



# Large shocks and the September 11th terrorist attacks on international stock markets

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## Abstract

This study investigates the effects of the terrorist attacks in U.S. on September 11, 2001, on international stock markets. We examine 10 daily stock market indexes using the outlier detection methodology. We show that the international stock markets experienced large (permanent and temporary) shocks in response to the terrorist attacks and its aftermath. We also show that taking into account these events can improve modelling financial risk, especially the volatility in stock market prices.

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## 1. Introduction

The United States experienced terrorist attacks on September 11, 2001, involving a dramatic economic impact. Recently, numerous studies investigated the effects of these tragic events on capital markets (Chen and Siems, 2004; Maillet and Michel, 2005), commercial airlines (Carter and Simkins, 2004; Drakos, 2004; Guzhva and Pagiavlas, 2004) and airline industry (Masse, 2001; Inglada and Rey, 2004; Ito and Lee, 2005; Blunk et al., 2006), among others. See also the special 2004 issues of *Journal of Monetary Economics* 51(5) and *European Journal of Political Economy* 20(2) for the effects of the terrorist attacks of 11th September and others. Moreover, Balke and

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Fomby (1991, 1994), Bradley and Jansen (1995), and Darné and Diebolt (2004) showed that specific events have a dramatic impact on modelling macroeconomic and financial time series. This type of event includes, for example, oil shocks, wars, financial slumps, changes of political regime, natural catastrophes, etc. They applied outlier detection methodology to detect the shocks that affected the economic time series.

In this investigation, we study the effects of the September 11, 2001 terrorist attacks on 10 daily stock market indexes using an outlier detection methodology. This methodology allows us to associate the (positive or negative) large shocks due to these events to the presence of outliers, and to seek the type of effects in the form of outliers: immediate, temporary or permanent. We show that the international stock markets experienced large (permanent and temporary) shocks in response to the terrorist attacks and its aftermath, involving abnormal returns.<sup>1</sup> This result confirms the tight linkages between the stock markets and the contagion effects of news (Hamao et al., 1990; Arshanapalli and Doukas, 1993; Hon et al., 2004). As shown recently by Kim, McKenzie and Faff (2004), Flannery and Protopapadakis (2002) and Nikkinen and Sahlström (2001, 2004), we also found that U.S. macroeconomic news announcements can have a great impact on the U.S. and European stock markets by detecting large shocks. These empirical findings give evidence for international transmission of stock prices shocks. Two explaining factors can be highlighted for this increasing international transmission in recent years: (i) the substantial development of technology, which allows traders to transmit information more quickly from one financial market to another, and (ii) the increased flow of capital between countries as a consequence of less restrictive controls on asset market transactions (Booth et al., 1997; Fernandez-Izquierdo and Lafuente, 2004).<sup>2</sup>

We also investigate the effects of these events in the form of outliers on the diagnostics of normality from linear and nonlinear modelling. Indeed, high-frequency time series of returns on financial assets typically exhibit excess kurtosis and volatility clustering.<sup>3</sup> The Generalized Autoregressive Conditional Heteroskedasticity [GARCH] model introduced by Bollerslev (1986) is frequently applied to describe these two stylized facts (Bollerslev et al., 1992). However, it is often observed that the estimated residuals from a GARCH model still have excess kurtosis (Baillie and Bollerslev, 1989; Teräsvirta, 1996). One possible cause for this outcome is the presence of outliers that are not captured by a GARCH model (Balke and Fomby, 1994; Fiorentini and Maravall, 1996). Furthermore, Johansen and Sornette (1998) showed that the largest stock market crashes are outliers and therefore they stressed the danger of amalgamating the existence of large crashes with the existence of a fat tail in the distribution of stock market prices. Moreover, the presence of outliers may have also undesirable effects on the tests of homoskedasticity (van Dijk et al., 2002; Carnero et al., 2001).

The outline of this paper is as follows. In Section 2 we describe the outlier detection methodology. In Section 3 we present empirical results for the 10 daily financial time series. We associate the shock dates with specific events. We examine the effects of outliers on the diagnostics of normality from linear and nonlinear modelling in Section 4. Section 5 concludes.

<sup>1</sup> Chen and Siems (2004) showed that specific events, such as terrorist and military attacks, can lead to significant abnormal returns in capital markets.

<sup>2</sup> Nevertheless, although the international transmission between stock markets appears to have increased in recent years, the observed relationships are still lower than might be expected. Roll (1992) documented three reasons for the observed low relationships between different stock markets: (i) a technical aspect of index construction (some indices are more diversified than others), (ii) differences in industrial structures, and (iii) differences in exchange rate behavior and policies.

<sup>3</sup> In fact, large observations occur more often than one might expect for a normally distributed variable, and these large returns tend to occur in clusters.

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