Short and Long-Term Effects of September 11 on Stock Returns: Evidence from U.S. Defense Firms

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Abstract

Using the multivariate regression methodology, we investigate the short-term effect of September 11, 2001 on US defense firms. Our findings suggest that the market differentiated among US defense firms based on the percentage of defense sales to total sales. In addition, the behaviour of the abnormal returns does not change when we use models that account for time variation of stock return volatility (GARCH). In the long-term, our results suggest that the US defense firms only outperform over a twelve-month period. However, the significant abnormal performance disappears over an eighteen-month period.

JEL classification numbers: G14, G21, C22

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1 Introduction

The objective of this paper is to study the short- and long-term performance of the US defense industry in the aftermath of September 11. We would naturally expect

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that US defense firms would be positively affected because of the potential increases in US defense spending. Indeed, the total cost of US military operations from fiscal year 2001 through May 2007 reached $610 billion (Congress Report Service, 2007 (CRS)). Of this total, CRS estimated that Operation Iraqi Freedom received about $450 billion (74%), Operation Enduring Freedom (Afghanistan) about $127 billion (21%), and enhanced base security about $28 billion (5%), as well as another $5 billion that CRS could not allocate (1%). The Congressional Budget Office estimated that war costs for the next 10 years could be anywhere from $1 trillion to $1.45 trillion by 2017. Some economists believe that the cost of the Iraq War could even exceed $2 trillion by 2015 (Bilmes and Stiglitz, 2006). Conversely, the impact of the event could be negative because of the existence of civilian activities in US defense firms. For example, Boeing, which is a very important contractor to the US Department of Defense, also has civilian activities and is in fact a major player in the aerospace industry. According to the CEO of Boeing, Phil Condit, the company has experienced the biggest downturn ever on the commercial side and a significant growth on the defense side (BBC interview, September 2, 2002).

Several factors justify such studies. First, unlike the previous papers that studied the impact of the short-term effect of September 11 (Carter and Simkins, 2004; Chaudry, 2005; Chen and Siems, 2004, Hon, Strauss and Young, 2004; Karyoli and Martell, 2010), very few have studied the attack's long-term effect on stock prices (Chaudry, 2005; Richman, Santos and Barkoulas, 2006).[3] Second, to the best of our knowledge, this research is the first to assess the performance of US defense firms after September 11. This contrasts with previous research focusing on the effect of September 11 on US firms in general (Carter, 2006; Chaudry, 2005; Karyoli and Martell, 2010). Third, a similar attack could happen again. It

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[3] These studies have captured the long-term effect by estimating the beta after September 11. In our study, we use stock return to assess the performance of US defense firms.

would be useful from a portfolio management perspective to identify those firms that would be less affected and to assess their performance. For instance, many corporate executives believe terrorism related business risks will increase in the coming years (Lloyd's of London, 2007).

In this investigation and for the short-term, we use a multivariate regression model methodology (MVRM) to assess the short-term effects of this event. The use of this technique allows us to test a number of hypotheses including whether the market reaction was uniform among defense firms or whether there was differentiation based on firm specific characteristics.

To assess the long-term effect of September11 and given the sensitivity of abnormal performance to specific measurement methods, we use three different metrics. The first is the buy-and-hold return in excess of the market return. The second is the daily cumulative abnormal return, which is a less biased method for assessing the long-term return (Fama, 1998; Mitchell and Stafford, 2000). The last is the Fama and French multifactor model in which the daily calendar-time return on a portfolio of defense firms is regressed on three factors (Fama and French, 1993). The model is used to control for event clustering and cross correlation in defense firms. The reminder of the paper is organized as follows. In section 2, we present the literature review and research questions. Section 3 presents the methodology. In section 4, we describe our sample. Section 5 presents the results, while section 6 concludes.

2 Literature review and research questions

A number of studies have investigated the short-term effect of September 11 on US financial markets. For example, Carter and Simkins (2004) study the reaction of US airline stocks to the September 11 attack. Their research indicates that major and non-major airlines exhibit significant negative abnormal returns for September 11. Furthermore, the market reacted differently for various air transport firms. Chaudry (2005) investigates the return and time varying beta effect of the September 11 attack for 20 US firms and found that the direction of the effect varied according to the firms. In addition, not all firms experienced an increase in their beta. Cummins and Lewis (2003) analyze the returns of 43 property-casualty insurers and also find evidence of strong negative reactions to 9/11.Doherty, Lamm-Tennant and Starks (2003) develop a testable hypothesis on the cross-sectional variation in price reaction of insurance companies following September 11, employing capacity constraint, post loss investment and a variety of implicit insurance contract models, and find results in support of their hypothesis. Finally, Kallberg, Liu and Pasquariello (2008) analyze the behavior of New York real estate investment trusts in response to the 9/11 attack and report an initial positive reaction followed by downward revisions of expectations a couple of weeks after the attacks.

Other research focuses on the short-term effect of September 11 on the world capital markets (Richman, Santos and Barkoulas, 2005; Chen and Siems, 2004; Hon, Strauss and Young, 2005). For example, Chen and Siems (2004) find that September 11 had a significant impact on the stock market around the world. Hon, Strauss and Young (2004) investigate the contagion effect of the September 11 attack and report an increased correlation across global stock markets in the aftermath of September 11. Along the same line Eldor and Melnick (2004) show that financial markets are efficient in pricing the shocks associated with terrorist attacks. Richman, Santos and Barkoulas (2005) document an increase in the level of systematic risk for 10 stock markets. The majority of industrial and emerging economies did not experience statistically significant increases in systematic risk in the post September 11 period. Dakos (2004) investigates the effects of terror attacks of September 11 on a set of airline stocks listed at various international stock markets. Utilizing the Market Model as the relevant return generating mechanism, he documents a structural break in systematic risk (beta) for airline stock. Nikkinen and Vähämaa (2010) examines the effects of terrorism on stock market sentiment by focusing on the behavior of expected probability density functions of the FTSE 100 index around September 11 attack. They find that terrorism has a strong adverse impact on stock market sentiment. In particular, terrorist attacks are found to cause a pronounced downward shift in the expected value of the FTSE 100 index and a significant increase in stock market uncertainty. More recently, Chesney, Reshetar and Karaman (2011) examine the impact of terrorism events (Including September 11 event) taking place in 25 countries over an 11-year period on the behaviour of stocks, bonds and the commodity market. They find that terrorist attacks have a significant effect on global, European, American, and Swiss markets.

All these studies show that the September 11 event had a significant negative impact on stock returns around world. These studies used market indices in order to assess the impact of September 11 on the financial markets.

Despite the existence of a large academic literature on the subject, there are still unanswered questions regarding the short and long-term influences of the event on US defense firms, namely:

What is the short-term effect of September 11 on US defense firms?

Is the reaction to such an event uniform among all US defense firms?

What is the long-term effect of September 11 on US defense firms?

3. Methodology

In this investigation, we use a multivariate regression model methodology (MVRM), similar to that used by Shipper and Thompson (1983) and Binder (1985a, 1985b), to assess the short-term effect of this event. The use of this technique will allow us to test a number of hypotheses including whether the market reaction was uniform among defense firms or whether there was differentiation based on firm specific characteristics. For example, a defense firm with civilian activities should react in a different way from a firm with strictly military activities. The use of this model is also helpful because it explicitly incorporates the contemporaneous dependence of the disturbances into the test statistic. This is important since the September 11 attack affected all firms during the same calendar time period, creating cross-sectional correlation of the error term. Therefore, we estimate a system of equations in which returns for each of our sample firms are represented as follows:

$$R_{i,t} = \alpha_i + \beta_i R_{m.t} + \alpha'_i D_a + \beta'_i D_a R_{mt} + \delta_i D_1 + \varepsilon_{i,t} \quad (1)$$

Where $R_{i,t}$ is the return on firm i at time t, $R_{m.t}$ is the return on the CRSP value-weighted market index at time t, D_a is a dummy variable that takes the value of one after September 11 and zero otherwise, D_1 is a dummy variable that takes the value of one on September 11 and zero otherwise, δ_i is the parameter used to measure the abnormal return on the event window for firm *i*, and $\varepsilon_{i,t}$ is the error term from the regression on date t for firm *i*. This term is treated as normally distributed with a mean of zero and a constant variance. We include parameters α', β' and D_a to assess any shift in risk perceptions after the attacks. Equation 1 is estimated using returns for 250-day period around September 11 events.

A number of hypotheses can be tested with the MVRM. We begin by testing whether significant abnormal returns occurred in response to the September 11 attack.

Hypothesis 1 (H_1): $\delta_i = 0$

Rejection of H_1 suggests that the market viewed the attack as having important implications for US defense firms and the information was updated in the stock prices.

We test an additional hypothesis to examine the overall economic significance of the market's reaction to September 11. Hypothesis 2 tests whether the sum of the abnormal returns for each firm is zero.

Hypothesis 2 (H_2): $\sum \delta_i = 0$

Rejection of H_2 indicates that the abnormal returns of US defense firms are jointly non-zero which indicates a potential contagion effect in response to the attack. If H_2 is rejected, we need to determine whether the abnormal returns were uniform among the different US defense firm.

Hypothesis 3 (H_3): $\delta_1 = \delta_2 ...... = \delta_n$

To assess the long-term effect of September11 and given the sensitivity of abnormal performance to specific measurement methods, we use three different metrics. The first is the buy-and-hold return in excess of the market return. The second is the daily cumulative abnormal return, which is a less biased method for assessing the long-term return (Fama, 1998; Mitchell and Stafford, 2000). The last is the Fama and French multifactor model in which the daily calendar-time return on a portfolio of defense firms is regressed on three factors (Fama and French, 1993). The model is used to control for event clustering and cross correlation in defense firms.

The Buy and Hold Return (BHAR) for each firm from period T1 to T2 is calculated as follows:

$$BHAR_{(T_1,T_2)} = \left[\prod_{t=T_1}^{T_2}(1+r_{it})\right] - \left[\prod_{t=T_1}^{T_2}(1+r_{mt})\right] \tag{2}$$

Where r_{it} is the daily return for firm i on day t and r_{mt} is the return on the CRSP value-weighted market index for the same day. The holding period begins with the first trading after September 11 (T1). T2 is the last day of the holding period. For each holding period, we calculate equally-weighted and value-weighted average BHARs where the weight is the relative market capitalization of a defense firm in the sample. The statistical significance of the average buy and hold returns is calculated using two different procedures. The first one is the conventional t-statistic. The second procedure is the calculation of a bootstrapped skewness-adjusted t-statistic (Lyon and al., 1999). The bootstrapped skewness-adjusted t-statistic is computed as:

$t_{sa} = \sqrt{n}\left(S + \frac{1}{3}\gamma S^2 + \frac{1}{6n}\hat{\gamma}\right)$ where $\hat{\gamma}$ is the estimate of the coefficient of skewness and $\sqrt{n}S$ is the conventional t-statistic.

The procedure was used to obtain an appropriate critical value when using the bootstrapping approach (Lyon and al. (1999)).

We also calculate the abnormal performance using the cumulative abnormal return approach (CAR) since it is a less biased method to assess the long-term return

(Fama, 1998; Mitchell and Stafford, 2000). CARs are calculated as follows:

$$CAR_{(T_1,T_2)} = \sum_{t=T_1}^{T_2} \left(r_{it} - r_{mt} \right) \tag{3}$$

Where r_{it} is the daily return for firm i on day t and r_{mt} is the return on the CRSP value-weighted market index for the same day. The holding period starts with the first trading day after September 11, 2001. Both equally-weighted and value-weighted averages are calculated.

An important issue in calculating the BHARs is to account for cross-sectional correlation between the long-horizon returns of different firms that may result in mis-specified test statistics. The calendar time approach is used to control for event clustering and cross correlation in defense firms. The Fama and French three-factor model is employed rather than the capital pricing model (CAPM) because of the well-known failure of the CAPM to describe the cross-section of expected returns (Fama and French, 1993). For each calendar day, we form both equally-weighted and value-weighted portfolios of defense firms. The returns of the portfolios are used to estimate the Fama and French three factor model as follows:

$$r_t - r_{ft} = \alpha + \beta\left(r_{mt} - r_{ft} \right) + \gamma SMB_t + \lambda Hml_t + \varepsilon_t \tag{4}$$

Where r_t is the calendar time portfolio of defense firms on day t and r_{ft} is the risk free return for the same day t. The independent variables of the regression are the excess market return ($r_{mt} - r_{ft}$), the difference in returns of value-weighted portfolios of small firms and large stocks (SMB_t), and the difference in returns of value-weighted portfolios of high book to market stocks and low book to market stocks (HML_t). We have constructed the SMB and HML in keeping with Fama and French (1993). The intercept term α is used as an indicator of risk-adjusted performance of defense firms.

4. Data

The data source of defense firms is the 2001 edition of the world's top 100 defense firms, a ranking published annually since 1991 by a defense news media group. The ranking is based on annual defense sales. Our initial sample comprises 42 US firms. Of these, we drop 20 firms due to a lack of information on stock prices and another 2 because their defense revenue was less than 10% of total revenue. Our final sample consists of 20 US firms. We use daily returns for each firm. The stock price series are extracted from Datastream. The time period extends from March 2001 to March 18, 2003. We choose to focus on the September 11 effects and therefore do not go beyond March 18 because the Bush administration decided to invade Iraq on March 19, 2003.

Table 1 shows the list of US defense firms and the distribution of defense revenue to total revenue in our final sample.

TABLE 1: The list of US defense firms

Firms	(% Sales)
Lockheed Martin Corp.	93.80
Oshkosh Truck Corp.	29.3
Alliant Techsystems	88.9
L-3 Communications Corp.	76.9
Boeing Co.	32.6
United Technologies Corp.	13.6
Harris Corp.	42.4
Northrop Grumman	68.9
ITT Industries	27.9
Kaman Corp.	34.4
General Dynamics Corp.	64
Jacob Engineering Group Inc.	18.5
Titan Corp.	78.6
Raytheon Co.	71
URS	15.1
Computer Sciences Corp.	15.8
Textron Inc.	11.7
Cubic Corp.	56.2
DRS Technologies Inc.	97.1
Teledyne Technologies	37

The sample consists of twenty firms. The sales data are from a defense news media group in 2001.

5. Results

5.1. Short-term performance of US defense firms

Table 2 presents the SUR estimates for equation 1. The estimates provide the basis for testing whether September 11 contained new information for defense firms.

TABLE 2: Short-term performance of US defense firms after September 11, 2001.

Firms	α_i	β_i	δ_i	α_i'	β_i'
Lockheed Martin Corp.	0.0002 (0.0015)	0.4002* (0.1123)	0.1381* (0.0180)	0.0018 (0.0021)	-0.3389* (0.1711)
Oshkosh Truck Corp.	-0.0018 (0.0026)	0.5470* (0.1995)	0.0819* (0.0320)	0.0042 (0.0038)	-0.0110 (0.3039)
Alliant Techsystems	0.0015 (0.0021)	0.4148* (0.1574)	0.1869* (0.0252)	0.0003 (0.0030)	-0.3787 (0.2397)
L-3 Communications Corp.	-0.0021 (0.0019)	0.8346* (0.1433)	0.3368* (0.0230)	0.0039 (0.0027)	-0.5215* (0.2182)
Boeing Co.	-0.0022 (0.0018)	0.8152* (0.1367)	-0.1351* (0.0219)	0.0031 (0.0026)	0.3619 (0.2082)
United Technologies Corp.	-0.0009 (0.0016)	0.9183* (0.1242)	-0.2739* (0.0199)	0.0032 (0.0023)	0.2712 (0.1892)
Harris Corp.	0.0021 (0.0020)	1.3127* (0.1532)	0.1119* (0.0246)	-0.0012 (0.0029)	-0.9310* (0.2334)
Northrop Grumman	-0.0007 (0.0016)	0.4959* (0.1176)	0.1349* (0.0189)	0.0020 (0.0022)	-0.6864* (0.1791)
ITT Industries	0.0011 (0.0012)	0.6659* (0.0881)	0.0012 (0.0141)	0.0013 (0.0017)	-0.0543 (0.1342)
Kaman Corp.	-0.0009 (0.0029)	0.7120* (0.2150)	0.0761* (0.0345)	0.0007 (0.0041)	0.0552 (0.3275)
General Dynamics Corp.	0.0010 (0.0017)	0.5733 (0.1290)	0.1096* (0.0207)	-0.0008 (0.0024)	-0.1295 (0.1964)
Jacob Engineering Group Inc.	0.0007 (0.0022)	0.5913 (0.1685)	0.1011* (0.0270)	-0.0002 (0.0032)	0.1565 (0.2566)
Titan Corp.	-0.0014 (0.0033)	1.7787* (0.2458)	0.1943* (0.0394)	0.0004 (0.0046)	-0.6116 (0.3743)
Raytheon Co.	-0.0012 (0.0021)	0.3404* (0.1563)	0.2316* (0.0251)	0.0032 (0.0029)	-0.4120 (0.2380)
URS	-0.0003 (0.0024)	0.6941* (0.1845)	0.1584* (0.0296	0.0033 (0.0035)	-0.0842 (0.2809)
Computer Sciences Corp.	-0.0031	1.6021*	-0.0053	0.0061	-0.9260*

	(0.0036)	(0.2692)	(0.0432	(0.0051)	(0.4099)
Textron Inc.	-0.0007	0.8161*	-0.0370	-0.0001	0.5635*
	(0.0021)	(0.1554)	(0.0249	(0.0029)	(0.2367)
Cubic Corp.	0.0000	0.6584*	0.0968*	0.0058	-0.1061
	(0.0025)	(0.1874)	(0.0300)	(0.0035)	(0.2854)
DRS Technologies Inc.	0.0028	0.5161*	0.2183*	-0.0010	-0.4565
	(0.0029)	(0.2213)	(0.0355)	(0.0042)	(0.3370)
Teledyne Technologies	0.0004	0.8835*	-0.0116	-0.0019	0.3650
	(0.0018)	(0.1329)	(0.0213)	(0.0025)	(0.2024)
	H_2		**H_3**		
F-statistic	27.69*		25.15*		

The equation is as follows:: $R_{i,t} = \alpha_i + \beta_i R_{m.t} + \alpha'_i D_a + \beta'_i D_a R_{mt} + \delta_i D_1 + \varepsilon_{i,t}$ Where $R_{i,t}$ is the return on firm i at time t, $R_{m.t}$ is the return on the CRSP value-weighted market index at time t, D_a is a dummy variable that takes the value of one after September 11 and zero otherwise, D_1 is a dummy variable that takes the value of one on September 17 and zero otherwise, δ_i is the parameter used to measure the abnormal return on the event window for firm i, and $\varepsilon_{i,t}$ is the error term from the regression on date t for firm i. The term is treated as normally distributed with a mean of zero and a constant**.** H_2 is the hypothesis testing whether the δ's all are equal to zero. H_3 is the hypothesis testing whether all the δ's are equal among themselves. The sample period goes from March 2001 to March 2002. Data sources: Datastream. * represents significant coefficients at the 5% level.

The results indicate that September 11 had a positive and significant effect on 70% of our sample. The abnormal returns for the firms range from 7% to 33%. In addition, the percentage of defense sales to total sales is usually higher than 40% for the firms. We also notice that only 10% of our sample exhibits a significant negative return on September 17. Further, five out of twenty firms in our sample show a significant decline in their beta after the attack. The negative coefficients indicate that the beta of the firms may have decreased in September and the following period. This decline occurs again for firms with defense revenue higher than 40% of total revenue.

The H_2 and H_3 tests are also presented. The F test rejects the null hypothesis that there was no impact on abnormal returns after the September 11 attack (H_2). We also reject H_3. These results indicate that the market does not price all firms in the same way. Even though such an event has a large emotional impact, investors seem to differentiate between firms.

The results from the table 2 indicate that defense sales could serve as a good measure with which to assess the degree of exposure to the September 11 attack. Accordingly, we subdivide our sample into two portfolios based on the percentage of defense revenue to total revenue, thereby giving rise to: (1) firms with high defense revenue and (2) firms with low defense revenue. To classify a firm with high defense revenue, the percentage of defense revenue to total revenue should be higher than the median of the sample. We then re-estimate equation 1 for the two portfolios. Table 3 shows that the portfolio with low defense sales exhibits a positive and statistically significant abnormal returns. However, the impact of September 11 was not statistically significant for firms with low defense sales. The latter result indicates that the existence of fewer defense activities in these firms helped them to minimize the effect of the September 11 attack.

TABLE 3: Return equations of portfolios of US defenses firms

	α_i	β_i	δ_i	α_i'	β_i'
LDSF	-0.0008 (0.0011)	0.8245* (0.0795)	-0.0044 (0.0127)	0.0020 (0.0015)	0.0698 (0.1210)
HDSF	0.0002 (0.0011)	0.7325* (0.0812)	0.1759* (0.0130)	0.0014 (0.0015)	-0.4572* (0.1236)
			H_2		**H_3**
F-statistic			95.007*		132.09*

The equations are as follows:

$$R_{i,t} = \alpha_i + \beta_i R_{m.t} + \alpha'_i D_a + \beta'_i D_a R_{mt} + \delta_i D_1 + \varepsilon_{i,t}$$

$$R_{j,t} = \alpha_j + \beta_j R_{m.t} + \alpha'_j D_a + \beta'_j D_a R_{mt} + \delta_j D_1 + \varepsilon_{j,t}$$

Where i is the index associated with the low defense revenue portfolio (LDSF) and j is the index associated with the high defense revenue portfolio (HDSF), $R_{i,t}$ ($R_{j,t}$) is the return on portfolio i (j) at time t, $R_{m.t}$ is the return on the CRSP value-weighted market index at time t, D_a is a dummy variable that takes the value of one after September 11 and zero otherwise, D_1 is a dummy variable that takes the value of one on September 11 and zero otherwise, δ_i (δ_j) is the parameter used to measure the abnormal return on the event window for portfolio i (j), and $\varepsilon_{i,t}$ $(\varepsilon_{j,t})$ is the error term from the regression on date t for portfolio i (j). The term is treated as normally distributed with a mean of zero and a constant variance. H_2 is the hypothesis testing whether the δ's all are equal to zero. H_3 is the hypothesis testing whether all the δ's are equal to each other. The sample period goes from March 2001 to March 2002. Data sources: Datastream. * represents significant coefficients at the 5% level.

In order to assess the validity of our results based on portfolio formation, we also regress a firm's excess returns on the percentage of defense revenue to total revenue as continuous variables. Results reported in table 4 indicate that, for our event window, the defense revenue factor is statistically positive at the 5% level.

TABLE 4: Cross-sectional regression of abnormal returns for the event day

Parameter	Coefficient	Standard error
Constant	-0.0708	0.0454
%DS	0.0032*	0.0008
R^2	0.47	
F-statistic	15.88*	

This table presents cross sectional regression for the abnormal returns of defense firms on September 11, 2001. %DS is total defense sales to total sales. * represents significant coefficients at the 5% level.

5.2. Long-term performance of US defense firms

The 12- and 18-month BHARs are reported in table 6. When the returns are equally weighted, the US defense firms outperform the market index by 27.52% after one year. The positive abnormal returns of US defense firms diminish substantially when returns are value weighted for the same holding period. After one year, the value-weighted BHARs are only 1.68%. When we investigate whether our value-weighted BHARs are driven by a few large firms by excluding Boeing from our sample (a weight average of approximately 30%), the value-weighted BHARs are not different from the equally-weighted BHARs. For an investor buying US defense firms after September 11, 2001 and holding them for 18 months, the US defense firms trail the market by an average of 1.07% and 0.48% for equally-weighted and value-weighted returns respectively.

Due to the skewness of the BHAR distribution, the bootstrapping method suggested by Lyon et al. (1999) was used. The bootstrapped skewness-adjusted t-statistics are reported in table 5 and show that the results are not markedly different from when we use the conventional t statistics.

TABLE 5: Long-term performance of US defense firms

Panel A	Long-term measure	12 months	18 months
BHARs	Equally-weighted	27.52%	-1.07%
	t-statistic	3.07*	-0.12
	Bootstrapped skewness-adj.	2.95*	-0.13
	Value-weighted	1.68%	-0.48%
	t-statistic	1.56	-0.93
	Bootstrapped skewness-adj.	2.39*	-1.29

Panel B	Long-term measure	12 months	18 months
CARs	Equally-weighted	24.06%	-2.73%
	t-statistic	2.53*	-0.21
	Value-weighted	0.79%	-0.29%
	t-statistic	2.36*	-0.49

Panel A reports the 12- and 18-month buy-and-hold returns (BHARs) which are measured as follows:

$$BHAR_{(T_1,T_2)} = \left[\prod_{t=T_1}^{T_2}(1+r_{it})\right] - \left[\prod_{t=T_1}^{T_2}(1+r_{mt})\right]$$

Where r_{it} is the daily return for firm i on day t and r_{mt} is the return on the CRSP value-weighted market index for the same day. The holding period begins with the first trading after September 11 (T1). T2 is the last day of the holding period. The equally-weighted average and value-weighted average are calculated for each holding period. The weight is the relative market capitalization of a defense firm in the sample.

Panel B reports the 12- and 18-month cumulative abnormal returns (CARs) which are measured as follows:

$CAR_{(T_1,T_2)} = \sum_{t=T_1}^{T_2} (r_{it} - r_{mt})$ Where r_{it} is the daily return for firm i on day t and r_{mt} is the return on the CRSP value-weighted market index for the same day. The holding period starts with the first trading day after September 11, 2001. T2 is the last day of the holding period. The equally-weighted average and value-weighted average are calculated for each holding period. The weight is the relative market capitalization of a defense firm in the sample.
The sample period goes from September 11, 2001 to March 18, 2003. Data sources: Datastream.
* represents significant coefficients at the 5% level.

We calculate abnormal performance using the cumulative abnormal return approach. The results reported in table 7 indicate that the equally-weighted 12- and 18-month returns are respectively 24.06% and -2.73% for US defense firms. As with the BHARs, the value-weighted CARs tend to decrease the degree of over-performance for the 12-month holding period, this decrease being explained by the existence of Boeing in our sample. The results indicate that the equally-weighted and value-weighted BHARs of US defense firms for the 18 month-holding period are negative but not statistically significant.

As a final check of the robustness of our results, we use the Fama and French three factor model. Table 8 reports the 12- and 18-month performance of US defense firms using the intercept from the Fama and French three factor regression. The ordinary least regression is presented in table 8. The intercept is positive and statistically different from zero when we use the equally-weighted portfolio over the 12-month holding period.[4] However, the magnitude of the abnormal returns is lower when we use the value-weighted portfolio, and the intercept in this case is not statistically significant. Once again, the existence of Boeing in our sample could explain the decline. For instance, when we exclude this firm from our sample, the intercept becomes statistically significant. When we examine the 18-month holding period, we find that US defense firms earn negative abnormal returns. The under-performance is not statistically significant for both equally- and value-weighted US defense firms.

TABLE 6: Long-term performance of US defense firms using the Fama and French three-factor approach

Panel A	**Holding period: 12 months**	
	Equally-weighted	Value-weighted
α	0.0016 (0.0008)	0.0005 (0.0009)
β	0.5407 (0.0652)	0.9392 (0.0740)

[4] For the robustness check, we also consider monthly returns instead of daily returns to estimate the intercept since the usage of the monthly returns are less susceptible to the bad asset-pricing model problem. The results are not affected by this change.

γ	0.3868 (0.1284)	0.2125 (0.1453)
λ	-0.2093 (0.1540)	0.1265 (0.1749)
Panel B	**Holding period: 18 months**	
	Equally-weighted	Value-weighted
α	-0.0003 (0.0006)	-0.0002 (0.0007)
β	0.8382 (0.0482)	1.0001 (0.0569)
γ	0.2063 (0.1017)	0.1878 (0.1199)
λ	0.2820 (0.1197)	0.3763 (0.1411)

The returns of the portfolio are used to estimate the Fama and French three-factor approach as follows: $r_t - r_{ft} = \alpha + \beta(r_{mt} - r_{ft}) + \gamma SMB_t + \lambda Hml_t + \varepsilon_t$ Where r_t is the calendar time portfolio of defense firms on day t and r_{ft} is the risk free return for the same day t. The independent variables of the regression are the excess market return ($r_{mt} - r_{ft}$), the difference in returns of value-weighted portfolios of small firms and large stocks (SMB_t), and the difference in returns of value-weighted portfolios of high book to market stocks and low book to market stocks (HML_t). We have constructed SMB and HML in keeping with Fama and French (1993). The intercept term α is used as an indicator of risk-adjusted performance of the defense firms. The sample period goes from September 11, 2001 to March 18, 2003. Data sources: Datastream. * represents significant coefficients at the 5% level.

5. 3 Robustness Check

In the previous section, we used multivariate equation estimates to investigate the presence of abnormal returns in our sample. In this section, we model conditional residual variances using the GARCH process. The objective is to examine whether abnormal returns found are still present when we use a different estimation approach.

In an event study framework, this adjustment is important when the event results in changes in volatility. Indeed, the abnormal returns identified in an event study could be due to a change in volatility rather than a change in the required return (Brown, Harlow and Ticnic, 1998).

In order to do that, we use GARCH. When using a GARCH parameterization, we let Γ be a 2 x 2 positive definite matrix, B be a symmetric 2 x 2 matrix for GARCH effects, A be a symmetric 2 x 2 matrix for ARCH effects, ε_{it} is the vector $(\varepsilon_{it}, \varepsilon_{jt})'$ which follows a bivariate normal distribution of mean zero and conditional variance H_t. The conditional variance model we consider is as follows

$$H_t = \Gamma + BH_{t-1}B' + A\varepsilon_{t-1}\varepsilon'_{t-1}A'. \tag{5}$$

Table (5) indicates that the behaviour of abnormal returns does not change markedly following the GARCH modeling of conditional residual variances. We also reran all of the previous analyses using the MSCI index return instead of the CRSP weighted average index. Results are not reported here and are not significantly affected by this change.

TABLE 7: Return equations of portfolios of US defense firms using a bivariate GARCH model

	α_i	β_i	δ_i	α_i'	β_i'
LDSF	0.0009 (0.0007)	0.7704* (0.0688)	-0.0105 (0.00118)	0.0008 (0.0011)	0.1109 (0.1101)
HDSF	0.0002 (0.0008)	0.7428* (0.0500)	0.1634* (0.0059)	0.0008 (0.0013)	-0.3121* (0.1105)

The equations are as follows:

$$R_{i,t} = \alpha_i + \beta_i R_{m.t} + \alpha'_i D_a + \beta'_i D_a R_{mt} + \delta_i D_1 + \varepsilon_{i,t}$$

$$R_{j,t} = \alpha_j + \beta_j R_{m.t} + \alpha'_j D_a + \beta'_j D_a R_{mt} + \delta_j D_1 + \varepsilon_{j,t}$$

$$H_t = \Gamma + B H_{t-1} B' + A \varepsilon_{t-1} \varepsilon'_{t-1} A'$$

Where i is the index associated with the low defense revenue portfolio and j is the index associated with the high defense revenue portfolio, $R_{i,t}$ ($R_{j,t}$) is the return on portfolio i (j) at time t, $R_{m.t}$ is the return on the CRSP value-weighted market index at time t, D_a is a dummy variable that takes the value of one after September 11 and zero otherwise, D_1 is a dummy variable that takes the value of one on September 17 and zero otherwise, δ_i (δ_j) is the parameter used to measure the abnormal return on the event window for portfolio i (j), and $\varepsilon_{i,t}$ ($\varepsilon_{j,t}$) is the error term from the regression on date t for portfolio i (j). The term is treated as normally distributed with a mean of zero and conditional variance H_t .* represents significant coefficients under robust standard errors (Bollerslev and Wooldridge, 1992) at the 5% level of significance. Standard error are in parentheses. The sample period goes from March 2001 to March 2002. Data sources: Datastream.

6 Conclusion

In this paper, we investigate the short- and long-term performance of the US defense industry in the aftermath of September 11. We use a multivariate regression analysis to test a number of hypotheses, including whether the market reaction was the same for each firm or whether the market differentiated based on differences among defense firms. We find that defense firms are not equally exposed to the September 11 attack. Indeed, 60% of our sample exhibit significant negative abnormal returns. In addition, the impact is not statistically significant for almost one third of our sample. More importantly, we find that investors distinguish between defense firms based on the level of defense sales. In the long-term, given the sensitivity of abnormal performance to specific measurement methods, we use three different metrics. The first is the buy-and-hold return in excess of the market return. The second is the daily cumulative abnormal return, which is a less biased method for assessing the long-term return (Fama, 1998; Mitchell and Stafford, 2000). The last is the Fama and French multifactor model in which the daily calendar-time return on a portfolio of defense firms is regressed on three factors (Fama and French, 1993). The model is used to control for event clustering and cross correlation in defense firms. Our results indicate that US defense firms exhibit positive abnormal returns after twelve months. However, when we examine the 18-month holding period, we find that the US defense firms earn negative abnormal returns. Nonetheless, the under-performance is not statistically significant for both equally- and value-weighted US defense firms.

These results make an appreciable contribution to research related to terrorism and stock markets through their discussion of the long-term effect of terrorism on firms' returns. We also show how some firms could benefit from terrorism activities such as the September 11 event. Finally, in spite of the emotional impact of this event, our results are consistent with the proposition of rational pricing in the U.S. financial markets and suggest that the market differentiated among defense firms.

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