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Deregulation's Impact On Airline Safety

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ABSTRACT

Concomitant with changes in the structure and operations of the domestic airline industry since deregulation have come three major concerns about airline deregulation's potential effects on safety. First, heightened competition accompanying deregulation was feared to result in less safe operations and maintenance by the established jet carriers themselves. Critics point to dramatic fines recently imposed on several carriers for safety violations, well-publicized crashes of several aircraft from all segments of the industry in 1985 and 1986, and the seemingly increasing number of "near misses" as evidence of deteriorating safety. Second, deregulation permitted widespread entry into the industry by entirely new jet airline companies some of whom were feared to lack the necessary operational experience of the established trunk and local service airlines. Third, as entry and exit requirements were eased, jet carriers withdrew service to many small communities and were replaced by commuter airlines leading to concern that safety would degrade because of the historically poorer safety record of the commuter airline industry.

This paper analyzes safety in the airline industry from both a cross-sectional and time-series perspective. Systematic differences in safety performance among various segments of the airline industry are examined in both the pre- and post-deregulation periods to determine whether the safety the industry or any of its subsets has deteriorated since deregulation. The analyses go beyond simple comparisons of aggregate fatality rates and examine both injuries and non-fatal accidents as well as the frequency of various types of accidents.

I. INTRODUCTION

The U.S. domestic airline industry has changed dramatically since passage of the Airline Deregulation Act of 1978 and the accompanying increase in service and fare competition. While deregulation's impact on safety raised some concern prior to passage of the act, such concerns have grown, fueled by a series of well-publicized accidents in 1985, recent fines assessed against large well-established carriers for maintenance and safety violations, and reports of growing numbers of "near misses" in congested airspace. While the most highly publicized accidents of 1985 and 1986 involved foreign or charter carriers or seemed clearly related to weather and were thus unrelated to deregulation, the heightened concern about aviation safety has nevertheless focused attention on the airline industry's adaptation to deregulation and the possible effect on safety. Specifically, four questions have arisen:

Have the economic pressures for cost reductions accompanying deregulation led to an increase in accidents that might likely result from shortcomings in maintenance procedures?

Has increased pressure on the Air Traffic Control System from the combination of deregulation-induced changes in routes and schedules coupled with the 1981 dismissal of the striking PATCO controllers reduced safety?

Has the growth of new entrant and former intrastate jet carriers degraded the safety of the industry?

Has the substitution of commuter airlines for the former trunk and local service airlines in small community service increased risk for travelers to and from these communities?

A. Airline Industry Changes Since Deregulation

Deregulation has, of course, brought forth a wide array of changes in the domestic airline industry (Meyer and Oster,, 1981; Bailey, Graham, and Kaplan, 1985). From the standpoint of airline safety, however, the operational changes induced by route and scheduling strategies as well as the impact on finances would seem of greatest importance. A dominant feature of post-deregulation route strategies has been the expansion and strengthening of hub and spoke route networks by all of the established jet carriers (Meyer and Oster, 1987; Morrison and Winston, 1986). Hub and spoke route networks, of course, rely on connections with more spokes providing more connecting opportunities so that large hub and spoke systems have service advantages over small systems, at least up to the point where the hub airport's landing and takeoff capacity becomes saturated with the accompanying rise in delays. The concentration of operations during hub and spoke operations can put intense pressure on the air traffic control system. Moreover, the reliance on connections increases difficulties for passengers and airlines caused by late flights and thus may increase pressure on airlines to maintain schedules.

A second important feature of post-deregulation route strategies has been the transfer of low-density service to and from small communities from local service airlines (and to a lesser extent trunks) to commuter carriers (Meyer and Oster, 1984). With deregulation's route entry and exit freedoms, the local service and trunk airlines' jets could be deployed far more profitably in denser and longer haul markets than in those serving small communities. This aircraft reassignment opened up replacement service opportunities for commuters and helps explain the commuters' rapid post-deregulation growth. The commuter airlines' market niche even before deregulation had been to provide service to smaller communities whenever and wherever the larger jet carriers pulled out in search of better opportunities elsewhere. Deregulation simply enhanced those opportunities and hastened this "rationalization" of small community airline service.

The accelerated transfer of small community service from jet airlines to commuters gave rise to the concern that travelers to and from small communities might face dramatically increased risks from the poorer safety performance of commuters. Widely cited statistics based on fatalities per passenger mile gave credence to the perception that commuters were less safe. Commuters were often portrayed as from 10 to 30 times more dangerous than the jet carriers they replaced. Although the differences between the risk faced by passengers on commuters and passengers on jet carriers have been shown to be not nearly as great as distance-based measures would imply, the safety of commuter airlines remains a concern of many travelers (Oster and Zorn, 1983a).

Another important post-deregulation development was the rapid growth of "new entrant" jet carriers—either entirely new companies, such as Midway or People Express, or those that emerged from the ranks of intrastate carriers previously confined by CAB regulation to operations within a single state or from the ranks of supplemental carriers confined by CAB regulation to nonscheduled charter operations (Meyer and Oster, 1984). With deregulation entry and fare freedoms, such carriers expanded rapidly, raising concerns whether maintenance and training procedures could keep up with such growth.

Finally, intense post-deregulation competition increased pressure for cost-cutting, raising fears that some carriers, particularly those in financial difficulty, may be devoting inadequate resources to maintenance. As evidence, it is sometimes pointed out that two of the carriers receiving large fines for maintenance violations were financially troubled Eastern and Pan Am. Although deregulation has probably helped rather than hurt carrier finances, the concerns about cost-cutting pressure and maintenance remain (Gomez-Ibanez, Oster, and Pickrell; Morrison and Winston; Meyer and Oster, 1987).

II. CHARACTERISTICS OF THE ANALYSIS

Because of the domestic airline industry's diversity, highly aggregated safety statistics can provide misleading comparisons of air travel safety with other modes or within the airline industry. Measures of air travel safety must adjust for varying stage lengths, different mixes of equipment, the variety of airports served, varied maintenance requirements and practices, and differing training and operational procedures. This analysis separates the industry into subsets of similar operating characteristics and examines the variation in safety rates for these segments over time. Some of the factors thought to affect safety within the industry can thus be isolated and examined.

The airline industry falls easily into two distinct groups—jet carriers and commuters. Jet carriers are defined as those airlines with aircraft fleets predominately powered by jet engines, whose operations are subject to Federal Aviation Administration (FAA) Part 121 operating regulations. Jet carriers are divided into the established trunk and local service airlines and the other jet carriers newly permitted under deregulation's freedoms to offer scheduled interstate passenger service. Trunk carriers are those that evolved from the 16 carriers certificated when economic regulation of the industry began in 1938. Local service carriers were certificated on an experimental basis in 1944 to extend air service to small communities and became permanently certificated in 1955. Over the years, some local service airlines have evolved to resemble small trunk operations but throughout most of the 1970–1985 period their route structures and operating policies still differed from the trunks in important ways (Meyer and Oster 1981). While the local service airlines have operated some propellor equipment, they are nevertheless considered as jet carriers for this analysis.

Commuter airlines, as defined in this study, operate predominately propellor-driven aircraft seating 60 or fewer passengers, are covered by FAA Part 135 regulations, and conduct relatively short-haul flights on low-density routes (Oster and Zorn, 1983b). Carriers operating fleets with mostly propellor-driven aircraft are considered commuters even if they acquired some jet aircraft after deregulation or operate under Part 121 regulations. This definition of commuters parallels the definition of regional airlines used by the Regional Airline Association.

A. Measures of Safety

This study focuses on the likelihood that a passenger will be killed or seriously injured while taking an airline flight, how and why that likelihood varies across segments of the industry, and how and why that likelihood may have changed over time. Thus, passenger fatalities, serious passenger injuries, accidents resulting in passenger fatalities, and accidents resulting in serious injuries to passengers are used as measures of risk in the numerator of safety rates. Accidents resulting in minor injuries or no injuries to passengers are also included. While fatal and serious injury accidents are obvious cause for immediate concern, frequent non-injury accidents may be a portent of problems that could lead to more severe accidents in the future. Moreover, the difference between an accident that kills many passengers and one in which passengers escape unharmed is often very small.

In transportation exposure to risk is often measured by either the distance traveled or the number of trips. For airline travel, most accidents occur during the takeoff and landing phases of flight, so the risk of being killed, injured, or involved in an accident is much more strongly related to the number of takeoffs and landings than to the distance traveled (Oster and Zorn, 1982). Long flights amass many passenger miles yet expose passengers to the same takeoff and landing risk as short flights. Thus, passenger fatality rates based on passenger departures or aircraft accident rates based on aircraft departures are far more useful for comparing risk in different segments of the industry than mileage-based measures.

National Transportation Safety Board (NTSB) Accident Briefs for Part 121 and Part 135 operations provide a rich source of accident data for both jet carriers and commuters including the number of fatalities and injuries for both passengers and crew, a description of the aircraft involved, details concerning the circumstances surrounding the accident, and probable cause and contributing factors. Data regarding passenger fatalities, serious injuries, fatal accidents, serious injury accidents, and other accidents were derived from this source.

Operations data for jet carriers, including aircraft departures and passenger enplanements, were obtained from Civil Aeronautics Board (CAB) Form 41. The U.S. Department of Transportation has continued collection of these data after the sunset of the CAB. Commuter operations data are more limited than jet carrier operations data. Passenger enplanements were obtained from CAB Form 298 for the 1970 through 1980 time period. Data for the 1981 through 1985 period were obtained from the annual reports of the Regional Airline Association. For those carriers operating under Part 121 but still classified as commuter carriers for purposes of this study, enplanement data were obtained from CAB Form 41 and Regional Airline Association annual reports.

Limitations on operations data require some compromises in constructing safety measures. For example, aircraft departure data are not available for many commuters. As a result, aircraft accident rates based on aircraft departures could not be constructed for commuters as they were for jet carriers. Similarly, there are no data on passenger departures for either jet carriers or commuters so enplanement data must act as a reasonable proxy. A passenger is counted as a single enplanement for each flight boarded but if the flight involves multiple stops a passenger is still counted as one enplanement even though that passenger is subjected to additional risk with each takeoff and landing. For flights with intermediate stops, enplanements are less than passenger departures so that passenger fatality rates based on passenger departures would be lower than those based on enplanements. The differences are not large, however. For example, 88.9 percent of commuter flights were either nonstop or one-stop in 1978 with the percentage increasing to 89.1 percent in 1983. Similarly, for trunk and local service airlines, 71.3 percent of flights were either nonstop or one-stop in 1978 with the percentage increasing to 81.2 percent in 1983. Thus, any bias introduced by using enplanements is small and, more importantly, constant over time for commuters where the enplanement-based measures are relied upon most heavily. For jet carriers, the bias may be somewhat larger but has declined since deregulation. In any event, the bias is less of an issue for jet carriers because aircraft accident measures can be used.

To focus on the effects of deregulation, the analysis was further limited to domestic scheduled passenger service with international, caribbean, and charter operations and accidents excluded. Operations in the non-continental states (Alaska and Hawaii) were also excluded because commuters, in particular, serve a much different role in these areas and frequently face a much harsher operating environment making comparisons across segments of the industry problematic (Oster and Zorn, 1982).

III. AIRLINE SAFETY SINCE DEREGULATION

In the wake of deregulation, competition among carriers, enhanced flexibility in setting route strategies, and shifts in service responsibilities among segments of the industry have kindled rising public concern over safety within the industry. Table 1 suggests, however, that this concern about worsening safety as a result of deregulation may well be unwarranted no matter what measures of airline safety are used. During the post-regulation period (1979-1985), passenger fatality, passenger injury, and aircraft accident rates were consistently lower for both jet carriers and commuters than had been the case in the pre-deregulation period (1970-1978). Moreover, as the table indicates, these differences were generally statistically significant. Only the passenger fatality rate for trunk carriers did not drop and it was essentially unchanged.

A comparison of commuter and jet carrier rates in the table also suggests that commuters are, indeed, less safe in the aggregate than jet carriers. As will be discussed later, however, several other factors must also be considered in assessing the impact of commuter substitution on airline safety.

A. Economic Pressures and Airline Maintenance

The record high fines levied against American, Pan Am, and Eastern coupled with several post-deregulation commuter accidents in which equipment failure was a clear contributing factor have combined to raise the question of whether the increased competitive pressures accompanying deregulation have caused the airlines to cut corners in maintenance practices in an attempt to lower costs (Air Transport World, 1987). One approach to assessing the impact of deregulation on maintenance practices is to examine the frequency of accidents in which inadequate maintenance might have been a contributing factor. Thus for the purposes of this study, accidents for jet carriers (and commuter airlines) were put into one of eight categories according to their "primary contributing factor":

1) Equipment Failure
2) Seatbelt Not Fastened
3) Weather
4) Pilot Error
5) Air Traffic Control
6) Ground Crew Error
7) General Aviation
8) Other

Many, indeed most, accidents result from several factors coming together at the same time. Determining a primary contributing factor for multiple-cause accidents is a difficult task requiring admittedly subjective judgements. The goal, however, was not to determine the "main" cause, but rather to apply a consistent set of criteria that would allow a longitudinal analysis of the relative frequency of types of accidents. Thus before presenting the results of the analyses, it is important to be clear about what sorts of accidents were included in each category.

1. Equipment Failure. If the events that culminated in the accident were precipitated by mechanical or electrical malfunction in the aircraft, the accident was considered as equipment failure even if there were other important factors. In some cases, such as improper installation of a part or failure to detect cracks or corrosion, more meticulous maintenance might have prevented the accident. In other cases, such as failure of a tire that did not show

TABLE 1
AIRLINE SAFETY RATES
DOMESTIC SCHEDULED SERVICE
1970-1985

Industry Segment	1970-1985	1970-1978	1979-1985
Passenger fatalities per one million enplanements:			
Trunks	0.37	0.36	0.38
Local Service	0.29	0.65	0.01**
Other Jet Carriers	n.a.	n.a.	0.42
Commuters	1.66	2.65	1.27*
Serious passenger injuries per one million enplanements:			
Trunks	0.11	0.19	0.03**
Local Service	0.25	0.52	0.04*
Other Jet Carriers	n.a.	n.a.	0.05
Commuters	0.93	1.62	0.66*
Fatal aircraft accidents per one million aircraft departures:			
Trunks	0.31	0.38	0.22
Local Service	0.45	0.62	0.22*
Other Jet Carriers	n.a.	n.a.	0.90
Commuters	n.a.	n.a.	n.a.
Serious aircraft accidents per one million aircraft departures:			
Trunks	1.78	2.42	0.86**
Local Service	0.86	0.92	0.77
Other Jet Carriers	n.a.	n.a.	0.90
Commuters	n.a.	n.a.	n.a.
Minor aircraft accidents per one million aircraft departures:			
Trunks	2.34	3.08	1.30**
Local Service	2.13	2.54	1.53*
Other Jet Carriers	n.a.	n.a.	1.51
Commuters	n.a.	n.a.	n.a.

n.a. - not available due to data limitations

* - lower than the 1970-78 rate at the 90 percent confidence level
** - lower than the 1970-78 rate at the 95 percent confidence level

Source: Derived from computer printout of Part 121 and 135 operation accident briefs provided by the National Transportation Safety Board; U.S. Civil Aeronautics Board, Forms 41 and 298; and Regional Airline Association, Annual Reports, various years.

excessive wear, maintenance practices could not reasonably be blamed. No attempt wwas made to distinguish whether inadequate maintenance was at fault. Rather all equipment failure accidents were treated the same on the assumption that equipment failures where maintenance was not a factor would be randomly distributed over time so that any time trend in equipment failures resulted from changing maintenance practices or improved aircraft design.

2. Seatbelt Not Fastened. A surprisingly common source of serious passenger injury is passengers not having their seatbelts fastened when turbulence is encountered despite the seatbelt sign in the cabin being illuminated and passengers being asked to fasten their seatbelts. If the seatbelt sign was illuminated in sufficient time for passengers to return to their seats and fasten their seatbelts prior to the injury, the accidents were placed in this category, If, however, the turbulence was unexpected and the seatbelt sign was not on, the accident was placed in the "weather" category discussed below.

3. Weather. Weather is a factor in many airline accidents but is frequently not regarded by the National Transportation Safety Board as the cause of the accident. Rather, the NTSB often determines the cause to be the cockpit crew not responding properly

to weather conditions. This approach taken for this study differs from the NTSB approach in that accidents were rarely classified as "pilot error" if weather was a significant contributing factor. Thus an accident was usually classified as weather even if the pilot taking precisely the right action at precisely the right time could have prevented the accident. There were, however, some exceptions to this approach. If an aircraft took off under weather conditions that led to a takeoff accident, the accident was considered pilot error. If an aircraft was unable to stop after landing on a slick runway, it was considered a weather accident, unless the pilot landed excessively long on the runway, in which case it was considered pilot error. Similarly, if a pilot attempted to land when the airport was below minimums and an alternate airport was available, it was judged pilot error.

4. Pilot Error. In addition to the weather-related examples cited above, an accident was classified as pilot error only in those cases where the error appeared undeniable. Examples of pilot error include attempting a landing without lowering the landing gear, taxiing into a stationary object, or running out of fuel because of failure to switch fuel tanks during flight.

5. Air Traffic Control. An accident was classified as air traffic control when normal action by a controller could have prevented the accident such as ATC failing to advise a flight of unsafe weather.

6. Ground Crew. Accidents attributed to ground crew error included such cases as a service truck colliding with a parked aircraft and a ground crew member walking into a propellor while delivering a message to the pilot of an aircraft about to depart.

7. General Aviation. General aviation accidents included those where the accident would not have occurred without general aviation aircraft operating in the area. It was not necessary that the general aviation aircraft was judged at fault, just that its presence contributed to the accident.

8. Other. Accidents not falling into one of the above categories were classified as "other." Such accidents included a wide array of causes ranging from a passenger tripping over a baby bottle in the aisle to injuries sustained during an evacuation due to a bomb threat. There were also two accidents in late 1984 and seven accidents in 1985 that were classified as other because NTSB accident investigations had not yet released findings of the causes of the accidents.

B. Jet Carriers Before and After Deregulation

Table 2 shows the total accident rates for jet carriers broken down among the eight principal contributing factors. The two columns on the left show the

TABLE 2
JET CARRIERS
TOTAL ACCIDENT RATE BY PRINCIPAL CONTRIBUTING FACTOR
DOMESTIC SCHEDULED SERVICE

Aircraft Accidents per One Million Aircraft Departures

Contributing Factor	Combined Trunk and Local Service Carriers 1970-78	Combined Trunk and Local Service Carriers 1979-85	Trunk 1979-85	Local Service 1979-85	Other Jet 1979-85
Equipment Failure	1.49	0.43**	0.59	0.11++	0.30
Seatbelt Not Fastened	1.49	0.68**	0.70	0.66	0.60
Weather	0.82	0.33**	0.32	0.33	0.60
Pilot Error	0.54	0.21**	0.16	0.33	0.60+
Air Traffic Control	0.26	0.11*	0.05	0.22	0.60++
Ground Crew Error	0.23	0.11	0.10	0.11	0.30
General Aviation	0.10	0.04	0.00	0.11+	0.00
Other	0.39	0.50	0.43	0.66	0.30
Total	5.28	2.42**	2.38	2.52	3.31

* - lower than the 1970-78 rate at the 90 percent confidence level
** - lower than the 1970-78 rate at the 95 percent confidence level

+ - different from the Trunk rate at the 90 percent confidence level
++ - different from the Trunk rate at the 95 percent confidence level

Source: Derived from computer printout of Part 121 operation accident briefs provided by the National Transportation Safety Board; U.S. Civil Aeronautics Board, Form 41.

combined accident rates for the trunk and local service carriers for both the pre-deregulation and post-deregulation periods. As can be seen in these columns, the rates declined for seven of the eight types of accidents; the only exception was the "other" category.

Perhaps the most striking observation is that the rate for equipment failure related accidents in the post-deregulation period is seen to be less than one third of the pre-deregulation rate. Had deregulation induced shortcuts in aircraft maintenance, the rate of equipment failures would be expected to have increased. The sharp decrease suggests that, at least through 1985, deregulation has not caused widespread maintenance deficiencies.

The accident rates are also down for both air traffic control and for general aviation although the rates are low both before and after deregulation. Part of the post-deregulation period was prior to the PATCO strike (in August 1981), but much of the period was after the striking controllers had been dismissed. In terms of frequency of accidents, there is no evidence that the air traffic control system has functioned less safely after deregulation than before. Similarly the rate of general aviation related accidents has not increased since deregulation. Thus despite the added pressure on the air traffic control system and on the airspace surrounding large airports because of the periodic concentration of flights from intensified hub and spoke operations, the rates for the types of accidents that might have been expected to increase have instead gone down.

Deregulation has also increased pressure on airline labor for less restrictive work rules. Pilots and cabin attendants fly more hours per month and ground crews perform a wider variety of tasks than prior to deregulation (Meyer and Oster, 1987). Despite these pressures, the rates for pilot error and grow crew error have both declined. The rate for accidents where the seatbelt was not fastened has also declined, suggesting that if anything cabin attendants have been more rather than less effective in making sure that passengers fasten their seatbelts when turbulence is expected. Again the types of accidents that might have been expected to have increased because of labor practice changes induced by deregulation have been less frequent following deregulation than they were before.

The rapid growth and route expansion of the new entrant jet carriers has been a major development following deregulation and has raised concerns about these carriers' impacts on safety. One fear was that it would be difficult to achieve adequate training and maintenance practices in the face of rapid growth and a second fear, raised by the Air Florida accident in Washington in 1982, was that expansion might confront these carriers with weather and operating conditions for which they were not fully prepared. As table 1 indicated, however, these other jet carriers have a safety record very similar to other segments of the jet carrier industry. Of the five measures in table 1, only the rate of fatal accidents per one million departures is higher than comparable rates for trunk airlines. In essence, the other jet carriers experienced three such accidents rather than the one that might have been expected based on the trunk and local service airlines' experience.

The three columns on the right in table 2 break down the accident rates by primary contributing factor for all three segments of the jet industry. The other jet carriers' experiences are seen to be quite similar to the trunks and local service airlines. The accidents are evenly distributed among contributing factors with no factors appearing disproportionately represented. While tests for statistical significance indicate that the rates for two of the categories are higher than for the trunks, these same tests indicate that the total accident rate is not higher than the trunk rate. In sum, while these other jet carriers may have experienced a somewhat higher rate of fatality-causing accidents, their safety experience does not appear to differ markedly from the other segments of the jet industry.

This "other jet carrier" category also includes carriers that might not be considered new entrant airlines in the manner of carriers such as Air Florida, Midway or People Express. World Airways, for example, was new to scheduled passenger service but had considerable experience in charter service with the type of aircraft (DC-10) involved in their post-deregulation accident in Boston. Similarly, carriers such as Southwest and PSA had many years of experience flying jet aircraft in intrastate service prior to deregulation. Thus, the experience of these other jet carriers reported in tables 1 and 2 does not support the contention that the new entrant jet carriers have degraded the safety of the airline industry.

C. Commuter Substitution in Small Community Service

As commuter carriers replace withdrawing jet carriers, small community residents have been concerned about degradation in their air transportation safety. Table 1 suggested that such substitutions may indeed increase risk to travelers to and from small communities. During the entire 1970-1985 period passengers were more than four times as likely to be killed when boarding a commuter flight than one operated by trunk or local service carriers. More importantly, in the post-deregulation period commuter air travel remained more risky than jet air travel, by more than a factor of three.

However, table 3 demonstrates that safety rates within the commuter industry decline with increasing carrier size. In the 1970-1978 period, the top twenty carriers, in terms of passenger enplanements, were more than 4.5 times safer than the rest of the top fifty carriers (carriers 21 through 50 based on size) in terms of passenger fatalities per one million enplanements, and more than 19 times safer than the rest of the industry, the relatively small carriers who make up the non-top fifty category. In terms of passenger serious injuries per one million enplanements, the top twenty carriers were almost 2.5 times safer than the rest of the industry. The top twenty carriers provide most of the replacement service for withdrawing jet carriers.

The implications for commuter replacement of different safety records for commuters and jet carriers must also consider that service patterns typically change when commuters replace jet carriers. For example, between 1978 and 1986 there were 55 communities which lost jet carrier service and had commuter carriers provide replacement service. Commuter replacement service in the 60 city-pair markets serving these cities resulted in an increase in the average frequency of weekday flights of from 2.88 in 1978 to 6.29 in 1986.[1] In addition, the

TABLE 3
COMMUTER CARRIERS
PASSENGER FATALITY AND SERIOUS INJURY RATES
DOMESTIC SCHEDULED SERVICE
1970-78 VERSUS 1979-85

	1970-78	1979-85
Total Industry:		
Passenger Fatalities per One Million Enplanements	2.65	1.27*
Serious Passenger Injuries per One Million Enplanements	1.62	0.66*
Top Twenty Carriers:		
Passenger Fatalities per One Million Enplanements	0.69	0.67
Serious Passenger Injuries per One Million Enplanements	0.93	0.21
Rest of the Top Fifty:		
Passenger Fatalities per One Million Enplanements	3.27	1.21+
Serious Passenger Injuries per One Million Enplanements	2.27	0.48
Rest of the Industry:		
Passenger Fatalities per One Million Enplanements	13.32	4.08**++
Serious Passenger Injuries per One Million Enplanements	4.30	3.00++

* - lower than the 1970-78 rate at the 90 percent confidence level
** - lower than the 1970-78 rate at the 95 percent confidence level

\+ - higher than the Top Twenty rate at the 90 percent confidence level
++ - higher than the Top Twenty rate at the 95 percent confidence level

Source: Derived from computer printout of Part 121 and 135 operation accident briefs provided by the National Transportation Safety Board; U.S. Civil Aeronautics Board, Forms 41 and 298; and Regional Airline Association, Annual Reports, various years.

average number of intermediate stops on flights between the small community and its nearest major hub decreased from 0.59 in 1978 to 0.30 in 1986. Thus on average, service has improved in these communities where commuters have provided substitute service for jets because passengers have more frequent connections with fewer intermediate stops to hubs where they can link up with jet carrier service.

Because the replacement service includes fewer intermediate stops, the relative safety rates of commuters and jet carriers should be adjusted to reflect the additional risk from extra takeoffs and landings on the jet flights. The average number of takeoffs and landings associated with jet service to these small communities was 1.59 (the original takeoff and subsequent landing and 0.59 takeoffs and landings at intermediate stops), but only 1.30 for commuters serving the same cities. Thus, to get comparable safety measures that take into account this improvement in service and its impact on safety, the jet carrier rate should be inflated by 22.3 percent and compared with the rates for the larger commuter carriers.

Even with this adjustment a simple comparison between jet carriers and aggregate commuter safety measures is not appropriate. In 55 of the 60 city-pair markets, the replacement commuter carrier was either a top twenty carrier or a top fifty carrier in a code-sharing marketing alliance with a major jet carrier (Oster and Pickrell, 1986). As can be seen by comparing tables 3 and 1, the safety record of the top twenty commuters, even without adjusting for fewer intermediate steps, is about the same as the pre-deregulation record of the local service airlines that had served 45 of the 60 markets prior to 1978.

A final consideration is that the typical result of increased commuter service frequency in small communities in the wake of jet carrier exit was increased ridership (Meyer and Oster 1981). The added convenience offered by commuters attracts passengers who had previously opted for the automobile. Assuming that the average commuter flight length of between 120 and 130 miles substitutes for a more circuitous auto trip to the same hub airport of about 150 miles and further assuming that average auto occupancy for such trip is about 1.5 (slightly below the average for all intercity auto trips), the comparable fatality rate associated with motor vehicle trips is somewhere between 1.9 and 2.3 passenger fatalities per one million passenger trips. Comparing this motor vehicle fatality rate to that of the top fifty commuters indicates that travel is safer for those passengers switching from auto to commuter as a result of improved commuter service. Thus commuter service to small communities may actually improve the transportation safety record once these appropriate adjustments have been made.

D. Commuters Before and After Deregulation

Part of the improvement in the safety record of commuter carriers that is evident in both tables 1 and 3 can be attributed, at least in part, to revisions in commuter safety regulations that occurred in 1978. In response to concerns about commuter airline safety the FAA tightened regulations in three areas. First, pilot qualifications were upgraded to parallel pilot qualifications for established jet carriers. Second, maintenance requirements were improved to include more detailed and extensive procedures for all types of classes of aircraft used by Part 135 operators. Third, training programs of Part 135 operators were enhanced (Oster and Zorn 1983b). The safest portion of the industry, the top twenty commuters, experienced the smallest improvement in their safety records, most likely because they had previously instituted many of the procedures that the FAA mandated in 1978 and thus the safety revisions had little additional effect. On the other hand, the dramatic improvement in safety for the rest of the top fifty and the rest of the industry are most likely the direct result of the 1978 safety revisions.

Table 4 breaks down the passenger fatality rate for the entire commuter industry into the eight principal contributing factor categories for both the 1970-1978 pre-deregulation period and the

TABLE 4
COMMUTER CARRIERS
PASSENGER FATALITY RATE BY PRINCIPAL CONTRIBUTING FACTOR
DOMESTIC SCHEDULED SERVICE
1970-78 VERSUS 1979-85

Passenger Fatalities per One Million Enplanements

Contributing Factor	All Commuters 1970-78	All Commuters 1979-85	Top Twenty 1979-85	Rest of Top Fifty 1979-85	Rest of Industry 1979-85
Equipment Failure	1.07	0.35*	0.11	0.52++	1.15++
Seatbelt Not Fastened	0.00	0.00	0.00	0.00	0.00
Weather	0.61	0.27	0.15	0.03	1.21++
Pilot Error	0.46	0.05	0.07	0.00	0.06
Air Traffic Control	0.04	0.00	0.00	0.00	0.00
Ground Crew Error	0.00	0.01	0.01	0.00	0.00
General Aviation	0.22	0.20	0.00	0.45++	0.64++
Other	0.24	0.39	0.32	0.21	1.02++
Total	2.65	1.27*	0.67	1.21+	4.08++

* - lower than the 1970-78 rate at the 90 percent confidence level

\+ - higher than the Top Twenty rate at the 90 percent confidence level
++ - higher than the Top Twenty rate at the 95 percent confidence level

Source: Derived from computer printout of Part 121 and 135 operation accident briefs provided by the National Transportation Safety Board; U.S. Civil Aeronautics Board, Forms 41 and 298; and Regional Airline Association, Annual Reports, various years.

1979-1985 post-deregulation period. As the two columns on the left indicate, most of the improvement in the commuter airline passenger fatality rate between the two periods comes from a reduction in fatalities due to three reasons: equipment failure, pilot error, and weather. Given the thrust of many of the 1978 FAA safety regulation revisions, this pattern of fatality rate reduction might have been expected. The tightened maintenance procedures have probably contributed to the reduction in accidents involving equipment failure. The added pilot certification requirements coupled with added recurrent training have likely contributed to both reduced pilot error and reduced weather-related fatalities. Weather-related fatalities may have also been reduced by tightened regulations regarding navigational equipment for IFR flights.

The three columns on the right of table 4 show the 1979-1985 passenger fatality rate by type of accident for three segments of the commuter industry: the top 20 carriers, the rest of the top 50 (those carriers ranked in size from 21 through 50), and the rest of the commuter industry (those carriers ranked 51 and below). The most striking pattern in the table is the increasing rate of equipment failure related fatalities as the carrier size decreases. Even with the tightened FAA regulations, the larger carriers may still have more effective maintenance practices than the smallest carriers.

One hypothesis as to why carrier size might contribute to lower rates of equipment failure is that a larger carrier can afford greater specialization in maintenance and a more extensive inventory of parts. Another possible reason for the higher rate of equipment failure among the smallest carriers is that they are least likely to operate a fleet of all turbine-engine aircraft and more likely to operate small piston-engine aircraft seating nine or fewer passengers. Piston engines have far more moving parts and are more complex to maintain, particularly it appears for small carriers. A mixed fleet of both piston and turbine engines aggravates the maintenance specialization and spare parts inventory, again particularly for smaller carriers. Moreover, many of the 1978 FAA revisions did not apply to operators of aircraft seating nine or fewer passengers so that these aircraft may not be subject to some of the same tighter maintenance requirements (General Accounting Office, 1984). Indeed, even aircraft seating 10 to 19 passengers had somewhat less extensive requirements than for larger aircraft, a difference that may have contributed to some accidents (NTSB, 1986; Aviation Week and Space Technology, 1986).

IV. SUMMARY AND CONCLUSIONS

For both commuters and jet carriers, the rate of accidents related to equipment failure are substantially lower in the post-deregulation period suggesting that at least through 1985 there is no evidence of increased accidents from worsening maintenance practices. Despite increased pressure on the air traffic control system because of increased emphasis on hub and spoke operations and the reduction in the number of air traffic controllers, the rates of air traffic control related accidents are lower in the post-deregulation period than prior to deregulation. While the accident rates, based on limited operations, appear higher for the new entrant and former charter and intrastate jet carriers than for the established trunk and local service carriers, the differences are small and do not suggest a serious degradation of safety.

While the commuter industry as a whole has a safety record clearly inferior to that of the established jet carriers, three factors suggest that there has not been a substantial reduction in safety for travelers to and from small communities as a result of the transition to commuter service. First, the larger commuter carriers have a safety record nearly comparable to that of the local service jet carriers before deregulation and these larger carriers have provided most of the replacement service. Second, commuter flights between small communities and large hubs typically operate with fewer intermediate stops than the jet flights they replace thus exposing passengers to fewer takeoffs and landings. Third, many of the commuter passengers had previously used auto for their trips because of the relatively low frequency of the prior jet flights thus shifting those passengers to a safer mode of travel. In sum, airline safety has been improving for decades because of such factors as improved aircraft design and construction, improved pilot training particularly with the use of cockpit simulators, and better air traffic control procedures. Airline deregulation does not appear to have interfered witth this continuing trend of improvement.

ENDNOTES

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1. These 55 communities were identified in U.S. Civil Aeronautics Board Staff Study, *Report on Airline Service, Fares, Traffic, Load Factors, and Market Shares, Service Status on September 1, 1984* (Washington: Government Printing Office, December 1984). The service levels for 1978 and 1986 were derived from the July 1 editions of the *Official Airline Guide*, North American Edition, for 1978 and 1986.

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