FEDERAL AVIATION ADMINISTRATION METHODOLOGY

Christopher J. Mayer
Federal Aviation Administration

Introduction

The Airline Deregulation Act of 1978 substantially changed an industry that was regulated in almost all phases of operation for over fifty years. Much public discussion has centered on whether deregulation has lived up to the promises of its early proponents. Discount fares have spurred many more first-time fliers and made flights much more accessible for leisure travel. Non-restricted fares, however, have gone through the roof as airlines used their computer reservations systems and travel restrictions to segment the market for air travel. Real yield, defined as revenue per passenger mile, has actually increased since 1978. Some economists have suggested that increasing concentration at major airports, caused by the hub-and-spoke system and recent mergers, presents a formidable barrier to entry and will result in still higher fares. Early proponents and current advocates disagree, saying that airline markets are contestable (competitive).

This paper focuses on structural changes since deregulation, particularly on shifts in aggregate supply and demand and new fare structures. The research began when I was employed by the Federal Aviation Administration (FAA) to evaluate their forecasting process, which had come under significant political criticism due to its consistent underestimation of traffic growth. Although there was little evidence that political factors biased FAA forecasts, I found the FAA process had some structural problems. Also, FAA forecasters were relying less on their econometric model and more on "judgment" and "intuition" to produce their projections. They argued that the large fluctuation in air travel and fares made it difficult, or even impossible, to specify a structural or forecasting model for air travel.

The goal of this paper is to quantify a forecasting model for the airline industry. In addition, I will attempt to illustrate what demand "would have been" had deregulation never occurred in order to understand better the changes since 1978. Given the forecasting applications of this work, I will utilize macro/aggregate data. As noted later, these are not the best data to use for drawing conclusions about specific aspects of pricing. However, a model using city-pair data to create a "bottoms-up" forecast would be extremely complicated and less reliable.

Deregulation Hits the Airline Industry

From its infancy, the airline industry was heavily regulated. During the 1920s and 1930s passenger traffic was marginally profitable and was sustained mostly through large air mail and passenger subsidies. The Kelly Act of 1925, and subsequent legislation, gave the Postmaster General control of routes and effectively limited competition. (The "Big Four" airlines--United, American, TWA and Eastern-- received nearly 94 percent of the airmail contract money.[1]) In 1938 Congress passed the Civil Aeronautics Act, creating a new regulatory authority for aviation and freezing the industry structure as it was at that time.

This new regulatory authority, reorganized as the Civil Aeronautics Board (CAB) in 1940, had the authority to:

1. control entry into the industry,
2. control entry and exit on specific routes,
3. regulate fares and control subsidies to airlines,
4. approve mergers and intercarrier agreements, and
5. investigate deceptive trade practices and "unfair" competition.[2]

In using these powers, the CAB was to maintain the (possibly contradictory) goals of promoting adequate and efficient service by airlines at reasonable fares and fostering competition necessary for sound development.

During the forty years between the Civil Aeronautics Act and deregulation, the CAB maintained a tight grasp on the industry. Although the Board created a new class of airlines for local service, no new trunk carriers were approved. Of the original sixteen trunks, only eleven remained as of 1978, and the "Big Four" were still the same. Subsidies for trunks were completely eliminated by the late 1950s, although commuters continued to receive them.

Fares also retained their original structure, mostly varying by distance rather than by cost of providing service. With the introduction of long-range propeller aircraft in the late 1940s and

1950s and jet airplanes in the 1960s the relative cost of long-haul service fell substantially. Rates were reduced to reflect lower average costs, but fare formulas retained the same form, not reflecting differences in the marginal cost of service on different routes. By the 1970s passengers on long-distance flights were substantially subsidizing those on short-haul routes and denser markets were subsidizing thinner ones. Any deviations from these posted fares needed CAB approval and were often contested by other airlines. These lengthy and expensive procedures discouraged airlines from offering any substantive fare discounts.

Route entry was similarly discouraged. Obtaining the "Certificate of Public Convenience and Necessity" that was required to begin serving a city pair was very difficult. Carriers needed to show that entry would not harm any existing airlines and would be profitable. Other airlines would often contest these hearings, with many cases drawn out for years before any decision was reached. In practice, very few new certificates were approved.

The Board also restricted the type of routes an airline could serve and the aircraft it could operate. Only trunks could operate all types of aircraft and receive approval for any market. Local carriers used narrow jets and propeller airplanes and were allowed to serve only regional markets. Commuters could serve any markets, but only with airplanes under 20 seats (30 seats after 1972 and 60 seats after deregulation) while intrastate carriers were restricted to service within a given state.

Despite (or because of) this strict regulation, airlines were never particularly profitable. On lucrative markets they competed away profits with higher service levels, including increased capacity and flight frequency and better on-board service. The CAB often blocked exit from less profitable routes. To discourage competition, the CAB would disallow recovery of expenses relating to price or service wars. (In recessions, this strict regulation prevented airlines from changing prices to cover their costs.) In a growing economy when industry profits declined, the CAB intervened by giving airlines antitrust immunity to meet and agree on capacity reductions. This became a vicious circle; regulation led to further service competition causing reduced profitability and calls for stricter regulation. Even with capacity restrictions (in the form of minimum load factor requirements) and stringent fare regulation, the industry's financial condition remained poor.

By the mid 1970s, high fares and inefficient service levels caused increasing numbers of economists and politicians to call for (economic) deregulation of airlines. Observations of the unregulated California and Texas interstate markets, with fares 50 percent lower than those of national trunks on comparable routes, helped fuel the discussion. The (Senator Edward) Kennedy Oversight Hearings of 1975 began the official process toward deregulating the airline industry.

The CAB also started moving in this direction. In 1976, under Chairman Robson, it relaxed charter restrictions and approved some limited discount fares. Alfred Kahn continued this process during his tenure as chairman, allowing further fare reform and more liberal route access. By 1978 fares were falling for the first time since 1966 (in real terms), and airline operating profits were at their highest level since the mid-1960s[3]. Given these conditions, Congress easily passed the Airline Deregulation Act of 1978.

The Act provided for a slow elimination of the CAB's authority, with the Board ceasing all operations by January 1, 1985, and transferring its remaining authority to the Department of Transportation. Entry and exit regulations and route restrictions were to be slowly eliminated (the latter by January 1, 1982), opening the market for increased competition. Subsidies for service to small communities were assured under the Essential Air Service Program, but other subsidies were to be phased out over a six-year period.

Although the CAB would be around another six years, its own policy changes quickly reduced its role in the industry faster than even Congress had anticipated. Within a year after deregulation, carriers were able to enter almost any market. In the eighteen months following the Act, city-pair authorizations increased from 24,000 to over 106,000[4].

Initially carriers rapidly expanded into new markets, often without a strategy toward their overall route structure. As time passed, airlines began to consolidate their operations, forming hubs at major airports. For instance, in 1978 68 percent of all trips were taken on a single airplane. By the beginning of 1982 this figure had reached a high of 73 percent, but then it fell steadily, with single-plane service comprising only about 65 percent of all trips at the end of 1987[5]. Most of these connections are on the same airline, or a "code-sharing" partner operating in conjunction with the other carrier. (The "code-sharing" agreements are contracts whereby one carrrier's flights, usually commuter, are listed under the code of a larger, major airline. The two airlines act as one for marketing and operating purposes.) Carlton, Landes and Posner[6] show that consumers greatly prefer single-carrier connections. Although hubbing had begun on a small scale before 1978, deregulation allowed airlines to take full advantage of its revenue efficiencies including higher load factors and more frequent service between hubs and other cities.

New entrants also began to flood the market. By September, 1981, there were ten new airlines at the national level and many more commuters. In subsequent years dozens of new carriers would enter (and exit) the market, leaving the industry in a constant state of flux. Most of these new-entrants and former intrastate airlines, such as Southwest, PEOPLExpress, Air Florida and World, had significantly lower cost structures than the incumbents, often by 50 percent or more. (This included both direct operating costs as well as capital expenses.) The new carriers were mostly non-union, paid significantly lower wages, and demanded more work. They flew older airplanes and used them much more frequently than incumbents. Savings were also gained by service cutbacks, such as cutting ticket offices and eliminating food or snacks on many flights.

Competitive pressure resulted in sharp fare wars. This had started before deregulation when, in 1977, the CAB approved limited 30-day advance purchase discounts on some trans-continental flights. By 1978, the Board had reformed its fare policies, allowing airlines freedom to set fares in a "suspend-free" zone ranging from 10 percent above approved coach fares to 70 percent below. This policy led to immediate discounting as carriers attempted to fill previously unused seats. Although industry profitability initially jumped, the oil crisis halted this trend. Real fuel prices almost doubled in 1979, and fares could not keep pace. The upper fare region became a binding constraint as the CAB was too slow to raise coach fares. This inherent regulatory lag led the Board to expand its zone of flexibility in May, 1980.

Since that time, CAB fare regulation has ceased to be a factor. Real fares fell during the early 1980s (and have remained low until recently) as intense competition led to fare wars and increased discounting. The structure of fares also changed. Many new entrants offered uniformly low coach fares. Incumbents responded with increasingly complex fare structures that attempted to discount fares for price sensitive customers while keeping high regular coach fares for business travelers. As a further lure for these valued customers, they set up Frequent Flyers Programs that gave away free travel based on mileage flown. These perks, along with the new entrants' reputation for poor service, helped the major carriers keep the business travelers. (An Air Transport Association survey showed that in 1979 3 percent of all fliers took 36 percent of all trips[7].)

Attracting frequent flyers allowed the incumbent carriers to survive, even with their high costs. Discount fares became more prevalent in the 1980s, but full coach fares rose sharply despite the competition. [ATA figures show that in 1980 48 percent of all passenger miles on major carriers were discounted, at an average of 43 percent below the full fare. By 1987 91 percent of the passenger miles were flown at an average discount of 62 percent[8].] (Figure 1) Requirements such as

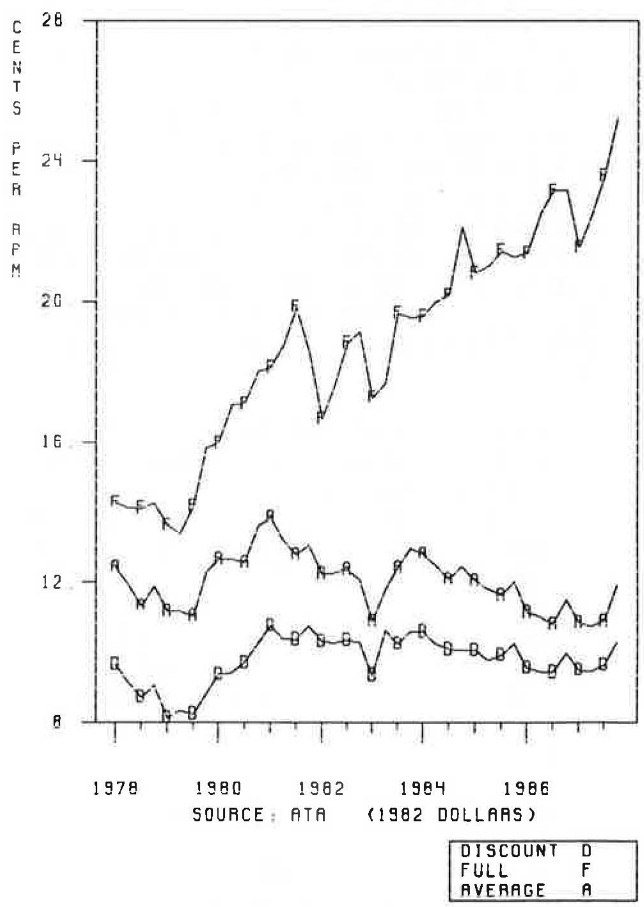

FIGURE 1. Real Yield, By Fare Type

advance purchase, Saturday night stay and limited refunds allowed airlines to price discriminate in a fashion matched by few other industries. Unable to attract lucrative business travelers that made up half of all passengers, most new entrants went bankrupt or merged with an established carrier. Between 1979 and 1987 the industry had 84 mergers or failures. The major airlines commanded 93 percent of all revenue passenger miles (RPM) in 1987, higher than even 1978 when they had 91 percent of industry RPM. USAir/Piedmont was the only new carrier in that group, but both its components were successful regional airlines before deregulation.[9]

Recent mergers have further strengthened the remaining major carriers. In 1986 and 1987 there were many large transactions, including Texas Air's purchase of Eastern Airlines and PEOPLExpress (it already owned NY Air and Continental), United's purchase of Pan Am's Pacific routes and mergers between US Air/PSA/Piedmont, Republic/Northwest, TWA/Ozark, Delta/Western and American/Air Cal. These combinations resulted in an industry with a few mega-carriers and little room for new entrants. Hubbing further strengthened the airlines' market power by giving each carrier control of its own hubs. For example, TWA has a market share over 75 percent at its hub in St. Louis, while Northwest similarly controls its hubs in Memphis, Detroit and Minneapolis. Such domination by one or two airlines has become common at most major airports. In contesting the US Air/Piedmont merger, America West suggested that,

> *"There is...consistent evidence that a market share above 30 percent at an airport without government imposed capacity constraints will be associated with higher fares than those charged on routes including only airports at which the airline is a small player."*[10]

Circumstantial evidence supports these conclusions--yields have risen significantly in 1987 and 1988 as airline concentration has increased.

Evaluating FAA Forecasts

Given this turbulent past, it would seem quite difficult to forecast industry traffic growth. The current FAA forecasting model utilizes econometrics as well as intuition to forecast various "workload measures". These workload measures, such as instrument operations at towered airports and aircraft-handled at Air Route Traffic Control Centers (ARTCC's), are the bottom-line requirement of the FAA. In addition, secondary measures such as load factors, RPM, enplanements, and yields are calculated and published as inputs in the process. Although the FAA forecasts look at many other sectors including commuter, general aviation, and military flights, this paper explores only the model used to forecast commercial air carrier operations. Some of the comments, however, will be applicable to other areas of the forecasting process.

In evaluating an econometric model, one must recognize that there are four potential sources of forecasting error:

1) Specification Error: This results if all of the assumptions implied by econometrics do not hold. For example, a particular equation might be missing an important variable. A researcher might use a logarithmic form when a linear specification was actually correct. Or the equation's coefficients or structure might vary over time (e.g., one would expect the price equation to change significantly after deregulation, when airlines were free to set their own fares).

2) Conditioning Error: This is a frequent source of problems. It occurs when predictions of the inputs to the forecasting model are not accurate (e.g., an unexpected rise in the price of oil, or a sudden recession).

3) Sampling Error: Even if a model is perfectly specified, coefficient estimates will still not be exact because they are based upon a finite sample of data. The longer the time frame, the smaller this error becomes.

4) Random Error: This is a shock that comes exogenously (i.e., is unrelated to any of the inputs) and temporarily changes the predicted variable. For example, a terrorist attack might have a temporary negative effect on demand for international flights.

To correct the first two types of error FAA uses a process of consultation with independent outside aviation experts to obtain their judgments and intuitive sense about potential changes in the air travel and airline industry.

The FAA model (Figure 2) begins with cost and efficiency measures that are used to predict industry yields. The yield prediction is then combined with an estimate of future GNP to forecast revenue passenger miles (RPM). RPM is converted to enplanements and used with predictions about the average load factor, aircraft size, and trip length to estimate future operations -- both instrument flight rule (IFR) and visual flight rule (VFR)--at airport control towers, air route traffic control centers (ARTCC), and other FAA facilities.

To help evaluate past performance, Table 1 lists the percentage difference between FAA one-year forecasts and actual values of selected statistics. The numbers show that forecasts of key traffic variables after deregulation have been low. The average percentage error on forecasts of total operations (not including 1981, the year of the air traffic controllers' strike), an important workload measure, is -1.9 percent. This error seems to stem, at least partially, from mistakes on key inputs. High estimates of fuel prices and yields may have caused low forecasts of RPM and enplanements. It is unclear how to view the role of "intuition" in producing this model. For example, the estimates of yields were too high, but few analysts expected the bitter fare wars that occurred in the mid 1980s. These figures do suggest, however, that there may be some systematic problems in the forecasting model that are causing low forecasts.

The FAA forecasting process, including its level of technical detail and reliance on econometrics, is probably average for the industry. Aircraft manufacturers, such as McDonnell Douglas and Boeing, have much larger staffs that use more detailed models to forecast world air traffic and cargo demand and break it down by region and airplane size. Other manufacturers have cut their forecasting staffs significantly, instead relying on their "intuition" and market knowledge to predict demand.

The airlines have also decreased the size of their forecasting departments and are looking at much shorter-term forecasts. One forecaster for a major airline estimated that he spent 50-60 percent of his time producing 30-90 day revenue and traffic forecasts and most of the remaining time on 1-2 year forecasts. He noted that management was much less concerned with a longer time frame and considered long-range predictions unreliable. Most of the airlines still produce "top down" (national) forecasts and estimate their share of the market. Some carriers, however, are moving more toward regional projections that are less reliant upon aggregate econometrics and more useful for city-pair predictions.

TABLE 1. ACCURACY OF FAA FORECASTS, PERCENT DIFFERENCE FROM ACTUAL

YEAR	IFR OP's (ARTCC)	IFR OP's (TOWER)	OP'S (TOTAL)
1976	4.032	3.158	5.376
1977	0.769	-2.970	-1.020
1978	1.471	-1.923	0.000
1979	0.714	0.935	0.000
1980	3.597	3.774	5.941
1981	8.462	5.882	0.526
1982	-7.087	-4.211	-3.333
1983	-2.256	-3.960	-4.124
1984	-2.128	-6.195	-7.339
1985	0.000	-1.695	-0.885
1986	-3.750	-2.344	-3.252
1987	-2.924	-4.348	-2.290

YEAR	GNP	FUELPR	SEATS/AC	TRIPLEN
1982	1.509	*	1.526	0.958
1983	1.788	*	-0.261	-0.546
1984	-0.627	8.578	1.175	1.516
1985	1.040	-2.107	2.632	-0.475
1986	0.728	22.992	0.196	-0.301
1987	-0.521	20.079	0.460	-1.418

YEAR	YIELD	ENPLAN	ASM	RPM	LOADS
1982	14.416	-6.195	*	-5.294	1.541
1983	9.677	-2.101	*	-2.773	-1.173
1984	-4.930	-0.223	*	1.304	5.536
1985	7.673	-3.995	*	-4.439	-2.956
1986	7.692	-5.036	-4.444	-5.299	-0.829
1987	3.835	-1.904	0.498	-3.292	-3.728

*-missing or unpublished

Some airline forecasters noted the significant information advantage they have over FAA in forecasting demand. Airlines have access to advance bookings that give a better idea of future changes. (This allowed airlines to conclude very quickly that the stock market crash would not significantly reduce air travel.) Computer systems will track frequent flyer miles to determine their effect on future traffic growth. Finally, and most importantly, the forecasters have access to future marketing strategies that will help predict areas of growth and movements in fares (i.e., they are making predictions based upon expected business actions that make it more likely that their forecasts will be accurate).

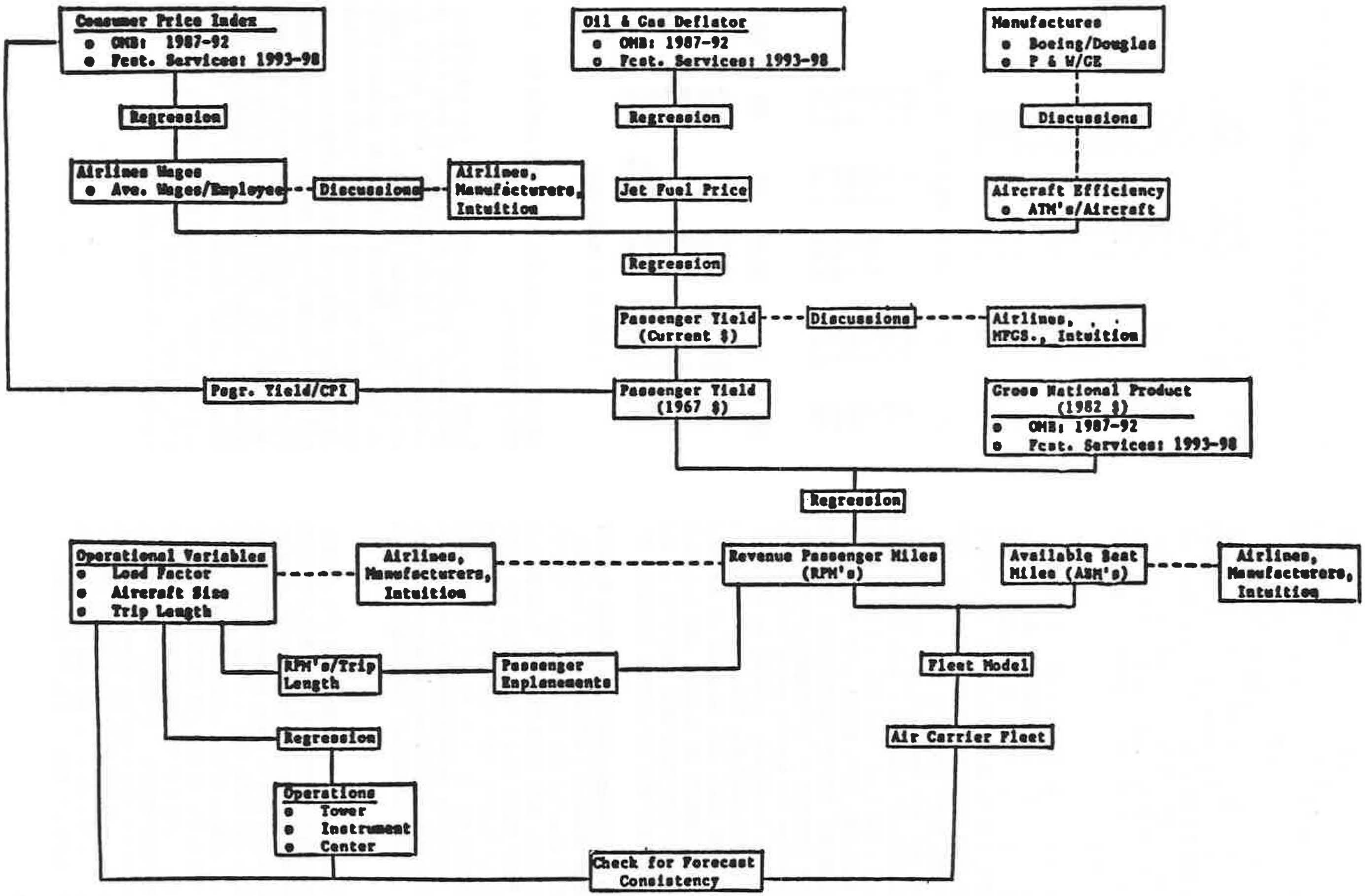

FIGURE 2. Commercial Aviation Forecasting System

Potential Improvements

One must note that it is easy to conclude that a model is missing important elements. Many econometricians are tempted to add variables to a model because the additional variables will increase the R-squared value. (i.e., the explanatory power of the regression). New variables, however, can create potential problems for forecasting both in terms of complexity and accuracy.

Data Sources. Deregulation caused significant changes in the airline industry. Fares were no longer regulated, and airlines were free to enter and exit any route they wanted, provided there were landing slots available at both endpoints. A major assumption of econometrics is that the structure of an industry remains constant (so that the coefficient estimates do not change). It is possible to test whether a specific econometric relationship remains the same over time.

For example, look at the demand equation used by the FAA to forecast RPM. Table 2 lists the results of regressing RPM on real yield (RYIELD), real GNP (RGNP), both in logs, and on quarterly dummy variables, all using quarterly data. The first regression runs from the fourth quarter of 1969 to the end of 1987. The others split that sample into two periods at the third quarter of 1979. It is quite clear that the coefficients change significantly during this period. A Chow test comparing the first regression with the other two clearly rejects (at the 1-percent level) the hypothesis that the coefficients remain the same. This suggests that using pre-deregulation data to estimate this equation will result in biased coefficients. Changes in GNP and yield have much larger numerical effects on RPM after deregulation than they had before. (This is consistent with the advent of discount fares that have made air travel much more accessible to those with lower incomes and route structures that are more responsive to demand.)

Log vs. Linear Form. Currently the FAA estimates all equations in linear form:

$$y= \alpha + \beta^* x_1 + \Gamma^* x_2 + \epsilon$$

This form implies that changes in the explanatory variables enter additively to the dependent (left-hand-side) variable. This means that a one unit change in x_1 will cause y to increase by β. In the first RPM equation in Table 2 this implies that a one thousand dollar increase in GNP results in 18.6 additional RPM. (Note: GNP is measured in billions, while RPM is denoted in millions.)

Some suggest that logarithmic form is more appropriate:

$$\log(y)= \alpha + \beta^*\log(x_1) + \Gamma^*\log(x_2) + \epsilon,$$

which is equivalent to: $y= c^* x_1^{\beta} {}^* x_2^{\Gamma} + \epsilon$

Using log form is appropriate if changes enter in a multiplicative fashion (i.e., holding elasticity constant) In this case, a one percent change in x_1 will move y by β percent.

Boeing solves this problem by estimating its demand equation using both log and linear form, arriving at a final forecast that is a weighted average of the forecasts of each equation. There is no theoretical reason to support such a system. The form that is used should depend on the particular variables in the equation and how the forecaster expects they will affect the dependent variable. In the FAA forecast model there are some equations, particularly the RPM model, that might be better specified in log form.

TABLE 2. REGRESSING RPMS ON REAL YIELD AND REAL GNP

VAR	1969:4-1987:4	1969:4-1979:3	1979:4-1987:4
CONSTANT	2.809 (1.403)	-1.450 (-2.373)	-2.010 (-2.320)
QTR1	-.006 (-1.057)	-.005 (-.540)	-.136 (-1.767)
QTR2	.061 (8.875)	.057 5.287)	.062 (7.170)
QTR3	.100 (13.609)	.117 (8.845)	.084 (10.536)
RGNP	1.212 (4.998)	1.677 (6.709)	1.869 (20.591)
RYIELD	-.719 (-7.333)	-.549 (-3.042)	-.893 (-10.365)
RHO	.987	.729	.461
R^2	.995	.984	.992

Note: All variables are in log form
Dependent Variable: Revenue Passenger Miles (RPM's)
QTR1, QTR2, QTR3 are quarterly dummy variables
All equations corrected for 1st order autocorrelation using a maximum-likelihood search procedure, RHO is shown below. t-statistics in parentheses below coefficient estimates

Simultaneous Equation Bias. Suppose we look at a simple system of two equations as follows:

1) $DEMAND = a + b^*(INCOME) + c^*(PRICE) + \epsilon_1$

2) $PRICE = \alpha + \beta^*(COST) + \Gamma^*(DEMAND) + \epsilon_2$

Regressions using ordinary least squares (OLS) assume that shock ϵ_1 is normally distributed with mean zero and unrelated to DEMAND. In this system of equations, however, that is no longer true. Let ϵ_1 be positive. This will result in an increase in DEMAND, causing PRICE to rise in equation 2. When PRICE rises it has further effects on DEMAND. The above scenario suggests that the error is related to DEMAND, violating one of the key assumptions of OLS. An increase in ϵ_1 will be attributed to PRICE, leaving equation 1 with a biased estimate of c, the PRICE coefficient.

This example is quite likely applicable to the forecasting model. Unless one assumes that yields are determined strictly by cost variables, it is probable that demand affects prices and yields. (Note that yields fell significantly during the 1982 recession, but costs remained much more stable.) Since yields also enter in the demand RPM equation, a simultaneous-equations bias is presumably present. This bias can be corrected with a technique called two-stage least squares (2SLS). In the above example, 2SLS would use an "exogenous" variable, (such as cost), called an instrument, outside the demand equation to remove the changes in price that are due to shocks in ϵ_1 This leads to consistent estimates of the parameters in the demand equation.

Enplanements vs. RPM. Enplanements, not RPM, are the final demand input in the FAA operations workload equations. A forecast of enplanements is obtained by dividing RPM by the (predicted) average trip length. This process could be simplified by estimating enplanements directly using the same equation as RPM. Both of these statistics are measures of demand. Direct estimates of enplanements would reduce one potential source of error, while the RPM equation could still be used for published predictions.

Air Traffic Delays. Delays are a particularly difficult variable to measure, let alone to use in a forecast. For example, the Department of Transportation now publishes monthly on-time reports for each major airline and fines carriers for flights that are consistently late. Airlines have responded by increasing published travel times, rather than rescheduling flights to less congested times or airports.

It is unclear how to calculate delays. Are they based on time beyond the "optimal" travel time for a route, or on deviations from the published flight schedule? Furthermore there are no reasonable time series that document delays. The FAA measure of delays only counts flights that are more than fifteen minutes late. Its accuracy has often been questioned. Air traffic controllers report delays, but large delay statistics reflect negatively on controller performance. Many in the airline industry have suggested that accurate delay figures would cause a public outcry demanding additional resources to reduce congestion. However, industry forecasters do not consider delays significant enough to include in their forecasts. One forecaster at a major airline commented that congestion just causes most travelers to allow additional travel time.

How to Handle the Hub and Spoke System. Although the FAA recognizes its significance, the forecasting model does not explicitly consider hubbing because it affects many variables. Increased number of connections cause RPM and enplanements to increase, although passengers are making the same number of trips. Yields decrease because fares are determined by the endpoints of a trip rather than routing. Recent experience suggests that longer trips, where many airlines offer connections, are often less expensive than shorter ones on less competitive routes. The price differences are not completely explained by lower costs per seat mile on longer routes. In fact, hubbing allows carriers to use larger airplanes with lower costs per seat as well as more frequent service.

Figure 3 plots the percentage of trips taken on direct flights since 1976. (i.e., flights such that the passenger never leaves the plane from origin to destination). Interestingly this figure is upside-down u-shaped, rather than being strictly downward sloping as might be expected. Deregulation brought an immediate increase in route authorizations as airlines rushed to increase their flight schedules. Interline connections, common before deregulation, became rare as carriers set fares to keep passengers on-line from origin to destination. Hubs began to operate efficiently around 1983, increasing in size ever since.

Statistics from the Origin and Destination ten-percent ticket sample might be used to correct forecasts for the effects of hubbing, although the change in the forecast might be small for a given year because hubbing moves very slowly compared to other variables. (Note: I recently

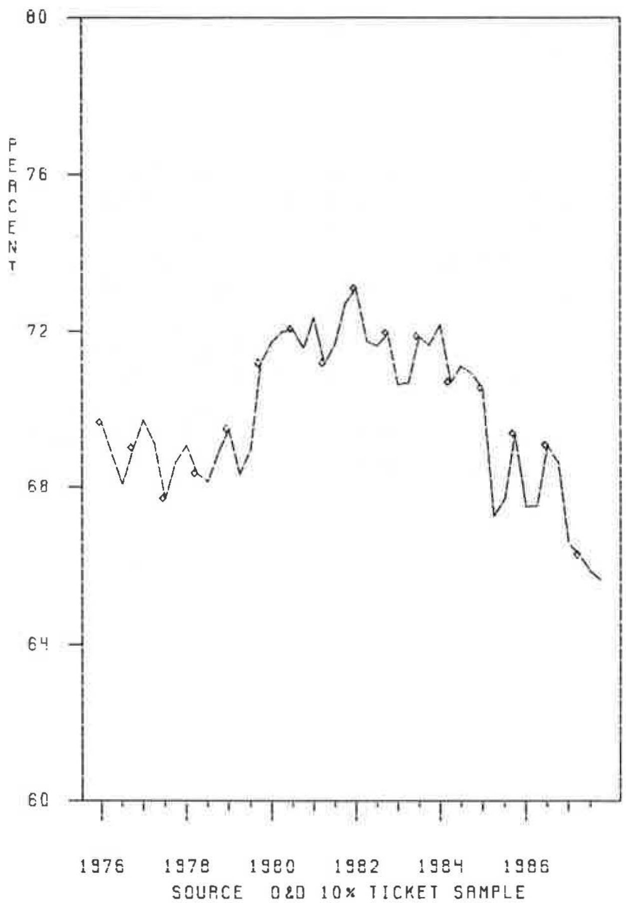

FIGURE 3. Percent of Trips, Direct Flights

discovered that the O&D sample suffered possibly major flaws in the reporting system for most of the period of deregulation. Some airlines never reported frequent flyer trips; many airlines made mistakes on routing. The routing errors, especially those that did not correctly list all connections, could seriously bias the data gathered. The extent of the damage will not be known for some time.) One useful statistic is the extra RPM or enplanements caused by connecting flights (Table 3). Later these statistics are used for supply forecasting and to calculate an average non-stop yield that is helpful for demand predictions. The estimates might also help plan manpower requirements, as hubs place greater strains on air traffic controllers by bunching flights during certain times.

TABLE 3. RPM'S/ENPLANEMENTS AND CONNECTING FLIGHTS

YEAR	TOTAL RPM's / NON STOP RPM's	TOTAL ENPLANEMENTS / TOTAL TRIPS
1977	1.043	1.36
1979	1.042	1.35
1981	1.041	1.31
1983	1.042	1.32
1985	1.045	1.35
1987	1.045	1.37

Efficiency. There are many possible measures of efficiency in the airline industry, including Available Ton Miles (ATM) per aircraft and ATM per worker are commonly used. Table 4 lists the results of regressing real cost per available seat mile (ASM) against these two efficiency measures. Not surprisingly, labor efficiency (ATM per worker) had a significant negative effect on costs, while technological improvements (ATM per

TABLE 4. - REGRESSING REAL COST PER ASM

VARIABLE	
CONSTANT	.244 (.145)
QTR1	-.003 (-.423)
QTR2	-.002 (-.352)
QTR3	-.012 (-1.893)
REAL FUEL PRICE	.167 (6.063)
AVG. REAL WAGE	.361 (2.818)
AVG. STAGE LENGTH	.051 (.194)
ATM PER WORKER	-.495 (-4.523)
ATM PER AIRCRAFT	.016 (.051)
RHO	.517
R^2	.969

Note: All variables are in log form.
Dependent Variable: Real Cost Per ASM
PERIOD: 1982:1 to 1987:4
QTR1, QTR2, QTR3 are quarterly dummy variables.
All equations corrected for 1st-order autocorrelation using a maximum-likelihood search procedure, RHO is shown below. t-statistics are shown in parentheses below coefficient estimates.

aircraft) had an insignificant coefficient. This isconsistent with industry experiences after deregulation, when airlines forced labor to accept pay cuts and changes in work rules in response to competition from low-wage, non-union entrants. below. t-statistics are shown in parentheses below coefficient estimates.

Market and Pricing Power. Most analysts will concede that airlines possess some amount of market power. In discussing monopoly or oligopoly pricing, however, one must first define the relevant market. The Department of Transportation, in approving the recent mergers, has suggested that the airline industry is "contestable". (i.e., potential competition by other major carriers will serve to limit an airline's pricing power, even if the carriers in question do not fly a particular route). Other academics and industry analysts have questioned these conclusions, noting significant barriers to entry that seem to limit competition at hubs dominated by another carrier. Studies by Levine and others have shown that frequent flyer programs, computer reservations systems, limited landing slots, long-term gate leases, cost efficiencies from hubbing, and dominance of local airport committees all serve to limit the ability of an airline to enter and undercut prices in another airline's "turf".[11] One study by Borenstein at the University of Michigan found that fares increase when an airline has a large market share at one of the two endpoints.[12] A recent Department of Justice paper rejected "perfect contestability", finding that the degree of market power depended on the number of potential competitors, as well as the number and size distribution of incumbents.[13]

Most of these studies base their conclusions on micro (city pair) data, and (or hence) their measures of market power are harder to interpret in forecasting aggregate data. For example, after reading the Borenstein study one might attempt to measure market power based on a local concentration index at the airport level. Such a statistic, called a Herfendahl index, is calculated at the airport level and plotted in Figure 4. (Note: The Herfendahl index is defined by summing the squared market share of each airline at a given airport. Airline market shares were recalculated to account for mergers and "code-sharing" agreements. For example, if two airlines each have half the enplanements at airport A then:

$$H = (50)^2 + (50)^2 = 5{,}000$$

If four airlines each have a quarter of the market then:

$$H = (25)^2 + (25)^2 + (25)^2 + (25)^2 = 2500$$

The statistic in Figure 4 is created by taking a weighted average of H at each airport, where the weight is proportional to the number of enplanements at that airport. This statistic measures the level of concentration faced by the average passenger at his departing airport. A more accurate statistic would remove enplanements that are used for connecting flights. However, that level of detail is not reported in FAA records, although it might be possible, if expensive, to calculate using O&D data.

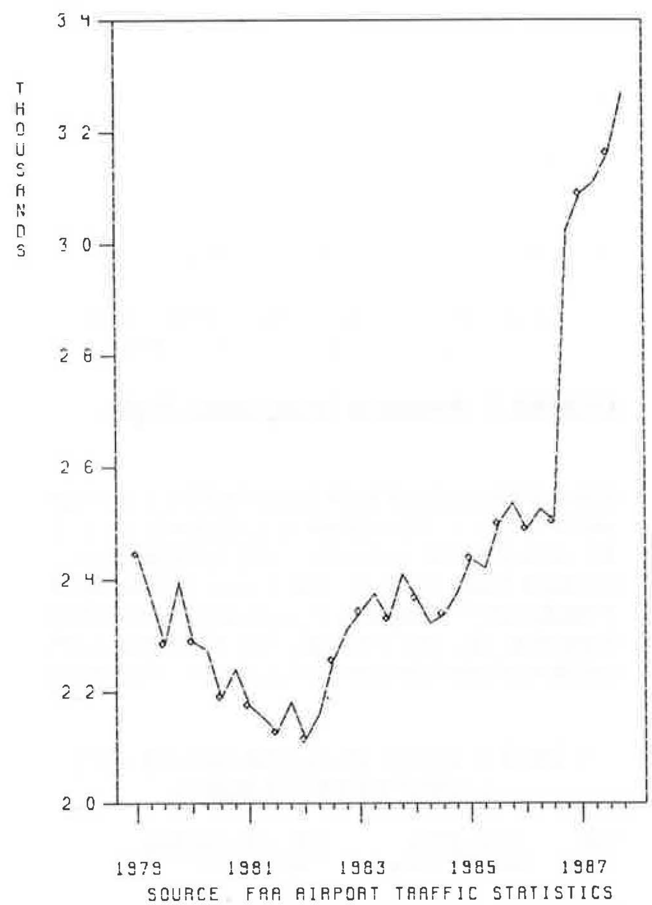

FIGURE 4. Airport Level Herfendahl

This measure, as shown in the next section, does not do a very good job of explaining price changes. This is because it is controlling for too many changes -- a problem that makes estimation harder with macro rather than city-pair data. For example, as airlines get a larger market share at the airport level, fares move in two directions. If the large market share indicates hubbing, it suggests that airlines will be flying more passengers using connecting flights with competition from other hubs. This results in lower yields on these itineraries. However, the local domination gained from these passengers allows that airline to charge higher fares for point-to-point service where they have a high market share at an endpoint. Difficulties in accounting for market power and separating it from hubbing make it difficult to get a good econometric estimate of yields.

Discount Fares Compounding the problem of estimating yields is the prevalence of discount fares that are now used in some form by over 90 percent of all travelers. (See Figure 1 for a breakdown of full and discount yields.) One might expect discount fares to spur additional traffic growth as well as dilute overall yields. This is especially true if discount fares are more prevalent on connecting flights. One might also expect discount fares to be much more responsive than full fares, to changes in market power, which seem to rise uniformly after deregulation. A model could better explain changes in demand after deregulation by accounting for changes in fare structure.

A major problem exists, however, in defining a discount fare. Full fares, as reported by the Air Transport Association (ATA), are currently used by a small and decreasing percentage of travelers. Discount fares range from those requiring a 30-day advance purchase, with a reduction of up to 75 percent off full fares, to "discounts" that can be obtained at the ticket counter the day of the flight. The quantity of discount seats available on a given flight varies, depending on expected demand, which is determined by future reservations. Airlines control the average yield on a flight by changing the quantity of various discount seats. On a given airplane there might be as many as thirty different fares charged to coach-class passengers. In this context, the ATA discount numbers are not ideal because they do not control for quantity. A better way to measure discounts, and again a more expensive method, would be to use the O&D sample and calculate aggregate 20th, 50th and 80th percentile fares.

Demographic Changes. There are several possible types of demographic movements that might affect air travel: age, income, or region. Although the demand equation accounts for GNP, one might hypothesize that the distribution of increases in GNP could matter, as families with different incomes have different propensities to fly. Regional shifts and age changes might also affect travel demand, using the same reasoning. These movements, however, are likely to be very slow, so they would be most applicable in long-term forecasts.

TABLE 5. DEMOGRAPHIC ESTIMATE OF ENPLANEMENTS YEAR 2010[1]

age group	per-capita enplanements (1986-7)	projected population (thousands)	projected enplanements (millions)
18-21	1.604655	15729	25.239
22-29	1.849117	31288	57.855
30-39	3.171652	35312	111.99
40-49	2.805058	40598	113.87
50-59	2.454716	40249	98.799
60-64	1.815891	16023	29.096
over 64	1.220244	39195	47.827
ESTIMATED ENPLANEMENTS USING AGE BREAKDOWN 2010			484.695

	per-capita enplanements	projected population	projected enplanements
all ages	2.236951	218394	488.537
ESTIMATED ENPLANMENTS USING TOTAL POP. CHANGES			488.537
PERCENT DIFFERENCE BY USING AGE BREAKDOWN			- .786

This table demonstrates that changes in the age distribution of the population should have very little effect on the 2010 forecast. In the above example, accounting for movement in the age spread of the population decreases the 2010 forecast by .786 percent, a very minor change for a forecast of more than 20 years.

The analysis assumes that all flights are taken by adults 18 years and older because their is detailed demographic data for this group in the Air Transport Association Gallup Poll. However, the percentage of the population under 18 years old is estimated to fall from the current 26.1 percent to 22.9 percent in 2010. Given this fact, and assuming the children fly less than the adult population, the impact of changing demographics should be even less than we estimate.

This analysis is only meant to isolate the effect of changing demographics and does not provide a realistic method of forecasting traffic. For example, it assumes that per-capita enplanements will remain constant at their 1986-7 average level. Our estimates for 2010 show that per-capita enplanements could double as a result of increase in real per-capita GNP and personal income per-capita income. (Note: The ATA Poll in 1987 shows that only 30 percent of the adult population flew in the last 12 months. Frequent flyers who take more than 12 round trips per year accounted for four percent of these fliers, but flew almost a third of all trips. Clearly there is much room for growth in per-capita flights as family income rises)

1/ Sources: ATA Gallup Poll, 1986 and 1987; and U.S. Bureau of the Census.

A first look at changes in travel demand due to movements in age distribution suggests that this is not a serious bias. Table 5, taken from page 12 of the *"FAA Long Range Aviation Projections, Fiscal Years 2000-2010"*, further details these conclusions. Table 6 lists the propensity to fly, by region of the country. The data imply that it is difficult to use demographics explicitly in a forecast. Changes are too slow to use in a regression with quarterly data. (A time series would be collinear with the constant.) Furthermore, forecasting solely on demographic changes does not control for other variables such as income and price, which are likely to have much larger impacts. Also, one would expect that income is heavily related to the other distributional propensities to fly. Therefore, inclusion of GNP in the demand equation captures much of the demographic movements.

TABLE 6. PROPENSITY TO FLY, BY REGION OF THE COUNTRY

EAST						
YEAR	1970	1974	1979	1983	1985	1987
FLOWN BUT NOT IN LAST 12 MONTHS	27	32	39	47	44	40
1-3 TRIPS IN LAST 12 MONTHS	20	23	24	19	24	24
4-6 TRIPS IN LAST 12 MONTHS	2	3	2	3	4	4
> 12 TRIPS IN LAST 12 MONTHS	3	1	2	2	2	3
NEVER FLOWN	48	41	33	29	26	29
MIDWEST						
YEAR	1970	1974	1979	1983	1985	1987
FLOWN, BUT NOT IN LAST 12 MONTHS	23	30	40	48	45	46
1-3 TRIPS IN LAST 12 MONTHS	15	18	18	14	22	22
4-6 TRIPS IN LAST 12 MONTHS	2	1	2	1	3	3
> 12 TRIPS IN LAST 12 MONTHS	2	1	2	1	1	2
NEVER FLOWN	58	50	38	36	29	27
SOUTH						
YEAR	1970	1974	1979	1983	1985	1987
FLOWN, BUT NOT IN LAST 12 MONTHS	19	24	33	36	37	40
1-3 TRIPS IN LAST 12 MONTHS	14	17	16	15	16	19
4-6 TRIPS IN LAST 12 MONTHS	2	3	3	3	3	3
> 12 TRIPS IN LAST 12 MONTHS	2	1	3	1	3	2
NEVER FLOWN	63	55	45	45	41	36
WEST						
YEAR	1970	1974	1979	1983	1985	1987
FLOWN, BUT NOT IN LAST 12 MONTHS	37	41	42	46	47	44
1-3 TRIPS IN LAST 12 MONTHS	26	27	32	27	30	32
4-6 TRIPS IN LAST 12 MONTHS	2	3	3	4	4	5
> 12 TRIPS IN LAST MONTHS	2	2	4	2	2	4
NEVER FLOWN	33	27	19	21	17	15

SOURCE: Air Transport Association/Gallup Air Travel Survey

The Regulated Airline Industry

In order to understand the changes brought by deregulation, one must first look at the industry as it existed prior to 1978. At that time fares werecompletely controlled by the Civil Aeronautics Board (CAB), using the Domestic Price Fare Index (DPFI), a fare formula of the form:

$$FARE= x_1 + x_2*(MILES<500) + x_3*(MILES,501\text{-}1500) + x_4*(MILES>1500)$$

The coefficients x_1-x_4 were mostly fixed in their proportions and inflated based upon the aggregate industry rate of return. With the introduction of long-range propeller aircraft, and later jets, the cost per seat mile of long flights fell dramatically, but the fare formula did not fully compensate forthis. On longer or denser routes where fares were "too-high", airlines competed away profits with larger aircraft and greater flight frequency. The industry rarely made the regulated rate of return.

In calculating the rate of return for the DPFI, the CAB used its own accounting system. Airlines reported their costs, revenue and traffic every six months. Adjustments were then made based upon CAB requirements and were calculated on averages. For example, after 1971 the CAB set a minimum load factor for the industry. Also, airplanes were required to fly, on average, a certain number of hours per day and have a minimum number of seats. (Note: All of these requirements were established to discourage "ruinous" competition based on excessive service.) Any carrier that did not meet the regulations would have its "allowable" expenses and capital depreciation reduced, increasing its "official" rate of return. Adjustments were also made for "night coach" service (80 percent of full coach fare) and "K-class" tickets (90 percent). Children and military travelers were treated separately, as were the discount fares that were approved beginning in the mid 1970s. Because the CAB used averages, it calculated "approved" yields based upon average stage length, rather than the distribution of flights. Given the non-linear fare formula, this would further bias the DPFI process. With all of these changes, "official" yields were often 15-20 percent below those predicted by the DPFI.

The "official" yields were then used to calculate CAB recognized rates of return. If these were too low, then the CAB would raise the coefficients in the fare formula by a constant percentage. Fare increases were based upon cost increases, but assumed traffic would remain constant. A former CAB employee commented that the CAB did not include future cost increases in the DPFI until 1977. However, regression analysis did not suggest the two-quarter lag that would result if past costs were used to calculate fare increases. (Note: In a recession with diminishing traffic, airlines were severely hurt because they could not adjust fares, which were based upon traffic from the previous six months. The fare inflexibility also hurt carriers coming out of a recession.)

Table 7 lists the results of regressing yield on cost per ASM as reported by the airlines (LCOST), load factor (LLOADS) and a dummy variable (DPRE1971) representing all quarters before 1971, the year CAB began requiring a minimum load factor. I also tried adding average aircraft size and average stage length, but these were major cost components and were collinear with LCOST. In addition, a former CAB employee noted that very few adjustments were caused by airlines not meeting these requirements. Log form was used because changes to yields were based on percentage changes in cost and load factor.

TABLE 7. REGRESSING YIELD ON COST PER ASM

VARIABLE	OLS	2SLS
CONSTANT	.597 (3.724)	.696 (4.071)
QTR1	-.015 (-2.149)	-.018 (-1.547)
QTR2	.023 (2.269)	.014 (1.009)
QTR3	.020 (1.489)	.006 (.325)
DPRE1971	-.036 (-1.889)	-.046 (-3.386)
COST	.697 (11.049)	.681 (14.114)
LOADS	-.494 (-4.244)	-.385 (-2.452)
RHO	.665	****
R^2	.984	****

Note: All variables are in log form
Dependent Variable: Yield
PERIOD: 1969:4 to 1977:4
OLS equation corrected for AR1 process
t-statistics are shown in parentheses below coefficient estimates.

The results were quite good. The elasticity of price with respect to cost was .69, which is reasonable considering that cost is measured per seat-mile, while yields are calculated only for occupied seats. Also, holding cost constant, one would expect increases in the load factor to decrease the allowed yields. Quarterly dummy variables all had expected signs. It seemed possible, however, that the yield variable in the OLS equation might be simultaneously determined with load factor, biasing the coefficient estimates. [Load factor = (total RPM)/(total ASM)]

To investigate, I ran 2SLS using real GNP as an instrument for load factor. This was enough to run a Hausman test of the null hypothesis (Ho:) that the OLS estimates are unbiased. (The Hausman test compares the coefficients and standard errors of the OLS and 2SLS estimates. If there is no simultaneous equations bias, the coefficients in both equations should be close, with lower standard errors in the OLS equation. If simultaneous equations bias is a problem, the OLS coefficients will be biased.) The statistic m = 1.096 $\approx X^2_1$ does not allow rejection of the null hypothesis (i.e., one cannot reject that the OLS and 2SLS coefficient estimates are the same). Although this is not evidence to accept Ho:, further thought suggests that simultaneity should not be a problem. The CAB fare formula was fixed in a given period and did not respond to shocks in demand. Only if airlines had freedom to discount, or to change the composition of discounts, could they adjust price to movements in demand.

Demand, pre-1978, was also easy to understand. The results of regressing RPM's on real GNP (RGNP) and real yield (RYIELD) are shown in Table 6 and appear quite reasonable. Demand has a price elasticity of -.36 and an income elasticity of 1.64. Studies have shown that changes in aggregate supply, either greater flight frequency or larger aircraft, have little effect on demand. (Individual airlines might offer more numerous flights on a route, however, because the carrier can attract a disproportionate share of its rivals' passengers.) Again, the possibility of a simultaneous equations bias exists and Table 8 lists the results of 2SLS, with real cost per ASM and a dummy for quarters before 1971 serving as an instrument for real yield. A Hausman test of the hypothesis that OLS estimates are unbiased gives m = .0759 $\approx X^2_1$ As in the yield equation, we cannot reject the unbiasedness of OLS coefficients.

TABLE 8. RESULTS OF 2SLS

VARIABLE	OLS	2SLS
CONSTANT	-1.555 (-.937)	-2.273 (-.822)
QTR1	-.010 (-1.002)	-.012 (-.924)
QTR2	.060 (5.326)	.060 (4.654)
QTR3	.122 (10.415)	.126 (7.452)
RGNP	1.629 (9.263)	1.698 (6.087)
RYIELD	-.373 (-3.093)	-.309 (-1.422)
RHO	.393	****
R^2	.980	****

Note: All variables are in log form.
Dependent Variable: Revenue Passenger Miles (RPM)
PERIOD: 1969:4 to 1977:4
OLS equation corrected for AR1 process.
t-statistics are shown in parentheses below coefficient estimates.

Effects of Deregulation

The model of the airline industry developed in the previous section gives an interesting opportunity to ask, "What if deregulation never occurred?" In order to answer that question, it is necessary to get estimates of the model's inputs; but these estimates must be exogenous to the airline industry. In particular, it is not accurate to use data for load factor and cost per ASM after 1978 when these variables have been profoundly affected by deregulation.

To obtain a projection for expenses after 1978, I used a cost breakdown based on 1977 CAB figures: Fuel represented 22 percent of operating expenses, non-fuel costs, including depreciation, wages, advertising, etc..., were the remaining 78 percent. To estimate cost changes, the fuel component was indexed using the oil and gas deflator and the non-fuel portion according to the Consumer Price Index. Cost per ASM after 1977 was determined by adding these two components. There are several problems with this measure, mostly relating to the technological change that might have taken place without deregulation. Airlines were still likely to upgrade to larger, more fuel-efficient aircraft. The recession of 1982 would likely have accelerated this process;

previous recessions under regulation caused retirements of older, less efficient aircraft to reduce capacity as well as seat-mile costs. Retirements would have been further encouraged with the new load factor standards, because expenses relating to excess capacity would have been disallowed. A newer fleet of larger aircraft would have resulted in lower fuel and non-fuel costs than I estimate. Any decrease in costs, however, could easily have been eaten up by higher labor costs. Unions in a regulated environment such as airlines or trucking have shown great ability to grab a portion of windfall profits.[14]

Overall, any bias would probably be in the upward direction. Real costs were steady, or even declining, throughout the 1970s. This cost measure increases slightly in real terms. Figure 5 plots the movement in my cost measure (PREDCOST) versus actual costs (COST), both measured in nominal terms. Note that actual costs move substantially below predicted costs after 1982 when new, low-cost airlines entered the market. Recently this difference has started to narrow as airlines have begun to compete using costly items such as frequent-flyer programs and higher quality service rather than just fighting for the lowest price.

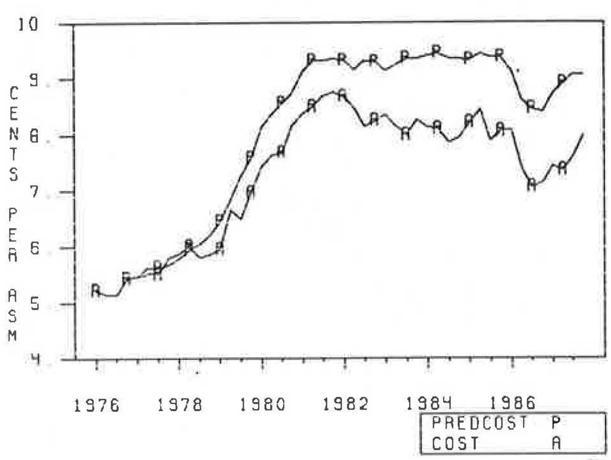

FIGURE 5. Predicted vs. Actual Costs

The load factor would also be difficult to predict. I use a constant 60 percent load factor after 1978, which was the announced CAB standard. In the 1970s airlines showed a great ability to meet CAB load factor requirements. If they exceeded these restrictions, they received higher actual rates of return because the additional passengers and revenue did not affect the yield formula. In practice, however, higher load factors were usually competed away by increased flight frequency.

Substituting these two measures in the previously derived yield equation gives an estimate of what yields would have been if deregulation had not occurred. Figure 6 plots predicted "regulated" yields (PRYIELD) versus actual yields (YIELD). Surprisingly, actual yields are much higher for most of the 1980s. This is even more startling because the cost estimates used for predicted yields may even be too high. One reason might involve the high load factor I imposed, a standard not in effect at the end of regulation. Choosing a lower load factor increases the predicted yields, but it still leaves them below observed yields for most of the 1980s. Another plausible explanation involves the use of discounts to attract traffic. Airlines were able to raise prices for those passengers who had a higher willingness to pay (i.e., business travelers) and give lower fares to leisure travelers[15].

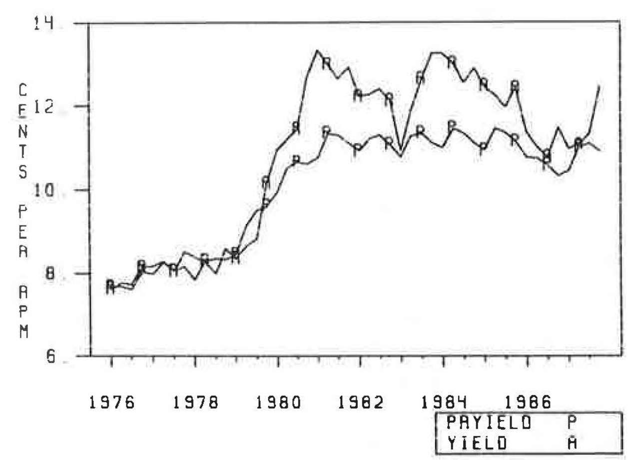

FIGURE 6. Predicted vs. Actual Yield

Combining the predicted yields, converted to real terms, with actual RGNP, which is assumed independent of deregulation, allows a forecast of RPM under regulated conditions. Such a prediction (PREDRPM) is compared to actual RPM (ACTRPM) in Figure 7. Even though this forecast uses predicted yields that might be too low and hence overstate what demand would have been under regulation, deregulation has allowed tremendous increases in passenger miles. By the end of 1987 under regulation there would have been 61.3 billion RPM (60.4 if we assume a 55 percent load factor standard), almost a 25 percent decrease from the 75.8 billion RPM that were

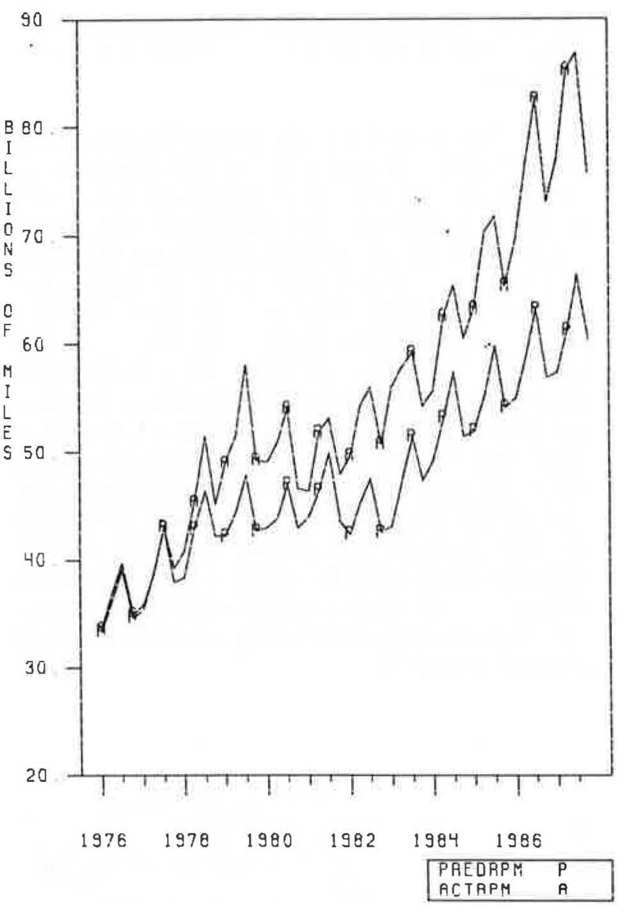

FIGURE 7. Predicted vs. Actual RPM

actually flown. The advent of the hub-and-spoke system has contributed to that rise, but estimatesfrom O&D data suggest this effect is less than five percent. The major part of the increase is probably due to the change in the routes that are now flown and the freedom to set fares according to demand. Figure 2 showed the structural break in the demand equation due to deregulation. After 1979, the income elasticity of demand was substantially higher than previously estimated. Price elasticity was also more negative. Airlines were free to set their route structures based upon demand and use hubs, which geometrically increase the potential travel options. In fact, Morrison and Winston[15] found the greatest gains from deregulation came from increased flight frequency and better service.

Explaining the Deregulated Airline Industry

Several factors explain the changes that occurred after 1978. Here I will develop a set of structural equations that govern the current industry and are useful for forecasting.

I specify a disequilibrium model where there is always aggregate excess supply, although local markets may come closer to clearing[16]. Because supply never equals demand (i.e., airlines never fill all of their seats), price moves as a function of both supply and demand. The following (general) model was used. (For simplicity, quarterly dummies and the constant are omitted).

1) DEMAND= a_1(FARE) + a_2(DISCOUNT FARE) + a_3(RGNP) + ϵ_1

2) ASM'S= b_1(YIELD) + b_2(RPMS) + b_3(COST VAR'S) + b_4(CONCENTRATION) + ϵ_2

3) FARE= c_1(ASM'S) + c_2(TRIPS) + c_3(RCOST) + c_4(CONCENTRATION) + c_5(TRIP LENGTH) + ϵ_3

For equation 1, I tested several specific measures of demand, including ENPLAN (enplanements), NSENPLAN, RPM and TRIPS, where:

TRIPS= NON-STOP RPM (Extra RPM to/from a hub were removed.)

NSENPLAN= NON-STOP ENPLANEMENTS (Extra enplanements were removed.)

For price, both FARE and RYIELD were used, with FARE=REVENUE/NON-STOP RPM (Yield, adjusted for hubbing.)

Supply shocks are allowed to enter demand only through price. This follows the industry view that aggregate changes in supply have little effect on demand. Also, in equation 3 demand and price are assumed to affect ASM only in expectation. (i.e., airlines publish their schedules well in advance and make commitments based on those schedules, implying that supply is predetermined and there is no simultaneous equations bias). All money-related variables are in real terms ($1982-4), and all variables are measured in logs.

To account for changing route structure, some demand-related variables that utilized passenger miles were modified for changes in hubbing. All of the hubbing corrections were made based on O&D data, which I recently discovered may be biased. If anything the bias is downwards, i.e., these variables do not account for the full extent of hubs, rather than overcorrecting for them. In analyzing the ATA discount data I assumed that all full-fare flights were non-stop. Consequently all connections were assumed taken by discount travelers. (Assuming that both types of travelers connected in the same percentage did not change the results.)

First I estimated the demand model, shown in Tables 9, 10, and 11 using ENPLAN, NSENPLAN and TRIPS, respectively, as measures of demand. (There were similar results using RPM.) Because changes in travel distance affect non-stop RPM's, the TRIPS equations also included a variable for average trip length (TRIPLEN):

TRIPLEN= NON-STOP RPM'S/NON-STOP ENPLANEMENTS

In all three equations, I compared OLS results to 2SLS, with ASM, CONCEN (the airport concentration index), DNS (percent of single plane trips), and RCOST (real cost per ASM) as instruments for FARE and TRIPLEN. The results of a Hausman test are given in the tables and provide some evidence that OLS estimates are biased. In the TRIPS equation (Table 9) the coefficient of TRIPLEN (.85) is significant and close to 1. This suggests that estimating NSENPLAN is equivalent to estimating TRIPS and accounting for average trip length.

In addition to the conclusion of simultaneity, the coefficients suggest further differences since

TABLE 9. ENPLAN

VAR	OLS	2SLS	2SLS
CONSTANT	-4.397 (-.998)	-6.705 (-1.316)	-4.971 (-.756)
QTR1	-.024 (-1.598)	-.034 (-2.029)	-.006 (-.226)
QTR2	.051 (3.703)	.043 (2.885)	.065 (2.667)
QTR3	.060 (2.286)	.041 (1.411)	.073 (1.691)
RGNP	1.747 (17.319)	1.694 (21.169)	1.752 (16.031)
TRIPLEN	.460 (.768)	.850 (1.263)	.429 (.475)
FARE	-.831 (-4.926)	-.807 (-3.941)	-1.225 (-3.143)
DISCFARE	****	****	.753 (1.438)
R^2	.992	****	****

Dependent Variable: TRIPS1
Period: 1981:1 to 1987:3
t-statistics are shown in parentheses below coefficient estimates.

NOTE: A Hausman test of equations 1 and 2 gives m = 4.151 ≈ X^2_2 (significant at an 87 percent confidence interval), which provides some evidence that OLS estimates are biased.

TABLE 10. NSENPLAN

VAR	OLS	2SLS	2SLS
CONSTANT	-1.827 (-2.674)	-1.300 (-1.726)	-1.858 (-1.565)
QTR1	-.034 (-3.358)	-.036 (-3.467)	-.032 (-2.441)
QTR2	.051 (5.069)	.049 (4.720)	.052 (4.276)
QTR3	.042 (4.117)	.040 (3.794)	.042 (3.509)
RGNP	1.854 (26.932)	1.810 (24.391)	1.839 (19.987)
RYIELD	-.799 (-11.730)	-.867 (-11.052)	-1.008 (-4.300)
RDISCYLD	****	****	.290 (.647)
R^2	.991	****	****

Dependent Variable: ENPLAN
Period: 1981:1 to 1987:3
t-statistics are shown in parentheses below coefficient estimates.

NOTE: A Hausman test of equations 1 and 2 gives m= 5.761 ≈ X^2_1 (significant at a 98 percent confidence interval), which provides strong evidence that OLS estimates are biased.

TABLE 11. TRIPS

VAR	OLS	2SLS	2SLS
CONSTANT	-1.256 (-1.728)	-.914 (-1.157)	-2.306 (-1.835)
QTR1	-.036 (-3.307)	-.037 (-3.383)	-.021 (-1.477)
QTR2	.042 (3.912)	.041 (3.728)	.055 (3.961)
QTR3	.037 (3.416)	.035 (3.241)	.048 (3.427)
RGNP	1.722 (23.379)	1.693 (21.621)	1.764 (17.718)
FARE	-.723 (-10.086)	-.766 (-9.439)	.874 (-3.337)
DISCFARE	****	****	.470 (1.005)
R2	.989	****	****

Dependent Variable: NSENPLAN
Period: 1981:1 to 1987:3
t-statistics are shown in parentheses below coefficient estimates.

NOTE: A Hausman test of equations 1 and 2 gives m = 1.904 ≈ X^2_1 (significant at an 83 percent confidence interval), which provides limited evidence that OLS estimates are biased.

regulation. The elasticities of demand with respect to both price and income are much greater (in absolute value) than in earlier years. The third column lists 2SLS estimates adding the average discount fare (DISCFARE) or yield (RDISCYLD) to account for the increased dispersion of fares. As noted earlier, the percentage of travelers using the ATA-measured discount fares does not remain constant over time, so it is not surprising that the results of this equation are less than satisfying. The coefficient for the discount fare (or yield) is never significantly different from zero, and the coefficient for average fare (or yield) is not realistic.

Equation 2, estimating ASM, should be considered only as a short-run predictor. Any long-term model must explain the role of capital accumulation in determining supply. For example, the cost of capital is not even mentioned in the above model. (Most major airlines have committed to major purchases of new aircraft without any indications of retiring older models. Older aircraft, however, will face severe and expensive restrictions because of increased governmental attention to safety and noise pollution.) Capital costs will also play a major role in the future as more airlines lease their aircraft, some with short-notice cancellation clauses. (Last year a leasing company placed the largest single order of aircraft in history.)

The results of equation 3, listed in Table 12, are quite satisfactory. (Both log and linear results are listed.) Most of the variation in ASM is explained by changes in variable costs (fuel prices - FUEL and average wages - WAGE), efficiency (available ton miles per worker - ATMPLAB), demand (RPM) and price (YIELD). Not surprisingly, the coefficient for the airport concentration index (CONCEN) was negative, but insignificant. Changes in concentration can result from increased hubbing, which would raise ASM, or increased market power, moving supply in the opposite direction. Also note that expected increases in demand, holding price and cost constant, are met by higher supply and higher load factors (i.e., the demand elasticity of ASM is less than 1).

Estimating fares, however, turned out much more difficult than anticipated. There are several possible formulations:

A) Estimate the equation as it stands.

B) Set $c_3 = 0$, letting costs enter through changes in ASM.

C) Set $c_1 = 0$, assuming aggregate supply does not affect price.

TABLE 12. RESULTS OF EQUATION THREE

VARIABLE	LOG	LINEAR
CONSTANT	6.136 (2.832)	53309.6 (1.669)
QTR1	.006 (.041)	97.691 (.061)
QTR2	-.058 (-3.291)	-5820.59 (-3.067)
QTR3	-.045 (-2.629)	-4297.74 (-2.241)
RPM (MILLIONS)	.793 (6.457)	1.180 (5.587)
RYIELD (CENTS)	.255 (1.529)	1572.60 (1.005)
FUEL (CENTS)	-.097 (-2.151)	-210.021 (-3.067)
WAGE (DOLLARS)	-.549 (-2.695)	-5.380 (-2.613)
ATMPLAB	.366 (2.290)	928.12 (2.381)
CONCEN	-.030 (-.349)	-1.197 (-.337)
R^2	.988	.987
DURBIN-WATSON	2.129	2.043

Dependent Variable: AVAILABLE SEAT MILES (ASM IN MILLIONS)
Period: 1982:1 to 1987:3
t-statistics are shown in parentheses below coefficient estimates.

(All systems were 2SLS with RGNP serving as an instrument for TRIPS.) None of these setups was clearly successful. The results of B and C are in the first two columns of Table 13. (Empirical testing showed that A was clearly incorrect.) Equation B had reasonable coefficient estimates, but the coefficients of ASM and TRIPS were not significant. Equation C is certainly not the correct specification. Results were similar for different log and linear specifications. Other failed strategies included using instrumental variables to correct ASM for changes in hubbing, treating TRIPLEN as endogenous, and removing TRIPLEN from the equation. Equation B suggests that airlines first choose a schedule based on cost and expected demand and then set fares based on realized demand and other airlines' supply, but not cost changes.

Although this story may seem reasonable at first glance, price setting seems more complicated than B would indicate. It is very hard to separate the effects of hubbing, discounts, concentration, cost, demand, and supply using aggregate data. Computer reservations systems have allowed airlines to use very sophisticated procedures to set fares. The average fare may have little meaning because prices are adjusted on a flight-by-flight basis. Price wars often occur in some regions, but never happen on every route.

TABLE 13. REDUCED FORM ESTIMATE

VAR	EQN B	EQN C	REDUCED FORM
CONSTANT	38.214 (2.661)	22.880 (7.909)	17.129 (3.419)
QTR1	.084 (1.958)	.059 (2.863)	.027 (1.001)
QTR2	.005 (.081)	.059 (2.805)	.036 (1.718)
QTR3	.161 (2.921)	.149 (4.969)	.116 (3.484)
ASM	-1.367 (-1.116)	**** ****	-.885 (-2.689)
TRIPS	1.125 (.930)	-.096 (-.918)	****
TRIPLEN	-5.172 (-2.423)	-3.238 (-6.218)	-2.278 (-3.334)
CONCEN	.409 (1.742)	.290 (2.441)	.252 (2.104)
COST	**** ****	.274 (1.303)	-.228 (-.767)
HUBS	****	****	-4.508 (-.885)
RGNP	****	****	1.169 (2.287)
R^2	****	****	.920

Dependent Variable: FARE
Period: 1981:1 to 1987:3
t-statistics are shown in parentheses below coefficient estimates.

The results (Table 13) seem very dependent on the functional form, suggesting that I have not yet specified the correct model. If this is the case, then the solution for the FAA forecasting process is to use the reduced form to obtain consistent forecasts, although the coefficients will have no structural meaning. In a simultaneous equations system, the reduced form regresses each endogenous variable (demand and price) on all exogenous and predetermined variables. An estimate of the reduced form for FARE is listed in the third column of Table 13. Further research is necessary to obtain a structural equation for fares or yields.

Conclusion

This paper confirms the results of many papers on the airline industry -- profound changes have occurred since deregulation, and consumers seem to be the large beneficiaries. RPM is 25 percent greater than if regulation had continued after 1978. Following Morrison and Winston and others, much of this growth seems to have occurred because the industry is more responsive to demand. Demand elasticities with respect to both price and income are larger (in absolute value), and we are able to reject with some confidence the unbiasedness of the OLS estimator after 1978, when previously that was not possible. Demand seems now to be simultaneously determined with price.

This paper should have many applications to the FAA forecasting process. The most significant result is that using pre-deregulation data to forecast demand causes biased coefficient estimates. This bias would result in under-forecasts of demand, a problem in recent FAA forecasts. Other biases might come from problems with simultaneous equations. Accounting for hubbing will remain difficult until all problems with the O&D data set are solved. Demand regressions (Tables 8, 9 and 10) show similar results regardless of whether they are corrected for hubbing. The advantage of using a formal correction is that it provides a systematic method for adjusting forecasts based on changes in hubbing. Problems in defining discount made it difficult to account directly for the changing distribution of fares. The ATA discount data were not useful in that regard. Future work might focus on using 20th and 80th percentile fares as better measures of discounting.

A structural fare/yield equation was less successful in resolving problems. The default is to use the reduced form to forecast yields/fares. This is similar to the current FAA procedure, except that using more variables, especially GNP, will provide a more efficient and accurate forecast.

A new equation is suggested to forecast short-run changes in ASM. FAA might develop an iterative approach to forecast ASM, demand, and fares, using forecasts of ASM to refine the predictions of demand and fares.

Future research should focus on the structure of fares, using percentile breakdowns as a start. Such a study might also better explore the role of concentration and other competitive measures in determining fares. The airport concentration index seemed to come up positive in most of the price equations, but this result cannot be confirmed until getting a properly specified model.

Given the results of this paper, it is clearer why FAA forecasters have had less confidence in their model since deregulation. This is not to suggest that "professional judgment" (or "intuition") does not have a proper role. Judgment allows the forecaster to correct for changes that are not included in the model. (e.g., triple frequent flyer miles, strikes, safety restrictions, terrorism, etc.) However, as one airline executive commented, the government should beware using too much "intuition" in its forecasts. Observers may allege that "professional judgment" is really politically motivated. This paper should help in developing a forecasting process that is more accurate and less vulnerable to political criticism.

FOOTNOTES

1) David, P. (1934), p. 167.

2) Bailey, Graham and Kaplan (1983), p. 7.

3) ibid., p. 33

4) ibid., p. 78

5) O&D 10-percent Ticket Sample Data, 1977-1987 (Table 12).

6) Carlton, Landes, and Posner, (1980), p. 65-73.

7) Air Transport Association 1987 Air Travel Survey, p.13.

8) Air Transport Association Annual Report, 1982-1988.

9) Federal Aviation Forecasts, (1987) pp. 35, 179-181.

10) Borenstein Testimony, DOT Docket 44719, AWA-T-2, p. 10.

11) Morrison and Winston, (1986), Bailey, Graham and Kaplan, (1985).

12) Borenstein, (1987), p.13.

13) Hurdle, et. al., (1988).

14) Rose, N., (1987).

15) The results, however, conflict with those published by Morrison and Winston (1986, p.14). They calculate a fare deflator of 1.93 between 1977 and 1983. (Their deflator is calculated in the opposite way from mine. Morrison and Winston use 1980-81 data to estimate a fare equation, where fare is defined by revenue per enplanement, and then substitute 1977 and 1983 data to get the "deregulated" fares for the years that are used in their index.) In contrast a deflator based on actual yields is 1.38. Using the 55 percent and 60 percent load factor data I get a deflators of 1.42 and 1.36, respectively. Why the difference? Morrison and Winston's fare equation contained several, but not all, cost components, so the cost measures that they used, especially fuel prices and wages, made up a correspondingly larger share of yields.

    Calculating the index in 1980-1 with high fuel prices and wages (new entrants were not yet in the industry) magnified the difference between 1977 and 1983. (This is especially true because the limited CAB fare regulation was still binding during parts of 1980.) Also, the structure of the airline industry, especially with regard to fare setting, was not yet settled during the early 1980s.

16) I also considered using a switching regression for the fare equation because the industry seems to suffer from periods of cut-throat pricing. Price wars, however, seem to be a regional rather than a national phenomenon (e.g., when PEOPLExpress entered the industry, airlines would fight only on routes that PEOPLExpress served.) A switching model would be much more useful in a study using time series, city-pair data.

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NOTE: This paper was begun while working for FAA evaluating their forecasting process. I would like to thank all the workers in the Office of Policy and Plans, especially Bob Bowles, Dave Richards (a former CAB regulator), Robert Stanley and, most of all, Gene Mercer (my former boss) for all their help. The staff in the Research and Special Programs Administration (DOT), particularly Charlie Bradford, helped develop the data in this paper. Mitch Peterson, Nancy Rose, Frank Fisher, and Jerry Hausman at MIT provided helpful comments along the way.