

THE COMPETITIVE IMPACT OF AIR CRASHES:
STOCK MARKET EVIDENCE*

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ABSTRACT

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We examine stock market reactions to commercial air crashes to test the hypothesis that consumers respond by switching to rival airlines and/or flying less. We focus on the stock price reactions of airlines not involved in the crash. If switching occurs, non-crash airlines should benefit to the extent that they are direct competitors of the crash airline. We develop a measure of market overlap, and regress individual non-crash airline abnormal returns on this measure allowing the constant term to capture any negative spillovers. The evidence supports both a switching effect and a spillover.

I. INTRODUCTION

The ability of free markets to supply product safety has been controversial for years. The key issue is whether firms selling unsafe products suffer profit losses from adverse consumer reaction, which in turn create an incentive to supply (costly) safety. This is important for the formulation of public policy. If market forces discipline firms then the need for regulatory oversight is reduced and perhaps eliminated.

The airline industry provides a unique opportunity to study this issue. Empirical work in the late 1980's established that serious commercial air crashes cause the involved airlines to lose market value. However, the reason for the loss remains unclear. Possibilities include expectations of adverse consumer reaction, increased regulatory surveillance, and/or higher insurance premiums. The few previous attempts to distinguish among these alternatives yielded ambiguous results.

We test whether the stock market reaction to air crashes is caused by an expected adverse response by consumers. First, consumers concerned with the crash airline's safety may switch to rival airlines. Second, a crash may raise concerns with other elements of the commercial air system, implying a "negative spillover" that would reduce demand for all airlines. For a sample of crashes, we determine the stock price reaction of airlines not involved in the crash, and measure their route overlap with the crash airline as a proxy for substitutability. The consumer switching effect should be greater for airlines with greater overlap, while those with little or no overlap should be affected only by the negative spillover, if at all. We find evidence of both effects.

The paper proceeds as follows. We summarize prior related work in Section II and then discuss theoretical issues in Section III. A description of our sample and data

follows, which focuses on the calculation of our market overlap index. Section V reports our event study results both for the airlines involved in the crash and for non-crash airlines. Section VI presents our main empirical results on the relation between non-crash airlines' abnormal returns and our market overlap index. Last, we summarize our conclusions, including policy implications.

II. PREVIOUS WORK

Several previous studies examine stock market reaction to product safety concerns, including air safety. They find negative reactions to adverse safety events, but are unclear as to the relative role played by consumer switching and other possible causes. For example, Jarrell and Peltzman¹ show that recalls of defective drug products cause substantial value losses for both the recalled product's manufacturer and its competitors. As they note, the latter effect suggests a negative externality that dominates any consumer switching. Mitchell² finds that the 1982 Tylenol poisonings produced similar financial losses on Tylenol's manufacturer Johnson and Johnson and the rest of the drug industry. Neither study tests directly for a switching effect.

Studies examining stock market reaction to commercial air crashes have focused mainly on the involved airline³ or the involved airplane's manufacturer⁴. They find a crash-related value loss of about 1.2 to 2.5 percent for the crash airline, and similar losses for the manufacturer. Secondary examinations of stock price reactions for non-crash airlines have found little or no impact.

Borenstein and Zimmerman⁵ look specifically at "externality effects" on other airlines but find little supporting evidence. They identify as possible causes of external effects consumer switching, general concerns with air travel safety, and increased

regulatory surveillance. Based on a sample of all fatal major airline crashes from 1960 to 1985, their “. . . direct estimation of consumer response does not support [the hypothesis that] wealth losses associated with accidents . . . result from adverse consumer reaction" (at 933).⁶ Importantly, they make no distinction between close and distant rivals, or between the consumer switching hypothesis and other possible impacts on non-crash airlines.

Mitchell and Maloney⁷ examine "the brand-name effect of airline crashes" (at 329) using a sample of 56 fatal crashes between 1964 and 1987. They partition the sample into airline "at-fault" crashes and all others. They find a statistically significant negative market reaction for the crash airline in the at-fault sub-sample only, concluding that ". . . airline crashes cause consumers to reduce their demand for the services provided by negligent carriers" (at 354), contrary to Borenstein and Zimmerman.⁸ They do not examine the impact of crashes on non-crash airlines.

In sum, there is clear evidence that the stock market imposes value losses on firms upon the release of negative product safety information, including airlines involved in crashes. However, air crash studies to date have produced little or no evidence of impacts on other airlines, and the source of the crash airline's stock reaction remains in dispute.

III. THEORETICAL ISSUES

If consumers infer from a crash that the crash airline's safety performance has declined, they may respond by switching to competing airlines. This is the crux of the product market response, as opposed to the financial market response. Expected lost revenue then causes a stock price decrease for the crash airline. A critical implication is

that ceteris paribus other airlines benefit from the crash to the extent that they offer competing services. Our core hypothesis is therefore that the stock price reactions of airlines not involved in a crash should be positively related to the non-crash airlines' "overlap" with the crash airline's market. The greater is the overlap (defined below), the greater is the opportunity for consumers to switch.

As noted by Mitchell and Maloney⁹, the crash airline likely will respond to a crash-induced inward shift in its demand curve with price cuts, cost-increasing service enhancements, or both. A value loss for the crash airline is still implied. However, consumer switching and associated rival value gains would be reduced, or perhaps eliminated. Accordingly, our test can only detect market expectations of actual switching, that is, the net result of "potential" switching (the ceteris paribus quantity impact of the inward demand shift) offset by mitigating crash airline strategies.

Consumers may also or instead interpret a crash as information that flying in general is less safe. Air safety is jointly produced by airlines and other elements of the commercial air system. These are shared by all airlines, including similar aircraft; airports and supporting air traffic control technology; and the Federal Aviation Administration (FAA) and its safety regulation apparatus.¹⁰ A crash might generate mistrust of the system, causing consumers to fly less regardless of the airline. It might also create political pressure for increased industry-wide regulatory scrutiny. In either case, a negative spillover exists that implies a decline in expected revenue and stock prices for all airlines. The spillover and switching effects can co-exist.¹¹ Consumers might both fly less often and avoid the crash airline when they do.

IV. THE SAMPLE AND DATA

Crash information is obtained mainly from National Transportation Safety Board Accident Briefs, including dates, involved airlines, and fatalities. Stock market data are from the CRSP¹² tapes that contain time series of daily stock returns and prices for New York Stock Exchange (NYSE) listed firms. The market overlap index data are from the Department of Transportation (DOT) Ticket Dollar Value Origin and Destination (O&D) data bank.

The crash sample is selected using several screening criteria. First, like prior studies, we include only crashes with at least one onboard passenger fatality. Second, we require each case to have complete data on the CRSP tapes and to be free of confounding informational events around the crash date likely to produce industry-wide effects.¹³ Third, DOT O&D data availability restricts us to crashes occurring between the fourth quarter of 1978 and the fourth quarter of 1996. Also, the crash airline must be included in the O&D data base to allow computation of the market overlap index. Last, like prior studies, we focus on crashes involving major national airlines, per industry classifications, excluding regional and commuter carriers.¹⁴

The sample includes 25 crashes and 250 non-crash airline observations meeting the above criteria, as summarized in Table 1. The Appendix provides more detail, including a description of the crash circumstances and speculation regarding possible causes contained in initial news reports. There is an average of ten non-crash airlines per crash ranging from four to eighteen, representing 20 different airlines. The time trend reflects the entry of new airlines in the early 1980's and the subsequent mid-decade mergers.

Our market overlap index is created from the DOT O&D data bank, a comprehensive quarterly database comprising a 10 percent sample of all airline tickets sold. Each record in the database corresponds to an individual ticket, and identifies the point of origin, the airline carrier, intermediate airports, the point of destination, the dollar fare, the distance(s), and the fare class(es). This enables us to estimate for each airline its revenue passenger miles (RPMs)¹⁵ derived from each route or city-pair, and, critically, to identify routes shared with the crash airline.

Our market overlap index PCTLAP is therefore calculated as the percentage of each non-crash airlines' RPMs derived from routes shared with the crash airline.¹⁶ The index can range from zero (no overlap) to 100 (complete overlap). It treats the services provided by competing airlines over the same route as homogeneous, that is, it assumes negligible product differentiation.¹⁷ Where possible, PCTLAP is computed for the quarter prior to the crash to exclude any crash effects.¹⁸ PCTLAP averages about 33 percent for the 250 non-crash observations, varying from zero to over 90 percent. PCTLAP equals zero for 25 observations, exceeds 50 percent for 85 observations, and exceeds 75 percent for 25 observations.

A market is defined as the route from a passenger's point of origin to his/her point of destination.¹⁹ This corresponds directly to the product consumed. We include non-stop, direct and one-connection routes in the same market, excluding alternatives requiring two or more plane changes. Most other airline studies also treat at most a single change-of-plane as a direct flight substitute.²⁰ Data processing and aggregation are as described in Kim and Singal.²¹

V. EVENT STUDY RESULTS

Our basic estimation technique is the standard event-time methodology, following Dodd and Warner.²² Specifically, for each airline stock, the market model is used to calculate daily and cumulative abnormal returns during the event window. The event date (day zero) is the crash date or, if the NYSE was closed at the time of the crash, the first trading day thereafter.²³

We first examine the stock market reaction for the airlines involved in the crash to calibrate our study with previous work. Three crashes included in the non-crash airline sample are excluded here because no data are available on the CRSP tapes for the involved airlines around the crash date.²⁴ The abnormal returns and associated statistics for the sample of 22 crash airlines with CRSP data are summarized in Table 2.²⁵ Individual crash airline cumulative abnormal returns for the (0,2) event window are shown in Table 1. The market reaction is negative on the day of the crash and on the two days immediately following. The bulk of the reaction occurs on day 0 (-1.17 percent) and day 1 (-0.93 percent), with a statistical significance of 10 percent ($Z = -1.86$) for day zero and not quite 10 percent ($Z = -1.47$) for day 1. The price reactions for days 3 through 5 (not shown) are negative, but economically and statistically insignificant.

Cumulatively, the bulk of the negative reaction occurs over the period (0,1) with a cumulative abnormal return (CAR) of -2.10 percent, significant at the 5 percent level ($Z = -2.35$). The abnormal losses continue to cumulate, reaching -3.63 percent by day 5 and stabilizing by day 10 at -3.51 percent (not shown). The price movements are essentially random beyond day 10. These results are strongly supported by the binomial test. On day zero, 77 percent of the sample airlines experience negative returns, and the proportion is 86 percent over the period (0,1). The respective binomial statistics are

significant at the 5 and 1 percent levels. These findings are consistent with previous studies whose crash airline samples overlap only partially with ours.

Since the focus of our study is the impact of the crash on "rivals", we next examine the market reaction of non-crash airline stock prices. We first present aggregate results that do not account for market overlap. Sample daily abnormal returns, cumulative abnormal returns, and test statistics for selected event windows are shown in Table 3.²⁶ The mean CAR(0,2) for the non-crash airlines at each crash is shown in Table 1. For the portfolio of all crashes, there is a positive (0.24 percent) abnormal return (AR) on day 0 with a non-significant Z-statistic and binomial statistic. The AR is economically and statistically insignificant on day 1. However, there is a negative AR of -0.72 percent on day 2 that is statistically significant at the 1 percent level by both the Z-statistic (-2.97) and the binomial statistic (-4.28). The cumulative returns reflect this pattern. CAR(0,1) is positive (0.25 percent) but statistically insignificant, while CAR(0,2) is negative (-0.48 percent) with a non-significant Z-statistic but with a binomial test statistic of -3.90, significant at the 1 percent level.

The results likely reflect the fact that the overall sample combines two different sub-samples. One has low route overlap with the crash airline and the other has high route overlap, each with significantly different abnormal returns (see below). The overall sample is therefore highly non-normal. In addition, because there is a potential for two distinct effects, a negative externality and a positive switching effect for the high overlap firms, the relevant test is not whether there are significant non-zero average abnormal returns for these sub-samples, but rather whether the price reaction of the high overlap

sample is significantly different from that of the low overlap sample. We test this hypothesis next using the individual airline abnormal returns obtained above.

VI. ABNORMAL RETURNS AND MARKET OVERLAP

Our central hypothesis is that the product market reacts to air crashes either by consumer switching and/or negative spillovers. We expect the switching effect to be stronger the greater the overlap with the crash airline. We therefore first report difference-between-means tests for non-crash airline sub-samples with above and below mean market overlap (PCTLAP, see Section IV), as shown in Table 4.²⁷ An economically and statistically significant difference of about 1.2 percent exists between the high and low PCTLAP sub-samples over the (0,2) event window. Non-crash airlines with little market overlap lose value while close rivals on average experience slight gains.

The last step in our analysis is a regression of individual non-crash airline abnormal returns on the overlap index PCTLAP. The constant term in the regression allows us to simultaneously test the negative spillover hypothesis that implies a negative abnormal return absent a switching effect (zero market overlap). We also incorporate a dummy variable TWA96 that equals one for non-crash airlines at the 1996 “crash” (mid-air explosion) of TWA flight 800. The exceptionally large negative abnormal returns for the non-crash airlines (see regression results below and Table 1) may be caused by the initial reports of a possible surface-to-air missile attack.²⁸ This suggests a new safety threat to all airlines beyond the control of present air security measures, that is, a large negative externality. Because our dependent variables are estimated with error, heteroscedasticity may be present. We therefore report weighted least squares

regressions where the weights are the inverse of the standard errors of the individual abnormal returns. This procedure assigns a greater weight to more precisely estimated returns, thereby increasing parameter estimation efficiency.

The results are summarized in Table 5.²⁹ First, PCTLAP is positive and statistically significant at the 10 percent level or better, supporting the switching hypothesis, and consistent with the means-tests of Table 4. Second, the constant term is negative in all equations. While it is not significant in the AR(0) equation, it approaches significance at the 10 percent level in the CAR(0,1) regression ($t = 1.57$), and is significant at better than the 1 percent level in the CAR(0,2) regression ($t = 3.27$). This suggests a negative spillover emerging on days 1 and 2, as additional information appears and the crash is given wider publicity.³⁰ For the CAR(0,2) equation, the switching effect offsets the externality (constant term) at PCTLAP = 73 percent; that is, rival airlines with higher overlap are forecast to gain because of the crash. Last, the TWA96 dummy is highly significant both economically and statistically, suggesting a special externality associated with this crash, reaching -6.54 percent for the (0,2) event window.

Two observations regarding the spillover effect are in order. First, the crash airlines suffer from this in addition to switching, which also affects them negatively. This implies that the crash airline CARs of Table 2 should be greater in magnitude (more negative) than the corresponding constant terms of Table 5, which is indeed the case. Second, Jarrell and Peltzman³¹ on drug recalls and Mitchell³² on the Tylenol poisonings each report larger industry-wide effects, about -1.2 percent and -6.8 percent, respectively. Since they do not isolate switching effects, they do not measure a "pure"

spillover. Hence, an appropriate comparison is with our non-crash airline CAR(0,2) of -0.48 percent in Table 3. The lower industry-wide impact for airlines may reflect the industry's overall excellent safety record.³³

VII. CONCLUSIONS

Previous work established that financial markets react to air crashes by reducing the market value of the crash airline, but did not establish the causal mechanism. We investigate whether a product market reaction is at work, in which consumers respond to crashes by switching to rival airlines and/or simply flying less. We find a positive relation between non-crash airline stock reactions and the degree of market overlap with the crash airline, supporting a switching effect despite likely mitigating strategies by the crash airline. This is consistent with the "brand name" effect observed by Mitchell and Maloney.³⁴ We also find that non-crash airlines with little market overlap lose value, that is, a negative spillover exists. Previous studies finding little or no reaction may have been observing the net impact of these offsetting effects.

Our results have public policy implications. The crash airline suffers significant financial losses from a crash, which appear to be related to consumer switching. While this suggests a traditional market incentive to "supply" safety, it can only apply to safety related factors under each airline's control. The evidence we find of a negative spillover suggests that consumers and/or insurers may be concerned about other elements of the commercial air travel system that are involved in the joint production of air safety. Perhaps regulatory concerns should be redirected from individual airlines toward system elements where market incentives are weak or absent.

APPENDIX: BRIEF DETAILS ABOUT SAMPLE AIRLINE CRASHES

Note: The cause-of-crash given below is based on initial newspaper stories.

1978 Dec. 28, 1815 PST Portland, OR United Airlines

10 persons on-board died, 175 survived. The DC-8 crashed into a residential area during a landing approach to the airport. The plane circled for more than 30 minutes with landing gear problems.

1979 Feb. 12, 1300 EST Bridgeport, WV USAir

2 persons on-board died, 23 survived. The aircraft flipped over and crashed during takeoff in a snowstorm. The runway had just been plowed.

1979 May 25, 1504 CDT Chicago, IL American Airlines

271 persons on-board died, none survived. The DC-10 crashed shortly after takeoff from O'Hare International Airport due to engine tearaway. The cause of the engine loss is unknown. Two persons on the ground were also killed.

1979 Oct. 31, 0542 (local) Mexico City, Mex. Western Airlines

72 persons on-board died, 17 survived. The DC-10 crashed on landing.

Preliminary investigation indicates that the pilot landed on the wrong runway, which was closed for repairs. Two persons on the ground were also killed

1982 Jan. 13, 1601 EST Washington, D.C. Air Florida

74 persons on-board died, 5 survived. The Boeing 737 crashed soon after takeoff in a snowstorm. The aircraft struck a bridge and plunged into the Potomac

River. There was evidence of ice buildup on the wings that may have contributed to problems with takeoff. There was no breakdown in air-traffic control that may have contributed to a crash. Four persons on the ground were also killed.

1982 Jan. 23, 1937 EST Boston, MA World Airlines

2 persons on-board died, 198 survived. The DC-10 skidded off the runway while trying to land in freezing rain and plunged into Boston Harbor.

1982 July 9, 1608 CDT New Orleans, LA Pan American Airlines

145 persons on-board died, none survived. The jetliner crashed in flames soon after takeoff from New Orleans International Airport. There was no speculation on the causes of the crash, but problems may have been related to weather. The crash caused several houses to catch on fire. Eight persons on the ground were also killed.

1982 Aug. 11, 0930 HST Honolulu, HA Pan American Airlines

1 person on-board died, 284 survived. The Boeing 747 from Japan to Honolulu landed safely after an explosion in the cabin. There were no clues relating to the explosion except that the FBI believed that an explosive device was placed aboard the plane.

1983 Jan. 9, 1940 CST Brainerd, MN Republic Airlines

1 person on-board died, 32 survived. The plane crashed into a snow bank inside runway-edge lights and skidded out of control. A propeller blade separated and whipped into the passenger compartment killing one person.

1985 Aug. 2, 1806 CDT Dallas, TX Delta Airlines

135 persons on-board died, 30 survived. The Lockheed L-1011 crashed near the airport while landing due to bad weather and lightning.

1987 Aug. 16, 2045 EDT Romulus, MI Northwest Airlines

156 persons on-board died, 6 survived. The DC-9 crashed during takeoff. After liftoff, the plane failed to climb normally, hit a pole, rolled, and crashed. The jet got no higher than 150 ft. before the crash. The initial causes were suspected to be pilot error and improper loading of the jet's cargo.

1987 Nov. 15, 1415 MST Denver, CO Continental Airlines 28 persons on-board died, 54 survived. The DC-9 stalled on takeoff and hit the right side of the runway. Though the exact cause of crash is unknown, ice buildup could have caused the aircraft to shake, explaining how one of the wings hit the ground. Pilot error is a strong possibility.

1987 Dec. 7, 1616 PST San Luis Obispo, CA Pacific Southwest Airlines 43 persons on-board died, none survived. The BAE-146 rapidly descended after the pilot reported hearing gunshots. There was a recently fired US Air employee on board the flight who had smuggled a gun. Investigators report that a passenger entered the cockpit just moments before the crash. Reports say that the former US Air employee had used an ID badge to board the aircraft with the pistol.

1988 Aug. 31, 0901 CDT Dallas, TX Delta Airlines

14 persons on-board died, 94 survived. The Boeing 727 crashed on takeoff. The aircraft experienced violent roll and struck the Instrument Landing System antenna about 1,000 feet beyond the runway. It was too early to speculate on the cause of the crash.

1988 Dec. 21, 1405 EST Lockerbie, Scotland Pan American Airlines 270 persons on-board died, none survived. The Boeing 747 crashed into the ocean. The cause of the crash was unknown.

1989 Feb. 24, 0209 HST Honolulu, HA United Airlines

9 passengers on-board died, 347 survived. As the jet was climbing after takeoff from Honolulu, an improperly latched cargo bay door blew open in flight, blowing 9 people out of the hole. Two engines were knocked out and wing flaps were malfunctioning. The pilot landed the plane safely in Honolulu.

1989 July 19, 1600 CDT Sioux City, IA United Airlines

111 persons on-board died, 185 survived. Three hydraulic systems on the DC-10 appear to have failed after an engine exploded, making control of the plane impossible and eventually leading to the crash. The mechanical mishap that caused the engine to explode is unknown. There were no reported weather difficulties.

1989 Sept. 20, 2321 EDT Flushing, NY USAir

2 persons on-board died, 61 survived. The Boeing 737 drifted to the right before takeoff followed by a bang. The captain aborted the takeoff but did not take action to stop the plane. The plane crashed into the East River.

1990 Dec. 3, 1345 EST Romulus, MI Northwest Airlines

8 persons on-board died. The DC-9 burst into flames at the Detroit Airport after being hit by another Northwest jet. There were poor weather conditions reported at the time reducing the visibility. The right rear engine was hit by the right wing tip of

the other aircraft. There were 198 persons on board the two planes. The other Northwest aircraft was safely evacuated.

1991 Feb. 1, 1807 PST Los Angeles, CA USAir

34 persons on-board died, 67 survived. The Boeing 737 collided with a commuter plane upon landing. The air traffic controller gave permission for both planes to land one minute apart on the runway. It is unclear why the USAir jet did not see the SkyWest jet on the runway in time to avoid collision. The Los Angeles airport is one of the 10 most dangerous airports because of night-time landing and takeoff procedures.

1991 March 3, 0944 MST Colo. Springs, CO United Airlines

25 persons on-board died, none survived. The Boeing 737 crashed into a dry lake while attempting to land. The plane was completing its final approach when it rolled steadily until it was almost vertical, and then nose-dived into the ground. There was a high wind warning issued just hours before the crash by the National Weather Service, and wind speed was about 32 mph. Wind shear is a probable cause.

1992 March 22, 2135 EST Flushing, NY USAir

27 persons on-board died, 24 survived. The Fokker F-28 crashed while trying to takeoff from La Guardia airport in a snowstorm. The plane skidded off the runway and fell into Flushing Bay. Everything but one wing and the tail landed in the water.

1994 July 2, 1843 EDT Charlotte, NC USAir

37 persons on-board died, 20 survived. The DC-9 collided with trees and a house after the plane executed a missed approach. Poor weather conditions seem to have been a contributing factor.

1994 Sept. 8, 1903 EDT Aliquippa, PA USAir

132 persons on-board died, none survived. The Boeing 737 seemed to lose power and altitude while preparing to land. The aircraft descended steeply and crashed. No weather problems were present, and the crew called in just minutes before the crash stating that all was normal. Faulty rudder control is a probable cause.

1996 July 17, 2045 EDT East Moriches, NY Trans World Airlines 230

persons on-board died, none survived. The Boeing 747 plunged into the Atlantic Ocean, just off Long Island. There was no weather interference. The exact cause is unknown, but several eye witnesses reported an explosion, leading to speculation regarding possible terrorist activity.

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TABLE 1
CRASH SAMPLE AND CUMULATIVE ABNORMAL RETURNS (CARs)

Crash Date	Crash Airline	No. of Deaths	Crash Airline CAR(0,2)	Crash Non-crash Airlines	No. of Airlines	Crash Airline CAR(0,2)	Mean Non-crash
781228*	United	10	-1.02	10		+0.73	
790212	US Air	2	-6.19	12		-3.17	
790525*	American	271	-6.18	9		+1.42	
791031	Western	72	-1.99	11		-0.13	
820113*	Air Florida	74	**		18		-0.47
820123*	World	2	-0.82	17		-1.81	
820709*	Pan Am	145	-0.60	16		-0.71	
820811	Pan Am	1	-3.31	16		-1.39	
830109*	Republic	1	-8.25	15		+0.61	
850802*	Delta	135	+2.01	17		+1.35	
870816*	Northwest	156	-1.31	10		+0.01	
871115*	Continental	28	-4.82	8		-1.69	
871207*	PSA	43	-5.41	9		-1.42	
880831	Delta	14	+2.08	9		+0.43	
881221	Pan Am	270	-1.55	8		-2.54	
890224	United	9	-4.95	8		-1.89	
890719*	United	111	-2.31	8		-0.64	
890920*	US Air	2	+1.61	8		-1.21	
901203	Northwest	8	**		8		+2.48
910201*	US Air	34	-4.95	7		-1.47	
910303*	United	25	-2.31	8		+1.82	
920322*	US Air	27	+1.61	5		-2.03	
940702*	US Air	37	-3.08	4		+2.09	
940908*	US Air	132	-9.93	4		-1.93	
960717*	TWA	230	**		5		-6.95
		Mean	-2.80			-0.74	

NOTE. Details on each crash are presented in the Appendix.

* NYSE closed at crash time-of-day, or not open at all on crash date (weekend or holiday). Event date is next trading day.

** No stock price data available on CRSP tape for crash airline around crash date.

TABLE 2
 CRASH AIRLINE AVERAGE DAILY AND CUMULATIVE
 ABNORMAL RETURNS WITH TEST STATISTICS (N=22)

Daily Abnormal Returns

Event Day	AR (%)	Z Statistic	Percent Negative	Binomial Test
0	-1.17	-1.86*	77.27	-2.56**
1	-0.93	-1.47	59.09	-0.85
2	-0.57	-0.90	63.64	-1.25

Cumulative Abnormal Returns

Event Window	CAR (%)	Z Statistic	Percent Negative	Binomial Test
(0,1)	-2.10	-2.35**	86.36	-3.41***
(0,2)	-2.67	-2.44**	81.82	-2.98***

*** 1 percent significance level (two-tailed test)

** 5 percent significance level (two-tailed test)

* 10 percent significance level (two-tailed test)

TABLE 3
 NON-CRASH AIRLINE AVERAGE DAILY AND CUMULATIVE
 ABNORMAL RETURNS WITH TEST STATISTICS (N=245)

Daily Abnormal Returns

Event Day	AR (%)	Z Statistic	Percent Negative	Binomial Test
0	+0.24	+0.98	51.84	-0.57
1	+0.01	+0.03	49.80	+0.06
2	-0.72	-2.97***	63.67	-4.28***

Cumulative Abnormal Returns

Event Window	CAR (%)	Z Statistic	Percent Negative	Binomial Test
(0,1)	+0.25	+0.72	51.84	-0.56
(0,2)	-0.48	-1.13	62.45	-3.90***

*** 1 percent significance level (two-tailed test)

TABLE 4
 DIFFERENCE-BETWEEN-MEAN ABNORMAL RETURN TESTS
 FOR NON-CRASH AIRLINES WITH ABOVE AND BELOW MEAN
 MARKET OVERLAP, PCTLAP (N=245)

	N	Mean	SE
<u>AR(0)</u>			
PCTLAP \geq 33.4	112	+0.533	0.330
PCTLAP < 33.4	133	-0.087	0.246
difference		0.620	
(t-statistic)		(1.51)	
<u>CAR(0,1)</u>			
PCTLAP \geq 33.4	112	+0.753	0.366
PCTLAP < 33.4	133	-0.202	0.326
difference		0.955*	
(t-statistic)		(1.95)	
<u>CAR(0,2)</u>			
PCTLAP \geq 33.4	112	+0.172	0.458
PCTLAP < 33.4	133	-1.032	0.331
difference		1.204**	
(t-statistic)		(2.13)	

** 5 percent significance level (two-tailed test)

* 10 percent significance level (two-tailed test)

TABLE 5
 REGRESSIONS OF NON-CRASH AIRLINE ABNORMAL
 RETURNS ON MARKET OVERLAP INDEX PCTLAP AND
 1996 TWA CRASH DUMMY (N=250)

Dependent Variable	Constant	PCTLAP	TWA96 Dummy
AR(0)	-0.115 +0.010*	-3.60***	
	(0.46) (1.92)	(4.02)	
CAR(0,1)	-0.494 +0.011*	-5.35***	
	(1.57) (1.69)	(4.76)	
CAR(0,2)	-1.170***	+0.016**	-6.54***
	(3.27) (2.13)	(5.11)	

NOTE. Absolute value of t-statistics in parentheses

*** 1 percent significance level (two-tailed test)

** 5 percent significance level (two-tailed test)

* 10 percent significance level (two-tailed test)

FOOTNOTES

*We gratefully acknowledge helpful comments from anonymous referees and seminar participants at CU-Denver, CU-Boulder, and 1997 Financial Management Association meetings. Remaining errors are our own.

¹ Gregg Jarrell & Sam Peltzman, The Impact of Product Recalls on the Wealth of Sellers, 93 J. Pol. Econ. 512 (1985).

² Mark L. Mitchell, The Impact of External Parties on Brand-Name Capital: The 1982 Tylenol Poisonings and Subsequent Cases, 27 Econ. Inq. 601 (1989).

³ For example, see Don M. Chance & Stephen P. Ferris, The Effect of Aviation Disasters on the Air Transport Industry, 21 J. Trans. Econ. & Policy 151 (1987); Severin Borenstein & Martin B. Zimmerman, Market Incentives for Safe Commercial Airline Operation, 78 Am. Econ. Rev. 913 (1988); Mark L. Mitchell & Michael T. Maloney, Crisis in the Cockpit? The Role of Market Forces in Promoting Air Travel Safety, 32 J. Law & Econ. 329 (1989); and Ivy E. Broder & John F. Morrall III, Incentives for Firms to Provide Safety: Regulatory Authority and Capital Market Reactions, 3 J. Reg. Econ. 309 (1991).

⁴ For example, see Andrew J. Chalk, Market Forces and Aircraft Safety: The Case of the DC-10, 24 Econ. Inq. 43 (1986); and Andrew J. Chalk, Market Forces and Commercial Aircraft Safety, 34 J. Ind. Econ. 61 (1987).

⁵ Borenstein & Zimmerman, supra note 3.

⁶ They add that "since deregulation, consumers' responses to crashes appear to have increased" (at 927), but remain only marginally significant. Our sample contains post-deregulation crashes only.

⁷ Mitchell & Maloney, supra note 3.

⁸ However, Nancy L. Rose, Fear of Flying? Economic Analysis of Airline Safety, 6 J. Econ. Persp. 75 (1992), commenting on the Mitchell and Maloney findings claims that "a pooling test across the two samples would not reject the hypothesis that both sets of results are drawn from the same distribution" (at 91).

⁹ Mitchell & Maloney, supra note 3.

¹⁰ For example, the popular press has frequently criticized the FAA itself. US News and World Report in its cover story "What's Wrong with the FAA" (June 26, 1995, at 28) documents lapses in FAA's rule making and oversight. The Wall Street Journal in an editorial entitled "User Friendly Skies" (July 19, 1993, at A10) points out FAA inefficiencies associated with government ownership, including outdated computer flight control systems.

¹¹ The spillover and switching effects may be correlated, causing an understatement of the difference between the two. For example, a non-crash airline with low overlap is expected to benefit little, if at all, from switching. Since it is flying mainly in a different part of the country, the publicity about the crash also may be less in the low-overlap airline's market, thereby attenuating the spillover effect.

¹² Center for Research on Stock Prices, University of Chicago.

¹³ Confounding events caused two crashes to be dropped. Eastern Airlines' January 1, 1985 crash coincided with a major labor strike at Eastern, and TWA's April 2, 1986, crash coincided with a takeover bid for TWA.

¹⁴ For example, ValueJet was a regional airline (per Air Transit World, May 1996) and so its highly publicized May 1996 crash is excluded. The smallest national carrier (TWA) was at that time about 3.6 times larger than ValueJet.

¹⁵ An RPM is the airline industry's measure of quantity. It represents carrying one fare-paying passenger for one mile.

¹⁶ An analogous index can be calculated from these data based instead on revenue. The simple correlation between the two is +0.99, and the analysis below is virtually unchanged if the revenue-based index is substituted.

¹⁷ To ensure greater product homogeneity across airlines, we exclude first class tickets from the analysis.

¹⁸ When data are missing for this quarter, we used the nearest quarter, but never more than two quarters away. Fourth quarter 1978 data are used for the 12/28/78 United crash.

¹⁹ Complete data are available for domestic airlines only. Since foreign travel may also be provided by foreign airlines, we do not have complete data for foreign markets. Therefore, these markets are excluded from consideration. The absence of foreign airline data, however, does not affect our analysis of domestic routes. By law, foreign airlines are not allowed to carry passengers between U.S. cities.

²⁰ See, for example, Severin Borenstein, Hubs And High Fares: Dominance and Market Power In the U.S. Airline Industry, 20 Rand J. Econ. 344 (1989); Gloria J. Hurdle, et al., Concentration, Potential Entry, and Performance in the Airline Industry, 38 J. Ind. Econ. 119 (1989); and E. Han Kim & Vijay Singal, Mergers and Market Power: Evidence from the Airline Industry, 83 Am. Econ. Rev. 549 (1993).

²¹ Kim & Singal, *id.* Like any large database, the O&D data have known problems for which we make adjustments where possible. For example, we exclude tickets with missing or clearly erroneous data. Because our analysis relies on ratios rather than absolute numbers, our results can be affected by remaining problems only if there is a systematic difference in the DOT's treatment of tickets on the crash airline's routes and other routes.

²² Peter Dodd & Jerold B. Warner, On Corporate Governance: A Study of Proxy Contests, 2 J. Fin. Econ. 401 (1983).

²³ Because some airlines appear more than once in the sample there is a possibility for data overlap. This may in turn bias the estimates of the beta coefficients downward if there is a crash during the overlap period. We checked the samples and found four such cases. We calculated the statistics both with and without the overlap cases and found no significant difference in the results. Another potential problem is clustering that may induce cross-sectional dependence among the excess returns. Industry clustering exists because all firms are in the same industry. Date clustering exists in the non-crash sample since there are at least five non-crash airlines per crash, but it is not severe because we have several different crash dates. The problem can be alleviated to some extent by using the approach of Stephen J. Brown and Jerold B. Warner, Using Daily Stock Returns: The Case of Event Studies, 14 J. Fin. Econ. 3 (1985). However, they show that the standard tests that ignore cross-sectional dependence are more powerful and induce little bias in variance estimates if the degree of dependence is small. To test the robustness of our results we also calculate statistics based on the dependence assumption, but do not report the results since they are similar to those obtained with

the basic method. We do not form portfolios of clusters because our main purpose is to obtain individual airlines' abnormal returns which in turn can be related to our market overlap measure.

²⁴ The crashes are Air Florida (1/13/82), Northwest (12/03/90), and TWA (7/17/96).

²⁵ The test statistic Z in Tables 2 and 3 is the mean standardized prediction error, which is distributed unit normal in the absence of abnormal performance.

²⁶ The aggregated non-crash airline results exclude the 1996 TWA crash (mid-air explosion) that caused unusually large negative abnormal returns for non-crash airlines. See Table 1 and the regression analysis of Section VI.

²⁷ The difference-between-mean tests exclude the non-crash airlines for the 1996 TWA crash (mid-air explosion) that caused unusually large negative abnormal returns for non-crash airlines. See Table 1 and the regression analysis below.

²⁸ For example, the New York Times reported on July 19, two days after the crash and day 1 in our event time, that “Based largely on witnesses’ accounts, Federal investigators yesterday offered several possible scenarios for the explosion . . . [including] . . . a surface-to-air missile fired from below” (at 1).

²⁹ We conducted additional analyses, summarized below, that are not reported in detail to conserve space but is available upon request. First, we tested for possible crash severity effects (for example, number of fatalities) using various proxies and found none. Borenstein & Zimmerman, supra note 3, also found no impact of crash severity in their attempt to estimate crash-induced demand changes for non-crash airlines. Markets may view severity as essentially random given that an accident has occurred. We also attempted to estimate, using various specifications, the possible effects of apparent

crash airline “fault”, per Mitchell & Maloney, supra note 3. We found none, likely because fault is usually ambiguous, particularly in the initial reports following the crash. Third, we find some evidence of “diminishing marginal returns” to increasing route overlap using non-linear specifications. Last, we eliminated 40 non-crash airline observations with possible confounding events. The results are qualitatively identical.

³⁰ Other studies reporting similar spillovers also observe lagged effects. For example, Jarrell & Peltzman, supra note 1, measure their spillover using a ten-day window centered on the drug recall event. Mitchell, supra note 2, reports essentially no effect until about ten days after the Tylenol poisoning event, and measures his spillover from day +11 to day +20.

³¹ Jarrell & Peltzman, supra note 1.

³² Mitchell, supra note 2.

³³ For example, see Rose, supra note 8.

³⁴ Mitchell & Maloney, supra note 3.