

# Investor Reaction in Stock Market Crashes and Post-Crash Market Reversals

DANIEL FOLKINSHTEYN, Ph.D.  
Assistant Professor of Finance  
Rohrer College of Business  
Rowan University  
Glassboro, New Jersey 08028  
E-mail Address: [Folkinshteyn@rowan.edu](mailto:Folkinshteyn@rowan.edu)  
Phone: 856-256-3038

GULSER MERIC\*, Ph.D.  
Professor of Finance  
Rohrer College of Business  
Rowan University  
Glassboro, New Jersey 08028  
E-mail Address: [Meric@rowan.edu](mailto:Meric@rowan.edu)

ILHAN MERIC, Ph.D.  
Professor of Finance  
College of Business Administration  
Rider University  
Lawrenceville, New Jersey 08648  
E-mail Address: [Meric@rider.edu](mailto:Meric@rider.edu)

\* Corresponding author

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## ABSTRACT

De Bondt and Thaler (1985, 1987) argue that investors tend to overreact to economic events. However, investor overreaction in stock market crashes has not been studied sufficiently. In this paper, we study this issue with data for five major stock market crashes during the 1987-2008 period. We find evidence of investor overreaction in all five stock market crashes. The prices of stocks investors bid down more than the average during crashes tend to increase more than the average in post-crash market reversals. The CAPM predicts that stocks with higher betas decrease more in down markets and increase more in up markets. In line with the prediction of the theory, we find that high beta stocks lose more value in crashes and gain more value in post-crash market reversals relative to low beta stocks. In the Fama-French (1992, 1993) three-factor asset pricing model, smaller firms and those with a low market-to book ratio are riskier investments. In line with the prediction of the theory, we find that these firms lose more value in stock market crashes. However, they do not gain more value in post-crash market reversals, implying that investor reaction against smaller firms and those with lower market-to-book ratios in stock market crashes is not an overreaction. Our regression results with the industry dummy variables indicate that investors overbid down the prices of high-tech stocks in the 1997 crash and manufacturing stocks in the 2008 crash relative to other stocks. However, the prices of the stocks in these industries increased more than the prices of the stocks in the other industries in the post-crash market reversals, implying investor overreaction in these industries in the 1997 and 2008 stock market crashes.

**Keywords:** stock market crash, post-crash market reversal, determinants of stock returns, investor reaction and overreaction

**JEL classification:** G00, G01, G10, G14

## 1. INTRODUCTION

Stock market crashes have received considerable attention in finance literature. Arshanapalli and Doukas (1993) and Lau and McInish (1993) study the co-movements of the world's stock markets before and after the 1987 stock market crash. Roll (1988) and Pan et al. (2001) study the effects of emerging markets in stock market crashes. Wang et al. (2009 and 2010) study the determinants of stock returns in stock market crashes.

De Bondt and Thaler (1985, 1987) argue that investors tend to overreact to economic events. Chopra et al. (1992), Rozeff and Zaman (1998), Bauman et al. (1999) and others provide empirical evidence for investor overreaction. In a recent article, Wang et al (2013) demonstrate that investors overreacted to the bankruptcy risk and technical insolvency risk characteristics of firms in the 2008 stock market crash. There are many possible explanations for this 'investor overreaction' phenomenon, from behavioral sentiment issues (Baker, Wurgler, 2006), to herding (Puckett, Yan, 2008) to market microstructure constraints (Park, 1995; Kaul, Nimalendran, 1990; Atkins, Dyl, 1990), to appropriate response to changing risk (Brown et. al., 1993). Amini et. al. (2013) present an overview of the literature on price reversals. Analysis of price reversals accompanying issue-specific public news or lack thereof on a shorter time frame tends to evidence of overreaction (e.g. Chan, 2003; Larson, 2003; Bremer, Sweeney, 1991). Chopra et. al. (1992) examine a longer time frame and also conclude there is evidence of overreaction. While some researchers attempt to measure investor sentiment directly (Baker, Wurgler, 2006), in this study we follow most prior research and focus on the price movements and company financials to investigate the issue of investor overreaction in general stock market crashes with data for the five most important stock market crashes during the 1987-2008 period.

A stock market crash is commonly defined as a sudden dramatic decline of stock prices across a significant cross-section of a stock market. There is no generally accepted threshold for duration or magnitude for the decline in stock prices. Wang et al. (2009) and Gulko (2002) define a stock market crash as 5% or greater decrease in stock prices in a single trading day. In this paper, we study the stock market crashes with a minimum of 9.8% cumulative decline in stock prices in several consecutive trading days.

Stock market crashes are generally followed by several days of sharp market reversal. If there is an overreaction towards stocks with certain financial characteristics during a crash, the reaction is reversed with a sharp market correction during the post-crash market reversal period. For instance, Wang et al. (2013) find that investors overreacted to the technical insolvency risk and bankruptcy risk characteristics of firms by bidding down their stock prices sharply in the 2008 crash. These stocks gained more value relative to other stocks in the post-crash market reversal. In this study, following the methodology used in Wang et al. (2013), we compare the crash and post-crash market reversal periods to determine if there was any investor overreaction in the five most important stock market crashes of the 1987-2008 period. The crash and post-crash market reversal periods included in the study are presented in Table 1.

Table 1: Crash and recovery event characteristics

Event	Crash dates	Crash return (%)	Recovery dates	Recovery return (%)
October 1987	Oct 14 – Oct 19	-28.51	Oct 20 – Oct 21	+14.92
October 1997	Oct 22 – Oct 27	-9.80	Oct 28	+5.12
August 1998	Aug 26 – Aug 31	-12.41	Sep 1	+3.86
April 2000	Apr 10 – Apr 14	-10.54	Apr 17 – Apr 18	+6.27
October 2008	Oct 1 – Oct 10	-22.90	Oct 13	+11.58

*This table details the five crash and recovery events that are the subject of this study. Included are the dates for crash and recovery, as well as the S&P 500 index returns for each.*

Our research makes several important contributions to the literature. We document a consistent pattern of investor overreaction in a large cross-sectional sample across five of the most significant stock market crashes of the past three decades. We also find that different stock characteristics had varying impact on the magnitude of overreaction among the events included in our study.

The paper is organized as follows: In Section 2, we provide information about our data and methodology. In Section 3, we present our regression results for the five stock market crashes included in the study. In Section 4, we present our regression results for the five post-crash market reversal periods. Our regression results with the combined data for all five stock market crashes are presented in Section 5. Section 6 summarizes our findings and concludes the paper.

## 2. DATA AND METHODOLOGY

The daily stock trading prices, used in the calculation of daily returns, are obtained from the Center for Research in Security Prices (CRSP) database. The 'crash return' is defined as the cumulative return over several consecutive daily price decreases in the S&P 500 index during the crash event. The 'recovery return' is defined as the cumulative return over several consecutive daily price increases in the S&P 500 index immediately following the crash event.

We use the event study methodology and calculate the cumulative stock returns during the crash and recovery windows using trading price data. We compute the CAPM betas of the stocks using the daily stock returns for the past 90 calendar days and the CRSP-provided returns on a value-weighted index which includes NYSE, NASDAQ, and ARCA securities. Firms with missing trading prices on key event dates and those with fewer than 30 trading quotes in the past 90 calendar days are excluded from the sample. Following Wang et al. (2009), we also exclude firms with a trading price of less than one dollar.

We use the Research Insight (COMPUSTAT) quarterly database to collect balance-sheet information on the individual securities. For each security and each event, we select the latest available COMPUSTAT quarterly observation within the year prior to the start of the event. Firms with missing data are excluded from the sample.

The study by Wang et al. (2013) finds that investors overreacted to the technical insolvency risk and bankruptcy risk characteristics of firms in the 2008 stock market crash. The current ratio measures the ability of a firm to meet its maturing obligations and is a standard measure of technical insolvency risk (see: Wang et al, 2013). The debt ratio is commonly used in empirical studies as a measure of firm bankruptcy risk (see, e.g., Mitton, 2002; Baek et al., 2004; Wang et al., 2013). The current ratio and the debt ratio are the two key financial ratios used in Ohlson's (1980) bankruptcy prediction model. We use these two financial ratios in our empirical tests to study investor reaction to technical insolvency risk and bankruptcy risk characteristics of firms in the five stock market crashes and post-crash market reversals included in the paper.

Sharpe's CAPM has been generally tested with data for normal time periods. Beta has not been studied sufficiently as a determinant of stock returns in stock market crashes and post-crash market reversals. We use beta as a control variable in our empirical tests and we study if it was a significant determinant of stock returns in the stock market crashes and post-crash market reversals included in the paper. In their three-factor CAPM, in addition to beta, Fama and French (1992, 1993) use firm size and the market-to-book ratio as determinants of stock returns. In our empirical tests, we also use these two variables as controls and investigate if they were significant determinants of stock returns in the stock market crashes and post-crash market reversals included in the study.

Industry dummy variables are commonly used in cross-sectional studies of stock returns (see, e.g., Mitton, 2002; Baek at al., 2004; Wang et al., 2009). To control for the industry effect, we construct five broad industry portfolios (French, 2008) based on SIC codes. The portfolios are 'cnsmr', including consumer durables, nondurables, wholesale, retail, and some services; 'manuf', including manufacturing, energy, and utilities; 'hitec', including business equipment, telephone and television transmission; 'hlth', including healthcare, medical equipment, and drugs; and 'allother', which includes mines, construction, building materials, transportation, hotels, business services, entertainment, and finance. Utility firms' financial decisions are affected by regulation, while financial firm financial ratios are not comparable to those of other firms. Therefore, following Fama and French (2001, 2002), Gadarowski et a. (2007), and Wang (2009 and 2013), we exclude utilities (SIC code 4900-4999) and financial firms (SIC code 6000-6999) from our sample.

The data items used in the study from the CRSP and COMPUSTAT databases are presented in Table 2. We list the variables constructed with the data in Table 3. After excluding observations with missing values, we winsorize extreme values using robust median-based measures of center and scale. At the end, we have 2591 observations for 1987, 4642 observations for 1997, 4443 observations for 1998, 4442 observations for 2000, and 3277 observations for 2008, a total of 19395 observations for the entire sample.

The descriptive statistics for the sample are presented in Table 4. The statistics in the table show a pattern of growing firm size over time, both in terms of total assets and market cap. Mean total assets gradually increases from 968 million in 1987 to 5,184 million in 2008, which is expected given the general growth of the economy as well as dollar inflation over the time period. The mean current ratio steadily grows from 2.8 in

Table 2: Data items used in the study

Variable	Source	Description
Indtret	CRSP	Combined index return, including NYSE, Nasdaq, ARCA
Adjtprc	CRSP	Adjusted trading price, present only if trades occurred during the day
Tprc	CRSP	Trading price, present only if trades occurred during the day
SIC	CRSP	SIC code
TCap	CRSP	Market cap, in thousands (rescaled to millions for convenience)
ACTQ	COMPUSTAT	Total current assets, in millions
LCTQ	COMPUSTAT	Total current liabilities, in millions
LTQ	COMPUSTAT	Total liabilities, in millions
ATQ	COMPUSTAT	Total assets, in millions

*This table lists all the data items used in this study, along with their descriptions and source databases.*

Table 3: Constructed variables used in the study

Variable	Description
crash.return	Simple total return for the 'crash' period for each event.
recovery.return	Simple total return for the 'recovery' period for each event.
beta	Stock beta calculated over the past 90 calendar days of daily stock data.
mkbk	Market to book equity ratio. $TCap / (ATQ - LTQ)$
dr	Debt to equity ratio. $LTQ / (ATQ - LTQ)$
cr	Current ratio. $ACTQ / LCTQ$
cnsmr	Dummy variable set to 1 for the 'consumer' industry portfolio.
manuf	Dummy variable set to 1 for the 'manufacturing' industry portfolio.
hitec	Dummy variable set to 1 for the 'high technology' industry portfolio.
hlth	Dummy variable set to 1 for the 'healthcare' industry portfolio.

*This table lists all the constructed variables used in this study, along with their detailed descriptions.*

1987 to 3.06 in 2000, then drops back down to 2.77 in 2008. The mean debt-to-equity ratio starts out high at 1.34 in 1987, decreases to 1.25 in 1997, then gradually increases to 1.29 by 2008. The crash and recovery returns are highly variable within each event sample showing that, even during significant overall market moves, there is wide variation in the performance of individual stocks.

We use the following multivariate regression model for each of the five crash events with the dependent variable as the crash return:

$$\begin{aligned}
 crash.return = & a_0 + a_1beta + a_2TCap + a_3mkbk + a_4dr + a_5cr + \\
 & + a_6cnsmr + a_7hitec + a_8hlth + a_9manuf + \square
 \end{aligned} \tag{1}$$

Table 4: Summary statistics

Variable	Min	1st Qu.	Median	Mean	3rd Qu.	Max	StDev
Panel 1: October 1987 crash (N = 2591)							
ATQ	1.1490	31.8315	91.9660	816.5115	316.4385	70011.0000	3563.7886
LTQ	0.0780	12.0445	41.7850	453.3846	160.1230	37782.9920	2000.1800
TCap	1.4640	30.8920	83.0500	770.5773	320.2284	90131.0462	3393.3567
cr	0.0087	1.5563	2.2342	2.9125	3.4175	10.2798	2.1339
dr	0.0106	0.4826	0.9761	1.3059	1.6356	5.9781	1.2208
mkbk	0.0058	1.3369	1.9994	2.5777	3.1089	11.7331	2.0237
beta	-2.3879	0.1750	0.5484	0.5738	0.9545	4.5528	0.6293
crash.return	-0.6316	-0.2609	-0.1905	-0.1931	-0.1228	0.5532	0.1020
recovery.return	-0.4576	-0.0837	-0.0282	-0.0130	0.0428	0.6667	0.1146
Panel 2: October 1997 crash (N = 4642)							
ATQ	1.4410	36.2522	108.8160	1051.7984	449.3995	97123.0000	4393.2305
LTQ	0.0260	9.9467	40.8380	610.9285	230.7760	58537.0000	2701.8275
TCap	1.8322	54.7386	165.4119	1480.0984	617.7851	167169.5000	7473.0607
cr	0.0271	1.4516	2.2292	2.9981	3.5716	10.2798	2.3685
dr	0.0006	0.3437	0.7755	1.2127	1.5520	5.9781	1.3103
mkbk	0.0029	1.7096	2.8001	3.7471	4.7682	11.7331	2.9319
beta	-5.0234	0.0694	0.4545	0.4323	0.8180	4.8331	0.6817
crash.return	-0.5000	-0.1299	-0.0798	-0.0862	-0.0385	0.4884	0.0768
recovery.return	-0.3824	-0.0134	0.0155	0.0237	0.0558	0.4444	0.0618
Panel 3: August 1998 crash (N = 4443)							
ATQ	1.6050	43.6285	137.9360	1217.3521	561.0190	93216.0000	4661.2033
LTQ	0.0470	12.0855	51.1720	712.1914	289.7520	58535.0000	2839.0516
TCap	1.4816	44.3123	139.2353	1650.2073	530.4988	280297.9988	9682.5562
cr	0.0580	1.4853	2.2571	3.0505	3.6478	10.2798	2.3972
dr	0.0011	0.3489	0.7932	1.2286	1.5764	5.9781	1.3193
mkbk	0.0030	1.1840	1.9648	2.8876	3.5119	11.7331	2.6669
beta	-4.3901	0.3863	0.7696	0.7988	1.1789	3.7778	0.6648
crash.return	-0.6826	-0.2048	-0.1349	-0.1439	-0.0769	0.5476	0.1011
recovery.return	-0.4326	-0.0192	0.0141	0.0227	0.0583	1.5000	0.0852
Panel 4: April 2000 crash (N = 4442)							
ATQ	1.7860	51.5080	176.8375	1709.5410	685.6862	244192.5300	8340.4210
LTQ	0.0230	13.7112	59.7980	960.3256	333.6790	114871.0000	4524.8562
TCap	1.3791	57.4360	228.0232	3019.5386	915.0303	490266.7536	18498.8881
cr	0.0447	1.3973	2.2103	3.1608	3.7976	10.2798	2.6193
dr	0.0008	0.3078	0.7918	1.2296	1.5936	5.9781	1.3343

mkbk	0.0011	1.1197	2.3643	3.9283	5.6450	11.7331	3.6984
beta	-3.6408	0.1954	0.5736	0.6757	1.0948	4.9892	0.7540
crash.return	-0.7903	-0.2777	-0.1309	-0.1643	-0.0366	0.5000	0.1627
recovery.return	-0.5000	-0.0166	0.0250	0.0509	0.1021	1.2500	0.1279

Panel 5: October 2008 crash (N = 3277)

ATQ	1.6800	138.6240	507.6410	4962.0087	2150.9130	342679.0000	19707.4593
LTQ	0.0090	38.3690	200.8270	2812.1049	1155.6970	200770.0000	11704.0347
TCap	0.5337	113.4000	414.1561	3425.5645	1568.3606	403366.2920	14974.2665
cr	0.0000	1.3428	2.0768	2.8281	3.3656	10.2798	2.2940
dr	0.0003	0.3633	0.8211	1.2518	1.5556	5.9781	1.3383
mkbk	0.0021	0.9472	1.6290	2.4103	2.9117	11.7331	2.4251
beta	-1.3277	0.5052	0.8322	0.8328	1.1382	3.0757	0.5048
crash.return	-0.8080	-0.3386	-0.2441	-0.2542	-0.1697	0.4119	0.1338
recovery.return	-0.4110	0.0461	0.0960	0.1061	0.1532	1.1000	0.0982

Panel 6: All data (N = 19395)

ATQ	1.1490	46.3940	160.8540	1869.6060	691.1090	342679.0000	9739.2313
LTQ	0.0090	13.7870	60.4540	1065.0142	339.9105	200770.0000	5709.7211
TCap	0.5337	52.7597	181.6923	2105.5643	736.1210	490266.7536	12388.6224
cr	0.0000	1.4434	2.2055	3.0072	3.5936	10.2798	2.3956
dr	0.0003	0.3575	0.8221	1.2393	1.5807	5.9781	1.3113
mkbk	0.0011	1.2328	2.1673	3.2096	3.9703	11.7331	2.9549
beta	-5.0234	0.2434	0.6337	0.6586	1.0433	4.9892	0.6793
crash.return	-0.8080	-0.2375	-0.1398	-0.1600	-0.0652	0.5532	0.1313
recovery.return	-0.5000	-0.0180	0.0242	0.0387	0.0862	1.5000	0.1048

*This table shows the summary statistics of the data samples for the five individual crash events in Panels 1-5, in chronological order, and for all data aggregated together in Panel 6. Included are the minimum, first quartile, median, mean, third quartile, maximum, and standard deviation. All variables are as defined earlier in Tables 2 and 3.*

We use the following multivariate regression model for each of the five post-crash market reversal events with the dependent variable as the recovery return:

$$\begin{aligned}
 \text{recovery.return} = & b_0 + b_1\text{CrashRet} + b_2\text{beta} + b_3\text{TCap} + b_4\text{mkbk} + b_5\text{dr} + \\
 & + b_6\text{cr} + b_7\text{cnsmr} + b_8\text{hitec} + b_9\text{hlth} + b_{10}\text{manuf} + e
 \end{aligned} \tag{2}$$

where  $b_0$  is a constant (the intercept term),  $e$  is the error term, and  $b_1, b_2, \dots, b_{10}$  are the regression coefficients. The independent variables of Model (2) are the same as in Model (1) except the crash returns (*CrashRet*) variable. Crash returns are used as an independent variable in Model (2) to determine if crash returns can explain post crash returns.

### 3. REGRESSION RESULTS FOR THE CRASH PERIODS

The multivariate regression analysis results for the five crash periods using Equation (1) are presented in Table 5. The F statistics indicate that all five regressions in the table are statistically significant. The explanatory power of the model varies between the events with the adjusted R-squared ranging from a low of 8.5 percent for 1997 to 44.9 percent for 2000.

For all the events, the regression coefficient of beta is significant and negative, which indicates that stocks with a higher beta lost more value in all five stock market crashes relative to lower beta stocks. This result is in line with the CAPM, which predicts that stocks with higher betas would lose more value in down markets relative to low beta stocks.

The regression coefficient of the size (TCap) variable is significant with a negative sign for the 1987 crash and with a positive sign for the 1998, 2000, and 2008 crashes. It is not statistically significant for the 1997 crash. The Fama and French (1992, 1993) three-factor CAPM argues that large firms are less risky than smaller firms. Therefore, the TCap variable should have a positive sign in a stock market crash. The 1998, 2000, and 2008 results confirm the prediction of the model. However, our results indicate that larger firms lost more value compared with smaller firms in the 1987 crash. There was a major market correction in stock prices in the 1987 crash. Investors might have thought that large firm stocks were more overvalued compared with small company stocks prior to the crash.

The regression coefficient of the market-to-book (mkbk) variable is significant with a negative sign for the 1987, 1997, 1998 and 2000 crashes and with a positive sign for the 2008 crash. According to Fama and French's (1992, 1993) three-factor CAPM, the market-to-book ratio is a risk factor in capital-asset pricing. A low market-to-book ratio implies that the firm may be in financial distress. These firms are expected to perform worse compared with high market-to-book firms in stock market crashes. Our regression result for the 2008 crash confirms the theory's prediction. However, the results for the 1987, 1997, 1998, and 2000 crashes do not support the theory's prediction. Wang et al. (2013) determine that bankruptcy risk was a serious concern for investors in the 2008 crash. Therefore, we find that firms with a low market-to-book ratio and greater risk lost more value in the 2008 crash. In the 1987, 1997, 1998, and 2000 crashes, however, perhaps investors considered firms with a high market-to-book ratio to be overvalued prior to crash and they simply bid down their prices more relative to low market-to-book ratio firms during the crash.

Our findings with the debt-to-equity (dr) variable also confirm our conclusion with the size (TCap) and mkbk variables. Bankruptcy risk was a significant concern for investors in the 2008 crash. Therefore, firms with a smaller size, lower mkbk, and higher dr lost more value in the 2008 crash. However, the dr variable is significant with a positive sign in the 1997, 1998, and 2000 crashes. Firms with a high dr performed better in these crashes relative to low dr firms.

Since technical insolvency risk and bankruptcy risk were significant concerns for investors in the 2008 crash, like the dr variable, the current ratio (cr) variable is also

Table 5: Multivariate Regression Analysis Results for the Crash Events

	Dependent Variable: crash.return									
	1987		1997		1998		2000		2008	
	Result	VIF	Result	VIF	Result	VIF	Result	VIF	Result	VIF
Intercept	-0.1473 *** ( -21.2710 )		-0.0737 *** ( -19.5091 )		-0.1069 *** ( -20.9620 )		-0.0685 *** ( -11.1651 )		-0.2271 *** ( -29.6074 )	
beta	-0.0513 *** ( -16.9161 )	1.0716	-0.0147 *** ( -9.0265 )	1.0533	-0.0327 *** ( -14.7215 )	1.0512	-0.0438 *** ( -15.9216 )	1.3129	-0.0528 *** ( -11.6407 )	1.0811
TCap	-0.0024 *** ( -4.2735 )	1.0589	0.0000 ( 0.3134 )	1.0597	0.0006 *** ( 3.7445 )	1.0632	0.0008 *** ( 7.8633 )	1.0498	0.0003 ** ( 2.1699 )	1.0293
mkbk	-0.0063 *** ( -6.7088 )	1.0779	-0.0036 *** ( -9.1968 )	1.1614	-0.0046 *** ( -7.8040 )	1.1966	-0.0133 *** ( -22.5216 )	1.4490	0.0057 *** ( 5.7418 )	1.1909
dr	-0.0013 ( -0.7928 )	1.2096	0.0061 *** ( 6.4851 )	1.3021	0.0027 ** ( 2.2034 )	1.2786	0.0106 *** ( 6.8937 )	1.2747	-0.0109 *** ( -5.6474 )	1.3756
cr	0.0026 *** ( 2.6369 )	1.2781	-0.0003 ( -0.5933 )	1.3492	-0.0014 ** ( -2.0241 )	1.2753	-0.0089 *** ( -10.9370 )	1.3948	0.0041 *** ( 3.7832 )	1.2710
cnsmr	-0.0020 ( -0.3294 )	1.1678	0.0135 *** ( 3.6521 )	1.2161	0.0181 *** ( 3.6768 )	1.1870	0.0292 *** ( 4.6953 )	1.3557	0.0277 *** ( 3.9136 )	1.1712
hitec	-0.0074 ( -1.1644 )	1.1678	-0.0163 *** ( -4.4810 )	1.2161	-0.0142 *** ( -2.9515 )	1.1870	-0.0569 *** ( -9.3125 )	1.3557	0.0197 *** ( 2.9537 )	1.1712
hlth	-0.0257 *** ( -3.1270 )	1.1678	0.0048 ( 1.0697 )	1.2161	-0.0009 ( -0.1613 )	1.1870	0.0188 ** ( 2.5156 )	1.3557	0.0018 ( 0.2137 )	1.1712
manuf	0.0015 ( 0.2521 )	1.1678	0.0095 ** ( 2.5203 )	1.2161	0.0118 ** ( 2.3481 )	1.1870	0.0519 *** ( 7.9981 )	1.3557	-0.0342 *** ( -4.8323 )	1.1712
N	2591		4642		4443		4442		3277	
Adj. R-squared	0.1530		0.0853		0.1002		0.4492		0.1142	
F statistic	52.9743 *** ( 0.0000 )		49.0916 *** ( 0.0000 )		55.9806 *** ( 0.0000 )		403.3583 *** ( 0.0000 )		47.9215 *** ( 0.0000 )	

This table shows the results of multiple regression analysis on the data for the individual events. The dependent variable is the crash return, and the independent variables are as listed in the table in the leftmost column. The regression specification is as follows:

$$crash.return = a_0 + a_1beta + a_2TCap + a_3mkbk + a_4dr + a_5cr + a_6cnsmr + a_7hitec + a_8hlth + a_9manuf + \epsilon$$

Each column shows the regression results for one of the events, left to right in chronological order, as labeled. Shown are the coefficients with significance indicators, and t-statistics below in parentheses. All variables are as defined earlier in Tables 2 and 3, but with TCap rescaled to billions. The last three rows list the number of observations, the adjusted R-squared, and the F statistic (with p-value in parentheses), for each of the regressions.

The variance inflation factors (VIF) are listed to the right of each coefficient for each regression. The VIF is used to test for multicollinearity in the model. Prior literature suggests that there is no major multicollinearity associated with a variable if the VIF value is less than 10 (Belsley et al., 2009).

\*\*\*, \*\*, \* indicate significance at the 1, 5, and 10 percent levels, respectively.

significant for the 2008 crash with a positive sign. Firms with a higher cr (i.e., firms with a better ability to meet their maturing obligations) lost less value in the 2008 crash. We find a similar result for the 1987 crash. However, the sign of the cr variable is significant

but negative for the 1998 and 2000 crashes. Firms with more investment in less profitable liquid assets lost more value in these crashes.

The regression coefficients for the industry dummy variables indicate that there is significant variation in the industry effect between the five crash events. With the exception of the 1987 crash, it appears that the consumer goods industry segment (cnsmr) generally performed better during crashes with positive and significant regression coefficients. Firms in the 'hitec' industry group performed better than the average in the 2008 crash and worse than the average in the 1997, 1998 and 2000 crashes. The healthcare (hlth) industry regression coefficient is significant only for the 1987 and 2000 crashes with firms in this industry underperforming the average in the former and outperforming the average in the latter event. The regression coefficient for the manufacturing (manuf) industry segment is positive and significant for 1997, 1998, and 2000, and negative for 2008, indicating that manufacturing firms performed better than the average in the 1997, 1998, and 2000 crashes and worse than the average in the 2008 crash.

We observe a pattern of opposition between the effects of the hitec and manuf industry sectors in stock market crashes. Whenever the regression coefficient of one is positive the other is negative, and vice versa. The cnsmr sector appears to perform consistently better than the average in crashes.

#### 4. REGRESSION RESULTS FOR THE POST-CRASH MARKET REVERSAL PERIODS

The results of the regressions specified by Equation (2) are shown in Table 6. The F statistics indicate that all five regressions are statistically significant. The explanatory power of the model varies between the events but is on average higher than in the crash regressions with the adjusted R-squared ranging from a 14.7 percent for 1998 to 36.5 percent for 2000.

For all the events, the regression coefficient of the crash return variable is significant with a negative sign indicating that firms that experience a larger negative return during the crash period make up for it with a larger positive return in the post-crash market reversal. It implies investor overreaction during the crash period with a significant market correction in the post-crash market reversal.

The regression coefficient of beta is significant with a positive sign for all events except the 1987 post-crash market reversal event. The 1997, 1998, 2000, and 2008 results are in line with the prediction of the CAPM. The model predicts that stocks with higher betas earn higher returns relative to low beta stocks in up markets.

The regression coefficient of size (TCap) is significant with a positive sign for all post-crash market reversal events (i.e., large company stocks outperform small company stocks in all post-crash market reversals). This result is in line with the prediction of the Fama-French (1992, 1993) three-factor CAPM. The regression coefficient of the market-to-book ratio (mkbk) is positive and significant for all post-crash market reversal events except the 1987 event. The 1997, 1998, 2000, and 2008 results are in line with the

Table 6: Multivariate Regression Analysis Results for the Post-Crash Market reversal Events

	Dependent Variable: recovery.return									
	1987		1997		1998		2000		2008	
	Result	VIF	Result	VIF	Result	VIF	Result	VIF	Result	VIF
Intercept	-0.1407 *** ( -19.2657 )		-0.0188 *** ( -6.4352 )		-0.0226 *** ( -5.1592 )		-0.0214 *** ( -3.7491 )		-0.0043 ( -0.7503 )	
crash.return	-0.6303 *** ( -32.9123 )	1.1847	-0.3346 *** ( -30.6716 )	1.0954	-0.2936 *** ( -23.8415 )	1.1137	-0.3016 *** ( -21.8479 )	1.8191	-0.3111 *** ( -26.5342 )	1.1320
beta	-0.0024 ( -0.7661 )	1.1904	0.0062 *** ( 5.0965 )	1.0719	0.0097 *** ( 5.2136 )	1.1026	0.0156 *** ( 5.9968 )	1.3880	0.0304 *** ( 9.8079 )	1.1260
TCap	0.0054 *** ( 9.8094 )	1.0664	0.0003 *** ( 2.9949 )	1.0597	0.0003 *** ( 2.7754 )	1.0666	0.0002 ** ( 2.2810 )	1.0644	0.0003 *** ( 3.3464 )	1.0308
mkbk	0.0004 ( 0.3911 )	1.0967	0.0017 *** ( 5.6126 )	1.1826	0.0008 * ( 1.6933 )	1.2131	0.0026 *** ( 4.6154 )	1.6148	0.0022 *** ( 3.2669 )	1.2029
dr	-0.0007 ( -0.4099 )	1.2099	-0.0012 * ( -1.7844 )	1.3139	-0.0028 *** ( -2.7505 )	1.2800	-0.0026 * ( -1.8033 )	1.2883	-0.0020 ( -1.5663 )	1.3891
cr	-0.0012 ( -1.3039 )	1.2815	-0.0002 ( -0.4664 )	1.3493	-0.0004 ( -0.6623 )	1.2764	0.0006 ( 0.7674 )	1.4324	-0.0006 ( -0.7816 )	1.2765
cnsmr	0.0148 ** ( 2.5141 )	1.1743	0.0084 *** ( 3.0749 )	1.2461	-0.0020 ( -0.4876 )	1.2059	0.0015 ( 0.2597 )	1.4947	-0.0127 *** ( -2.6658 )	1.2069
hitec	-0.0045 ( -0.7287 )	1.1743	0.0103 *** ( 3.8083 )	1.2461	-0.0055 ( -1.3869 )	1.2059	0.0079 ( 1.3953 )	1.4947	0.0072 ( 1.6089 )	1.2069
hlth	-0.0024 ( -0.2971 )	1.1743	0.0056 * ( 1.6889 )	1.2461	0.0023 ( 0.4889 )	1.2059	-0.0207 *** ( -3.0082 )	1.4947	0.0058 ( 1.0368 )	1.2069
manuf	0.0144 ** ( 2.4458 )	1.1743	0.0029 ( 1.0374 )	1.2461	-0.0063 ( -1.5338 )	1.2059	0.0104 * ( 1.7345 )	1.4947	0.0175 *** ( 3.6771 )	1.2069
N	2591		4642		4443		4442		3277	
Adj. R-squared	0.3655		0.2203		0.1473		0.2476		0.2604	
F statistic	150.2226 *** ( 0.0000 )		132.1373 *** ( 0.0000 )		77.7482 *** ( 0.0000 )		147.1743 *** ( 0.0000 )		116.3384 *** ( 0.0000 )	

This table shows the results of multiple regression analysis on the data for the individual events. The dependent variable is the recovery return, and the independent variables are as listed in the table in the leftmost column. The regression specification is as follows:

$$\text{recovery.return} = b_0 + b_1\text{crash return} + b_2\text{beta} + b_3\text{TCap} + b_4\text{mkbk} + b_5\text{dr} + b_6\text{cr} + b_7\text{cnsmr} + b_8\text{hitec} + b_9\text{hlth} + b_{10}\text{manuf} + e$$

Each column shows the regression results for one of the events, left to right in chronological order, as labeled. Shown are the coefficients with significance indicators, and t-statistics below in parentheses. All variables are as defined earlier in Tables 2 and 3, but with TCap rescaled to billions. The last three rows list the number of observations, the adjusted R-squared, and the F statistic (with p-value in parentheses), for each of the regressions.

The variance inflation factors (VIF) are listed to the right of each coefficient for each regression. The VIF is used to test for multicollinearity in the model. Prior literature suggests that there is no major multicollinearity associated with a variable if the VIF value is less than 10 (Belsley et al., 2009).

\*\*\*, \*\*, \* indicate significance at the 1, 5, and 10 percent levels, respectively.

prediction of the Fama-French model. The model predicts that high market-to-book stocks would outperform low market-to-book stocks in up markets.

The regression coefficient of the debt-to-equity ratio (dr) is negative and significant for the 1997, 1998, and 2000 market reversal events. Since these coefficients are positive and significant during the crash, it implies that investors overreacted by bidding down the prices of low dr firm stocks too much in these crashes, which resulted in a significant market correction after the crash. The regression coefficients for the current ratio (cr) variable are statistically insignificant in all five post-crash market reversal events. It implies that there was no investor overreaction to the cr variable in the market crashes which would have resulted in a significant market correction in the post-crash market reversal.

The signs and significance of the regression coefficients for the industry portfolios vary between the events. The industry effect appears to be generally less significant in the post-crash market reversal period than in the crash period. The results imply investor overreaction in the hitec industry in the 1997 crash and in the manuf industry in the 2008 crash. Stocks that lost more value than the average in the hitec industry in the 1997 crash and in the manuf industry in the 2008 crash gained more value than the other stocks in the post-crash market reversal.

## 5. REGRESSION RESULTS WITH COMBINED DATA FOR ALL FIVE CRASHES

Although the five stock market crash events have a number of distinct characteristics, running regressions with the combined sample may provide some useful insights about the overall mean effects of the variables across all crashes. We present our regression results with the entire data set for all five market crash and post-crash market reversal events in Table 7. The F statistics indicate that both the crash regression and the post-crash market reversal regression are statistically significant at the 1-percent level.

The regression coefficient of the crash return variable is significant with a negative sign for the post-crash market reversal. It indicates that stocks that lose more value in crashes tend to gain more value in post-crash market reversals. It implies investor overreaction in stock market crashes.

The regression coefficient of beta is significant in both regressions and it has a negative sign for the crash and a positive sign for the post-crash market reversal. It implies that stocks with higher betas lose more value in crashes and they gain more value in post-crash market reversals relative to low beta stocks. This finding is in line with the prediction of the CAPM that high beta stocks lose more value in down markets and gain more value in up markets relative to low beta stocks.

The regression coefficient of size (TCap) is significant with a positive sign in both regressions. It implies that stocks with larger market capitalization perform better compared with stocks with smaller market capitalization both in crashes and in post-crash market reversals. This finding is in line with the Fama-French (1992, 1993) three-factor CAPM, which argues that large firms are less risky and investors require lower returns from these firms.

Table 7: Multivariate Regression Analysis Results with All data

	Crash		Recovery	
	Result	VIF	Result	VIF
Intercept	-0.1105 *** ( -37.0608 )		-0.0303 *** ( -13.1203 )	
crash.return			-0.3533 *** ( -65.6199 )	1.1753
beta	-0.0596 *** ( -45.3342 )	1.0555	0.0128 *** ( 12.3274 )	1.1675
TCap	0.0003 *** ( 3.9674 )	1.0394	0.0005 *** ( 8.5186 )	1.0403
mkbk	-0.0043 *** ( -13.5286 )	1.1725	0.0020 *** ( 8.4087 )	1.1835
dr	0.0027 *** ( 3.6819 )	1.2621	-0.0022 *** ( -3.9176 )	1.2630
cr	-0.0024 *** ( -5.8554 )	1.3109	-0.0008 ** ( -2.5083 )	1.3132
cnsmr	0.0258 *** ( 8.8553 )	1.1970	0.0000 ( -0.0178 )	1.2142
hitec	-0.0131 *** ( -4.5731 )	1.1970	0.0032 ( 1.4898 )	1.2142
hlth	0.0108 *** ( 3.0476 )	1.1970	0.0004 ( 0.1694 )	1.2142
manuf	0.0165 *** ( 5.5528 )	1.1970	0.0036 ( 1.6086 )	1.2142
N	19395		19395	
Adj. R-squared	0.1488		0.2487	
F statistic	377.6166 *** ( 0.0000 )		643.0842 *** ( 0.0000 )	

This table shows the results of multiple regression analysis on the entire data sample. In the first column, labeled 'Crash', the dependent variable is the crash return, and the independent variables are as listed in the table in the leftmost column:

$$crash.return = a_0 + a_1beta + a_2TCap + a_3mkbk + a_4dr + a_5cr + a_6cnsmr + a_7hitec + a_8hlth + a_9manuf + \epsilon$$

For the second column, labeled 'Recovery', the dependent variable is the recovery return, and the independent variables are as listed in the table in the leftmost column:

$$recovery.return = b_0 + b_1crash\ return + b_2beta + b_3TCap + b_4mkbk + b_5dr + b_6cr + b_7cnsmr + b_8hitec + b_9hlth + b_{10}manuf + e$$

Shown are the coefficients with significance indicators, and t-statistics below in parentheses. All variables are as defined earlier in Tables 2 and 3, but with TCap rescaled to billions. The last three rows list the number of observations, the adjusted R-squared, and the F statistic (with p-value in parentheses), for each of the regressions.

The variance inflation factors (VIF) are listed to the right of each coefficient for each regression. The VIF is used to test for multicollinearity in the model. Prior literature suggests that there is no major multicollinearity associated with a variable if the VIF value is less than 10 (Belsley et al., 2009).

\*\*\*, \*\*, \* indicate significance at the 1, 5, and 10 percent levels, respectively.

When the regression coefficient of a variable is significant with different signs in the crash and post-crash market reversal periods, it implies investor overreaction during the crash. The regression coefficient of the mkbk variable is significant in both regressions and it has a negative sign for the crash and a positive sign for the post-crash market reversal. It implies that investors consider high mkbk stocks to be overvalued prior to crashes and they bid down their prices more relative to low mkbk stocks in stock market crashes. However, there is a significant market correction for the prices of high mkbk stocks in the post-crash reversals implying investor overreaction towards these stocks during the crash.

The regression coefficient of the debt-to-equity ratio (dr) variable is significant in both regressions and it has a positive sign for the crash and a negative sign for the post-crash market reversal implying investor overreaction during the crash period. The result implies that the stocks of firms with higher debt ratios generally perform better in crashes (excluding the 2008 crash when investors had a serious concern with bankruptcy risk) but they perform worse in post-crash market reversals compared with the stocks of firms with lower debt ratios.

The regression coefficient of current ratio (cr) is significant with a negative sign in both regressions. It implies that the stocks of firms with more investment in less profitable current assets generally perform worse both in crashes and in post-crash market reversals. However, this is an aggregate result for all crashes. Because technical insolvency risk was a major concern for investors, low cr firms lost more value relative to high cr firms in the 1987 and 2008 stock market crashes (see Table 6).

All regression coefficients for the industry dummy variables are statistically significant for the crash period. The sign of the regression coefficient for the cnsmr, hlth, and manuf industries is positive. It implies that the stocks of firms in these industries generally perform better than the average in stock market crashes. The sign of the regression coefficient for the hitec industry is negative in the crash regression. It implies that the stocks in this industry generally perform worse than the average in crashes. The regression coefficients of all four industries are insignificant for the post-crash market reversal period. This implies that the stocks in all four industries generally perform similarly in post-crash market reversals with no major market correction for any industry to correct an overreaction during the crash periods.

## 6. SUMMARY AND CONCLUSIONS

DeBondt and Thaler (1985) argue that investors tend to overreact to economic events. In a recent study, Wang et al. (2013) find that investors overreacted to the technical insolvency risk and bankruptcy risk characteristics of firms in the 2008 stock market crash. In this paper, we study the determinants of stock returns in five major stock market crashes and post-crash market reversals during the 1987-2008 period to investigate if there was any investor overreaction in these crashes.

The regression coefficient of the crash return variable is statistically significant with a negative sign in all post-crash market reversal regressions. This result implies that

there is investor overreaction in stock market crashes. Stocks that lose more value in crashes tend to gain more value after the crash with a significant market correction in the post-crash market reversal.

Sharpe's CAPM predicts that high beta firms lose more value in down markets and gain more value in up markets compared with low beta firms. As predicted by the theory, in this paper, we find that high beta companies lose more value in stock market crashes and gain more value in post-crash market reversals.

In the Fama-French (1992, 1993) three-factor CAPM, in addition to beta, firm size and market-to-book ratio are also market risk factors and determinants of stock returns. The model argues that smaller firms and those with lower market-to-book ratios are riskier. Therefore, investors would require a higher rate of return with a larger risk premium when valuing these firms. As predicted by the theory, we find that smaller firms and those with lower market-to-book ratios lose more value in stock market crashes. However, the sign of the regression coefficients for these variables does not change in the post-crash market reversals. It implies that investor reaction against smaller and lower market-to-book ratio firms in stock market crashes is not an overreaction.

The regression coefficient of the *dr* variable is significant with a positive sign in the 2008 crash. Since bankruptcy risk was a serious concern for investors, high *dr* firms lost more value relative to low-*dr* firms in the 2008 crash. However, the regression coefficient for the *dr* variable is not significant in the post-crash market reversal. It implies that investors' bidding down the prices of high *dr* firms was not an overreaction in the 2008 crash.

Our crash regressions show that, because technical insolvency risk was an important concern for investors, firms with a higher *cr* and greater ability to meet their maturing obligations, lost less value relative to lower *cr* firms in the 1987 and 2008 crashes. However, the regression coefficient for the *cr* variable is not significant in the post-crash market reversal regressions. It implies that investors' bidding down the prices of low *cr* firms was not an overreaction in the 1987 and 2008 crashes.

The industry dummy variables indicate that there is no specific pattern of industry effect in stock market crashes. However, investors appear to have overreacted against *hitec* stocks in the 1997 crash and against *manuf* stocks in the 2008 crash with a significant market correction in the values of these stocks in the post-crash market reversals.

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