



HAS THE 911 INCIDENT INDUCED ANY STRUCTURAL CHANGE IN THE U.S. STOCK MARKET?

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Abstract

This paper employs the structural-change test to predict structural change in the U.S. stock market, associated to the September 11 incident. More than 500 U.S. companies are examined in this study. It provides the first piece of statistical evidence showing that there are insiders who know the attack beforehand and try to profit from the U.S. stock market. Besides, structural change in the stock price level has been detected in only 15 out of those 38 companies with unusual trading activities before the incident, indicating that the impact of the 911 attacks on the American financial system is very limited.

Keywords: Structural change; Change date; Sup-Wald test.

1. Introduction

The 911 incident¹ has an immense impact on the U.S. stock market. Its effect on the companies' profitability is immediate². In spite of the Federal Reserve Board's effort to buoy the market by cutting the interest rate by half of a percentage point, the stock prices plummeted sharply when the Exchange resumed trading on 17th of September³.

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¹ The September 11, 2001 Terrorist Attacks were a series of suicide attacks against civilians of the United States. According to the official 9/11 Commission Report, nineteen men affiliated with Osama bin Laden and Al-Qaeda, a loose network of Sunni Islamist terrorists, simultaneously hijacked four U.S. domestic commercial airliners. Two were crashed into the World Trade Center in Manhattan, New York City. The third aircraft crashed into the U.S. Department of Defense headquarters, the Pentagon. The fourth plane crashed into a rural field in Somerset County, Pennsylvania, following passenger resistance. The official count records 2,986 deaths in the attacks.

² For example, Continental Airlines reported third-quarter of 2001 net income has fallen 98 percent. Lehman Brothers Holdings, reported fourth-quarter net income of 2001 has fallen 67 percent.

³ Six months later, the stock prices of some companies were still below the level before the attacks.

The objective of this paper is two-fold. First, it examines whether the fall of the stock prices is a temporary event, or a structural change which damages the confidence of investors in the U.S. stock market in the long term⁴. Companies studied in this paper include those which are most vulnerable to the attacks. Using the daily data of more than 500 U.S. companies, it is interested to see if the major 911-related industries, namely the airlines, insurance and banking industries are seriously hit by the incident.

Second, it has been observed that the stocks of the airlines and the related industries have experienced unusual large volume of transactions before the attacks. For instance, there was circumstantial evidence that the put options of the AMR Corp. and the United Airlines were being sold before the attacks. The stocks of some giant insurance companies, such as AXA, AIG, Chubb, CNA Financial, John Hancock and MetLife were also heavily sold before the attacks. Other stocks being heavily sold before the attacks are the Bank of America, Bank of New York Company Inc., Citigroup and American Express Co.. However, Eichenwald and Edmund (2001) reported that there may not be enough statistical evidence to prove that the attacks were known in advance. In light of this, the current study provides statistical evidence for the existence of short selling activities before the attacks by using a simple structural-change model.

The paper is organized as follows: Section 2 describes the model and the test. Section 3 presents the empirical findings. Section 4 concludes the paper.

2. The Model and the Sup-Wald Test

The structural-change model dates back to Page (1954), and has been widely studied in various academic disciplines during the previous decades. Generally speaking, the parameters of interest in a change-point model include the location and the magnitude of the change. Major estimation methods such as Maximum Likelihood, Least Squares (Hawkins, 1986; Chong, 2001), Bayesian, and Nonparametric method (Csörgö and Horváth, 1988) have been proposed for these two parameters. Comprehensive surveys on this topic include Hackl and Westlund (1989), Krishnaiah and Miao (1988) and Shaban (1980). Empirical works in economics include Banerjee, Lumsdaine and Stock (1992), Christiano (1992), Chu and White (1992) and Zivot and Andrews (1992). All these studies assume that the change date is not known a priori.

In this paper, the change date is also treated as an unknown, although most stocks dropped sharply on the first day when the New York Stock Exchange resumed trading after 911. This study examines if the stock prices have a shift in level due to the 911 attacks. The following mean-shift model is considered:

$$\begin{aligned} y_t &= \beta_1 + u_t & \text{for } t < k_0, \\ y_t &= \beta_2 + u_t & \text{for } t \geq k_0; \quad (t = 1, 2, \dots, T), \end{aligned} \quad (1)$$

⁴ Two of the 911 related studies are Hon, Strauss and Yong (2004) and Drakos (2004).

where y_t is the closing price of a particular stock at time t , and u_t are the error terms. This is a single-change model with i.i.d. innovations. The change date k_0 is endogenized in our estimation. The values of β_1, β_2 and k_0 are to be estimated.

For any given $k \in \{2, 3, \dots, T-1\}$, the least squares estimators for the pre- and post-shift parameters are respectively

$$\hat{\beta}_1(k) = \frac{1}{k-1} \sum_{t=1}^{k-1} y_t, \quad (2)$$

and

$$\hat{\beta}_2(k) = \frac{1}{T-k+1} \sum_{t=k}^T y_t. \quad (3)$$

If there is no structural change, the probability limits of the pre- and post-shift estimators are the same. While in the presence of change, their probability limits are different. The residual sum of squares at time k is defined as:

$$RSS_T(k) = \sum_{t=1}^{k-1} (y_t - \hat{\beta}_1(k))^2 + \sum_{t=k}^T (y_t - \hat{\beta}_2(k))^2. \quad (4)$$

Under general regularity conditions, the change-point estimator and the pre- and post-shift estimators will be consistent if there is a structural change.

There are a ($t=1, 2, \dots, T$) number of tests for structural change in the literatures. Earlier works presume that the change date is known a priori; see for example, Quandt (1960), Chow (1960) and Hawkins (1977). As it is more reasonable to endogenize the change date in empirical applications, tests for unknown change point have become increasingly popular (Davies, 1987; Hawkins, 1987; Chu and White, 1992; Hansen, 1992; Andrews, 1993; Andrews and Ploberger, 1994; Diebold and Chen, 1996; Kuan, 1999).

In this paper, the Sup-Wald test of Andrews (1993) is employed to test if there is a structural change in the U.S. stock market due to the 911 incident.

The Sup-Wald test for the null hypothesis of

$$H_0 : \beta_1 = \beta_2,$$

against the alternative hypothesis of

$$H_1 : \beta_1 \neq \beta_2,$$

The test statistic at a particular time k is defined as:

$$\sup_k W(k) = \frac{k(T-k)}{RSS_T(k)} \left(\hat{\beta}_2(k) - \hat{\beta}_1(k) \right)^2. \quad (5)$$

Define

$$k = [T\tau], \quad (6)$$

where $\tau \in (0,1)$ is the change fraction and $[\cdot]$ is the greatest integer function. It has been shown (Andrews, 1993) that as $T \rightarrow \infty$,

$$\sup_{\tau \in \mathbf{S}} W([T\tau]) \xrightarrow{d} \sup_{\tau \in \mathbf{S}} \frac{(\tau B(1) - B(\tau))^2}{\tau(1-\tau)}, \quad (7)$$

where $B(\tau)$ is a Brownian motion on $[0,1]$, \mathbf{S} denotes a set whose closure lies in $(0,1)$. In this paper, we use $\mathbf{S} = [0.15, 0.85]$.

If the null hypothesis of no change is rejected, the change point estimator is defined as

$$\hat{k} = \arg \max_{k \in [0.15T, 0.85T]} W(k), \quad (8)$$

and the final pre- and post-shift estimators are evaluated at the estimated change point.

3. Data and Results

First, this study examines the impact of the 911 incident on 38 major companies which have unusual trading activities before the attacks identified by the Securities and Exchange Commission of the U.S.. Most of them are in the airlines, insurance and banking sectors. The list includes those companies previously mentioned in the introduction. Companies, which might be beneficiaries of the attacks, such as the military contractors, from giants like Lockheed Martin to smaller companies like L-3 Communications are also in the list. Other companies in the list include cruise companies such as Carnival and Royal Caribbean, and those which are located in the World Trade Center, such as Morgan Stanley, Lehman Brothers Holdings and Marsh & McLennan Companies, Inc..

For comparison, these 38 companies are classified into six categories, namely, the Airlines industry, Insurance industry, Banking and Finance industry, Military Contractors, Tourism industry and other industries.

The null hypothesis that there is no change in the stock price is to be tested against the alternative that there is a change. The data used are the daily closing prices of each stock from May 1, 2001 to January 31, 2002 extracted from the DataStream. The change date is searched within the middle 70% of the data set. A rejection of the null hypothesis will lead to the conclusion that there is a change in the stock price level.

The 1, 5 and 10% asymptotic critical values of the Sup-Wald test are 12.35, 8.85 and 7.17 respectively. The results are shown in Tables 1 to 6. The superscripts *a*, *b* and *c* denote the test statistic is significant at 1, 5 and 10% levels respectively.

All the eight companies in the airline industries as shown in Table 1 have experienced a drop in stock price level during the sampling period. Five of these eight companies in the airlines industry have suffered a significant downward shift in their stock prices. According to the values of the test statistic, the United Airlines was most seriously affected among all these 38 companies.

Table 1
Test Results for the Airlines Industry

Company	Sup-Wald Date	Test	$H_0 : \beta_1 = \beta_2$	$\hat{\beta}_1(\hat{k})$	$\hat{\beta}_2(\hat{k})$
1. The Boeing Co.	9/7/01	7.20 ^c	Reject	58.97	36.34
2. AMR Corp.	9/17/01	9.21 ^b	Reject	35.37	21.37
3. Continental Airlines	9/17/01	8.67 ^c	Reject	47.21	22.28
4. Delta Air Lines Inc.	9/10/01	8.34 ^c	Reject	43.61	27.55
5. Northwest Airlines Inc.	9/10/01	5.61	Not Reject	24.37	14.81
6. Southwest Airlines Co.	9/04/01	0.21	Not Reject	18.54	17.24
7. United Air Lines Corp.	9/17/01	22.40 ^a	Reject	34.55	15.31
8. US Airways Group Inc.	8/27/01	4.77	Not Reject	21.36	6.32

Table 2 shows the test results for insurance companies. It is clear from Table 2 that two out of the ten insurance companies are found to have a significant structural change, namely AXA-Spons ADR and CNA Financial. Both have a change date before September 11th. Notice that John Hancock Financial and XL Capital have an increase in their stock prices during the sampling period. This indicates that some insurance companies may have benefited from the attacks because of an increase in demand for insurance services.

On the other hand, all the three military contractors as shown in Table 3 have experienced a rise in their stock prices due to the 911 attacks. However, the rise is not significant enough to conclude that there is an upward structural change.

To one's surprise, none of the nine financial companies in Table 4 has a downward shift in their stock prices. All of them have a test value of less than 3. In fact, three of them, namely Bank One, Bear Stearns, and Marsh & McLennan actually have exhibited an upward shift in prices. This reflects that the banking and financial sectors are not affected by the attacks.

Turning to the tourism industry, the two companies as shown in Table 5 do exhibit downward price movements, although not statistically significant. Note that their Sup-Wald dates are just one working day apart from September 11th. This shows that the cruise industry can be quite sensitive to attacks.

Table 2
Test Results for the Insurance Industry

Company	Sup-Wald Date	Test	$H_0 : \beta_1 = \beta_2$	$\hat{\beta}_1(\hat{k})$	$\hat{\beta}_2(\hat{k})$
9. AIG	8/13/01	0.46	Not Reject	83.15	79.10
10. AXA-Spons ADR	9/6/01	7.24 ^c	Reject	28.85	21.10
11. MetLife Inc.	7/23/01	0.44	Not Reject	30.71	28.75
12. Chubb Corp.	7/10/01	0.51	Not Reject	74.58	69.18
13. CNA Financial	8/3/01	10.43 ^b	Reject	38.48	27.72
14. Cigna Group	7/13/01	0.04	Not Reject	91.93	84.27
15. John Hancock Financial	12/3/01	0.23	Not Reject	38.64	40.53
16. Progressive Corp.	11/6/01	0.01	Not Reject	0.52	0.46
17. Royal & Sun Alliance	9/10/01	5.16	Not Reject	35.10	27.56
18. XL Capital Ltd.	10/3/01	3.25	Not Reject	77.62	90.76

Table 3
Test Results for the Military Contractors

Company	Sup-Wald Date	Test	$H_0 : \beta_1 = \beta_2$	$\hat{\beta}_1(\hat{k})$	$\hat{\beta}_2(\hat{k})$
19. Lockheed Martin Corp.	9/17/01	6.72	Not Reject	37.95	46.73
20. Raytheon Co.	9/17/01	2.24	Not Reject	28.18	32.83
21. L-3 Communications Holdings	9/10/01	0.20	Not Reject	77.03	86.58

Table 4
Test Results for Banking and Financial Industry

Company	Sup-Wald Date	Test	$H_0 : \beta_1 = \beta_2$	$\hat{\beta}_1(\hat{k})$	$\hat{\beta}_2(\hat{k})$
22. Bank of America Corp.	11/2/01	0.36	Not Reject	59.30	62.55
23. Bank of New York	7/16/01	2.12	Not Reject	51.16	39.59
24. Bank One	11/19/01	0.24	Not Reject	35.63	38.23
25. American Express Co.	8/29/01	1.72	Not Reject	40.33	32.94
26. Citigroup	8/13/01	0.45	Not Reject	50.80	47.05
27. Morgan Stanley Dean Witter	8/8/01	1.41	Not Reject	63.32	53.03
28. Bear Stearns Companies Inc.	11/2/01	0.48	Not Reject	54.56	59.04
29. Lehman brothers Holdings Inc.	8/8/01	1.35	Not Reject	74.34	64.12
30. Marsh & McLennan Co. Inc.	11/5/01	0.24	Not Reject	99.79	104.95

Table 5
Test Results for Tourism Industry

Company	Sup-Wald Date	Test	$H_0 : \beta_1 = \beta_2$	$\hat{\beta}_1(\hat{k})$	$\hat{\beta}_2(\hat{k})$
31. Carnival Corporation	9/10/01	1.20	Not Reject	29.85	24.70
32. Royal Carribean	9/17/01	2.54	Not Reject	21.63	13.76

The test results for the other industries are summarised in Table 6. It is observed that none of the six companies in Table 6 has a downward shift in their stock prices. In contrast, the price of Vornado Realty Trust actually shifted upwards.

The Sup-Wald date corresponds to the date with the greatest value of the Wald test. Note that for a number of companies, their Sup-Wald dates are within the week before the 911 attacks. They are the Boeing Co., Delta Air Lines Inc., Southwest Airlines Co., Northwest Airlines Inc., AXA-Spons ADR, Royal & Sun Alliance, L-3 Communications Holdings, Carnival Corporation, General Motors and Hercules Inc..

If the null is rejected, then the pre-shift and post-shift parameters are estimated, and the Sup-Wald date will become the estimated change date. Among those companies which Sup-Wald dates are before 911, the Boeing Company, Delta Air Lines Inc. and AXA-Spons ADR are concluded to have a structural change. This indicates that there were short selling activities in the stock market before the 911 attacks.

Table 6
Test Results for the Other Industries

Company	Sup-Wald Date	Test	$H_0 : \beta_1 = \beta_2$	$\hat{\beta}_1(\hat{k})$	$\hat{\beta}_2(\hat{k})$
33. General Motors	9/6/01	3.67	Not Reject	59.90	46.39
34. Hercules Inc.	9/10/01	1.97	Not Reject	11.87	9.15
35. W.R. Grace & Co.	7/6/01	0.80	Not Reject	1.97	1.64
36. Vornado Realty Trust	12/14/01	0.91	Not Reject	38.96	41.79
37. Lone Star Technologies Inc.	7/12/01	6.99	Not Reject	41.95	17.57
38. LTV Corp.	11/19/01	3.67	Not Reject	0.13	0.02

To see the overall impact of the attacks on the U.S. stock market as a whole, this study also conducts a comprehensive study for the companies in the SP500. The complete test results for all the SP500 companies are available from the author upon request. We found that most of the blue-chip companies do not have a structural change. The only 15 companies in the SP500 list which have a change are reported in Table 7.

Among these 15 companies in Table 7, eight companies have change dates that are close to 911, four companies in the SP500 list are concluded to have the estimated change date within a week before the attacks, namely, Boeing, Delta Airlines, Franklin Resources Inc. and Providian Finl. Corp..

Table 7
Test Results for the Companies in the SP500

Company	Sup-Wald Date	Test	$H_0 : \beta_1 = \beta_2$	$\hat{\beta}_1(\hat{k})$	$\hat{\beta}_2(\hat{k})$
1. AES	9/17/01	9.35 ^b	Reject	39.88	15.61
2. Allstate Corp.	7/19/01	12.24 ^b	Reject	43.26	33.30
3. AMR Corp.	9/17/01	9.21 ^b	Reject	35.37	21.37
4. Boeing	9/7/01	7.20 ^c	Reject	58.97	36.34
5. Converse Tech.	7/10/01	13.23 ^a	Reject	61.81	23.29
6. Constellation Energy	7/20/01	10.39 ^b	Reject	44.63	26.88
7. Delta Airlines	9/10/01	8.34 ^c	Reject	43.61	27.55
8. Eastman Kodak	9/19/01	11.21 ^b	Reject	45.78	30.08
9. Ford Motor	8/20/01	7.27 ^c	Reject	25.34	16.87
10. Franklin Resources Inc.	9/6/01	7.86 ^c	Reject	43.77	35.18
11. GAP Inc.	8/17/01	8.87 ^b	Reject	29.46	14.45
12. Immunex	10/10/01	8.49 ^c	Reject	16.51	26.31
13. Providian Finl. Corp.	9/5/01	9.89 ^b	Reject	51.64	7.78
14. Tellabs	6/15/01	8.17 ^c	Reject	35.55	14.85
15. Textron Inc.	9/17/01	9.83 ^b	Reject	55.53	38.58

4. Conclusion

The 911 attacks have an adverse impact on consumers' and business confidence, deepening the economic downturn and postponing recovery of the U.S.. It also exposes the vulnerability of the New York Stock Exchange. This paper achieves two objectives. First, it tests if the drop in stock prices is a temporary event or a structural change. It is concluded that among the 38 listed companies which have unusual trading activities before the attacks identified by the Securities and Exchange Commission of the U.S., seven are considered to have a change in the stock price level. Five of these companies are in the airlines or related industries, namely the Boeing Co., AMR Corp, Continental Airlines, Delta Air Lines Inc. and the United Air Lines Corp.. According to the value of the Sup-Wald test statistic, the United Airlines seems to be the most seriously hit company among all the companies. Therefore, it can be concluded that the 911 incident does have significant impact on the U.S. airlines industry. However, the banking and insurance sectors are not seriously affected. None of the companies in the banking and financial sector studied in this paper is concluded to have a structural change. Only 15 out of the SP500 companies are concluded to have a structural change during the sampling period. This shows that the 911 attacks, although inflicted irreparable losses of innocent lives and caused untold physical damages, did not destroy or diminish the strength of the American stock market as a whole.

This study also provides statistical evidence which supports the hypothesis that speculators have advanced knowledge of the 911 incident and short sell the stock of those companies before September 11th. It is found that, for the Boeing Co., Delta Air Lines Inc. and AXA-Spons ADR, Franklin Resources Inc. and Providian Finl. Corp., their estimated change dates are within the week before the 911 incident. Thus, contrary to the report by Eichenwald and Edmund (2001), this paper provides the first piece of statistical evidence showing that there are insiders who know the attacks beforehand and try to profit from the U.S. stock market.

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