AVIATION DEREGULATION AND SAFETY IN THE UNITED STATES: THE EVIDENCE AFTER TWENTY YEARS

by

IAN SAVAGE
Department of Economics & the Transportation Center
Northwestern University

Correspondence Address
Professor Ian Savage
Department of Economics
Northwestern University
2001 Sheridan Road
Evanston, Illinois 60208, USA

Phone: (847) 491-8241
Fax: (847) 491-7001
e-mail: ipsavage@northwestern.edu

Presented at the "Taking Stock of Air Liberalization" symposium in honor of the 25th anniversary of the Centre de researche sur les transport, Université de Montréal, and the 60th anniversary of Transport Canada, Montréal, Québec, April 24-25, 1997. Published in Marc Gaudry and Robert R. Mayes (eds) *Taking Stock of Air Liberalization*, Kluwer Academic Publishers, Boston, 1999, pages 93-114.

Abstract

Fatality rates for travel on jet airlines have continued their long-run decline since deregulation. However, accident rates which fell significantly in the 1960s and 1970s have remained constant since 1980 primarily because the technology of aviation safety has not changed significantly. The exception is in the commuter aviation sector where changes in safety regulation in 1978, and the substitution of turbo-prop for piston-engine aircraft, have produced a dramatic improvement in safety performance.

Despite the improved fatality rates there are valid concerns such as financial distress leading to skimping on safety expenditures, new entrant airlines with poor safety records, the substitution of turbo-prop aircraft for jets, poor government oversight of airlines, and increasing congestion at major airports. I estimate that deregulation has resulted in between 9 and 12 additional aviation fatalities each year. However, that number pales into insignificance compared with the 200 to 300 lives saved each year because deregulation encouraged people out of their cars and onto the airlines.

Ten years ago my colleagues and I at Northwestern University organized a conference to consider whether economic deregulation of the aviation (and trucking) industries in the United States had resulted in a diminution of safety performance (Northwestern University Transportation Center, 1987; Moses and Savage, 1989a, 1990).

At that time deregulation had occurred relatively recently having been phased in over the period 1978-83. The insights offered by time-series analyses of pre- and post-deregulation safety performance were therefore limited. A decade later much more data are available and it is now possible to observe where deregulation "fits" in the long-term history of safety in commercial aviation.

1. The Historical Perspective

Five-year moving averages of the number of commercial aviation passenger fatalities, and the number of revenue passenger miles from the early 1950s to the mid-1990s are shown in figure 1. Both series have been indexed to 100 for the period 1950-1954. Passenger miles have increased almost 35 fold since the early 1950s whereas the total number of annual fatalities has remained about the same. In the early 1950s about 110 passengers a year were killed in aviation crashes, which is about the same as it is nowadays. In between times the five-year moving average fatality count has been as high as 200 a year in the early 1960s, and as low as 60 a year in the early and late 1980s.

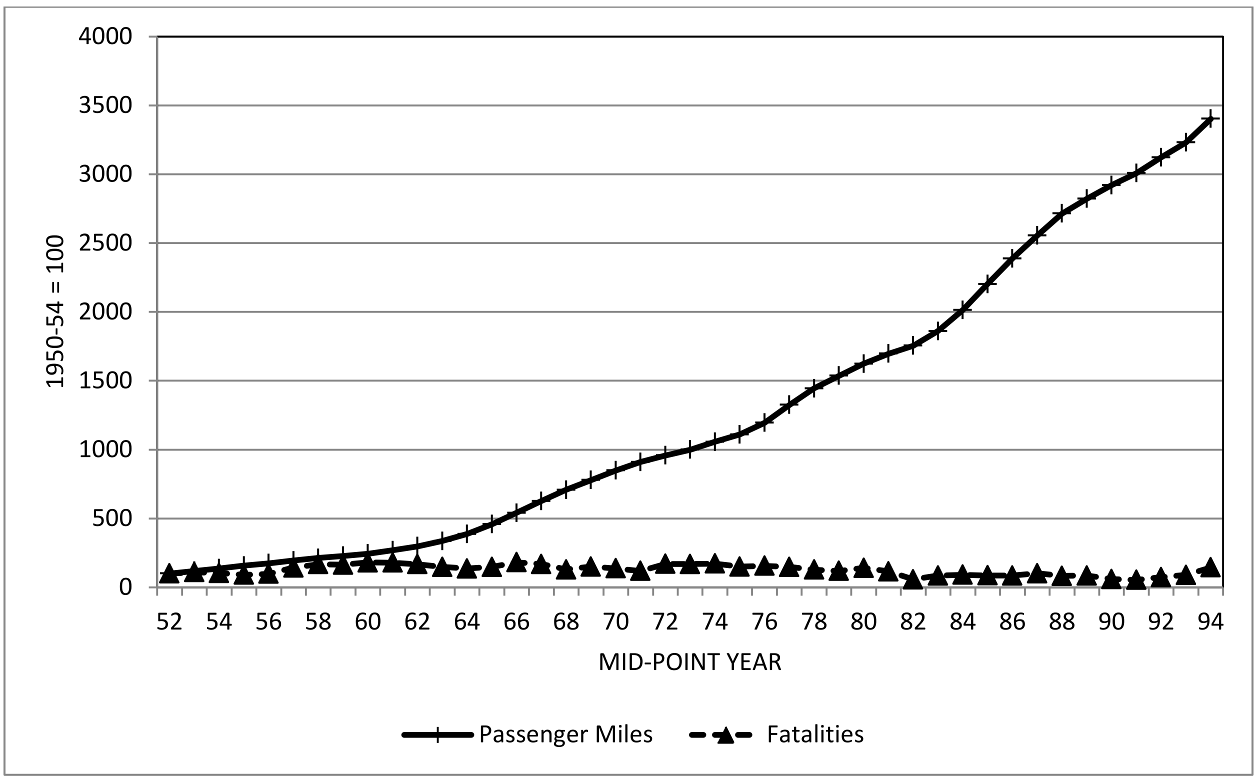

Figure 1: Five-Year Moving Average Passenger Miles and Fatalities

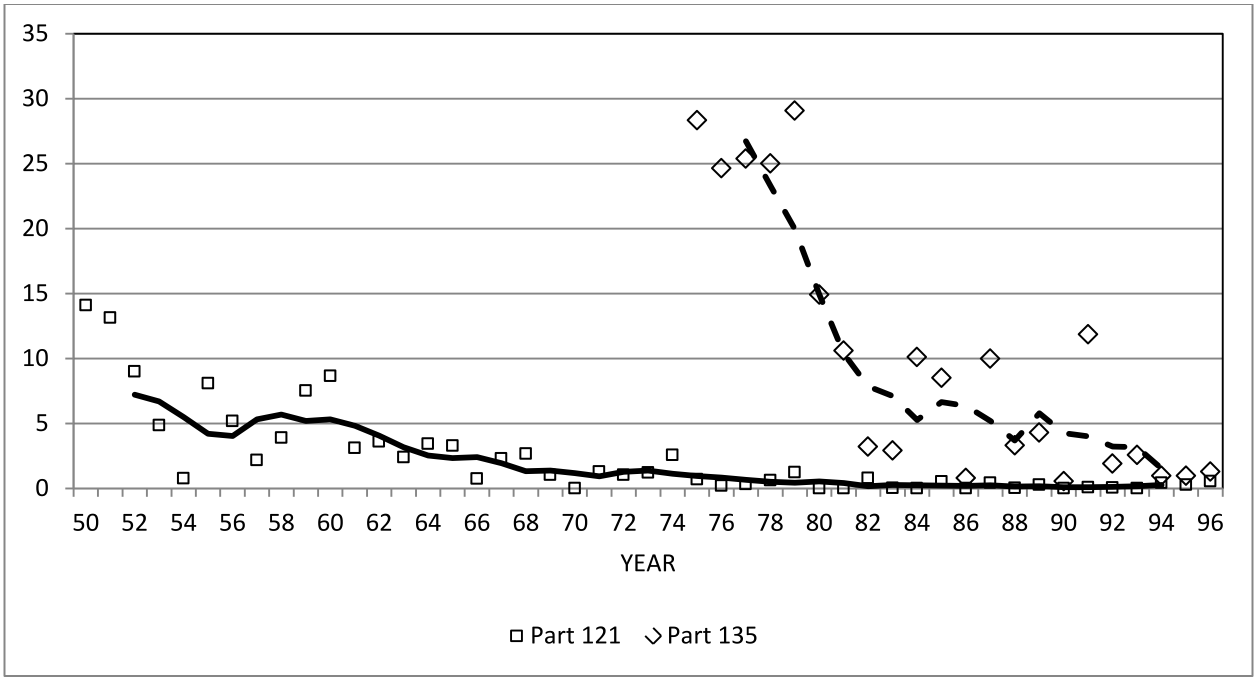

Figure 2: Fatalities per Billion Passenger Miles with Five-Year Moving Average

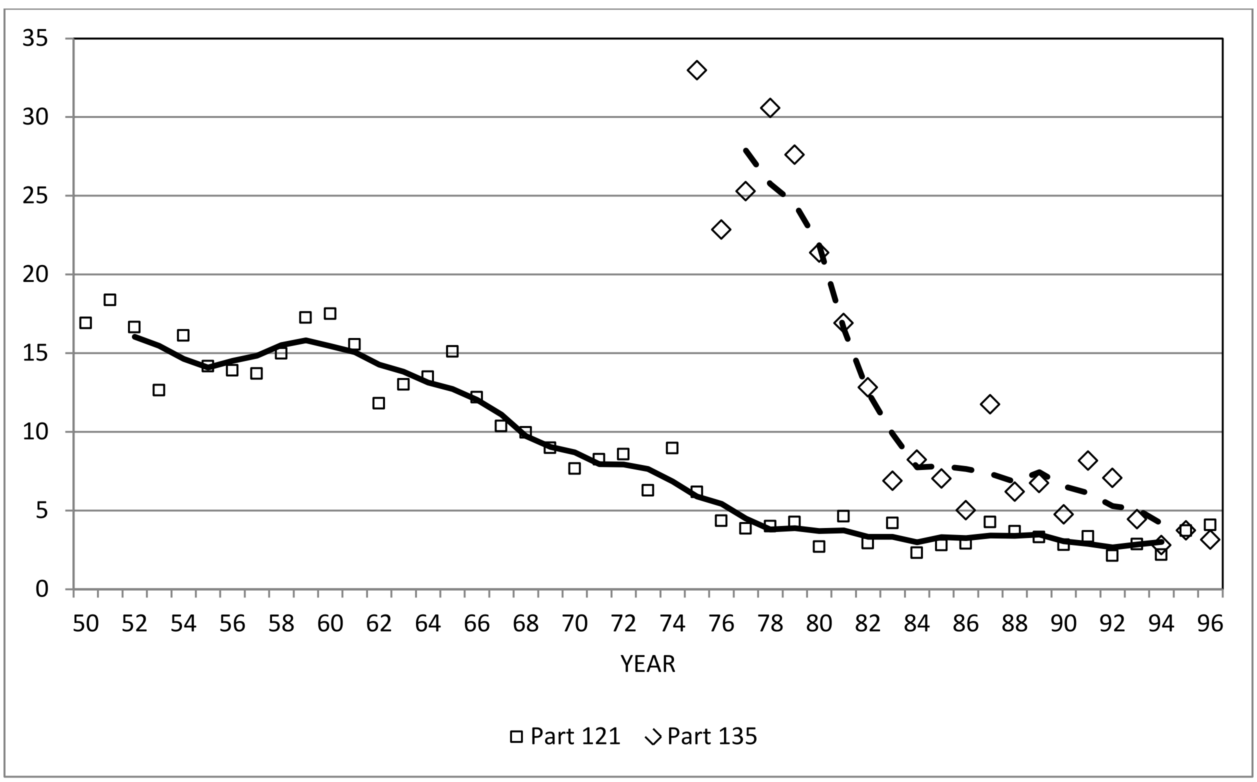

Figure 3: Accidents per Million Departures with Five-Year Moving Average

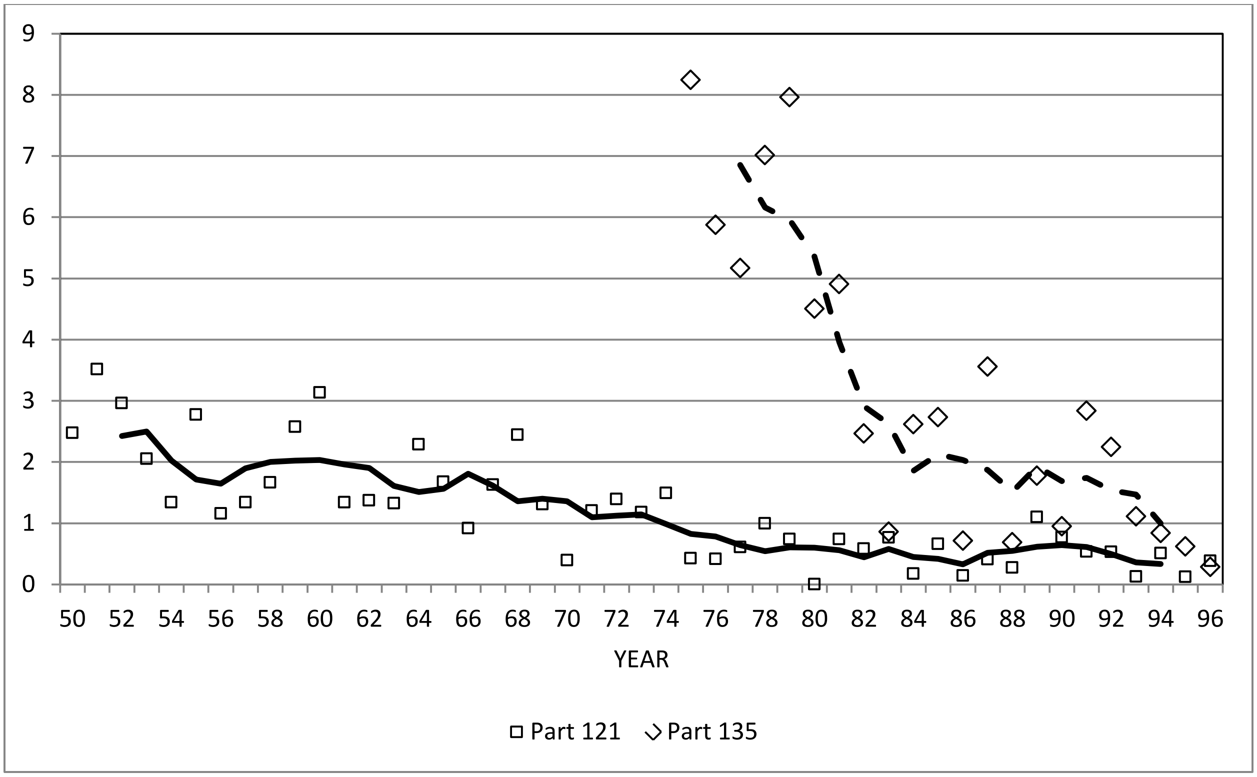

Figure 4: Fatal Accidents per Million Departures with Five-Year Moving Average

The implication is that the fatality rate must have fallen considerably over the period. The annual passenger fatality rate per billion passenger miles is shown as the symbols in figure 2, with a five-year moving average plotted as the solid lines. The graph differentiates between the large carriers, regulated under Part 121 of the federal regulation, and the commuter airlines operating aircraft with 30 or fewer seats regulated under Part 135.

The most notable feature is the major improvement in the fatality risk for commuter airlines since 1975. Whereas the risk in 1975 was perhaps six times that of flying large airlines, nowadays the risk is converging on that of the large Part 121 airlines. It is worth remembering that the Part 135 carriers still only account for 1.3% of the industry's passenger miles. The Part 121 carriers saw their most rapid improvement in the 1960s and 1970s. Since that time the fatality risk has remained at a very low level. A more detailed discussion of the Part 121 fatality rate is reserved for the next section of the paper.

Figures 3 and 4 present a similar analysis but this time using some more engineering-based measures of accident rates. Accidents (in figure 3) and fatal accidents (in figure 4) are shown relative to the number of aircraft departures. This measure of aircraft activity is usually preferred as a measure of exposure as the vast majority of crashes occur during the takeoff and landing stages of flight. Changes in accident rates over time mirror the fatality-rate trends described in figure 2.

2. Time Trend for Part 121 Carriers

Figure 5 is an enlargement of figure 2 showing the fatality risk for the Part 121 carriers since 1961. A visual inspection of this graph, and also the accident rates shown in figures 3 and 4, suggest a massive improvement in the 1960s which accompanied the technological improvements of air traffic control and the introduction of jet aircraft. The rate of improvement was much more modest in the 1970s, and then the accident rates in figures 3 and 4 appear to have leveled out since 1980. There has been an upswing in the fatality rate in the 1990s, but that may be an artifact of a highly unusual string of five crashes between 1994 and 1996 where aircraft in flight have crashed killing everyone (or almost everyone) aboard. Even including these crashes, the passenger risk is half that in 1980.

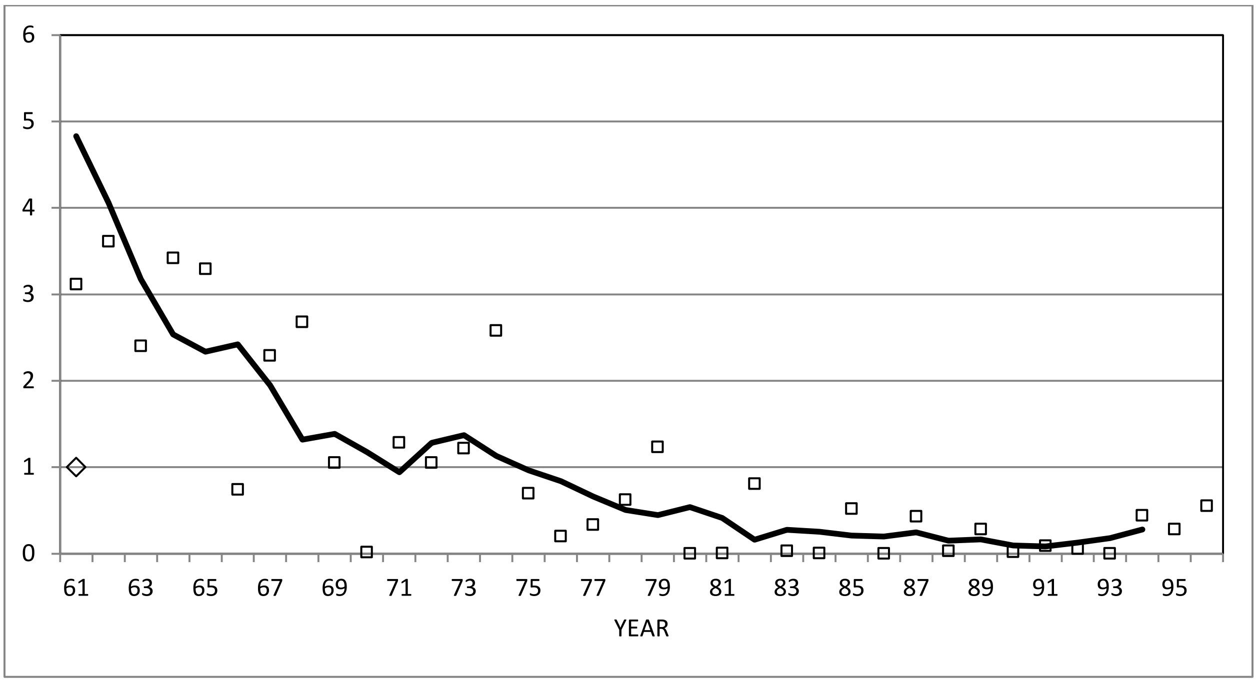

Figure 5: Part 121 Fatalities per Billion Passenger Miles with Five-Year Moving Average

The changes in each decade for the three measures of safety are shown in table 1. The data are expressed as an average *annual* change in the decade. A five-year average using the years at the turn of each decade as the midpoint is used for the calculations to try to avoid problems of unusual numbers of accidents or fatalities in any one year.

One will note that fatality risk has fallen much faster than the decline in accident rates. In part this is due to the considerable increase in average journey length (passenger miles divided by passenger enplanements) from just more than 500 miles in 1950 to almost 1,000 miles today. This reduces the risk per passenger miles given that the majority of the risk is in the takeoff and landing stages of flight. Crashes have also become more survivable. In the 1950s an average accident killed 80% of the passengers aboard, while today that figure is less than 40%.

Table 1: Annual Percentage Change in Each Decade

	Passenger Fatalities per Passenger Mile	Accidents per Departure	Fatal Accidents per Departure
1950s	- 3.7%	- 0.4%	- 2.2%
1960s	-14.1%	- 5.6%	- 3.9%
1970s	- 7.4%	- 8.2%	- 7.9%
1980s	-16.4%*	- 2.1%	+ 0.6%
1990s	+32.8%*	+ 0.8%	-13.4%

* The 1990s figures are compromised by a string of five high fatality accidents in 1994-96. The annual percentage change for the 1980s and 1990s combined is -4.3%

To determine statistically whether deregulation had changed the rate of improvement, Rose (1990) and Kanafani and Keeler (1990) fitted regressions to data on accidents per million departures and fatalities per ten million passenger miles respectively. Data from the mid-1950s or 1960s up until the late 1980s were used. Both regressed a time trend and a deregulation dummy combined with the time trend for the period after 1978 on the logarithm of accident rates. Neither found that deregulation had disturbed the long running trend. I came to the same conclusion by replicated both studies using data up to and including 1996.

However, one could take a different approach to the problem by fitting a time trend to the data for the period between 1960 and 1978 and then observing whether the actual data since 1978 are consistent with the extrapolated time trend. I did so for two measures of safety: accidents per million departures, and passenger fatalities per billion passenger miles. For the latter I used five-year moving averages for the base data so as to avoid the wild fluctuations from year to year, and the problem of taking logarithms for years when there are no passenger fatalities.

Figures 6 and 7 show the data as the symbols, and the extrapolated 1960-1978 time trend as the solid and then (after 1978) dashed lines. In figure 6, one can immediately see that the number of accidents leveled off after 1978 and now lies considerably above the trend line from the 1960s and 1970s. However, the post-deregulation fatality rate, shown in figure 7, has continued to follow the decline from the previous decades, at least until the rash of high-fatality accidents in the mid-1990s. The declining fatality rate in the face of constant accident rates is explained in part by the increase in average journey length by 20%, from 825 to 990 miles, since 1978.

Critics of deregulation would look to the analysis in figure 6, and argue that deregulation has stalled the improvement in safety. They would argue that the aviation system in 1996 is quite similar to that in 1980. There have not been the dramatic changes in aviation technology similar to those in the 1960s and 1970s. The technology of air traffic control is unchanged in the past sixteen years, and the same Boeing 727s and DC9s form the backbone of the domestic fleet.

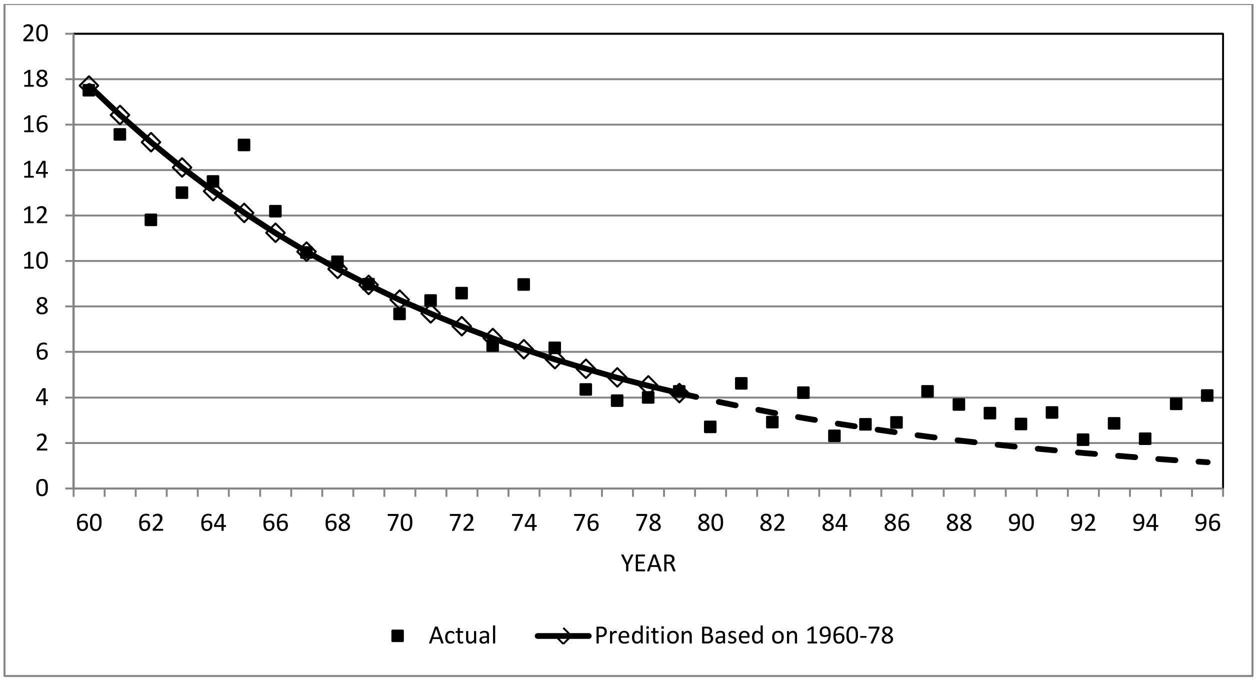

Figure 6: Part 121 Accidents per Million Departures with 1960-78 Trend Line

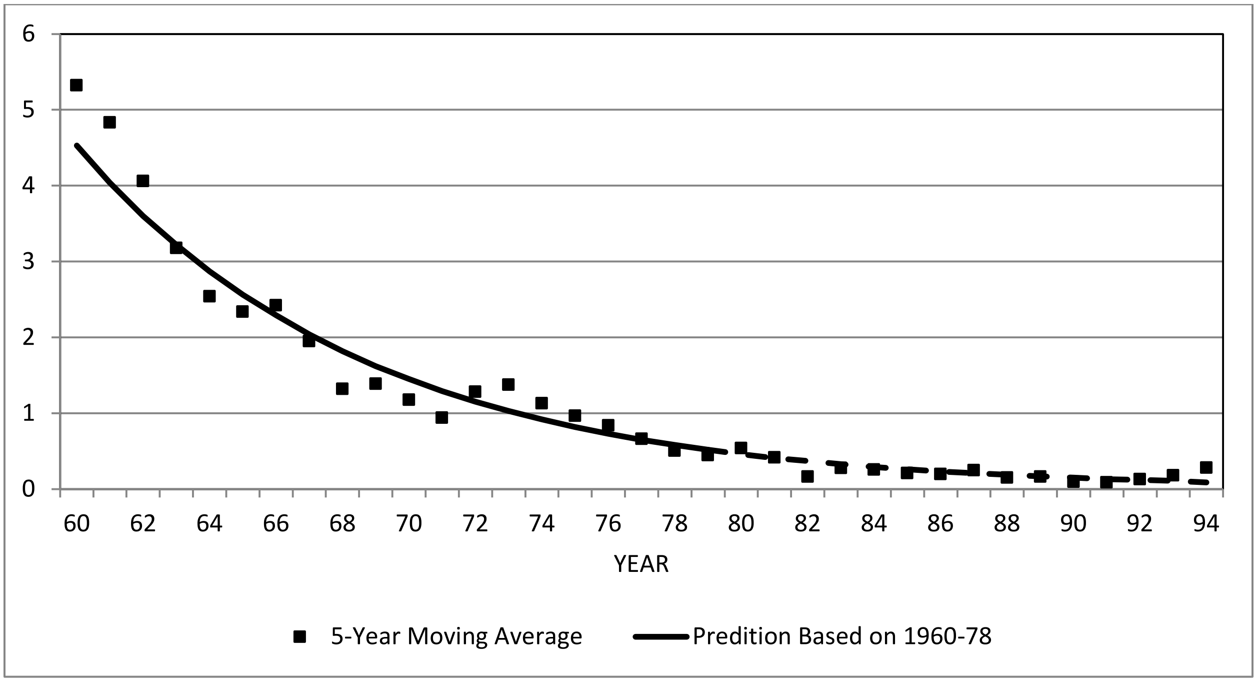

Figure 7: Part 121 Fatalities per Billion Passenger Miles with 1960-78 Trend Line

To support a hypothesis that deregulation has harmed safety, one would have to argue that deregulation has held back technological advances. Such an argument would be quite subjective and speculative. The second generation jets have been such a design success that it is quite likely that they would have persisted in service even if a cozy regulated environment had generated the cash to fund replacements. It is still argued in aviation circles whether the fly-by-wire third generation jets are safer than the second generation jets. Declining world fuel prices since 1980 would have justified retention of less fuel-efficient aircraft under any regulatory regime. One wonders whether the sad saga of the Federal Aviation Administration's (FAA) attempts to upgrade the air traffic control system would have been any more successful under continued regulation. To the extent that traffic growth since deregulation has increased the income of the Aviation Trust Fund, there should have greater funding available and political will to overhaul the system.

In conclusion, fatality rates have continued their long-run decline since deregulation. However, accident rates since 1980 have remained constant, primarily because the technology of aviation safety has stood still. However, I think it is a stretch to argue that deregulation caused that technological standstill. I think the aviation community is still looking for the "silver bullet" that will produce the technological leap forward that will reduce accident rates by the orders of magnitudes seen in the 1960s and 1970s.

3. <u>Time Trend for Part 135 Carriers</u>

One may well argue that this segment of the industry is a child of deregulation. Prior to deregulation many secondary airports were served by infrequent jet service providing multiple-stop point-to-point service. With the move to hub-and spoke operation many of these secondary airports saw an increased level of service to hub airports where there are convenient connections to many destinations. A recent General Accounting Office (GAO) report (1996a) found that the number of departures from small communities had increased by 50% between 1978 and 1995. While the number of destinations that can be reached by nonstop service has declined, the range of possible destinations available by one-stop service has expanded considerably. The disadvantage, in safety terms, was the substitution of "commuter" aircraft for jet aircraft.

In the late 1970s flying a commuter airline was considerably more hazardous that flying on a large jet airline. By any measure it was at least six times as risky. Then in 1978 there was a major overhaul of safety regulations including new pilot qualification and training requirements, new maintenance requirements, and an upgraded list of required safety equipment. Since then, the accident rate has declined significantly.

The main explanation is that increased traffic required the deployment of larger aircraft with turbo-prop rather than piston engines, as vividly shown in table 2. In 1978 70% of the commuter airline fleet was powered by piston engines, and 80% of the passenger miles flown were in aircraft with less than 20 seats. By 1994 the proportions were almost exactly reversed. Seventy percent of the fleet was turbo-prop powered and 80% of passenger miles were on aircraft with larger than 20 seats, and almost a third of passenger miles on aircraft with more than 40 seats. Clearly the growth of this sector of the industry has led to the kinds of technology-lead improvement in safety that was witnessed in the Part 121 carrier sector in the 1960s and 1970s.

Table 2: Change in Composition of the Commuter Airline Fleet

	1978	1994
Number of Aircraft	1195	2170
Method of Propulsion (as a proportion of the fleet)		
Single-engine piston	18%	12%
Multi-engine piston	56%	14%
Turboprop	23%	72%
Jet	3%	2%
Seating Capacity (as a proportion of revenue passenger miles flown)		
1-9	22%	2%
10-19	58%	19%
20-30	9%	22%
31-40	5%	27%
41+	7%	31%

Source: Regional Airline Association *Annual Reports*

With the rapid change in the technology of the commuter airline industry, the traditional dividing line between large jet and commuter carriers has become somewhat fuzzy. The dividing line between Part 121 and Part 135 safety regulations was set in 1978 at aircraft with 30 seats. At that time almost 90% of passenger miles on commuter airlines were on aircraft with 30 or fewer seats, so one could say that Part 121 was synonymous with jet carriers and Part 135 with commuter airlines. However, over time some commuter airlines have elected to comply with the more stringent Part 121 regulations and other have had to do so because they acquired larger aircraft. Indeed by 1994 60% of commuter passenger miles were on aircraft with more than 30 seats. In 1997 the boundary between Part 121 and 135 operations was lowered to aircraft with 10 seats. Now more than 98% of the flying on commuter airlines will be done on aircraft certified under the Part 121 regulations.

Figures 1 through 4 differentiate between Part 121 and Part 135 carriers rather than between jet versus commuter carriers. This makes the improvement in accident rates for the Part 135 carriers even more remarkable because since 1990 most of the larger commuter carriers have transferred from the Part 135 category to the Part 121 category.

4. Public Perceptions

Despite the seemingly positive view contained in analysis of statistical risks, public perceptions of events are somewhat different. In general, I would suggest that public attitudes to aviation safety have not changed much in the past decade.

Ten years ago a particularly disastrous year for airline safety worldwide in 1985 led to considerably concern that economic deregulation had led to a decline in safety. The weekly news magazines presented tales of crashes, escalating numbers of near midair collisions, and allegations of improper maintenance. In the minds of the public, the latter was confirmed by the record fines for maintenance irregularities imposed on household name airlines. The popular belief, expressed for example by Nance (1986), was that deregulation had led to competitive pressures on air carriers to reduce expenditures on safety related items, allowed entry into the market by inexperienced new carriers, and led to the substitution of riskier commuter airlines in secondary markets. In addition many believe that the congestion caused by the greater number of airline flights, occasioned by the substantial rise in demand since deregulation, has led to an increased probability of collision.

These concerns were graphically illustrated by a *Time* magazine cover story on January 12, 1987. Ten years later *Time* ran another cover story (March 31, 1997). The story was not much different. The latter story reported on a book written by Mary Schiavo (1997), the former Inspector General of the Department of Transportation, which described the dangers caused by the entry of new inexperienced airlines, sloppy maintenance practices, and general failures by the FAA in certification of aircraft and airlines. Ten years ago the concerns led to the establishment of a Presidential Commission on Aviation Safety in 1987. A decade later the President established another commission under Vice-President Al Gore.

While the story may be the same, the details of the plot had changed in subtle ways. Commuter airlines no longer produce the same amount of concern, mostly likely due to the rapid improvement in their safety performance. Concern about financially stressed airlines skimping on safety has diminished as the weakest carriers have exited the market and buoyant business conditions in the mid-1990s have improved the fortunes of even the companies with traditionally poor financial performance. The concern about airport congestion and its relationship to an increased number of collisions also appears to have disappeared off the radar screen, although one still despairs that the same vacuum tube technology and elderly computers are used for air traffic control. Geriatric jets have become a much talked-about issue. Following the bombing of a Pan American aircraft over Scotland in 1988 security has become an increasing concern.

Most importantly the villain of the story has changed. Schiavo's book points the finger not at the curse of deregulation, as Nance had done ten years earlier, but rather at the failure of the FAA to carry out the duties assigned to it. Perhaps in the minds of the general public, as opposed to industrial organization economists, deregulation has faded into the realm of ancient history to be filed away along with leisure suits, high inflation, and disco records.

To a great extent the public's continued concerns about aviation safety are valid. For jet airlines accident rates have not changed substantially since the end of the 1970s. There continues to be spectacular crashes and exposés of errors and mismanagement which are guaranteed to be racy subjects for a press story. Barnett (1990) calculated the ratio of front-page stories in the *New York Times* to the fatality risk for six common mortality risks, and found that reports on aviation safety appeared 50 times more frequently than any other risk. One might conclude that aviation safety continues to provide a good story, albeit that the cast of characters and the villain keeps changing.

5. Deregulation and New Entrant Jet Airlines

The initial concern about inexperienced new entrant jet carriers stemmed from the 1982 crash of an Air Florida Boeing 737 at Washington National Airport due in part to poor certification of its pilots. Kanafani and Keeler (1989) used data for the period 1982-1985 to compare the records of 20 established carriers and 25 "new entrant" airlines. The two groups of carriers were compared on the basis of maintenance expenditures, the results of FAA inspections, near midair collisions, and accidents. The researchers were unable to establish that new entrants had an inferior safety record. Indeed there was weak statistical evidence that new entrants spent relatively more on aircraft maintenance and were involved in fewer near midair collisions. Classification of which firms were "established" and which were "new entrant" proved to be a bit of a problem. The reborn-out-of-bankruptcy Braniff and Continental Airlines were included as "new entrants" in this study, although their presence was recognized by firm-specific dummy variables. Two formerly-intrastate carriers were given different classifications. Pacific Southwest Airlines was classified as an established carrier whereas Southwest Airlines was classified as a new entrant.

While the names of the new entrant airlines have changed over time the concern about new entrant airlines has not disappeared. While Southwest and America West Airlines have become major airlines, other new entrant airlines such as Air Florida, the original Midway, New York Air and People Express exited the market to be replaced by the likes of American Trans Air, Western Pacific, Reno Air, Kiwi International, Vanguard and the infamous ValuJet. The 1996 in-flight fire and subsequent crash of a ValuJet DC9 near Miami led to the well-reported public dispute between the aforementioned Mary Schiavo and David Hinson and Frederico Peña the heads of the FAA and the Department of Transportation respectively. Shocking stories of maintenance irregularities and in-flight problems led to the suspension of operations by ValuJet and the retirement or resignation of senior FAA officials.

Clearly Kanafani and Keeler's study could be repeated using data from the early 1990s. As I was limited for time, I could not undertake a full econometric analysis, but I could calculate some mean values of three leading indicators of safety performance for the period between 1991 and 1995: accidents and incidents, near midair collisions, and pilot deviations, all measured as a rate per 100,000 departures. I grouped the Part 121 scheduled carriers into three categories: established jet airlines, commuter airlines operating under Part 121 regulations, and new entrant jet airlines.

Results of the analysis are shown in table 3. All the differences between the groups for each of the three measures are statistically significant. Surprisingly, the commuter airlines operating aircraft with 31 or more seats under the Part 121 regulations have the best safety performance. New entrant jet carriers have an accident and incident rate that is 50% higher than that of established jet airlines. However, their rate of pilot deviations is lower. Their higher rate of near midair collisions might be misleading if one does not take into account the areas in which the airlines are flying, and one should remember that involvement in a near midair collision does not imply blame. Based on this quick analysis, I think there is some evidence that a more careful study would reveal that recent new entrants do have less safe operations than established carriers. This view is supported by the analysis of the GAO (1996b) who found that jet carriers with less than five years of experience had higher rates of incidents and also FAA enforcement actions taken against them than more established firms.

Table 3: Safety Performance 1991-1995

Rate per 100,000 departures	Accidents & Incidents	Near Midair Collisions	Pilot Deviations
Established	5.05	0.99	2.46
Part 121 Commuter	2.38	0.53	0.19
New Entrant	7.59	1.70	1.48

Established Carriers (5,800,000 annual departures): Alaska, Aloha, America West, American, Continental, Delta, Hawaiian, Midwest Express, Northwest, Southwest, TWA, United, USAirways, USAirways Shuttle.

Part 121 Commuter (840,000 annual departures): Air Wisconsin, Atlantic Southeast, Business Express, Continental Express, Executive, Horizon, Mesa, Trans States, Simmons, UFS.

New Entrant (145,000 annual departures): American Trans Air, Air South, AmeriJet, Carnival, Frontier, Kiwi, Morris, Midway, Reno, Spirit, Tower, ValuJet, Vanguard, Western Pacific.

Based on table 3 we can make some very crude estimates of the effect of new entrant carriers on annual aviation fatalities. That is, what would be the effect if the 145,000 departures each year operated by new entrant airlines were performed by established carriers? I will assume that new entrant carriers have an accident rate 50% higher than that of established firms. Given that the fatality rate for Part 121 carriers over the period 1992-1996 was 17.7 fatalities per million departures, the safety effect of new entrant carriers is 1.3 extra fatalities per year.

6. Deregulation and Financial Pressure

In the years after deregulation, unit costs fell. Poorly-managed or badly positioned carriers sort bankruptcy protection, and then either reemerged with different cost structures or exited the industry. In the early 1980s there was considerable concern that many airlines, and especially those near bankruptcy, were shaving costs in such a way that reduced safety.

While not an unbiased source of information, a survey of its members by the Air Line Pilots Association in 1986 (Fingerhut, 1986) describes the concerns. Half of the pilots surveyed felt that economic deregulation had greatly affected safety, with almost all acknowledging there had been some impact. In attributing the cause of this decline, nearly 70% felt that financial pressure on airlines was partly to blame, 40% felt inexperienced managers were partly the cause, and 60% said that the FAA was partly responsible. Evidence for the effect of financial pressure on safety can be detected elsewhere in the questionnaire. Ten percent of pilots said they were frequently pressured into flying aircraft in contravention of the "Minimum Equipment List," which specifies combinations of onboard equipment that can be <u>in</u>operative without grounding the plane. Another 40% said that they were sometimes pressured. About half the pilots felt that the aircraft they flew had an excessive number of components whose maintenance had been deferred, with the same proportion believing that the airworthiness of their aircraft had declined since deregulation.

Moses and Savage (1989b) conducted an econometric investigation of the data and found that pilots who worked for airlines that had made financial losses in the period between 1980 and 1985 were statistically more likely to believe that deregulation had harmed safety. There was a very strong connection between financial condition and pilots' opinions on whether their initial training was inadequate, and whether the maintenance and airworthiness of their aircraft had declined.

There is some theoretical economic basis for believing the opinions of the pilots. Golbe (1981, 1988) and Bulow and Shoven (1978) demonstrate that firms close to bankruptcy might choose to select low safety levels because the downside risk of crashes would not be borne by stockholders if bankruptcy is declared. However, the effect on safety provision by firms whose financial position is declining, yet are not in danger of declaring bankruptcy, is theoretically indeterminate (Golbe, 1986). In other words, the safety-profitability issue is an empirical and not a theoretical one.

Rose (1990) conducted econometric investigations relating financial condition and accident experience. This work updated and expanded the analysis of Golbe (1986) who found an insignificant yet positive relationship (more profits equals more crashes) based on pre-deregulation data. Rose's work used data for 35 large scheduled air carriers over the period 1957 to 1986. A Poisson model is used with total accidents per departure as the dependent variable, and the previous year's operating margin (1 - operating expenses/operating revenue) as the primary financial measure. She found a negative relationship that was statistically significant at the 10% level: more profits implied lower accident rates. A decrease in financial performance from average to one standard deviation below average was estimated to increase the accident rate of the carrier by 7.5%. Models using firm fixed effects suggest that the effect may be larger and more robust in terms of statistical significance. When categorized by size of firm, it would appear that the profitability - safety relationship only holds for middle and small carriers. There was no statistical relationship for large carriers whatever the functional form.

Rose then estimated a similar model for 26 carriers over the period 1981-1986 using incidents, reported non-accident events involving actual or potential hazards to safety, as the dependent variable. There was a strong negative relationship between operating margin and incidents for small and medium sized carriers, but not for large carriers.

So, how do the findings of Rose and the survey of pilots square with the data shown at the beginning of the paper? The early 1980s were marked by a recession that hurt airline finances in general, and in addition certain carriers suffered severe financial difficulties. Those carriers included Eastern Air Lines which was classified by Rose as a large airline, and Pan American, Continental, Braniff, People Express and Frontier which were classified as medium-sized. Yet the early 1980s saw a continued improvement in accident rates, and some of the safest years on record with no passenger fatalities recorded in 1980 and 1986, and only one in each of 1982 and 1984.

One should remember that 75% of Rose's data set is prior to deregulation. While bankruptcy was rare prior to deregulation, changes in profitability and variations in profitability between carriers was not. It is possible that Rose's results were driven by events in 1960s or

1970s when more financially able firms were more quickly able to invest in the safer second-generation jet aircraft.

However, Rose's analysis of incident rates in the early 1980s, coupled with Moses and Savage's (1989b) analysis of the pilots' survey and the anecdotal evidence of Nance (1986), do suggest that something untoward was going on at financially-stressed carriers, even those which were large household-name firms. Over the past ten years my own informal conversations with people in the industry have also provided me with anecdotal support for these assertions. It is my opinion that we were "lucky" that there were no major fatal crashes in the early 1980s involving firms that were just about to exit the market.

Alternatively, the dichotomy can be explained by the specification of the safety production function which describes how safety inputs (training, maintenance and so on) are transformed into actual safety performance. It is possible that safety could be seen as *partly* a type of stock variable. Airlines close to bankruptcy may have, in better financial days, invested in hiring highly qualified personnel, organized extensive training programs, and bought new aircraft which were carefully maintained at state-of-the-art maintenance bases with large inventories of parts. While, as an economist, I question the very concept of a "margin of safety," I can readily acknowledge that there may well be a time lag between reduction in maintenance and training programs and a resulting increase in accident rates.

Crude estimates can be made of the effect of financial pressure on safety. In recent years about 12% of, or 960,000, annual Part 121 departures have been operated by carriers that were recently in Chapter 11 bankruptcy protection. Rose calculates that firms that have operating margins two standard deviations below that of the mean for the industry have a 14.8% higher accident rate. Based on an average Part 121 fatality rate for 1992-1996 of 17.7 per million departures, financial stressed carriers may have led to 2.5 additional fatalities each year.

7. Deregulation and the Growth of Commuter Airlines

Much of the debate concerning the impact of airline deregulation on safety has concerned the substitution of less safe Part 135 carriers on services previously operated by Part 121 jet carriers. However, the magnitude of the risk difference between the two types of service is the subject of some controversy. Table 4 presented calculations of a contemporary comparison of risks of flying Part 135 versus Part 121 carriers. Four measures of risk are shown: accidents per departure, fatal accidents per departure, fatalities per passenger mile, and fatalities per passenger enplaned. The data for exposure is 1995, while the count of fatalities and accidents is the annual average for the period 1992-1996.

Measured in terms of aircraft departures, accidents occur 50% more frequently and fatal accidents 150% more frequently on Part 135 as compared with Part 121 aircraft. When measured from a consumer's point of view, the risk per passenger mile is almost six times higher on a Part 135 aircraft. However, this measure is misleading because average journey lengths vary so much. The average journey length on a Part 121 carrier is 990 miles while that on a Part 135 carrier is 240 miles. Given the high proportion of the risk of air travel is in takeoffs and landings, a more appropriate comparison is the risk per passenger enplaned. Here the risk is much closer, with Part 135 carriers having a fatality risk about 46% higher than Part 121 carriers.

Table 4: Comparison of Accident Rates 1992-1996

	PART 121	PART 135
Accidents per Million Departures	2.98	4.41
Fatal Accidents per Million Departures	0.34	1.06
Passenger Fatalities per Million Enplanements	0.26	0.38
Passenger Fatalities per Billion Passenger Miles	0.27	1.56

Oster, Strong and Zorn (1992) argue that a further adjustment is necessary in the comparison. When Part 135 service was substituted for Part 121 service the number of intermediate stops (and hence takeoffs and landings) was reduced from an average of 0.59 to 0.30 per trip. The Part 121 accident rate should therefore be inflated by 22% to account for the additional takeoff and landing risk. The risk per enplanement on a Part 121 carrier should therefore be about 0.317 per million enplanements as compared with the 0.38 risk on a Part 135 carrier. The net result is that Part 135 carriers are about 20% riskier than Part 121 carriers. Of course, as can be seen from the figures presented earlier in the paper, the risk differential would have been much larger in the early 1980s when the accident rate on Part 135 carriers was much higher.

To calculate the net effect of the higher accident rate of Part 135 carriers it is necessary to speculate on the number of passenger enplanement who now travel on a Part 135 aircraft and previously would have traveled on a Part 121 aircraft. I decided to try to calculate upper and lower bounds. The upper bound is based on the assumption that Part 135 carriers would have continued to hold their mid-1970s 0.5% share of the market, as opposed to the 1.3% to 1.5% share that they hold now. Of course, as the total market has grown over the years, this assumption implies that the number of passengers who have to substitute Part 135 for Part 121 service has also grown. A lower bound is based on the assumption that the number of annual passenger enplanements who had to substitute Part 135 for Part 121 service remained at the 8.5 million which was applicable to the early 1980s.

I divided up the post deregulation period in three (1980-1984, 1985-1989, and 1990-1996) to reflect the improved accident record of the Part 135 carriers over time. I calculated the number of passenger enplanements that would be made on Part 121 rather than Part 135 for an average year in each time period, and estimated the number of fatalities that would be avoided by using the average fatality rate for both types of service. The fatality rate for Part 121 carriers was inflated by 22% to represent the, previously discussed, increased number of takeoffs and landings required for Part 121 service.

The results of the analysis are shown in table 5. My estimate of the upper bound of the number of fatalities caused by a substitution of Part 135 for Part 121 service since 1980 is 136 passengers. The lower bound is 89. Therefore, the substitution of Part 135 for Part 121 service has led to between 5.2 and 8 additional passenger fatalities per year.

Table 5: Additional Fatalities Caused by Part 135 Substitution

Annual Averages		1980-84	1985-89	1990-96
Fatality Risk per 1,000 enplanements	Part 135	0.00115	0.00089	0.00062
	Part 121	0.00017	0.00027	0.00027
Enplanements Substituted (000s) per Year	Upper	8,510	14,187	20,214
	Lower	8,510	8,510	8,510
Additional Annual Fatalities	Upper	8	9	7
	Lower	8	5	3

Of course, the growth of the airline industry in general has had a spillover effect on that segment of the market what always was and still is served by commuter airlines. These markets may have seen the influx of new technology and new aircraft. It is possible that these passengers have witnessed an improvement in their safety that would not have occurred without the spur to aircraft design and construction caused by deregulation. However, one should remember that there are still markets served by piston-engine aircraft with 20 or fewer seats whose safety record is inferior to turbo-props.

8. Deregulation and the Level of Surveillance

Ten years ago there was considerable concern that the level of surveillance activity by the FAA had not responded to the changes caused by deregulation. The FAA’s workload had increased dramatically compared with that needed to oversee the stable and predictable industry that existed in the days of entry control. The number of large jet air carriers increased from 60 in 1978 to 148 in 1985. FAA resources were needed to provide initial certification of these carriers. In addition, the new regulations for Part 135 carriers in 1978 required considerable time certifying airlines, pilots and aircraft. Despite the increase in workload, the decline in FAA staff numbers initiated in the early 1970s continued unchecked through January of 1984. O’Brien (1988) calculates that the net result was a decline in the number of inspectors per airline from 4 in 1978 to 1.5 in 1985. The FAA admitted that in order to carry out certification duties “routine operations and maintenance compliance (i.e. inspection and surveillance) were mostly left undone” (Kern, 1988). The trend was only reversed in 1984 when the FAA conducted a number of major safety audits of the aviation industry resulting in large fines against household-name firms.

It is my opinion that in the period between 1978 and 1984 FAA surveillance activity was clearly out of line with the needs of the market. Yet analysis of overall accident data indicates nothing untoward during these years. How close, if at all, America came to an increased accident rate due to inadequate surveillance of new entrants and financially-stressed carriers is an issue we can probably never resolve.

But are things much different ten years later? The early 1990s saw another growth in the number of new airlines after a period of consolidation in the late 1980s. The ValuJet affair revealed deficiencies in the FAA oversight of the industry. A recent GAO report (1996b) is subtitled “long-standing problems in FAA’s inspection program.” An appendix to this report lists 31 GAO reports written over the period 1985 to 1996 critical of the FAA’s inspection programs.

In the report the GAO writes "[o]n a broader scale, serious problems that hamper the effectiveness of FAA's aviation safety inspection program have remained unresolved for nearly a decade." Schiavo (1997) goes further, alleging that the mission of the FAA to "promote" aviation, which was only rescinded in the light of the ValuJet affair, had led to a very cozy relationship between the FAA and the industry it was supposed to be overseeing. In writing this paper I reread the charter of the 1987 Presidential Commission and it is clear that the problems at the FAA were well known a decade ago.

9. Deregulation and the Quantity of Infrastructure

Ten years ago there was also concern that the infrastructure of the industry has been severely strained since deregulation. The number of departures by Part 121 and 135 scheduled carriers had increased by 44% from 1978 to 1987. In addition, flights had become concentrated at specific airports at certain times due to the adoption of hub-and-spoke operating practices. Yet, capacity has not increased. Prior to the opening of Denver in 1995, the last major new airport was Dallas-Fort Worth in 1973. In 1987 the number of air traffic controllers was still below what it was when most controllers were fired because of illegal strike action in 1981. Air traffic control re-equipment programs were, on the evidence of the GAO, running years late. The system had in many ways been the victim of its own success.

Ten years later the increase in the number of departures has been much more modest at 12%. However, the re-equipment of the air traffic control system is not much further forward. The grand National Airspace System Plan of 1981 was eventually canceled in 1994 when it was years late and considerably over budget. The FAA has been the butt of jokes about vacuum-tube technology and a series of embarrassing failures of aged computers at control towers in 1995 and 1996. Yet there have been some improvements. Doppler equipment to detect windshear has been deployed at some places, collision warning detection and avoidance equipment has been fitted to Part 121 aircraft; and small private aircraft have been required to be fitted with mode C transponders in certain areas so that they can be adequately monitored by air traffic control and other air traffic.

Many may remember that the most talked-about issue in 1987 was the congestion at major airports with the resultant well-publicized traffic delays, and an increased rate of near midair collisions and runway incursions. Nowadays complaints about traffic delays and collisions are not as vociferous. It is possible that the 1990 requirement that airlines reveal the on-time ratio for individual flights has put an end to a practice from the 1980s when airlines were, to put it charitably, "optimistic" about the elapsed flight times shown in their public schedules. To the dismay of economists, pricing solutions to congestion are no nearer to fruition. Peak load pricing is not employed, and aircraft are still charged a landing fee on the basis of weight.

There would appear to be evidence that the dramatic increase in air travel in the early 1980s was imposed on an infrastructure system near technological capacity, becoming increasingly technologically outdated and seriously impaired by the dismissing of air traffic controllers in 1981. Many people allege that the failure of the air traffic control system to respond to the increased demand was due to congressional intervention concerning the spending of the Aviation Trust

Fund, and government procurement rules which delayed buying new equipment to update the system. There has been continual discussion over the past fifteen years of removing the air traffic control portion of the FAA from the aegis and budgetary control of the Department of Transportation. It would be made financially independent, and its funds provided entirely by existing user fees.

10. Deregulation and Reduced Road Traffic

Deregulation has attracted a large number of new customers to airlines. It is quite likely that some of these new airline trips are substitutes for trips previously taken by automobile. There could be direct substitution when, for example, a commuter airline trip was substituted for driving to the nearest hub airport, or an indirect substitution when the increasing attractiveness of airline travel substitutes an aviation vacation for one that previous was made to another destination by automobile. Given that fatalities per billion passenger miles in the late 1980s were 12.8 for auto travel and 0.27 for airline travel, the nation would experience a substantial benefit from any diversion from the automobile.

Bylow and Savage (1991) estimated an aggregate time-series demand model for intercity auto travel which included variables representing the price and availability (number of flight departures) of airline service. Annual data was used for the period between 1965 and 1988. They then estimated reduced form equations for the combined Part 121 and 135 airline industry over the same period so as to calculate the changes in airline fares and departures occasioned by deregulation. Deregulation was found to have lowered real airfares by 8.6% and increased departures by 6.7%. Substituting these numbers into the automobile model predicted that deregulation led to a reduction in annual automobile miles by 2.2%

Translating the reduction in vehicle miles into reduced fatalities requires assumptions concerning the types of roads that the reduction occurs on, and also the types of drivers who shift from automobiles to air. The death rate on rural roads is 50% above the national average; for while congested urban streets result in a large number of crashes, the relatively low vehicle speeds reduce the probability that a fatality will occur. Evans, Frick and Schwing (1990) analyzed the sex and age of airline passengers and suggest that such people, when driving, have a 24.1% lower fatality rate than the average driver. Airline passengers are predominantly in the 30-50 age group, whereas the age group of auto drivers which have the highest fatality rates are young people under 25.

Based on these calculations, Bylow and Savage estimate that for each year between 1978 and 1988 between 200 and 300 road deaths were averted due to deregulation of the airlines. Even the lower bound of this range is much larger than the average number of deaths in commercial aviation each year.

11. Summary and Conclusions

Table 6 summarizes the calculations we have already made concerning the effect of the various facets of airline deregulation on annual fatalities. Deregulation is estimated to result in between 9 and 12 additional fatalities each year in the aviation sector. However, that number pales into insignificance compared with the number of lives saved because deregulation encouraged people out of their cars and onto the airlines. The net result is a saving of between 193 and 298 lives each year. Thus the policy debate on the impact of airline economic regulatory reform on safety should be focused on the mode shifting implications rather than concentrating on effects internal to the airline industry such as financial distress, new entry, and the substitution of turbo-prop aircraft for jets.

Table 6: Summary of the Effect of Deregulation on Safety

Change in Annual Fatalities	High	Low
New Entrant Part 121 Airlines	+ 1.3	
Financially-Stressed Part 121 Airlines	+ 2.5	
Substitution of Part 135 Aircraft	+ 5.2	+ 8
Reduced Automobile Traffic	- 307	- 205
Net Effect	- 298	- 193

Even the decline in safety within the airline industry need not be seen as bad. The architect of deregulation Alfred Kahn (1988) hypothesized that quality was overprovided, or provided inefficiently, in the era of regulation. Therefore, an efficient market solution may entail reductions in overly large stocks of safety investments, and the excessive use of current safety inputs. Such reductions can lead to increases in accident rates. Nevertheless, the solution achieved can represent an increase in social welfare. Morrison and Winston (1986) calculated annual benefits from deregulation of about $22 billion at current prices. Empirical estimates of the value of life are controversial. Even if the extra 9-12 aviation fatalities per year are valued at a figure toward the top of the range, say $4 million, the disbenefits would amount to between $36 and $48 million, or at best about a fifth of one percent of the benefits.

Conversely, taking into account the reduced road traffic, and valuing life at a conservative $1.5 million, there would be safety benefits valued at between $0.3 billion and $0.5 billion to add to those calculated by Morrison and Winston.

12. Data Sources

Data for large aircraft cover the whole period from 1950 to the present. Data for small aircraft (under the Part 135 regulations) start in 1975. Throughout this paper, we will only be considering scheduled service, and do not consider charter or on-demand air taxi operations. Sabotage and terrorism accidents have been excluded.

Number of Accidents, Fatal Accidents and Passenger Fatalities. Since 1966 these data have been collected by the National Transportation Safety Board (NTSB). Previously, they were collected by the Civil Aeronautics Board (CAB). Historical information back to the early days of commercial flight in 1938 is published on the web site of the Air Transport Association of America. An aviation accident is defined 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.”

Number of Incidents, Near Midair Collisions and Pilot Deviations. These data are collected by the FAA. An incident is “an occurrence other than an accident associated with the operation of an aircraft that could affect the safety of operation." Near midair collisions occur when aircraft come with 500 feet. A pilot deviation is "the actions of a pilot that result in the violation of a Federal Aviation Regulation ... .”

Number of Aircraft Departures. Since 1983 these data are collected by the Department of Transportation (DOT). Previously, they were collected by the CAB.

Number of Passengers Enplaned, and Revenue Passenger Miles on Large Aircraft. Since 1983 these data are collected by the DOT. Previously, they were collected by the CAB. They are published in the monthly *Air Carrier Traffic Statistics*, of which the December edition reports annual totals.

Number of Passengers Enplaned, and Revenue Passenger Miles on Small Aircraft. Total industry data are reported in the *Annual Report* of the Regional Airline Association (previously the Commuter Airline Association) and are based on data collected by the DOT, and previously the CAB. Since some members of the Regional Airline Association operate large aircraft, it was necessary to subtract from these figures the data for those airlines that appear in the publication described in the previous paragraph.

13. <u>References</u>

Barnett, Arnold (1990). “Air safety: end of the golden age.” *Chance: New Directions for Statistics and Computing* 3:8-12.

Bulow, Jeremy, and John Shoven (1978). “The bankruptcy decision.” *Bell Journal of Economics* 9(2):437-456.

Bylow, Lance F., and Ian Savage (1991). “The effect of airline deregulation on automobile fatalities.” *Accident Analysis and Prevention* 23(5):443-452.

Evans, Leonard, Michael C. Frick and Richard C. Schwing (1990). “Is it safer to fly or drive?” *Risk Analysis* 10(2):239-246.

Fingerhut, Vic (1986). “The pilots view of air safety.” *Air Line Pilot* 55:17-22.

General Accounting Office (1996a). *Airline Deregulation: Changes in Airfares, Service , and Safety at Small, Medium-Sized, and Large Communities*. Report GAO/RCED-96-79. Washington D.C.: U.S. Government Printing Office.

General Accounting Office (1996b). *Aviation Safety: New Airlines Illustrate Long-Standing Problems in FAA's Inspection Program*. Report GAO/RCED-97-2. Washington D.C.: U.S. Government Printing Office.

Golbe, Devra L. (1981). "The effects of imminent bankruptcy on stockholder risk preferences and behavior." *Bell Journal of Economics* 12(1):321-328.

Golbe, Devra L. (1986). "Safety and profits in the airline industry." *Journal of Industrial Economics* 34(3):305-318.

Golbe, Devra L. (1988). "Risk-taking by firms near bankruptcy." *Economics Letters* 28(1):75-79.

Kahn, Alfred E. (1988). "Surprises of airline deregulation." *American Economic Review Papers and Proceedings* 78(2):316-322.

Kanafani, Adib, and Theodore E. Keeler (1989). "New entrants and safety." In Leon N. Moses and Ian Savage (eds.) *Transportation Safety in an Age of Deregulation*. New York: Oxford University Press.

Kanafani, Adib, and Theodore E. Keeler (1990). "Air deregulation and safety: some econometric evidence from time series." *Logistics and Transportation Review* 26(3):203-209.

Kern, John S. (1988). "Effect of deregulation on the Federal Aviation Administration's inspection and surveillance efforts." *Proceedings of the Transportation Deregulation and Safety Conference*. Evanston, Ill.: Northwestern University Transportation Center.

Morrison, Steven A., and Clifford Winston (1986). *The Economic Effects of Airline Deregulation*. Washington, D.C.: Brookings Institution.

Moses, Leon N., and Ian Savage (1989a). *Transportation Safety in an Age of Deregulation*. New York: Oxford University Press.

Moses, Leon N., and Ian Savage (1989b). "The effect of airline pilot characteristics on perceptions of job safety risks." *Journal of Risk and Uncertainty* 2(4):335-351.

Moses, Leon N., and Ian Savage (1990). "Aviation deregulation and safety: theory and evidence." *Journal of Transport Economics and Policy* 24(2):171-188.

Nance, John J. (1986). *Blind Trust*. New York: William Morrow.

Northwestern University Transportation Center (1987). *Proceedings of the Transportation Deregulation and Safety Conference*. Evanston, Ill: Northwestern University Transportation Center.

O'Brien, John E. (1988). "Deregulation and safety: an airline pilot's view." *Proceedings of the Transportation Deregulation and Safety Conference*. Evanston, Ill.: Northwestern University Transportation Center.

Oster, Clinton V., John S. Strong and C. Kurt Zorn (1992). *Why Planes Crash: Aviation Safety in a Changing World*. New York: Oxford University Press.

Rose, Nancy L. (1990). "Profitability and product quality: economic determinants of airline safety performance." *Journal of Political Economy* 98(5):944-964.

Schiavo, Mary (1997). *Flying Blind, Flying Safe*. New York: Avon Books.