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Market Forces and Airline Safety: An Empirical Reevaluation

by Carl A. Scheraga, Scott Ornstein***

ABSTRACT

The recent publicity with regard to commercial airline accidents and near accidents has sparked new debate over the issue of safety in the industry under deregulation, with the main issue being the unregulated market's ability to impose significant penalties for poor safety attitudes. This study shows that although there are large movements in the price of airline stocks subsequent to accidents, the market imposed costs do not provide a direct motivation for enhanced safety performance. Instead, the market's reaction to airline accidents is based on the nature of airline stocks as short term investment tools.

It is necessary, therefore, to continue to carefully evaluate the role of government in the promotion of airline safety in a deregulated environment. One cannot assert, without qualification, that free market forces, in and of themselves, will provide individual firms with the impetus to provide the socially optimal level of safety performance.

INTRODUCTION

The recent publicity given to commercial airline accidents and near accidents has sparked new debate over the issue of safety in the industry under deregulation. Of concern is the seeming lack of institutional means to forcefully motivate a safety-conscious attitude on the part of airlines, who may be overly preoccupied with cost competitiveness. At the heart of the issue is the question as to the unregulated market's ability to impose significant penalties for poor safety attitudes.

One response to the airline safety issue is to examine basic statistics with regard to fatalities and near misses. McKenzie and Shughart (1987) note that the average number of air-travel fatalities per billion passenger miles fell sharply over the time periods 1972 to 1978 and 1979 to 1986, before and after deregulation. The data concerning near misses is not as transparent. Except for 1981 and 1982, near misses increased continuously over the time period 1972 to 1986. It is, however, hard to interpret such statistics as the particular numbers are highly sensitive to changes in reporting systems and media attention.

A second response is to take a longer-run perspective and to try and ascertain whether there are existing economic forces that will continue to enforce an acceptable level of airline safety in a deregulated environment. Certainly, even in the face of deregulation, the judicial system imposes significant penalties on commercial carriers in the form of wrongful death judgements. The insurance costs that are borne are also of considerable magnitude. Nevertheless, it is interesting to examine the ability of market forces to impose costs on carriers in relation to their safety postures. Such market forces reflect a loss of consumer confidence in the quality of service provided by a particular air carrier.

This study does not, therefore, attempt to examine the issue of the relative safety of airlines before and after deregulation. Rather it seeks to measure the efficacy of market forces, not related to legal or insurance institutions, in assessing penalties to culpable parties in airline accidents. These market forces exist in both the regulated and unregulated environment.

PREVIOUS MARKET STUDIES AND THE MOTIVATION FOR THIS STUDY

The theory of efficient capital markets suggests that such market imposed forces, as well as those determined by the judicial system and the insurance market, should be reflected by an adjustment in a firm's stock price. A desirable feature of this theory is that since stock prices represent a capitalization of future cash flows, one should be able to measure the long term effects of safety-related incidents.

Several important studies have used the market model approach in assessing the impact of these market forces. Chalk (1986) examined the single event of the American Airlines crash in 1979. He found that McDonnell-Douglas suffered a loss of $200 million, a good part of which was attributable to the market's anticipation of a decline in future sales of aircraft for the company.

Borenstein and Zimmerman (1987) investigated a portfolio of airline accidents and calculated the market's <u>average</u> response.

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They assembled a data set of 68 accidents whose criteria for inclusion was on-board fatalities and some aircraft damage. They found that on average, crashes were associated with a statistically significant 1% loss in equity value, occurring within one day after the date of the accident.

Mitchell and Maloney (1989) enhance these results in their study by separating out stock market losses into components consisting of insurance costs increases and the decline in the value of an airline's brand name. Their results suggest that 42 percent of the adverse movement in stock prices could be attributed to the former component, with the rest due to the latter brand name effect.

Borenstein and Zimmerman do note an interesting anomaly when their results are examined in a disaggregated fashion. When they examine movement in stock prices for individual companies, in several cases, where the airline was directly at fault, there was a net positive impact on firm value. They attempt to reconcile this observation by suggesting that in some cases news about a crash coincided with other new information and hence the net positive effect on stock prices.

This last observation is an important one. What it suggests is that while on average the market may correctly assess responsibility for a particular accident, on a case by case basis, there may be other operative factors which may offset the market's correct assessment of responsibility. This study investigates the nature of these confounding factors. It should be noted that precedent for this type of disaggregation can be found in the work of Ruback (1982) who examined the effect on stockholder returns for the individual firms involved in the Conoco takeover. It is this study which formed the basis for the model used by Chalk in his study.

AIRLINE STOCKS AS INVESTMENT INSTRUMENTS

Four factors, in addition to the cause of accident, are hypothesized to influence the market's reaction. The first is the size of the air carrier relative to the total market for airline services. The larger air carriers have a higher public information profile and therefore information is more quickly and readily disseminated regarding an incident involving one of these airlines. Furthermore, these carriers handle more passengers with more flights per time period. Hence, the statistical probability of subsequent accidents is higher relative to smaller carriers. Additionally, as Taneja (1981) notes, airline stocks are generally considered short-term trading vehicles. The equity issues most likely to be held for this purpose are those of the larger carriers. Because of all these factors, a particular accident is more likely to have a negative impact on a firm's equity value the larger the air carrier that is involved.

One might suspect that the magnitude of the market's reaction to a particular incident is a function of the general financial health of the particular company associated with the accident. One standard and often used means of measuring the financial status of a firm is financial leverage (see Harris, 1987). Here, however, there may be offsetting effects, if financial leverage is measured by the ratio of the market value of equity to the book value of total debt, as was done in this study. On the one hand, a poor leverage ratio is a signal for the possibility of bankruptcy, and so the market is more likely to react negatively as financial leverage deteriorates. On the other hand, consistent with Taneja's observation noted above, those airline stocks sought as short term trading vehicles will be those with high financial leverage ratios. Hence, given the short term nature of these investments, these airline stocks will be those most quickly turned over subsequent to an accident. Indeed, with turnover measured as the ratio of shares outstanding to shares traded during the month of a particular accident, a statistically negative correlation was observed in the data sample between price and turnover. These premium stocks, viewed as short term investments with relatively high turnover rates, would be most likely to have a deterioration in the price of equity.

Turnover, as defined above, is also included as a third factor. This variable is used to measure the activity of trading in a particular airline stock. The more actively a stock is traded, the more likely there is to be a significant movement in share price.

The fourth and final additional factor is the number of serious injuries associated with a particular crash. The magnitude of this variable is used to capture the expected costs of lawsuits and increased insurance premiums.

HYPOTHESES TO BE TESTED

Based on the above discussion the following testable hypotheses are suggested:

H_1: The magnitude and direction of the movement in an air carrier's stock price (and therefore the cumulative impact over an event period consistent with that utilized in standard event studies) subsequent to a safety-related accident having a significant impact on consumers' perceptions with regard to quality of service is a function of the assignment of responsibility for the incident.

The alternative is to note that air carrier equity issues are investment tools with particular characteristics. Common stock of air carriers displaying particular financial attributes is more likely to be held by investors than that of air carriers not displaying these attributes. Hence:

H_2: Those airline stock issues being held as beneficial investment tools will be those most negatively impacted by air carrier accidents as their perceived financial utility declines. Over the length of the event period, the cumulative impact on these stock issues should be solely a function of these financial attributes.

THE BASIC MODEL

The standard market model of stock price behavior is used to measure abnormal stock market performance. Daily risk-adjusted returns were estimated over the 150 day period immediately preceding each incident [Equation (1)]. The daily parameter estimates were then used to calculate abnormal returns (AR_t) for the subsequent sixty day period including the event day [Equation (2)]. That is, for each incident:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \epsilon_{it}, \quad t = -150, \ldots, -1 \qquad (1)$$

where

R_{it} = Return of company i's stock on day t;

R_{mt} = Return on the CRSP Value-Weighted Market Index on day t;

$$\text{and } AR_{it} = R_{it} - (\alpha_i + \beta_i R_{mt}), \quad t = 0, \ldots, 59. \qquad (2)$$

One would expect abnormal returns to fluctuate as information is assimilated by the market. To test the statistical significance of each abnormal return a procedure described by Beaver (1981) and utilized by Hill and Schneeweis (1983) is implemented. Each AR_{it} is normalized as follows:

$$NAR_{it} = AR_{it}/S(AR_{it}) \qquad (3)$$

where $S(AR_{it})$ is the standard deviation of the residual for the estimation period. A value for NAR_{it} less than -1.96 or greater than 1.96 implies an abnormal return significantly different from zero at the 5% level.

However, since what is of interest is the total impact on the firm over the event period, cumulative abnormal returns (CAR_{it}) are calculated where

$$CAR_{it} = \Sigma AR_{it}, \quad t = 0, \ldots, 59. \qquad (4)$$

To test the statistical significance of each cumulative abnormal return, a normalized cumulative statistic is formed as follows:

$$NCAR_{it} = CAR_{it}/(\sqrt{L})S(AR_{it}), \quad L,t = 0, \ldots, 59 \qquad (5)$$

where again $S(AR_{it})$ is the standard deviation of the residual over the estimation period, and L is the length of the accumulation. Equation (5) follows from the fact that each cumulative abnormal return is the sum of individual, normally distributed residuals of constant variance. As above, statistical significance is obtained for values less than -1.96 or greater than 1.96.

The market model has a very straightforward interpretation. The return on a stock consists of two components. The first, or systematic risk component, measures movement in the individual stock due to marketwide factors. The second, or non-systematic risk component, measures movement in the individual stock due to firm specific factors. Systematic risk is captured by the $\beta_i R_{mt}$ term (where β_i is the correlation coefficient between R_{it} and R_{mt}) while non-systematic risk is embedded in the ϵ_{it} term. By using the market model to calculate abnormal returns during the sixty day event period, one can measure the effect on the value of equity due solely to the event, having removed marketwide influences. It should also be noted that abnormal returns are not absolute measures but rather deviations from the normal trend line as defined by equation (1).

THE SAMPLE

The data sample utilized was similar to the one employed by Borenstein and Zimmerman with two modifications. While the sample also spanned the 1962-1985 time period, several observations were added based on data obtained from the National Transportation Safety Board. In addition, to make the sample as homogenous as possible, accidents involving training flights were deleted from the sample. The resulting data set consisted of 67 observations fulfilling the Borenstein and Zimmerman criteria of on-board fatalities and aircraft damage. The data from the National Transportation Safety Board consisted of individual accident reports for all incidents during the relevant time period. Access to these reports allowed the specification of the identified cause-of-accident. The number and severity of injuries were also obtained from these reports.

The NTSB cause-of-accident determination was utilized in order to ascertain the ability of the market to correctly forecast the actual underlying cause of any given incident. The sixty day event period was utilized based on conversations with individuals at the NTSB. This seemed to be a good approximation for the typical time period in which the board was able to come to a fairly conclusive determination of cause for a given accident.

Data for daily stock returns was obtained from the Center for Research in Security Prices (CRSP) of the University of Chicago. Firm specific financial data came from the Compustat Industrial Tapes from Standard and Poor's, Inc.

THE RELATIONSHIP BETWEEN CUMULATIVE ABNORMAL RETURNS AND THE CAUSE OF ACCIDENT

If the suggested hypothesis, that the market imposes penalties for poor safety performance, is correct, a consistent relationship should be observed between the sign of the cumulative abnormal return calculated for each accident and the cause of the particular accident. The results for examining this suggestion are presented in Table 1.

The cumulative abnormal return presented for each company is for the last day of occurrence during the event period for the highest level of statistical significance. Thus, for the Eastern Airlines crash on December 29, 1972, there was a significant CAR at the 1% level, accumulated over the 11 day period, beginning with the day of the crash. However, in the case of the American Airlines crash on August 3, 1964, there were no significant CAR's at the 1% or 5% level. Hence the 10% significance level was reported for the CAR over a 36 day accumulation period. Anything less than the 10% level was not considered statistically significant. It should be noted, that in calculating the CAR's, when a crash occurred after market trading had closed for the day, the accumulation was calculated from the beginning of the next trading day.

Two other items are presented in Table 1. The first is a dummy variable representing the cause of the accident. The dummy was coded as a 1 if the cause of the accident was unequivocally the fault of the air carrier in question. It was coded as a 0, if the cause of the crash was a factor outside of the control of the air carrier. The second is the financial loss or gain to the firm due to the particular incident. This was calculated by multiplying the cumulative abnormal return by the market value of the firm's equity. The market value of equity was calculated as the market share price times the number of shares outstanding at the beginning of the month in which the accident occurred. Hence, for the Mohawk Airlines crash on July 2, 1963, an abnormal return of approximately 5.5% resulted in a loss of about $264,000.

In examining Table 1, it is apparent that not only are there statistically significant negative cumulative abnormal returns, but also significant positive ones or a complete lack of any significant CAR. The absence of a significant CAR would make sense if the airline were not at fault and therefore the market was not assessing any penalty. Even a significant positive CAR could be rationalized. If there had been a particularly spectacular accident, where the market had feared the worst in terms of the firm's liability, and then information had subsequently indicated that the carrier was not at fault, the market might actually rebound and show a significant positive abnormal return.

The above scenarios would be consistent with the notion that the market efficiently "regulates" safety. Unfortunately, the results in Table 1 indicate otherwise. There are numerous instances of the air carrier being at fault and the market either not reacting significantly, or in fact showing a positive significant cumulative abnormal return. It would not be legitimate to dismiss these cases as "statistical artifices". Instead, what is being suggested, is that there are other factors to which the market is reacting. These factors dominate any reaction the market might have in terms of the cause of a particular accident. Again, it should be noted, that the empirical problem just discussed would tend to be obscured if an aggregation sort of analysis were to be utilized. Additionally, the information in Table 1 makes it clear that the timing of the impact of an event on the market differs significantly across firms.

THE IMPACT OF FINANCIAL ATTRIBUTES ON CUMULATIVE ABNORMAL RETURNS

Table 2 presents cross-sectional regression results using the four financial variables, discussed above, plus the dummy variable to control for cause of accident, as determinants of the individual cumulative abnormal returns after ten, forty, fifty, and sixty days of the event period. All results were corrected for heteroscedasticity (see endnote). The results appeared consistent with the second of the two hypotheses developed above.

The coefficient on the relative firm size variable (SIZE) was statistically significant in all equations. A 1% increase in the size of the firm as a percentage of the total carrier market increased the negativity (decreased the positivity) of the CAR over a range of .53% to 1.3%. The coefficient on the leverage variable (LEV) was statistically significant in the fifty and sixty equations. In these equations, a 1% change in the financial leverage ratio increased the negativity (decreased the positivity) of the CAR over a range of 3.6% to 4.6%. The coefficient on the turnover variable (TURN) was barely

TABLE 1

Cumulative Abnormal Returns and Financial Losses/Gains

DATE	NAME	CAUSE	CAR	SIG	DAY	CHANGE (000)
021263	NORTHWEST	0	0.046397	10%	2	2584
070263	MOHAWK	1	-0.055141	5%	2	-264
120863	PAN AM	0	NONE	-	-	NONE
022564	EASTERN	0	-0.406680	5%	59	-44559
070964	UNITED	0	-0.220500	10%	52	-78106
080364	AMERICAN	0	-0.177250	10%	36	-70342
082664	TWA	1	NONE	-	-	NONE
112364	TWA	0	NONE	-	-	NONE
020865	EASTERN	0	0.151485	1%	5	22750
081565	CONTINENTAL	0	-0.066977	10%	3	-6039
081665	UNITED	0	NONE	-	-	NONE
091765	PAN AM	1	0.262942	10%	60	109091
110865	AMERICAN	1	-0.078702	10%	9	-39219
111165	UNITED	1	0.137468	5%	24	88776
120465	EASTERN	1	-0.288250	10%	60	-87269
120465	TWA	1	0.105282	10%	10	41850
080666	BRANIFF	1	-0.691470	1%	60	-336345
022467	NORTHEAST	0	NONE	-	-	NONE
030967	TWA	1	-0.218580	10%	40	-154790
062367	MOHAWK	0	NONE	-	-	NONE
083067	EASTERN	1	-0.300450	5%	51	-161492
110667	TWA	1	-0.172050	10%	49	-90122
112167	TWA	1	-0.159990	5%	29	-83805
112867	TWA	1	-0.063370	5%	4	-33194
012768	WORLD	1	0.276160	10%	25	69730
050368	BRANIFF	1	-0.369330	5%	52	-123033
061268	PAN AM	1	NONE	-	-	NONE
102568	NORTHEAST	1	NONE	-	-	NONE
122468	ALLEGHENY	1	0.347346	10%	54	23567
010669	ALLEGHENY	1	0.191775	5%	11	13532
011869	UNITED	1	-0.252450	10%	50	-199999
090969	ALLEGHENY	0	0.145744	10%	6	6286
111969	MOHAWK	1	NONE	-	-	NONE
060771	ALLEGHENY	1	NONE	-	-	NONE
090471	ALASKA AIR	1	-0.115890	1%	1	-1726
120471	EASTERN	0	0.089160	1%	2	20070
053072	DELTA	1	-0.060867	10%	6	-65631
120872	UNITED	1	-0.282260	5%	35	-215569
122972	EASTERN	1	-0.220750	1%	11	-94001
072273	PAN AM	0	NONE	-	-	NONE
072373	OZARK	1	-0.083090	10%	3	-2395
073173	DELTA	1	-0.031572	10%	1	-28799
110373	NATIONAL	0	-0.149910	10%	10	-24047
110373	PAN AM	0	NONE	-	-	NONE
013174	PAN AM	1	NONE	-	-	NONE
042274	PAN AM	0	NONE	-	-	NONE
090874	TWA	0	NONE	-	-	NONE

TABLE 1 (cont'd)

Cumulative Abnormal Returns and Finanacial Losses/Gains

DATE	NAME	CAUSE	CAR	SIG	DAY	CHANGE (000)
091174	EASTERN	1	-0.163450	1%	6	-16341
120174	TWA	1	NONE	-	-	NONE
121474	EASTERN	1	-0.195280	10%	14	-15358
062475	EASTERN	0	NONE	-	-	NONE
080775	CONTINENTAL	0	NONE	-	-	NONE
040576	ALASKA AIR	1	-0.078420	10%	2	NA
042776	AMERICAN	1	0.252514	1%	19	71225
032777	PAN AM	0	0.443783	5%	60	86890
012778	NATIONAL	1	-0.148810	5%	18	-17825
122878	UNITED	1	-0.284130	5%	36	-218771
021279	ALLEGHENY	1	0.424481	5%	36	34186
052579	AMERICAN	0	-0.150170	5%	11	-50084
103179	WESTERN	1	NONE	-	-	NONE
012382	WORLD	1	NONE	-	-	NONE
070982	PAN AM	0	-0.621810	5%	60	-143879
081182	PAN AM	0	-0.920060	1%	60	-229266
011183	UNITED	1	NONE	-	-	NONE
010185	EASTERN	0	0.509901	10%	60	94064
062785	AMERICAN	0	NONE	-	-	NONE
080285	DELTA	0	-0.254360	5%	60	-499318

significant in the forty day equation. However, the associated negative sign was as expected. A 1% change in turnover increased the negativity (decreased the positivity) of the CAR 1.8%. The coefficient on the injury variable (INJ) was significant in all the equations. The negativity (positivity) of the CAR increased (decreased) .06% to .13% per one hundred injuries. Most significantly for the present discussion, in none of the equations was the coefficient on the cause of accident variable (CAUSE) statistically significant.

The empirical results demonstrate that stock price reactions were a function predominantly of financial characteristic variables. The lack of statistical significance for the cause of accident variable suggests that the hypothesis that market forces correctly assign responsibility for a particular incident cannot be empirically supported. Furthermore, while the injury variable was consistently statistically significant, its effect on cumulative abnormal returns was comparatively small. This suggests that, at least in the short run, legal costs for injuries and replacement costs for damaged aircraft were covered by air carriers' insurance. All of the above is consistent with the hypothesis that movement in the equity market subsequent to an incident is a function of the characteristics of air carrier stocks as particular investment tools.

CONCLUSIONS

The size and sign of the cumulative abnormal returns observed are not determined solely by the cause of a particular accident. The picture that does seem to emerge from the results presented, is that the size and direction of stock price movements is a function of the market's perception of the ability of a particular stock issue to continue to perform well as a particular kind of investment tool. As Taneja notes, those equity issues which will continue to be the most attractive are those of carriers with "low debt, high profitability, and investment policies that are closely tailored to their financial ability". An increase in business risk subsequent to an airline crash would impact most on these investment-grade stocks. This would also explain the seemingly counterintuitive results for some of the signs on the CARs in Table 1. An equity issue not viewed as a high-grade, short-term investment tool, may respond very little, if at all, to a particular accident. If the price movement of such stocks is dominated by economic forces not related to public safety consciousness, then the absence of a statisti-

TABLE 2

Regression Results: Determinants of the Magnitude of the Cumulative Abnormal Returns

DEP VAR: CAR10 — R-SQUARE 0.2285

VARIABLE	PARAMETER	T RATIO	PROB>|T|
INT	0.118084	2.6886	0.0102
SIZE	-0.005319	-1.9917	0.0529
LEV	-0.005501	-0.5460	0.5880
TURN	-0.007069	-1.2286	0.2260
INJ	-0.000606	-2.5756	0.0136
CAUSE	-0.017329	-0.6478	0.5207

DEP VAR: CAR40 — R-SQUARE 0.2238

VARIABLE	PARAMETER	T RATIO	PROB>|T|
INT	0.214735	2.6675	0.0108
SIZE	-0.012936	-2.6346	0.0117
LEV	-0.021334	-1.1971	0.2380
TURN	-0.017791	-1.6394	0.1086
INJ	-0.000834	-1.7022	0.0961
CAUSE	0.003343	0.0681	0.9460

DEP VAR: CAR50 — R-SQUARE 0.2714

VARIABLE	PARAMETER	T RATIO	PROB>|T|
INT	0.229138	2.7881	0.0079
SIZE	-0.013114	-2.6137	0.0124
LEV	-0.035812	-2.0164	0.0502
TURN	-0.012209	-1.0864	0.2835
INJ	-0.001306	-2.4544	0.0183
CAUSE	0.015232	0.3052	0.7617

DEP VAR: CAR60 — R-SQUARE 0.2311

VARIABLE	PARAMETER	T RATIO	PROB>|T|
INT	0.233380	2.6633	0.0109
SIZE	-0.011254	-2.1062	0.0412
LEV	-0.045520	-2.5476	0.0146
TURN	-0.012402	-1.0135	0.3166
INJ	-0.001200	-1.9062	0.0635
CAUSE	-0.000638	-0.0122	0.9903

cally significant negative CAR subsequent to a safety-related incident is not surprising.

It is necessary, therefore, to continue to carefully evaluate the role of government in the promotion of airline safety in a deregulated environment. One cannot heroically assert that free market forces, in and of themselves, will provide individual firms the necessary motivation for the provision of the socially optimal level of safety performance.

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ENDNOTES

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The Breusch-Pagan Test was utilized to detect the relationship between the variance of the error term and the INJ variable. Specifically, the larger the number of injuries, the greater the uncertainty regarding total liability costs, and hence the larger the variance in the cumulative abnormal return. The actual form of the heteroscedasticity was estimated using the Park-Glejser Technique. Using this technique, one must be careful in interpreting the R-Square values. Using the SAS statistical package to perform weighted-least squares, the R-Square values are uncorrected for the mean and hence have a different interpretation than the usual one. They are presented, however, since the order of magnitude of the R-Square values did not change significantly before and after correcting for heteroscedasticity.