismograph which not only reflects the reaction to terrorist attacks, but may even be used to detect a rise in the risk of an attack perceived by investors. For example, in April 2007, the *Frankfurter Allgemeine Zeitung* published an article according to which the German Insurance Company “Extremus” (which is specialised in terrorism-insurances) had experienced an increase in the insurance contracts signed, weeks before the German Government announced a raise in the terrorist-threat level.

Table 1: Boston Bombings: timeline of the events

<p>April 15, 2013</p> <p>2:50 p.m.: An explosion goes off near the finish line of the 2013 Boston Marathon on Boylston Street, followed by another explosion seconds later about 1500 yards away on the same street.</p> <p>2:57 p.m.: Twitter of Boston Globe reports witnesses hearing “two loud booms” near the finish line.</p> <p>3:14 p.m.: First video of the scene following the explosion emerges.</p> <p>3:30 p.m.: Reports and images from the scene begin to circulate on social media, including some graphic photos.</p> <p>3:55 p.m.: Boston Police Department detonate an object near Copley Square in a controlled explosion.</p> <p>4:02 p.m.: First numbers of dead and injuries, reporting 2 dead and 14 injured.</p> <p>4:12 p.m.: Police respond to third explosion at the JFK Library, located in Dorchester MA.</p> <p>4:50 p.m.: Police department confirms the two explosions that occurred earlier in the day with Deval Patrick, and also confirm the third explosion and fire which they suspect is related.</p> <p>5:01 p.m.: Cellphone service in Boston is shut off to prevent any further detonation device setting off another possible explosion.</p> <p>5:06 p.m. Spokesman for the library claims the third incident could have just been a “mechanical room fire” - no injuries in the incident.</p> <p>6:12 p.m.: President Obama addresses the nation.</p> <p>8:49 p.m.: Governor Deval Patrick, in a press conference, says the FBI has taken over the investigation and it is confirmed that there are three deaths and at least 100 injured.</p> <p>April 16, 2013</p> <ul style="list-style-type: none">-Still no claim of responsibility for the attacks.-It is determined that the bombs were created from kitchen pressure cookers packed with explosives, nails and ball bearings - hidden in backpacks, which were left on the ground.-Pressure cooker bombs are difficult to trace which makes it hard to pin point an origin or suspect, as well as these being amateur devices (Al-Qaeda is becoming a less likely suspect with this news).-Photo of Jeff Bauman Jr., with both his legs blown off from the knee, spreads virally. <p>April 17, 2013</p> <ul style="list-style-type: none">-Photos of suspicious characters in the crowds at the finish line emerge in the news and online.-Boston remains under a heavy security presence - virtually in lockdown. <p>April 18, 2013</p> <p>5:10 p.m.: Photos and videos of Suspect No. 1 and No. 2 are released to the public - both men are considered “armed and dangerous” - they are later identified as Tamerlan and Dzhokhar Tsarnaev (26 and 19 respectively).</p>

Source: own elaboration from different online media.

To carry out this type of analysis we take as a base the principle of stock market efficiency (Fama *et al.* 1969; Fama 1970 and 1991), through which as long as liquidity is ensured, the incorporation of information to share prices — that is, the transformation of a news item into quantifiable economic information — takes place immediately. From this is derived, also, that share prices reflect at all times the existing information, so that a reaction only occurs in the face of fresh news (Abadie and Gardeazabal 2003:122).

Specifically, a terrorist attack implies an important rise in uncertainty among financial agents along with a perception of greater risk, as, on the one hand, the vulnerability of the system becomes evident — as further attacks cannot be ruled out — and, on the other, when the direct and indirect costs resulting from them are taken into consideration.⁵ These costs, depending upon the magnitude and intensity of the attacks, could lead to a slowdown in the general growth of the economy. This takes shape in the higher volatility of stocks and an increase in risk premiums. Consequently, investors will tend to re-organise their portfolios, getting rid of the higher-risk shares in favour of assets with similar liquidity but greater security, such as, for example, government bonds with short-term maturity dates or similar (Saxton 2002:2).

This reaction takes place almost immediately and reflects the perception of short-term costs, and normally the markets will return to the previous situation in a relatively short time. Normally, for this negative outlook to become medium-term there will have to be a *series of attacks* or, at least, the financial agents will believe that this is probably to happen. In other words, the impact of single terrorist events on stock markets is unnoticeable in the long term. Markets get used to terrorist actions and rapidly recover from their effects. Uncertainty is thus transferred to the derivatives market, which by means of the risk premium assesses long-term instability.

In this sense, share prices and the evolution of stock market indexes are a good source of information about the economic impact of terrorism (Campbell *et al.* 1997), since they reflect both companies' profit expectations and the likelihood seen by investors as to these being achieved. According to Frey *et al.* (2004:13), terrorist attacks influence both.

- a) Profit expectations are reduced due to the destruction of physical and intangible capital, but also when greater security measures increased production and transaction costs, and if consumers' fears reduce demand (as in the case of airlines following 11-S).
- b) The risk premium increases when terrorism involves greater uncertainty about the prospects for firms in the market.

Nonetheless, there exist some factors which limit the extent of this type of study. Thus, in the first place, the fall in stock market values does not measure a *direct cost*, in the sense of a *direct loss*, since for the investor the latter would depend upon the acquisition price, and it is — at least hypothetically — possible that, in spite of a significant fall in a share price after an attack, it could still be sold at a profit (albeit lower than what would have been obtained if the sale had been made the day before the attacks). As a result, this loss must not be treated as a real cost, since for that purpose it would be necessary for (a) the loss to have been realized and (b) to know the buying price.

However, it is a hypothetical cost, since the value of investors' portfolios is adversely affected as a result of the decapitalisation of the firms represented in them. This loss — which is reversible in principle (Chen and Siems 2004:349) — can, nevertheless be

⁵ As Martínez Cañete and Pérez-Soba (2002: 170), point out, uncertainty generated by the 3/11 attacks raised the risk premium of the market and thus the performance needed by investors to keep the shares in their portfolios. Thus a survey in October 2001 showed that extra profitability demanded by investors in order to acquire fixed interest stock had risen to 4 per cent, against 3 per cent in previous months

converted into a real one when the investor finds himself obliged to sell, for example, when he was trading with derivative futures. In any case, firms' decapitalisation is temporary, so another fundamental element to take into account would be the recovery period of the shares, which, in turn, depends on the general trend of the markets at the time of the attacks.

Another relevant factor — and one often ignored — is that share quotations already include in themselves certain risks, among which, depending on different factors, is a certain likelihood of a terrorist attack taking place. Likewise, we must point out one more limitation, namely, the difficulty of discriminating between those share price movements caused specifically by attacks, and the remaining factors — unrelated to or only indirectly linked to this fact — which may influence the investors' perception and actions (Frey *et al.* 2004:13-14), so this type of study is only valid in the very short term.

A final aspect to be taken into account is the need to avoid the error of accounting for the same cost twice, for example, including losses from a particular sector (tourism, airlines, etc.) on a par with stock market decapitalisation of these very same sectors, since the latter is merely the advance discount of these losses by investors (Navarro and Spencer 2001:23).

Nonetheless, faced with the question as to whether share prices are an adequate measurement of the cost of attacks, we may conclude that, as long as the previous reservations are borne in mind, they “may be the best single measure of the losses to the owners of capital linked to the physical damage, the expected decline in corporate profits associated with macroeconomic instability and — most elusive— the greater risk premium investors now attach to the ownership of equity” (*ibidem*).

PREVIOUS STUDIES

Although nearly all financial bodies and institutions regularly analyse stock market's reaction to particular types of events (political, economic, social, environmental or demographic), it was only after the attacks of 9/11 that this type of research — focused particularly on the repercussion of terrorism on stock markets — became more widespread academically, thus reacting to a growing demand for studies referring to the economic consequences of terrorism (Drakos 2004:445; Enders and Sandler 2006:2, Kollias *et al.*, 2011:532). This being said, the literature on the subject issue is still limited (Karolyi and Martel, 2010:285, Chesney *et al.*, 2011:253).

One of the earliest studies of this kind was published by Abadie and Gardeazabal (2003), who analysed the impact of ETA terrorism on share prices of firms considered to be Basque.⁶ To this purpose they compared the evolution of a hypothetical portfolio of 14 Basque shares, compared to another one made-up of 59 shares from the rest of Spain, during the 1998-1999 “truce” and throughout the period immediately after it. If Basque terrorism were seen as a factor of negative impact on that region's economy, the announcement of the truce would have had to be of positive impact on the shares of

⁶ Given that large firms — and we can consider quoted firms as such —, have both “Basque” and “non-Basque” capital, it is more practical to make a discrimination between firms in the sample on the basis of whether they are *perceived and considered* as Basque, normally starting with the name.

Basque companies, whereas the ending of the same truce should have had a negative impact. In fact, the findings obtained show that Basque shares performed very much better than non-Basque ones during the ceasefire period. In complementary fashion the authors estimate the coefficients of dummy variables which respectively measure the impact of the 22 days when bad news was prevalent and the 66 sessions with good news. In the case of Basque firms, the findings show a statistically significant and negative impact in the former case and a positive one in the latter. In the case of companies from the rest of the national territory, neither of the two dummies is statistically significant, thus proving the lesser impact of Basque terrorism beyond that Autonomous Community.

One of the most wide-ranging studies carried out so far, is that by Chen and Siems (2004), who analysed stock market reaction to fourteen terrorist and military attacks, from the sinking of the *Lusitania* in 1915 to the 9/11 attacks.⁷ The authors conclude that both terrorist attacks and military actions have a significant and almost immediate impact on world stock markets, albeit this impact may differ in intensity and duration. However, these effects are usually short-term ones, and the findings suggest that in recent times stock markets have been more resistant and better able to absorb them. One factor with a positive influence in this respect is the existence of a strong banking and financial sector, which enables markets to recover their stability rapidly. This is reinforced by close international communication and cooperation (Chen and Siems 2004:363-365).

Another interesting work is the one made by Eldor and Melnick (2004), who analysed the Israeli stock and exchange market reaction to terrorist attacks suffered by the population of this country between 1990 and 2003, and which has had important effects on the economic development of the State of Israel. According to a simulation carried out by these authors, — in which they take as a reference the S&P500 — if there had been no terrorist attacks in Israel between 2000 and 2003, the main stock exchange index in Tel Aviv, the TA100, would have evolved 30 per cent better than the real figure. The aim of the study by Eldor and Melnick is important for several reasons. Firstly, it is one of the few cases in which the terrorist phenomenon takes the form of a series of relatively continual attacks, so it is possible to analyse their impact, not just in terms of the type of, but also how intense and frequent they were. In this way the above-mentioned hypothesis can be checked, and according to this the repercussion of the attacks on stock markets is only important when the attacks are persistent over time.⁸

⁷ We consider as not very successful the decision to analyse jointly terrorist attacks and military events, despite being aware that in the literature definitions of terrorism that allow the latter to be included are to be found (the criterion used in choosing the events — e.g., two Gulf wars are absent — is not clear and the authors themselves admit to a certain bias in their selection). But even beyond definitions the question is not a vain one, since, for example, it implies that when designing the econometric model a period must be taken into account beginning between five and ten days prior to the effect in question really taking place — in which the ultimatum is given, formal declaration of war, etc. — and in which markets speculate on the likelihood of military conflict really happening. On the other hand, terrorist attacks are generally characterised precisely by not being predictable, except when the execution of a kidnapped is announced. If this previous situation arises, in which markets are already speculating on the likelihood of an event taking place, normally this information is progressively taken on board, so that the impact, as measured after the event, presents a value a long way short of reality. In accordance with the work by Cutler *et al.* (1989), this undervaluation could be as much as fifty per cent of the total impact.

⁸ We do not give a detailed description here of other works analysing the impact of other types of phenomena, of a non-terrorist nature, despite, as we have already mentioned previously, the fact that the literature frequently jointly analyses terrorist attacks and attacks classifiable, in accordance with

Therefore, the authors conclude that the impact of a terrorist attack does not depend primarily on its magnitude, but rather on its intensity. With regard to the second question, the authors affirm that markets are efficient in incorporating the information about the attacks, not finding any evidence about them having become desensitised over time.

For their part, Drakos (2004), Carter and Simkins (2004) and Choudhry (2005), have analysed the extent to which the 9/11 attacks changed the risk — as measured by the beta coefficient — of a share's volatility with regard to the general or sectoral index corresponding to each share. For this purpose the latter of these studies compared the betas in the period prior and subsequent to the attacks of 9/11 for a total of twenty US firms of varying sizes, geographical location and sectors. The findings obtained indicate a widely differing impact, depending upon the characteristics of each firm. Fifteen of the twenty firms saw their betas rise after the attacks, although in some cases the changes were marginal. Likewise, share volatility increased in half of the firms.

On the other hand, Drakos' (2004) work centres attention on just one sector, analysing beta alterations in the period following 9/11 as shown by thirteen US and non-US airlines. After 9/11 the share quotations of these companies showed an average fall of 30 per cent, whereas the American ones did so by an average 53 per cent. An important difference between the American companies and the rest can also be seen in the number of sessions required for pre 9/11 levels to be regained. The authors conclude that the risk associated with airline shares was drastically increased after 9/11. In all cases the betas showed a marked increase, and in nine of the thirteen companies studied these differences were statistically significant. When risk is broken down into its two main components — systematic and specific risk — the former almost doubles (in terms of beta) after the attacks, thus significantly increasing its relative importance.

Unlike the previous two, the article by Carter and Simkins (2004) goes a step further, by analysing not just the impact of the 9/11 attacks on the share prices of the airlines, but also whether investors' reaction was rational in the face of these prices. Just as occurred in the above-mentioned study, these authors detect a clearly negative market reaction, although it registered differing intensities for different airlines. Proof that those airlines with the highest capital reserves were less affected than the rest, enables them to conclude that investor reaction was rationally differentiated.⁹

As the final aspect, it is worth pointing out that Hon, Strauss and Young (2004), after analysing the reaction of the world's financial markets in the wake of 9/11, prove that a

international law, as military. This does not prevent these studies being relevant from the viewpoint of the analysis method used. Thus, Rigobon and Sacks (2005) study the reaction of financial markets in the months prior to the start of the Second World War, that is, in the face of a risk of it happening, and they make use of a comparison based on heteroscedasticity. However, this type of analysis is founded on the assumption of informative *ceteris paribus* which is very difficult to sustain if the analysis covers more than a few days. Nonetheless, the findings obtained coincide with those of Amihud and Wohl (2004) and Leigh *et al.* (2004), who on the other hand, measure expectations of war and, once that is included of when it will end, by means of the betting tax — the equivalent of a *Saddam Hussein contract* — of an Irish online betting shop. What is not clear is whether the expectations harboured by the betters are the same as those of financial agents.

⁹ The findings of this study coincide with those of Drakos (2004), since the increase in a share's systematic risk detected by the latter thus implies knowledge of capital costs and, consequently, a reduction in the performance rate and by Baumert (2009) who studies the reaction of the Spanish Stock Exchange after 3/11.

“contagion effect” took place — an increase in the correlation between them —, a result both of their strong interconnection, and of the practically simultaneous news flow. This fact has an important consequence, since it would imply that it is almost impossible to avoid the repercussions of large-scale terrorist attacks by means of the international portfolio diversification.¹⁰ Nevertheless, more recent studies (Chesney *et al.*, 2011:262-265), suggest that there indeed are several diversification strategies towards minimizing terrorist risk, mainly splitting the portfolio into two sort of assets: those which are likely to react to terrorist attacks and those which react to a lesser extent (mainly US Government bonds and stocks related to aero/defense and pharma biotech).¹¹

Zussman and Zussman (2006) use stock market data to evaluate the perceived effectiveness of “selective assassinations” as counterterrorist measure applied by the Israeli government. Working with data from Tel Aviv 25 stock market and for the time period of 136 trading days during which the counterterrorist measure was applied by Israeli Forces, the authors conclude, that the index reacts in a quite differentiated way: assassination attempts targeting political leaders have a negative effect on the stock market while assassinations of military leaders (except for *Fatah* ones) have a positive effect.

Arin, Cefferri and Spagnolo (2008) present in their article interesting results regarding the repercussion of terrorist events on stock markets working with data from six different countries (Indonesia, Israel, Spain, Thailand, Turkey and UK) considering not only on stock markets but also volatility. They conclude that the impact of this sort of event is significantly larger in emerging markets.

The work by Baumert (2009), taking advantage of the fact that the Madrid bombings (3/11) were one of the rare cases in which the Stock Exchange of the attacked country continued working normally and that during that day the information spread by news media nearly exclusively referred to the attack, used intraday data to contrast which specific type of news affected — and in which direction — the Spanish Stock Market. The study showed that there were two main sort of news which significantly impacted the market: the size of the attack (in terms of the number of death and injured officially announced over the day) and the alleged perpetrators (ETA vs. Al-Qaeda). In addition, the intraday information also confirms that, despite the overreaction, investors tend to act rationally, as the stocks which presented heavier losses were those more directly affected by the attack.

Studying the — up to now somehow neglected — Pakistani financial market’s reaction to terrorist activities between 2006 and 2008, Gul *et al.* (2010) illustrate a significant negative impact of terrorist events on the Karachi Stock Exchange Index (KSEI), although they do not achieve any significant results on other related variables. Also, their model shows some difficulties in separating terrorist events from other influencing factors.

¹⁰ In this same line, Chuliá *et al.* (2007) studying the volatility transmission between the US and Eurozone stock markets, have shown that this transmission is actually bidirectional and asymmetric.

¹¹ Of course investment banks have developed in the meantime and offer now “terrorist-free-investment funds”. For an assessment of terrorism-related investment strategies, see Karolyi (2008) and Karolyi and Martell (2010).

Brounen and Derwall (2010), have compared the price reactions of the major stock markets to terrorist events, concluding that they might be considered “mildly negative” — except for the case of 9/11 which showed an important and longer lasting repercussion —, although their impact proves to be still larger than those of comparable natural disasters such as earthquakes.

For their part, the study by Nikkinen and Vähämaa (2010), comparing the reaction of the FTSE 100 Index after the events of 9/11, 3/11 and 7/7 showed that these attacks significantly shifted the downwards investor’s expectations, and drastically increased stock market uncertainty (thus confirming the previous studies by Burch *et al.*, 2003 and Glaser and Weber, 2005 who in the aftermaths of 9/11 detected a negative move in investors sentiment). In addition, the authors also demonstrate that the implied probability density functions became more negatively skewed on the days of the terrorist attacks, proving that investors considered higher probabilities for further sharp downward movements in the FTSE index, although they were only of short duration.

The same set of attacks (9/11, 3/11 and 7/7) is studied by Baumert (2010) who analyzes the effect of those terrorist events on the major US, European and Japanese Stock Indices, proving that over the time period studied, both the size of the impact and its duration has diminished, a fact that allows for two (complementary) explanations: (a) Investors have overcome their initial “overreaction” of 9/11 and have learned to more objectively measure the real economic repercussion of a terrorist attack and (b) Investors have become more accustomed to the terrorist threat, incorporating the associated risk more systematically into share prices.

In contrast, a broader set of terrorist events (75 attacks between 1995 and 2002) is used by Karolyi and Martell (2010), who study the impact on the publicly traded firms directly targeted, thus being more representative of the types of risk that individual firms face in dealing with terrorism.¹² The results obtained by the authors allows to quantify this statistically significant impact in a mean loss of -0.83 per cent on the day of the attack (which corresponds to a market de-capitalization of around \$401 million). They authors also show that the overall impact of terrorist attacks is major in higher developed and more democratic countries — this somehow contradicting the results by Gul *et al.* (2010), and results more important in the case of human capital losses than the case of physical losses.

Kollias *et al.* (2011), using event study methodology and GARCH family models, study the impact of the Madrid and of the London bombings on equity sectors. Significant negative abnormal returns are widespread across the majority of sectors in the Spanish markets but not so in the case of London. Also the time of recovery is much faster in the latter case (the impact and volatility being in any case transitory), thus all results confirm those previously presented by Baumert (2010).

Finally, a similar approach is applied by Chesney *et al.* (2011) who combine a GARCH and Extreme Value Theory (VET) approach, to 25 countries and a eleven year timespan. The authors conclude that approximately two-thirds of the terrorist attacks considered lead to a significant negative impact on at least one stock market (the Swiss market being the most sensitive and the US American one —exception made of 9/11— the

¹² Broadly speaking, terrorist attacks on firms result in two sort of costs: tangible assets (properties, plants, equipment) and intangible assets (like human capital resources).

least sensitive one. Also, their study shows the most sensitive sectors are insurance and airlines, while the least sensitive one is banking.

EMPIRICAL ANALYSIS

The stock market reaction to the Boston bombing in comparison with 9/11, 3/11 and 7/7

Analyzing the reaction of the stock markets represents a particularly useful instrument when measuring the intensity and duration of the economic impact of a terrorist attack. With this aim, in the present section we try to quantify the depth and duration of the Boston bombings impact on the main international financial markets. When making this analysis it is necessary in turn to take into consideration the political measures adopted in the wake of each attack by the authorities concerned to offset these same effects. As mentioned by Brück and Wickström (2004:295), the latter depend, as well as on the specific type of attack and the multiplier effect, on each market's absorption capacity, as well as the financial policies adopted in each case. As Baumert (2010) conveniently showed, the magnitude of the attacks, measured by the cost of their organisation and execution, diminished exponentially from 9/11, over 3/11 to 7/7.

Obviously, also, the economic costs caused by the attacks, both in absolute and relative terms, have fallen over time. Thus, the direct economic impact of 9/11 can be quantified at \$47,000 million, — equivalent to 0.46 per cent of GDP —, compared to the €211,584,762 estimated for 3/11 — equivalent to 0.03 per cent of GDP — and the £44,207,254 we have previously estimated for 7/7 (about 0.02 per cent of national GDP), no estimation yet being available for the case of the Boston bombings.¹³ We can conclude, therefore, that the magnitude of the attacks has diminished, although to a greater extent from the viewpoint of execution and organization costs which from the economic impact stemming from them, are reflected in the fact that the ratio between the two magnitudes presents a noticeably more moderate decline.

This smaller “size” of the attacks also implies a lesser impact on financial markets — in terms both of their depth (magnitude) and duration (intensity) — which records the maximum losses suffered by the main stock exchange index of the country affected (Dow Jones, Ibex35 and FTSE) before they recovered to the values obtained before the event in question, and the number of sessions required for them to do so. Thus, after 9/11, the maximum loss suffered by the Dow was -14.3 per cent, and 44 sessions were needed (including five in which the New York exchange was closed) to reach the levels of September 10. The Ibex35, however, took no more than 20 sessions to recover (with a maximum loss of -7.15 per cent). Moreover, the impact of the London attacks lasted just one session (-1.35 per cent), as occurred with the Boston bombing (-1.79 per cent, although only roughly the half of it due to the explosions at the finishing line of the Marathon). Anyhow, the daily loss of the Dow Jones on the days of the attack still was the worst since November 7, 2012, and those of the S&P500 and of the Nasdaq even were the worst since November 2011.

Nonetheless, the maximum loss is only valid as an approximate measurement of the repercussion of the attacks on the stock markets, given that it does not take into account the influence of other factors — particularly the general market trend within which the

¹³ Although from the information available it might be assumed that the costs of organizing and perpetrating the attack might have been relatively small.

attacks occurred — so it is necessary to quantify the impact of the attacks by considering these elements simultaneously.

For this purpose, we carry out an analysis similar to the one presented by Chen and Siems (2004) in which a comparison is made of the “abnormal” variations experienced by stock market quotations after a terrorist attack, with regard to the “normal” one, considering as such the average of the thirty days prior to the event, in accordance with the following functions:

$$A_{i,t} = R_{i,t} - \bar{R}_i \quad (1)$$

$$\bar{R}_i = \frac{1}{30} \sum_{t=-30}^{-1} R_{i,t} \quad (2)$$

Where R designates the percentual variation observed at the close of day t with regard to the value at the close of the previous day (t-1) and A designates the abnormal variation experienced by the stock exchange index in question as a consequence of the attack, referring to the average variation R, calculated according to the function (2). The values thus obtained to the stock markets of Frankfurt, London, Madrid, Paris, Milan, New York and Tokyo and the terrorist events of 9/11, 3/11, 7/7 and 4/15, have been compared following the methodology originally presented by Brown and Warner (1985).

*Table 2: Statistical analysis of the impact of major terrorist attacks on stock markets
Abnormal returns on the day of the attacks. In brackets the t-value.*

Index	New York bombings (9/11)	Madrid bombings (3/11)	London bombings (7/7)	Boston bombings (4/15)
DAX30	-6.44*** (4.51)	-3.46*** (3.66)	-1.85*** (3.05)	-0.39*** (2.18)
FTSE100	-3.01*** (3.11)	-2.2*** (3.69)	-1.36*** (3.15)	-0.61*** (4.50)
IBEX35	-4.45*** (3.44)	-2.18*** (3.08)	-1.91*** (3.71)	-0.82*** (2.92)
CAC40	-7.39*** (7.37)	-2.97*** (4.12)	-1.39*** (2.48)	-0.67*** (3.45)
MIB30	-7.79*** (6.76)	-2.22*** (4.21)	-0.62 (0.95)	-0.61*** (2.28)
DOWJONES	-7.13*** (7.10)	-1.67*** (3.07)	0.31 (0.61)	-0.86*** (3.06)
NIKKEI225	-6.63*** (3.64)	-1.19* (1.36)	-0.12 (0.51)	-0.41*** (3.06)

* = statistically significant at the 10 per cent level.

** = statistically significant at the 5 per cent level.

*** = statistically significant at the 1 per cent level.

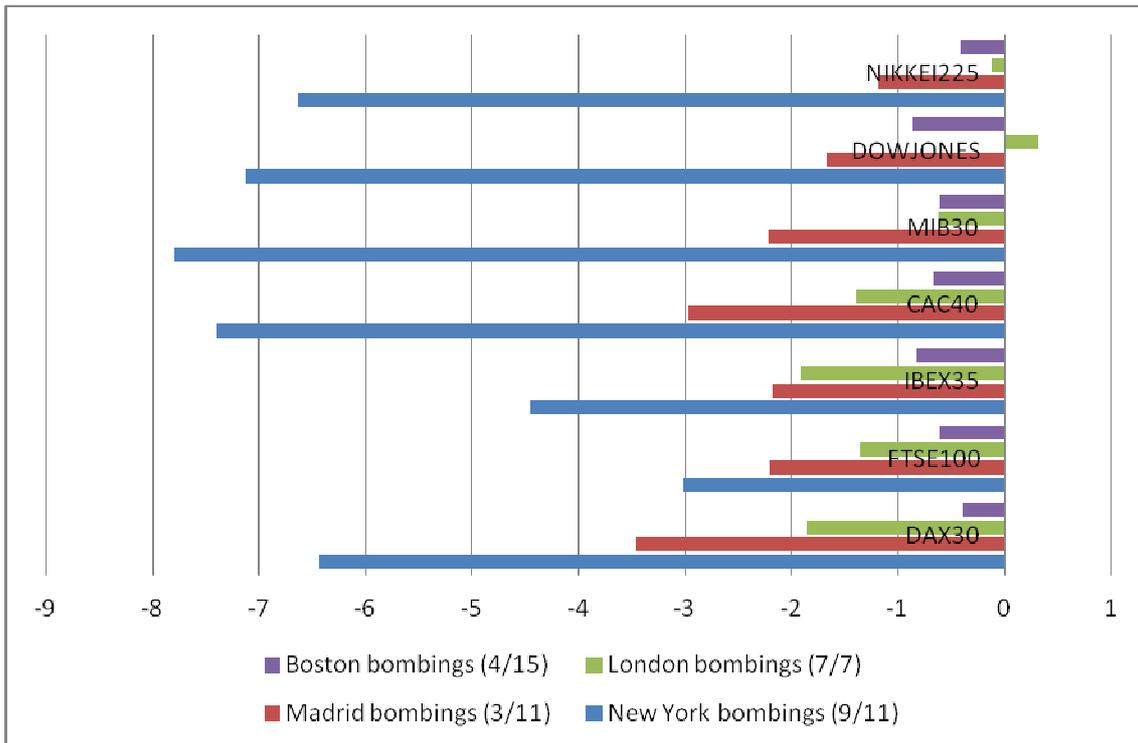
As can be seen in table 2, our results demonstrate that the reaction after each attack has diminished continuously (in those cases where it was statistically significant), with the exception of the Dow Jones, which — for obvious reasons — reacted again more heavily to the Boston bombings than it had done to the London ones. Anyhow, it should be noted that after 7/7 three cases (Milan, New York and Tokyo) did not result significant. At least in the case of New York, this might be explained by the less

sensitiveness of US financial markets to terrorist attacks except for when they are committed on their own soil (Chesney *et al.*, 2011). Nevertheless, in general terms, it is not possible to detect any desensitisation of the markets, as already stated by Eldor and Melnick(2004).

Second, it can be observed, that the reaction of the stock markets differed less than in any of the other previous attacks, thus presenting a reduction of the spread between them (see graph 2). This might indicate both a greater correlation among markets — a hypothesis that would fit the results presented by Hon, Strauss and Young (2004) — but also a more precise and rational differentiated evaluation of the economic consequences of an attack (Carter and Simkins, 2004).

Focusing our attention on the Boston bombing, it can be stated that they had a significant, negative impact on all mayor stock markets analysed: DAX30 (-0.39%), FTSE100 (-0.61%), IBEX35 (-0.82), CAC40 (-0.67), MIB30 (-0.61), DOWJONES (-0.81) and NIKKEI (-0.41). Nonetheless, albeit their significance, they were all relatively small or, to use the term employed by Brounen and Derwall (2010), “mildly negative”.¹⁴ However, in should be bore in mind, that our selection of markets is biased towards the developed countries which, according to Ceferri and Spagnolo (2008), present smaller impacts than underdeveloped.

Graph 1: Negative impact of major terrorist attacks on stock markets



Source: Own elaboration

Generally speaking, our results show that the impact caused by terrorist attacks on the main international capital markets have diminished both in terms of size and duration.

¹⁴ Nevertheless, this “mildness”, has to be understood in the context of the steadiness or even upward trends of international markets when the bombings occurred.

This fits the theory according to which it is the persistence of the terrorist phenomenon (and not the singular attack, despite its magnitude) which has a lasting effect on share prices, as postulated by Abadie and Gardeazabal (2003) — in terms of “bad news regarding terrorism” — and Eldnor and Melnick (2004) — in terms of real terrorist incidents —, the first applied to the Basque Country, the second to Israel, two regions which have suffered persistence terrorist violence. Altogether, our results fit — and thus at the same time validate — the previous studies by Chen and Siems (2004), Baumert (2010) and Kollias *et al.* (2011) presented above.

Intraday analysis

Unlike what happened on 9/11 (when Wall Street did not open until five days later) and 7/7 (when the UK government controlled the flow of news), the fact that the Boston bombings occurred while the US stock markets were operating, allow to study the immediate and direct impact of the news flow on the Dow Jones index. This sort of study has previously only be done for one major terrorist event: the Madrid bombings on 3/11 (see for this Baumert, 2009).

Contrasting what occurred in Madrid back in 2004, the Boston bombings hit the US stock markets on a negative trend. In fact, the Dow Jones that day had already lost more than one hundred points when the bombings occurred. Nevertheless, it is also true, that the Dow Jones had began to recover a couple of minutes before the attack. And needs to be stated, that from that point on — and until the closing of the market approximately 90 minutes later — it presented an upward, recovering trend, which was only inverted every time that additional news regarding the attacks spread. More specifically, there are four pieces of news which significantly caused this inversion of the upward trend into a negative one, after the bombs exploded on 2:50 pm (see graph 2):

- 2:57 p.m.: Twitter of Boston Globe reports witnesses hearing “two loud booms” near the finish line.
- 3:14 p.m.: First video of the scene following the explosion emerges.
- 3:30 p.m.: Reports and images from the scene begin to circulate on social media, including some graphic photos.
- 3:55 p.m.: Boston Police Department detonate an object near Copley Square in a controlled explosion.
- 4:02 p.m.: First numbers of dead and injuries, reporting 2 dead and 14 injured.

Thus, it can be affirmed that the news regarding the Boston bombing (spread mainly by social media) significantly impacted the Dow Jones, each new piece of information reverting the “natural” trend of the index.¹⁵ However, one day after the attack, on April 16, the New York Stock Exchange closed with the Dow Jones having nearly recovered all losses of the previous day.

¹⁵ This shows that in many respects, Twitter has become the latest news wire of Wall Street and that investors have come to rely on the social medium for minute-by-minute news and opinion (Witkowski and Patel, 2013).

Graph 2: Dow Jones on April 15, 2013



Source: Bloomberg Finance L.P.

Graph 3: Dow Jones on April 16, 2013



Source: Bloomberg Finance L.P.

ARMED TERRORISM VS CYBERTERRORISM

Financial markets can be seen to be involved in an attack not just as victims, but also as instruments. Thus, a recurring question which arises when analysing the stock market reaction after large-scale attacks, is the possibility that terrorist groups exploit ‘insider information’ about these events not just to finance them, but to obtain large profits from them which might be used in maintaining the infrastructure of the organization in question (Baumert, 2009, 2010:189-193). It might also enable them to have available liquidity, and make the development and execution of future attacks easier.

Basically, there are three ways by which this sort of ‘terrorist-insider-information’ could be used in speculating on a short-term fall in share prices (Baumert, 2010:191). The most frequent consists of buying put (sale) options. Another possibility is to make use, incurring the payment of commissions, of the loan of shares to sell them at market prices (short call or short selling). Finally, a third alternative consist of using the forward or future market with total leverage, that is, without any financial outlay on signing the contract, except for what is needed to constitute guarantees. These are returned once the same contract is settled, and one can position oneself to speculate on a fall in prices.

Although there are no evidences pointing towards this sort of speculation related to the Boston bombings — actually, the only asset which presented an “abnormal” loss was gold, which dropped -9.3 per cent on the day of the attacks and additional -4 per cent the day after (this representing the highest two-day loss since 1988) — suspicious arises if we take a look at what occurred just a couple of days later.

Only eight days after the Boston Bombings shook the world and its financial markets, the Associated Press’s (AP) twitter account was hacked. Specifically, on April 23, at approximately 12:07 p.m. the AP’s twitter page published one “tweet,” which read:



This one fake tweet, which could be viewed by the two million people who follow the news agency’s twitter account, caused the Dow Jones Industrial Average to drop by -145 points within minutes of the news (see graph 4).¹⁶ To put that into perspective, the Dow Jones lost around 265 points on the day of the bombings. And it has to be considered that an important part of this loss was reinforced by the fact of the bombings a week earlier. Or, in other words, the fake tweet benefited in its verisimilitude from the previous, “real” bombings. Simultaneously, the yield on the 10-year Treasury note fell 4 basis points and the CBOE Volatility Index (VIX) lost -0.42 per cent, the so-called fear index, spiked 10 per cent. Like one analyst stated, “it actually proves the power of

¹⁶ Thus evoking the reminiscence of the May 2010 “flash crash”.

Twitter, the idea that people take it so seriously that it would move the market. That's pretty impressive."¹⁷

However, shortly thereafter, the AP's twitter account was suspended and it was revealed that the tweet was fake and the system had been hacked.¹⁸ Roughly four minutes after the suspension, the Dow Jones promptly returned to its pre-tweet levels, the other indices also quickly recovering. This isolated event though brings up some serious questions regarding the financial systems and how it reacts to news presented on forums like Twitter,¹⁹ and how terrorist would be able to use cyberterrorism as a way of manipulating the stock markets for a financial profit.

Graph 4: Drop of the Dow Jones on April 23, 2013 as a result of the faked AP tweet



Source: Bloomberg Finance L.P.

While by no means is this the first breach of security in a business's computer system, this specific breach at the Associated Press illustrates the need for businesses and governments to take the threat of cyberterrorism seriously because of the link discovered between news, either real or fake, published on forums like Twitter and the subsequent reaction by the stock market.

¹⁷ <http://blogs.marketwatch.com/thetell/2013/04/23/twitter-hack-market-react-shows-sites-power-says-wedbush/>

¹⁸ As Associated Press later admitted, its main Twitter account had been compromised and the attack had been preceded by a phishing attempt on AP's corporate network.

¹⁹ Witkowski and Patel (2013) quote an interesting statement made by a chief investment officer regarding the effect of the fake tweet on the stock market: "It is however a commentary on high frequency trading's ability to demonstrate they are not liquidity providers, and that this market is vulnerable to a computer generated turbulence. There were no bids to hit, that makes you question how many real buyers, if any, were represented."

With this information, terrorist groups can now focus their energy on cyberterrorism as opposed to “traditional” terrorist weapons because the effects of the former can potentially be even worse than those of the latter. It also allows for the possibility for terrorist groups to make a profit off of a cyber-attack; similar to speculation that terrorist organizations use traditional attacks as a mean of financing (see for this Baumert, 2008). While the point drop was not as significant as the day of the bombings, it still clearly had a significant effect on the American stock market. In terms of a cost-benefit analysis, this cyber-attack clearly presents the better ratio. It has also to be pointed out, that this cyber-attack is not an isolated one, but just one more in a series of cyberterrorism against US-American financial institutions which started in autumn 2012 (Baumert, 2012) and had another peak in march 2013

CONCLUSIONS

The results of our paper show that the impact of the Boston bombings on the main international financial markets indices, namely the Dow Jones, the Ibex, the FTSE, the CAC40, the MIB, the DAX and the Nikkei, differ statistically —that is, can be considered abnormal— regarding the variations of the 30 trading days before the attack. In comparison to previous terrorist events (9/11, 3/11 and 7/7) the markets behaved according to the pattern observed in previous studies, that is, presenting a continuous and decreasing magnitude and duration in comparison (except, for obvious reasons, for the Dow Jones, the only one belonging to a country which has been hit twice by the terrorist phenomenon). Also, it can be observed, that the reaction-spread between indices has diminished accordingly, pointing either towards a greater correlation between markets, a better evaluation of the economic consequences of such attacks by financial agents or the fact that the risk of such an attack is being included more systemically in share prices.

It also proves that the news flows — for the first time not traditional media but new social media, mainly Twitter — had an immediate and direct impact on the DJ index, with each new piece of news negatively reversing the “natural”, recovering trend of the New York stock market on that fatidic afternoon. Our study also proves that the cyberterrorist attack of April 23, spreading a fake tweet through the AP account, caused an immediate and significant impact on the Dow Jones. This gives evidence to the vulnerability of the financial system to this sort of cyberterrorism which take advantage of security breaches, and which could even be used by terrorist or terrorist-related groups to speculate with falling stock prices. It is also points out the possibility that in the future these sorts of attacks could be targeted directly towards the financial market’s IT system.

In general terms, our findings fit the results obtained by previous studies, and point towards the fact that it is only the persistence of the terrorist phenomenon (and not the singular attack, despite its magnitude) which has a lasting effect on share prices, be it traditional “armed” terrorism or any new, innovative form of cyberterrorism.

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En la página 1, dentro de un recuadro sencillo, debe figurar el título (en negrilla y mayúsculas), autor (en negrilla y mayúsculas) e institución a la que pertenece el autor (en letra normal y minúsculas)

En la primera página del trabajo, se deberá incluir un Resumen en español e inglés (15 líneas máximo), acompañado de palabras clave

Los trabajos habrán de ser enviados en papel y en soporte magnético a la dirección del Instituto de Análisis Industrial y Financiero.