THE IMPACT OF DEREGULATION ON AIRLINE SAFETY: PROFIT-SAFETY AND MARKET-RESPONSE ARGUMENTS

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ABSTRACT

Is air travel less safe in a deregulated or market environment? This question has received considerable attention. The debate centers around two arguments. The profit-safety argument argues that deregulation leads to competitive pressures on airlines to reduce expenditure on safety-related items such as aircraft maintenance, thus resulting in less safe air travel. Alternatively, the market-response argument argues that market forces will promote air safety--airlines anticipating a deterioration in their financial condition following an accident will take safety precautions in a market environment. The evidence suggests that the validity of the profit-safety argument depends upon which airline safety investments affect aircraft accidents and whether these investments are affected by the financial condition of airlines. The validity of the market-response argument depends upon who is at fault in aircraft accidents.

1. Introduction

In 1978, United States (U.S.) air passenger service was deregulated following the passage of the Airline Deregulation Act. The 1988 National Transportation Act deregulated, in part, domestic air service in Canada. Recently, domestic air service in Australia was deregulated. In the United kingdom (U.K.), de facto liberalization of domestic air service began in 1980 and air markets in Europe are anticipated to become freer in the 1990s.[1]

Is air travel less safe in a deregulated or market environment? This question has received considerable attention. The debate centers around two arguments. The profit-safety argument argues that deregulation leads to competitive pressures on airlines to reduce expenditure on safety-related items such as aircraft maintenance, thus resulting in less safe air travel. Alternatively, the market-response argument argues that market forces will promote air safety--airlines anticipating a deterioration in their financial condition following an accident will take safety precautions in a market environment.

The evidence suggests that airline safety in the U.S. has not deteriorated under deregulation.[2] For the time period 1970-1975 (prior to deregulation), the average annual number of accidents for U.S. certificated air carriers was 40 and their average annual accident rate (total accidents per 100,000 departures) was 0.81.[3] For the time period 1980-1989 (following deregulation), the average annual number of accidents for U.S. certificated air carriers was 21.6 and their average annual accident rate was 0.31. Further, Kanafani and Keeler (1989) conclude that there is no difference in the safety performance of established U.S. airlines and new entrants who joined the industry following airline deregulation.

The purpose of this paper is to investigate the validity of the profit-safety and market-response arguments for explaining the impact of airline deregulation on airline safety. U.S. air safety under deregulation is investigated, since the U.S. has had extensive experience with deregulation (beginning in 1978). The next section models determinants of airline safety. The profit-safety and market-response arguments for explaining the impact of deregulation (or a market environment) on airline safety are presented within this analytical framework. The next three sections present empirical evidence for support (or not support) of these arguments. Conclusions are presented in the final section.

2. A Model of Determinants of Airline Safety

Airline safety (AS) is affected by two sets of factors--safety investments (SI) and operating conditions (OCs),[4] i.e.,

$$As = f(SI, OCs) \qquad (1)$$

Airline safety investments consist of actions by an airline to improve the safety of its service. Examples include utilizing more experienced pilots and implementing more intensive pilot training programs to reduce the

frequency of pilot error, and scheduling aircraft maintenance more frequently and purchasing newer aircraft to reduce the probability of aircraft failure. Airline operating conditions describe the environment in which an airline operates; OCs represents those operating conditions that directly affect airline safety. Examples include the weather, variations in airport quality and technology and traffic congestion that may increase safety risk, and advances in aircraft and air traffic control technology, and increases in government safety regulation that may improve safety over time.

Safety investments of an airline may, in turn, be influenced by its financial condition (FC) as well by its operating conditions (OCi); i.e.,

$$SI = g(FC, OCi) \qquad (2)$$

The variable OCi represents airline operating conditions that directly affect safety investments of airlines.

The profit-safety argument (for explaining the impact of deregulation on airline safety) states that a reduction in airline profits will result in airlines cutting back on safety expenditures, thus resulting in a deterioration in airline safety. In terms of functions (1) and (2), the argument states that a positive relationship is expected in function (2) between an airline's safety investments and its financial condition and a positive relationship is expected in function (1) between airline safety and safety investments. Thus, if the financial condition of airlines are negatively affected under deregulation, airline safety will deteriorate.

Rather than utilizing function (1) and (2), the validity of the profit-safety argument may also be investigated by utilizing the reduced-form function of functions (1) and (2), found by substituting function (2) into (1) and solving, or

$$AS = h(FC,OCs,OCi) \qquad (3)$$

The profit-safety argument predicts that a positive relationship is expected in reduced-form function (3) between airline safety and an airline's financial condition.

The relationship between airline safety and the financial condition of airlines may also be simultaneous--the latter affects the former and the former affects the latter. Not only may the financial condition of an airline affect its safety as in reduced-form function (3), but its safety in addition to its cost (CO) and revenue (RE) characteristics may also affects its financial condition, i.e.,

$$FC = i(AS,CO,RE) \qquad (4)$$

The market-response argument (for explaining the impact of deregulation on airline safety) suggests that function (4) exists and the relationship between an airline's financial condition and its safety in this function is positive. Airlines anticipating a deterioration in their financial condition following an accident will take safety precautions in a deregulated (or market environment). Thus the validity of the market-response argument may be investigated by investigating whether a positive relationship exists in function (4) between an airline's financial condition and its safety.

Functions (1), (2) and (4) constitute a model for investigating determinants of airline safety, indicating a simultaneous relationship among airline safety, safety investments and financial condition. The model also provides an analytical framework for investigating the validity of the safety-profit and market-response arguments for explaining the impact of deregulation (or a market environment) on airline safety. To the knowledge of this author, such a model has not been estimated in the literature but rather components of the model. Functions (1) and (2) or their reduced-form function (3) have been estimated to investigate the validity of the safety-profit argument; function (4) has been estimated to investigate the validity of the market-response argument. Results of these investigations are discussed in the following two sections. An estimation of the model (rather than estimation of its components as found in the literature) is presented in the section that follows these two sections.

3. The Profit-Safety Argument

The air-safety literature has generally investigated the validity of the profit-safety argument from estimation of reduced-form function (3). For example, Globe (1986) found no statistical relationship between air safety (measured by the square root of accidents) and profits in the airline industry. Further, if there is a relationship, it is likely to be negative--more profitable airlines have more accidents. Two sets of domestic data were utilized in the investigation--a cross-section data set consisting of eleven U.S. certificated airlines for the years 1963 to 1970 and a time-series data set for the U.S. airline profitability were considered--net income after taxes but before special items, deflated by the Gross National Product price deflator and the rate of return on regulatory investment.

In an earlier investigation of the profit-safety argument by Rose (1989), results are mixed. Based upon a data set of aggregate accidents by U.s. scheduled certificated airlines for the years 1956 to 1984, Rose obtained results that are similar to those of Globe: 1) no statistical relationship was found between accidents and airline profits and 2) the coefficient on the profit margins correspond to lower accidents. These results hold for total accidents, accident rates (total accidents per 100,000 departures) as well as for total fatal accidents. The average operating margin, defined as one minus the ratio of operating expenses to operating revenues lagged one time period, was the measure of airline profitability.

In the same paper, Rose (1989) also investigated the profit-safety argument utilizing an individual airline data set of 26 scheduled certificated airlines for the years 1957 to 1986. A statistically significant negative relationship was found between accident rates and the operating margins of the airlines--implying that lower profit margins correspond to higher accident rates. To test for the robustness of the relationship, the data set was divided into three time periods: 1957-1965, 1966-1975 and 1976-1986. For these three time periods, the relationship remains negative, but is only statistically significant for the 1966-1975 time period--thus providing mixed evidence on the robustness of the results.

In a more recent paper, Rose (1990) investigated the profit-safety argument utilizing a slightly larger data set of 35 large scheduled airlines for the years 1957 to 1986. Rose (1990) concludes that not only are higher operating margins (or operating profits) associated with reduced accident rates but also with reduced incident rates as well.[5] Rose further concludes that the effect seems strongest for the smaller airlines (among the large scheduled airlines) and is particularly pronounced for airline incident data.

An underlying argument to the airline profit-safety argument is that a positive relationship exists between airline profits and safety investment expenditures (such as maintenance) and that these expenditures, in turn, have a positive influence on airline safety; i.e., a decrease in profits will lead to a decrease in safety investment expenditures which, in turn, will lead to an increase in accidents. Talley and Bossert (1990) investigated this hypothesized scenario--modeled as functions (1) and (2) above--utilizing aggregate accident data of U.S. scheduled certificated airlines for the years 1959 to 1984. A statistically significant negative relationship was found between airline operating ratios (the ratio of total operating cost to total operating revenue) and relative maintenance expenditures (the ratio of maintenance expenditure to total operating cost)--thus implying that a decrease in profits will result in a decrease in maintenance expenditures. However, a statistically insignificant relationship was found between relative maintenance expenditures and airline accidents. Thus, the hypothesized scenario is only supported in part. A liberal interpretation of these results is that lower profits lower the safety margin (or maintenance expenditures) of airlines but, in turn, do not lead to an increase in accidents.

Talley and Bossert (1990) in estimation of reduced-form function (3) found a statistically insignificant relationship between accidents and airline operating ratios (i.e., between accidents and profits). The relationship, however, had the expected sign based upon the profit-safety argument.

4. The Market-Response Argument

The airline profit-safety argument is an argument against market forces for promoting airline safety--thus favors regulation and more stringent public-sector enforcement. Market forces, however, may in fact promote airline safety. Airlines anticipating a deterioration in their financial condition following an accident will take safety precautions in a market environment. The market-response argument for air safety favors deregulation and less stringent public-sector enforcement.[6]

A test of the market-response argument is found in a study by Mitchell and Maloney (1989). Specifically, Mitchell and Maloney address the following question: "Are consumers reluctant to fly with airlines that have poor safety records or do they treat crashes merely as random events that bear no reflection on the quality of the airline?". If the former is true, the goodwill (or the value of the brand name) of the airline will decline, having an adverse effect on the performance of the airline's stock and conversely, if the latter is true. The authors investigated the abnormal stock market performance of airlines immediately following a crash, i.e., an estimation of function (4) was performed. Two groups of crashes were considered--those caused by pilot error and those in which the airline was judged by the press or by the Federal Aviation Administration (FAA) not to be at fault. Fifty-six such crashes between 1964 and 1987 were examined. For crashes caused by pilot error, the airline experienced significantly negative stock returns; for crashes for which the airline was not at fault, there was no stock market reaction. Mitchell and Maloney (1989, p. 355) conclude: "since our results suggest the market is quite efficient at punishing airlines for at-fault crashes, the need for increased airline safety regulation is not apparent."

Airlines that are near bankruptcy might choose to reduce safety expenditures and risk an increase in accidents in an effort to avoid bankruptcy. If airline accident rates increase as a consequence, the goodwill of these

airlines will erode and their value to potential acquirers is likely to be lower. The tendency for failing airlines leaving the industry is to leave by merger or acquisition rather than by liquidation of assets. Apparently, the cost of leaving the industry by liquidation of assets (or by bankruptcy) is perceived by failing airlines to be higher than the cost to be incurred in leaving by merger or acquisition. Hence, even failing airlines may have a market incentive to encourage safety, thereby avoiding raising the risk of bankruptcy.[7]

In our discussion heretofore, we have reviewed literature that have addressed the validity of the profit-safety argument or the market-response argument for airline safety independent of the other argument. In the following section, we investigate whether these arguments as a group (i.e., from a simultaneous-equation perspective) are valid arguments for the impact of deregulation on airline safety.

5. A Simultaneous-Equation Perspective

We investigate the validity of the profit-safety and market-response arguments for airline safety from a simultaneous perspective by estimating a model consisting of functions (1), (2) and (4). Annual aggregate (i.e., time series) data for the tears 1959 to 1984 for U.S. aircraft accidents incurred by U.S. scheduled certificated airlines are used in the estimation. Our version of function (1) is:

$$AA = f'(ME,PE,FAC,AM,TIM,DEG) \qquad (1')$$

Where, AA represents aircraft accidents; ME represents airline relative maintenance expenditure (or the ratio or maintenance expenditure to total operating cost); PE represents pilot expertise measured by the number of U.S. air transport pilot ratings (ATPs) per U.S. commercial air pilot rating; FAC represents the number of U.S. FAA air traffic controllers; AM represents the number of aircraft miles flown (in millions) by certificated airlines; TIM represents a time trend variable that captures those factors (that are not readily quantifiable affecting airline safety) that vary through time rather than across airlines such as air traffic control conditions, congestion and technology; and DEG is a binary variable representing deregulated versus regulated time periods. Variables ME and PE represent airline safety investments, whereas FAC, AM, TIM and DEG represent airline operating conditions as described in function (1).

A negative relationship is expected between aircraft accidents and airline safety investment--relative maintenance expenditure (ME) and pilot expertise (PE). An increase in the number of air traffic controllers (FAC) is expected to result in a decrease in aircraft accidents. As the number of aircraft miles flown increases, the likelihood of an airline having an accident is expected to increase. Since technological change in airline service (proxied by TIM) has tendered to promote air safety, a negative relationship is expected between aircraft accidents and TIM. Since evidence suggests that U.S. air safety has not deteriorated under airline deregulation (and in fact may have improved), a negative relationship is expected between AA and DEG.

Data for variables AA and ME were obtained from the FAA Statistical Handbook of Aviation; data for variables PE and FAC were obtained from the FAA's Public Affairs Office in Washington, D.C., and data for the variable AM were obtained from the NTSB's (National Transportation Safety Board) Accidents, Accident Rates, Certified Route Air Carrier-All Scheduled Service. The DEG variable was assigned a one for the year 1978 (when the airline industry was deregulated) and for the time periods thereafter; for the previous time periods, DEG was assigned a zero. The time trend variable TIM was assigned a one for the first year (i.e., 1959) of the data set and higher integer values for the remaining years of the data set.

Our version of function (2) is:

$$ME = g'(OP,FAI,AH,TIM) \qquad (2')$$

Where, OP represents the operating margin or 1 minus (operating costs/operating revenue) of certificated airlines; FAI represents the number of U.S. FAA aviation safety inspectors; AH represents the number of aircraft hours flown (in 100,000s) by certificated airlines, and TIM is a time trend variable that captures changes in aircraft technology over time. Variable OP is a measure of the financial condition of airlines. Variables FAI, AH and TIM describe aspects of the environment in which airlines operate (i.e., operating-condition variables) that are expected to affect the relative maintenance expenditure of airlines. Data for the variable OP were obtained from the FAA Statistical Handbook of Aviation; data for the variable FAI were obtained from the FAA's Public Affairs Office in Washington, D.C.; and data for the variable AH were obtained from the NTSB's Accidents, Accident Rates, Certified Route Air Carrier--All Scheduled Service.

A positive relationship is expected between relative maintenance expenditure (ME) and operating margin (OP) or airline profits. Since the FAA inspects aircraft and specifies aircraft maintenance guidelines, an increase in the number of FAA inspectors (FAI) is expected to result in an increase in the relative maintenance expenditure of airlines. As the utilization of aircraft (proxied by AH) increases, the relative maintenance expenditure of airlines is also expected to increase. Since TIM is a proxy for technological change in airline service

and since more recent designed aircraft are expected to require less maintenance than earlier designed aircraft, a negative relationship is expected between relative maintenance expenditure and TIM.

Our version of function (4) is:

$$OP = i'(AA, AH, RPM, TIM) \qquad (4')$$

Where, RPM represents an airline's passenger revenue per passenger-mile (in cents) and TIM is a time trend variable that captures those factors that vary through time and affect the financial condition of airlines. Variable AH is a proxy for airline costs. Data for the variable RPM were obtained from the FAA Statistical Handbook of Aviation.

Based upon the market-response argument, a negative relationship is expected between OP (or profits) and the number of aircraft accidents. With AH being a proxy for airline costs, a negative relationship is expected between OP and AH. The relationship between OP and RPM is indeterminate--depending in part upon the price elasticity of demand for airline service in various markets. To the extend that technological change in airline service has lowered its costs, a positive relationship is expected between OP and TIM. For a summary list of the variables appearing in functions (1'), (2') and (4') and their definitions, see Table 1.

TABLE 1:
Variables and Definitions

Variables	Definition
AA	Aircraft accidents for U.S. certificated airlines
ME	Relative maintenance expenditure (ratio of maintenance expenditure to total operating cost) for U.S. certificated airlines
PE	Pilot expertise (or number of U.S. air transport pilot ratings per U.S. commercial air pilot rating)
FAC	Number of U.S. FAA air traffic controllers
AM	Number of aircraft miles flown (in millions) by U.S. certificated airlines
TIM	Time (equals "1" for 1959; "2" for 1960; etc.)
DEG	Deregulation binary variable (equals "1" for a deregulation time period; "0" for a regulation time period).
OP	Operating margin (1 minus the ratio of operating costs to operating revenue) for U.S. certificated airlines
FAI	Number of U.S. FAA aviation safety inspectors
AH	Number of aircraft hours flown (in 100,000s) by U.S. certificated airlines
RPM	Passenger revenue per passenger-mile (in cents) for U.S. certificated airlines

Two-stage least squares parameter estimates of the linear form of the above functions are found in Table 2.[8] In estimation of function (1'), safety investment variables, ME and PE, have correct signs, with their parameter estimates being insignificant and significant at the ten percent level, respectively. In estimation of function (2'), the parameter estimate for OP is highly significant and has the correct sign, i.e., higher profits are expected to result in increases in relative maintenance expenditures. These results suggest that the validity of the profit-safety argument will depend upon which safety investments of airlines are affected when airline financial conditions are adverse. For example, our results suggest that declining profits are expected to result in decreases in relative maintenance expenditures, but declining relative maintenance expenditures are expenditures, but declining relative maintenance expenditures are not expected to affect the number of airline aircraft accidents.

TABLE 2:
2SLS Parameter Estimates

Explanatory Variable	Dependent Variable AA	ME	OP
ME	-0.2446		
	(0.5862)		
PE	105.8333*		
	(54.3596)		
FAC	-17.7650***		
	(3.8206)		
AM	0.0028		
	(0.0039)		
TIM	-1.9268***	-0.2374**	0.058**
	(0.5937)	(0.1007)	(0.0024)
DEG	-0.1842***		
	(0.0373)		
OP		57.3916***	
		(19.2175)	
FAI		1.5139	
		(2.3094)	
AH		-0.0314	-0.0026**
		(0.0856)	(0.0011)
AA			0.0006
			(0.0006)
RPM			-0.0163***
			(0.0053)
Constant	129.8370***	14.6593***	0.2059**
	(21.1804)	(5.0239)	(0.0805)
R^2	0.97	0.67	0.50
DW	1.860	1.361	1.568

*** One percent level of significance
** Five percent level of significance
* Ten percent level of significance

Standard errors are presented in parentheses
DW represents the Durbin-Watson statistic.

In estimation of function (4'), the parameter estimate of AA is insignificant and has an incorrect sign according to the market-response argument. Thus, this result does not support the market-response argument. However, this may be due to the use of aggregate data.

6. Conclusion

Evidence suggest that U.S. airline safety has not deteriorated under airline deregulation. The profit-safety argument for explaining the impact of deregulation on airline safety argues that airline safety will deteriorate under airline deregulation--a decline in the financial condition of airlines under deregulation will result in a decrease in safety investments which, in turn, will result in an increase in accidents. The investigation of the validity of this argument in the literature has been based upon estimation of a reduced-form relationship between aircraft accidents and the financial condition of airlines. Evidence of such a relationship is mixed; recent evidence, however, suggests that such a relationship is mixed; recent evidence, however, suggests that such a relationship exists. The safety investments, relative aircraft maintenance expenditure and pilot expertise (i.e., hiring or investing in more experienced pilots), were found in our empirical simultaneous-equation investigation (of the validity of the profit-safety and market-response arguments) to have an insignificant and a significant effect, respectively, on aircraft accidents. Thus, it appears that the validity of the profit-safety argument will

depend upon which safety investments affect aircraft accidents and whether these investments are affected by the financial condition of airlines.

The market-response argument agues that airline safety will not deteriorate under airline deregulation--airlines anticipating a deterioration in their financial condition following an accident will take safety precautions in a market environment. Recent evidence in the literature indicates that for certain types of accidents, i.e., where the airline is at fault, the financial condition of an airline will deteriorate following an accident. In our empirical simultaneous-equation investigation, an insignificant relationship was found between airline operating margin (or profits) and aircraft accidents--thus not providing support for the validity of the market-response argument. However, this result may follow from the use of aggregate data. In summary, the evidence presented in this paper as well as that found in the literature suggest that whether deregulation will have an impact on airline safety will depend upon which airline safety investments are affected by the financial condition of airlines and whether these investments are determinants of aircraft accidents as well as who is at fault in aircraft accidents.

NOTES

1 For further discussion of airline deregulation from an international perspective, see Button (1990).
2. Support for this viewpoint is found in Moses and Savage (1990).
3. An accident is defined by the National Transportation Safety Board (NTSB) as "an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all persons have disembarked, in which any person suffers death or serious injury as a result of being in or upon the aircraft or by direct contact with the aircraft or anything attached thereto, or in which the aircraft receives substantial damage." A certificated air carrier is defined by the Federal Aviation Administration (FAA) as "an air carrier operator who conducts operations in accordance with FAR Part 121, who provides scheduled services on specified routes in aircraft with more than 30 passenger seats and a payload capacity of more than 7,500 pounds. These air carriers may also provide non-scheduled or charter service as a secondary operation." The accident and accident rate data were obtained from the Federal Aviation Administration (FAA).
4. For further discussion of this argument, see Rose (1990).
5. An incident is defined by the NTSB as "an aircraft occurrence not classified as an accident in which a hazard or potential hazard to safety is involved."
6. For further discussion, see Chalk (1987).
7. For further discussion, see Rose (1989).
8. Log-linear and linear functional specifications were considered in the estimations. However, the latter resulted in better estimation results and thus are only reported in this paper.

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