ACRP

REPORT 48

AIRPORT
COOPERATIVE
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Impact of Jet Fuel Price Uncertainty on Airport Planning and Development

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

AIRPORT COOPERATIVE RESEARCH PROGRAM

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Impact of Jet Fuel Price Uncertainty on Airport Planning and Development

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AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The ACRP was authorized in December 2003 as part of the Vision 100-Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), and the Air Transport Association (ATA) as vital links to the airport community; (2) the TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academies formally initiating the program.

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Primary emphasis is placed on disseminating ACRP results to the intended end-users of the research: airport operating agencies, service providers, and suppliers. The ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties, and industry associations may arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by airport-industry practitioners.

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The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

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FOREWORD

By Lawrence D. Goldstein
Staff Officer
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ACRP Report 48 provides background research, a computer model on the attached CD-ROM, and a user manual to help airport operators and planners measure the impact of changes in jet fuel price on supply and demand for air service at commercial service airports. The output of the model can ultimately be used to help evaluate the impact of uncertainty on airport development and finance. Applying specific input parameters, the model, embedded in a user-friendly program, allows airport planners and managers to assess how fuel, economic, and other uncertainties may affect their particular airport and to test the sensitivity of varying assumptions about key drivers of airport activity.

The supporting research examines historical changes in fuel prices in the context of changing economic conditions and uses this experience to assess risk in adhering to existing air traffic forecasts when planning future airport improvements or expansion. The model illustrates risk using confidence bands that indicate a range of forecasts as a function of changing jet fuel prices and other factors. The research also examines the historic link between changes in jet fuel prices in relation to periodic occurrence of recessions and how changing demand may, in turn, result in changes in fleet composition and size.

In the summer of 2008, jet fuel *prices* were up more than 200 percent over those experienced in 2000. During this same period, jet fuel *costs* increased from 15 percent to 40 percent of total domestic airline operating costs. These increases caused airlines to raise fares and other fees, cut schedules, and drop scheduled service to some communities. The volatility that began during that period contributed to large and unexpected fluctuations in activity at airports throughout the United States. Following that period, fuel prices declined but began to rise again at the end of 2010. Further changes in air service as well as service reductions are possible, especially if jet fuel prices return to or exceed the high levels that prevailed during 2008.

What exacerbates the problem is that jet fuel prices can change rapidly and in ways that are difficult if not impossible to forecast. As a result, the current level of uncertainty about future jet fuel prices can present significant challenges to airlines and airports as they plan to accommodate changing levels of demand. The premise of this research was that, if airlines and airports were better able to predict the effect of jet fuel price changes on airline service and airport development and finance, they could strategize better (both individually and, where appropriate, collaboratively) how to plan for and accommodate such change. The underlying research that formed the basis for the computer model uses economic data, airport characteristics and operations data, energy futures, and a variety of institutional projections to create a risk-based forecasting model. This model was tested through a series of presentations and applications, reaching out to airport sponsors, operators, and other airport professionals to generate useful feedback.

The report was prepared with airport planners in mind—more specifically, those involved in preparing and/or analyzing short- to medium-term airport activity forecasts (i.e., over a period of two-and-one-half to five years). These planners often have a basic understanding of how to prepare or look at trend-based forecasts but typically do not have the ability to measure or characterize the uncertainty inherent in such projections. This report and the associated computer model provide a practical means for planners to address uncertainty so they can answer substantive questions about how changes in fuel prices and/or the macro-economy can impact their activity forecasts. The software program helps airport planners anticipate changes to *existing* forecasts of air services at literally hundreds of different-sized airports in the United States.

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PART I

Background Research

SUMMARY

Impact of Jet Fuel Price Uncertainty on Airport Planning and Development

Recent volatility in aviation fuel prices has placed stress on airline cost structures, reduced profitability of particular aircraft types, and along with a historic recession has dampened overall economic activity and air travel. This extreme volatility has contributed to large and unexpected changes in activity at airports throughout the United States.

This project involved the development of models of airport activity which can be used to assess uncertainty in future projections of airport activity, particularly as they relate to large swings in fuel prices. The models have been embedded inside a user-friendly software program, the Airport Forecasting Risk Assessment Program, in order to allow airport planners and sponsors to more accurately assess how fuel, economic, and other uncertainties may affect their own airports.

Initial tasks in this project involved analysis of historical changes in fuel prices, a detailed literature review, collection of industry-level data, analysis of activity at different-sized airports, and an assessment of how airlines respond to fuel price changes. These efforts formed the basis for determining how airport activity may be affected by such changes (via air travel supply and demand impacts). Primary findings from this analysis include the following:

- Two of the three economic recessions since 1989 occurred contemporaneously with major fuel price spikes. Nevertheless, the continuous run-up in fuel prices between 2002 and 2008, during a period of relatively strong overall economic growth, suggests there is no simple correlation.
- Airlines can adjust their schedules fairly quickly in response to fuel spikes, but such adjustments are constrained by airlines' limited ability to change their aircraft fleets in the short run. In general, airlines appear to react to fuel spikes and recessions with a lag.
- Carrier reactions to fuel price spikes depend not only on whether they believe the increases to be temporary or more permanent, but also on the demand for aviation services by consumers in the context of the overall macroeconomy, and how sensitive that demand is to changes in air fares.
- While it is difficult to tie observed changes in activity at a specific airport to changes in fuel prices, a more generic analysis of domestic airports suggests that, at least since 1997 (when legacy carriers had largely completed the buildup of their large connecting hubs), smaller airports have experienced relatively larger variations in annual activity.

These findings formed the basis for designing the overall structure of, and inputs to, the air service models that are embedded in the final software. These models are intended to provide a plausible description of the major factors that may affect observed changes in domestic activity at U.S. airports. Using data on airport-level seat departures over the past 20 years, four separate statistical models were developed that could be applied to 271 specific airports

across the continental United States. The air service models explain percentage changes in annual seat offers. For projection purposes and use in the software, seat offers estimates from the statistical models are translated into operations and enplanements, which in turn are used to help project annual airport revenues.

For ease of use, the software is embedded inside a standard Microsoft® Excel spreadsheet file. Because every airport is different, the software tool is meant to assess risk in *existing* forecasts. Such a forecast might be an internal projection made by or for airport staff, or it could be from an external source such as the FAA's Terminal Area Forecast (TAF). The software allows the user to undertake sensitivity studies by varying assumptions about the key drivers of airport activity, with the software generating a range of likely outcomes based on these assumptions.

An important feature of the software is the ability to easily create a risk analysis using confidence bands for whatever forecast is being examined; these bands are generated using an analysis based on the historic range of errors in expectations of jet fuel prices and gross domestic product (GDP) growth. This approach answers a fundamental question: How might an airport forecast be affected given the historic errors in expected future jet fuel prices and economic growth? The software generates a one-page report that summarizes key inputs and the results of the risk analysis. This approach is designed to produce useful information for airport users to enable them to assess uncertainty about future air service, which in turn may have important implications for airport operating budgets and development programs.

As with any forecasting process, the user is ultimately responsible for the assumptions used in the analysis. The software provides a structured way to improve airport forecasts and create sensitivity cases, but it is not a substitute for a well-thought-out analysis.

CHAPTER 1

Introduction

The recent volatility in aviation fuel prices since 2008 has placed stress on airline cost structures, reduced profitability of particular aircraft types, and is coincident with a historic recession that has dampened overall economic activity and air travel. This extreme volatility has contributed to large swings in scheduled air traffic activity in the United States. Overall seat offers in the domestic market declined by well over 11 percent between April 2008 and April 2010. These reductions are not uniform, with activity at some sizable airports declining by as much as 25 percent or more. The fiscal impact on airports is large, but there may be more profound effects on long-term airport planning and development. The purpose of this project was to create tools to assist airports with anticipating changes in air service due to external shocks (particularly fuel price changes) that have important implications for airport development and finance.

The proposal and final work plan for this project called for the work effort to be divided into two phases. The ultimate goal of the Phase I tasks was to develop a model of airport activity which could be used to assess the uncertainty underlying future projections of airport activity, particularly as they relate to large swings in fuel prices. For Phase II, the goal was to embed the model inside a user-friendly software program in order to allow airport planners and sponsors to more accurately assess how fuel, economic, and other uncertainties may affect their own airports.

Exhibit I-1 provides a conceptual overview of the various activities during Phase I and Phase II of the work program. As indicated, substantial outreach was conducted in both phases to gather input from airports and other experts to inform the analysis and modeling activities.

During Task 1, industry-level data was gathered and a review of the literature was conducted to assess the impact of changes in fuel price and other parameters on the levels of carrier service at specific airports. A report detailing the findings from Task 1 was delivered to the project panel in February 2009. A detailed summary of the literature review from Task 1 is provided in the appendix to this report.

In Task 2, a major data collection effort was begun, with emphasis on obtaining long-term histories of both national economic data—such as fuel prices—and airport-specific data—such as local income and airport activity data. A report for Task 2 was delivered at the end of April 2009.

Examination and analysis of the data that was gathered formed the basis for determining how airport activity may be affected via supply and demand impacts identified in Tasks 3 and 4. The data and information obtained from these first four tasks form the basis for the presentation in Chapter 2, which discusses historical changes in airport activity and air services across the country, and how these observations can be correlated to overall economic activity in general and fuel prices in particular.

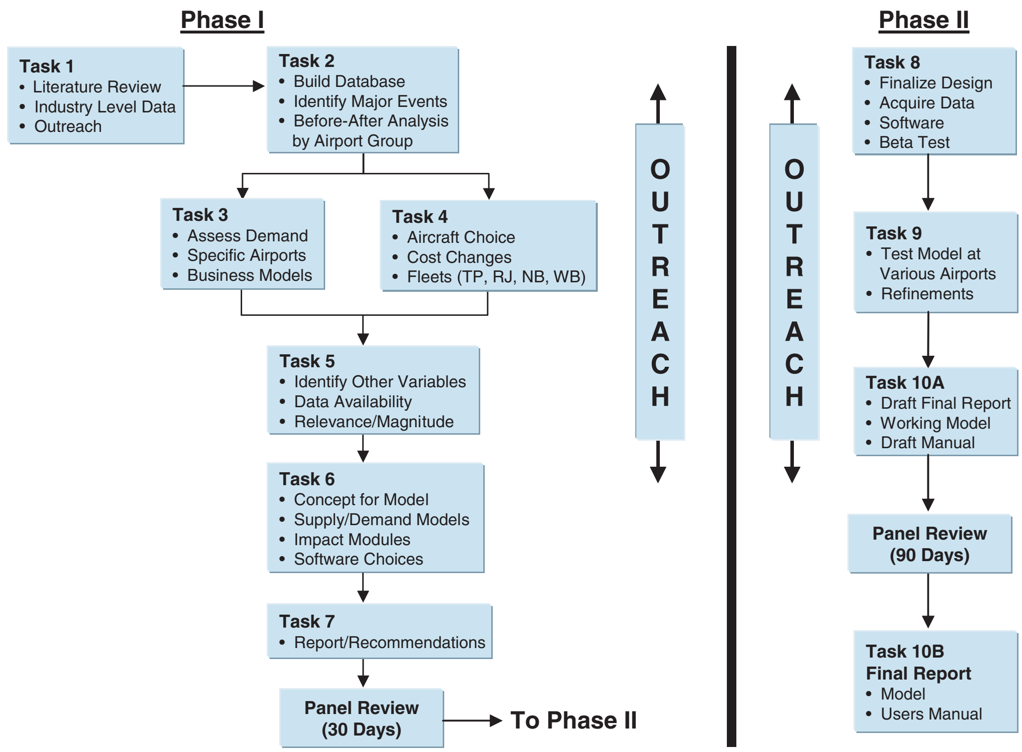
Building upon that foundation, Tasks 5 and 6 focused on building sound statistical models to identify the primary determinants of airport activity. A report summarizing the progress made on the air service models was delivered in June 2009. Chapter 3 provides a detailed technical description of the development and specification of the models.

In October 2009, the Task 7 report was delivered, detailing the initial ideas for the software and describing the final versions of the statistical models. The Task 7 report was also presented to the project panel in January 2010.

In Phase II, Tasks 8 and 9 were devoted to developing and testing software that embeds the statistical model and is designed to be used by airport professionals to help them assess uncertainty associated with activity forecasts at their individual airports. Chapter 4 describes the approach and design concepts used in developing the software. Valuable feedback was obtained from various airport representatives during the testing phase, along with additional feedback gathered from the project panel, which led to a number of revisions and enhancements to the software.

Chapter 5 presents suggestions for future research. An overview of how to use the final software product and a detailed software user manual for the Airport Forecasting Risk Assessment Program are provided in Part II of this report.

Exhibit I-1. Research program overview.



CHAPTER 2

Project Overview and Motivation

The fuel spike and severe recession in 2008 caused a significant reduction in air service at many commercial service airports in the United States. At the peak of the spike, fuel made up 40 percent of airline operating costs. Airports witnessed unanticipated changes in air services, which made both capital improvement programs and operating budgets subjects of concern. The Airport Forecasting Risk Assessment Program is designed to help airports account for the risk inherent in their future air services forecasts by establishing reasonable confidence bands around them; an example of such bounds is shown in Exhibit I-2.

2.1 Fuel Price Uncertainty and the Economy

The most recent fuel spike and recession are part of a larger, longer-term story about how the economy and fuel prices can affect airport activity. Exhibit I-3 shows the history of real jet fuel prices per gallon from 1989 through mid-2009. The prices are expressed in 2009 dollars. Also shown on the graph are vertical (red) lines indicating the months when the U.S. economy was in recession, as declared by the National Bureau of Economic Research.

The U.S. economy has had three official recessions since 1989. Two of them occurred contemporaneously with fuel spikes. In July 1990, the United States entered a recession that lasted until March 1991. In August 1990, Iraq invaded Kuwait, touching off the Gulf War. In July 1990, the price per gallon of jet fuel was 60.3 cents; by November 1990, the price had more than doubled to $1.28 (in nominal dollars).

The second recession took place between March 2001 and November 2001. In that period, the events of September 11 (9/11) had very adverse consequences for the U.S. airline industry. However, fuel prices in this period remained relatively stable. Again using nominal dollars, jet fuel sold for an average of 85.8 cents in March 2001 and sold for only 73.5 cents in November 2001.

Finally, the United States entered a recession in December 2007. In that month, the average jet fuel price in nominal dollars was $2.69; the price subsequently spiked to $4.11 in July 2008.

While the correlation between fuel price increases and major economic recessions is not surprising, the most remarkable feature of Exhibit I-3 is the substantial ramp-up in the real cost of jet fuel beginning in approximately 2002 and continuing well after the economy began to rebound in 2003. From January 2002 until January 2006, the real price of jet fuel tripled. It then more than doubled between January 2006 and July 2008. The volatility in the market is illustrated by the fact that, by January 2009, the price of jet fuel had fallen by more than 50 percent from its July 2008 peak, and in fact was at a lower level than in January 2006.

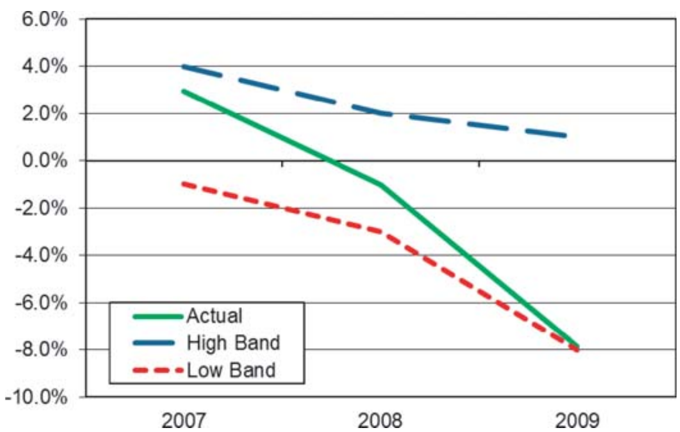
2.2 Effects on Aviation Markets and Carriers

Clearly there have been secular increases in the price of jet fuel over time, but how have they affected airlines? Exhibit I-4 illustrates jet fuel consumption over some of the same time horizon. There were substantial reductions in fuel consumption during the Gulf War (January 1992), just after the events of 9/11, and more recently with the most recent fuel spikes. U.S. industry fuel consumption reached a peak in June 2001. Consumption in November 2008 was about 10 percent lower than the peak.

Exhibit I-5 focuses on changes in fuel prices and consumption in the period since January 2003. The exhibit shows year-over-year percentage changes in both fuel prices and consumption measured on a monthly basis; it therefore provides a good illustration of the volatility in the marketplace. There were clearly three fuel spikes in this five-year timeframe: in the spring of 2003, in the fall of 2004, and in the period beginning in the late summer of 2007 until the summer of 2008.

There is a consistent decline in consumption on a year-over-year basis during all three spikes. Obviously the ability of

Exhibit I-2. Annual enplanements forecast with confidence bands.



the carriers to instantly change their fleets is limited, but they do have the ability to change their schedules fairly quickly. Not surprisingly, whether they elect to do so or not depends on whether they believe that the price spikes are temporary or are likely to be more long term.

Exhibit I-6 focuses on the run-up in fuel prices in 2007 and 2008. The lowest price in this two-year period was in February 2007 when the price per gallon was $1.77. From that point onward, the price climbed in an almost uninterrupted fashion reaching a peak in July 2008 at $3.83 per gallon, more than double the value just 16 months earlier. The price then fell precipitously to just over $2.50 in November 2008.

Exhibit I-7 shows the pattern of fuel consumption by the carriers during this same time period. Notice, first of all, that

Exhibit I-3. Recession periods and real jet fuel price per gallon.

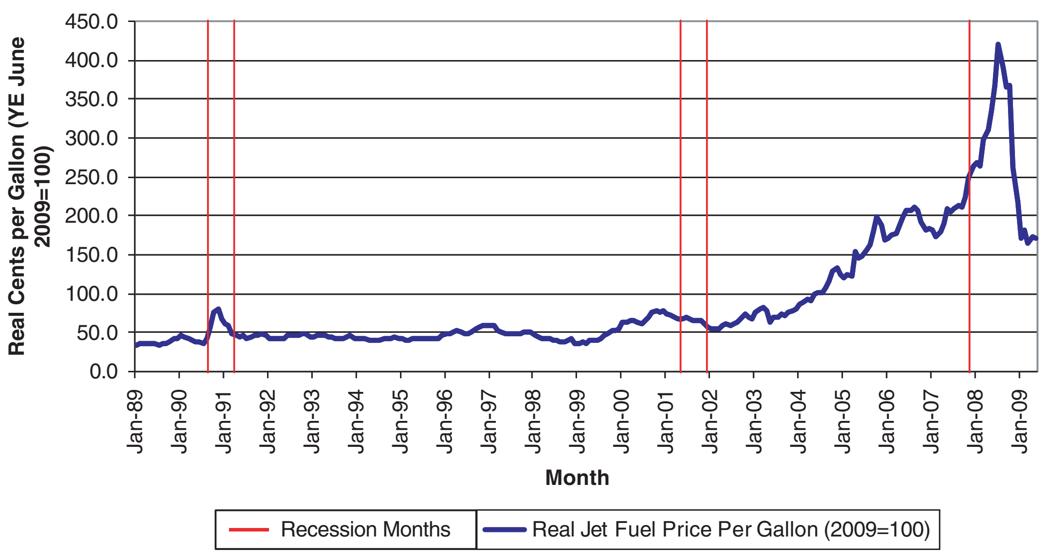
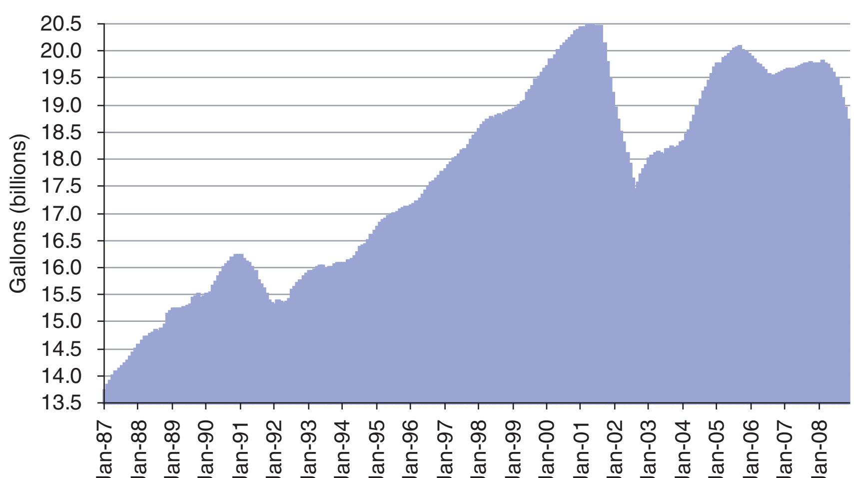
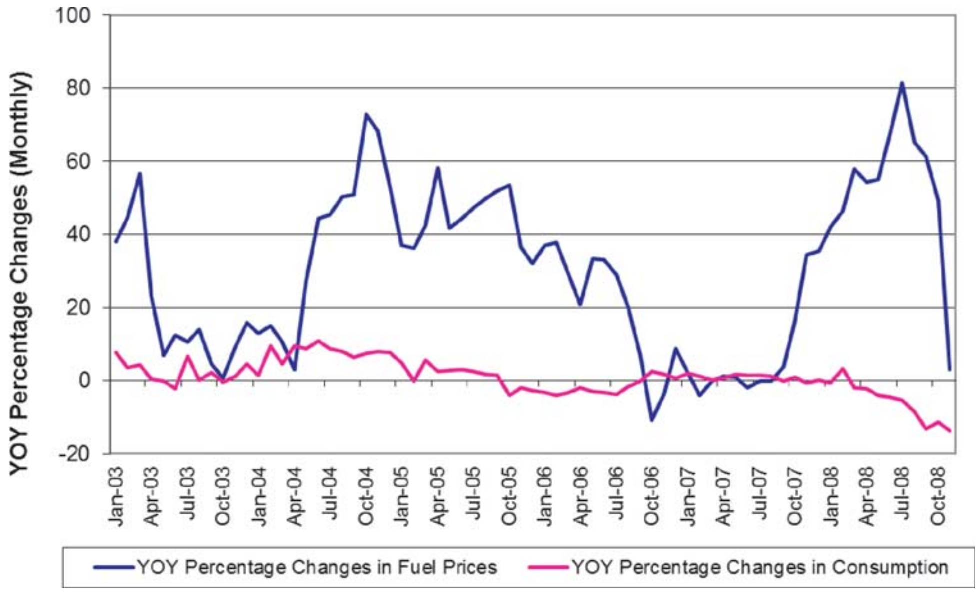


Exhibit I-4. Annualized gallons of jet fuel consumed.



Source: Air Transport Association

Exhibit I-5. Changes in fuel prices and consumption.



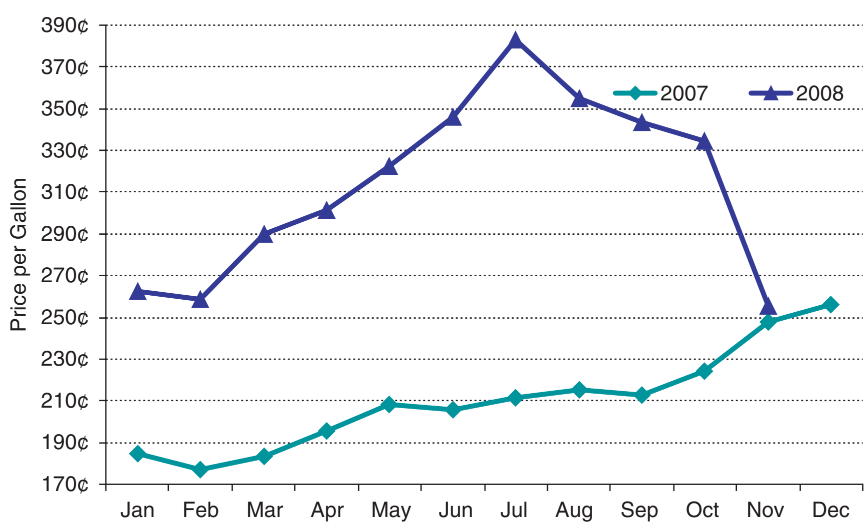
at every point (except February) consumption is lower in 2008 than in 2007. The seasonal pattern of air carrier operations is also apparent in the chart, with summer increases in operations, seasonal flying during the Easter holidays in March, and a significant reduction in activity beginning in September.

Another factor present in 2008 was the rapidly deteriorating conditions in the credit markets, which also had adverse implications for the macroeconomy. In fact, the fuel spike and the economic circumstances may very well have been linked. Higher fuel prices were suppressing aggregate demand even while there was turmoil in the credit markets. The longer-term implications of these circumstances for aviation and for the economy at large remain uncertain at this time.

What is clear in retrospect is that there was a combination of reduced economic growth and inflationary pressures caused by the fuel spike, which hit aviation both on the demand and supply sides. Carriers faced circumstances where they needed to raise prices to cover increased costs at a time when there was a significant deceleration in the demand for their services.

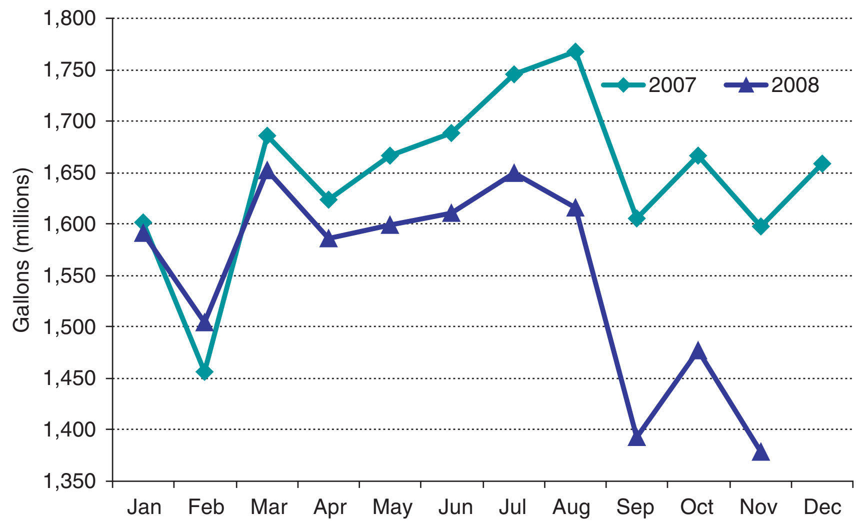
Economic theory would suggest that when carriers are faced with both inflationary cost increases and declining demand they would reduce operations of their least efficient aircraft and perhaps downsize across at least some portion of their schedule in order to match capacity to demand. Exhibit I-8 shows that with unemployment rising and incomes falling,

Exhibit I-6. Average jet fuel price (paid) per gallon in 2007–2008.



Source: Air Transport Association

Exhibit I-7. Gallons of jet fuel consumed in 2007–2008.



Source: Air Transport Association

domestic seat offers per day nationwide (a key measure of air services) did indeed fall by 7.9 percent in 2009.

However, a carrier's ability to undertake a downsizing strategy would be constrained by the logistics of its own schedule as well as its financial circumstances. In some cases, carriers may be forced to operate the aircraft they are best able to afford, rather than the aircraft that make the most economic sense for their route systems. To analyze this behavior, a small database was developed showing the characteristics of individual aircraft in U.S. carrier fleets as of the first quarter of 2008. As noted previously, it is expected that airlines would tend to reduce operations of their least efficient aircraft and would remove at least some of them from their fleets in reaction to the circumstance in which they found themselves in 2008.

Exhibit I-9 provides some confirmation of this hypothesis by relating the relative cost per seat to the percentage of the fleet changed in 2008. One would expect that aircraft with costs that are relatively low relative to their peers would fare better in adverse economic circumstances than more expensive aircraft. This hypothesis is consistent with a downward-sloping trend line like the one shown in the exhibit, with more aircraft being removed from the fleet as aircraft become less and less efficient (evidence of a positive premium to the average among their group).

Exhibit I-10 provides some additional evidence for the economic hypothesis described above. Here, older aircraft are more likely to be retired from the fleet (primarily because they are less efficient than newer aircraft).

Finally, Exhibit I-11 shows that a substantial percentage of the fleet retired in 2008 was attributable to airlines that ceased operations during the most recent fuel spike. In total, these defunct air carriers, all of which are relatively small, accounted for approximately 20 percent of the fleet reduction. (The carriers stopping services in 2008 were MaxJet, Aloha, ATA,

Exhibit I-8. Jet fuel prices and recession drive unprecedented withdrawal of domestic air service.

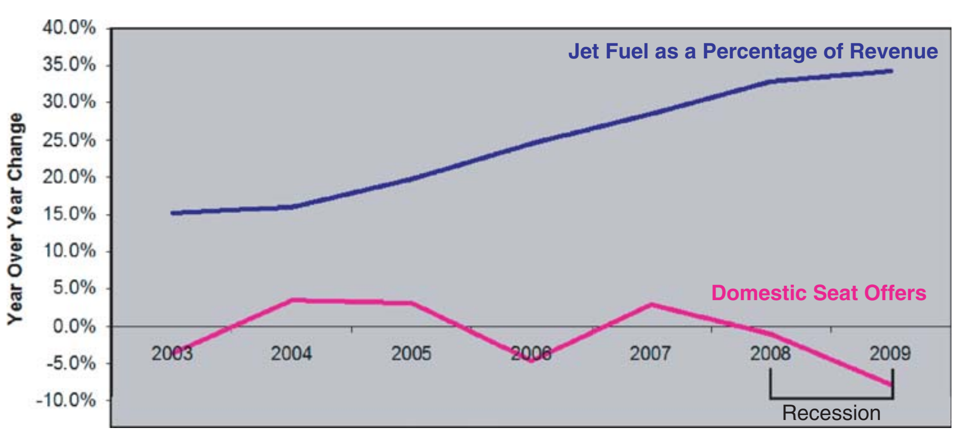
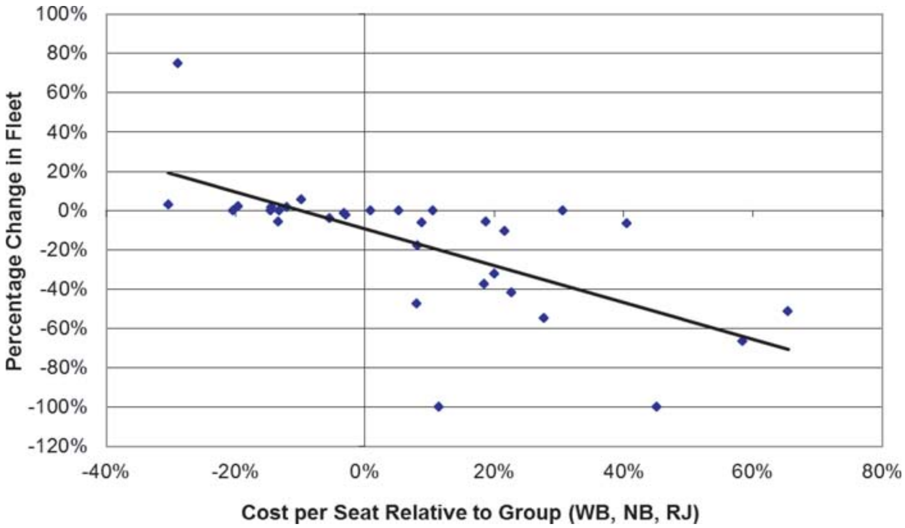
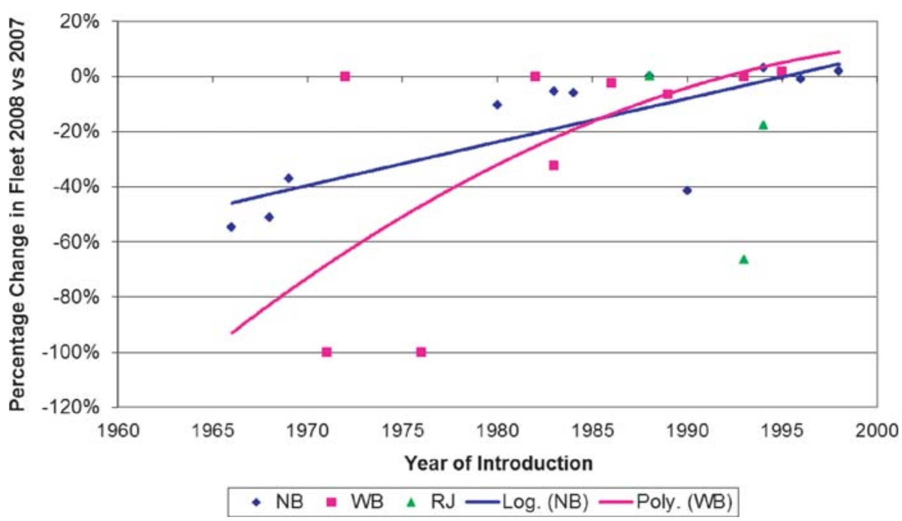


Exhibit I-9. Percentage reduction in fleet vs. relative group average seat cost (2008).



Note: WB = Widebody, NB = Narrowbody, RJ = Regional Jet

Exhibit I-10. Change in domestic fleet vs. year aircraft type introduced.



Note: WB = Widebody, NB = Narrowbody, RJ = Regional Jet

Exhibit I-11. Change in fleets due to carriers ceasing operations (2008).

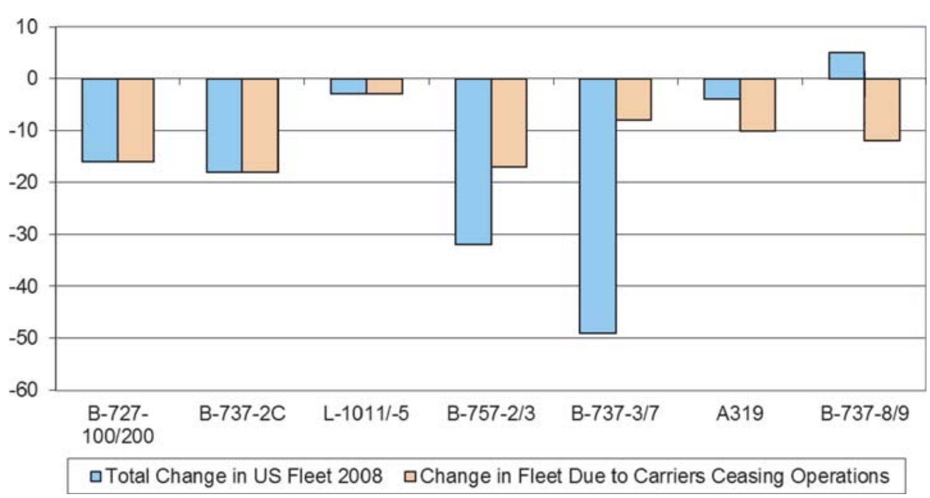
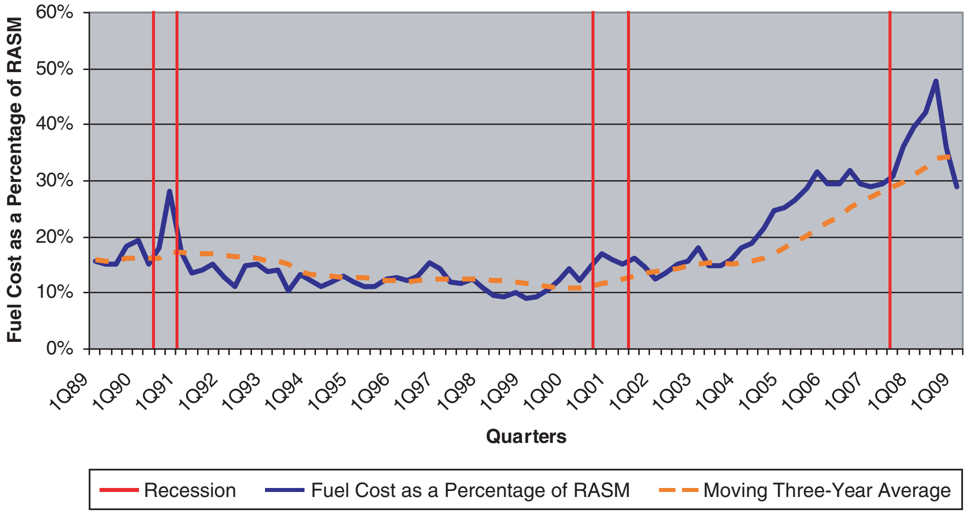


Exhibit I-12. Fuel cost as a percentage of revenue per available seat mile.



SkyBus, EOS, Champion, Avidwest, Vintageprops, and Gemini Air Cargo.)

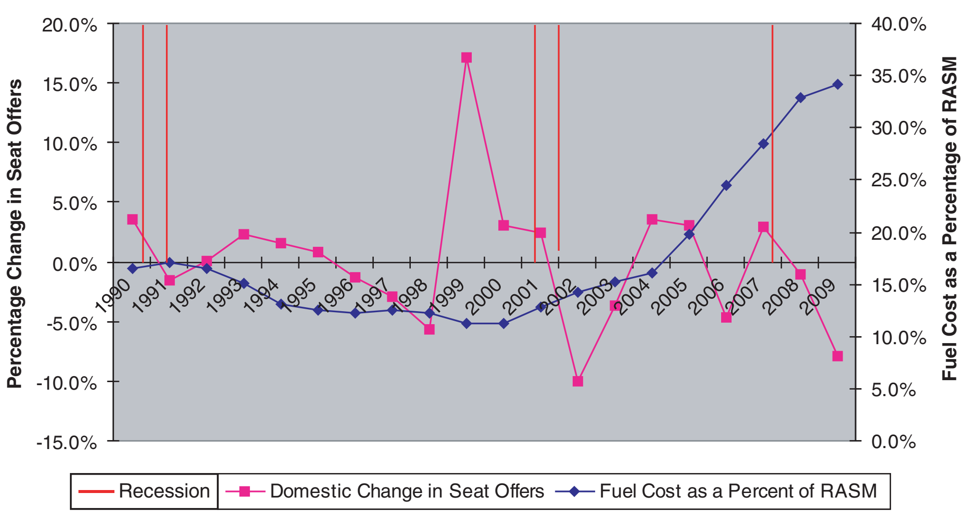
In total, U.S. carriers reduced the number of aircraft in their fleet by about 8 percent during 2008. The charts in this section suggest that, in general, the carriers attempted to retire the least efficient aircraft, subject to the logistical and financial constraints they faced in their schedules and lease obligations, respectively.

Another way to view the impact of fuel price spikes is to consider the extent to which carriers are able to pass jet fuel prices forward to consumers. This issue is taken up in Exhibit I-12, which shows fuel prices as a percentage of revenue per available seat mile (RASM) over the analysis period from the first quarter of 1989 through the first quarter of 2009. The effects of the fuel spike are even more apparent in this chart with the 1991 recession and the recession that started in late 2007 showing prominent rapid increases in the share of airline revenue accounted for by fuel. This illustrates the difficulty carriers may have in accommodating rapid changes in fuel prices, given the fixed nature of their scheduled networks.

Short-term volatility, however, is not the whole story. Also shown in the exhibit is a three-year moving average over the same time period for jet fuel prices as a percentage of RASM. Over the entire analysis period, the moving three-year average stayed below 20 percent until the first quarter of 2006. From that period forward there was a rapid increase, with the moving average peaking at 34 percent.

An important question for this work effort was the extent to which the instability in fuel prices and the secular rise in real fuel prices over time have affected air services in the United States. Exhibit I-13 begins to address this question for the domestic U.S. system. Found in this chart are percentage changes in

Exhibit I-13. Seat offers vs. fuel as a percentage of revenue per available seat mile.



domestic seat offers (year over year) versus the annual level of jet fuel prices as a percentage of RASM. Again, the vertical red lines illustrate periods of U.S. recession. What is most interesting about this chart is that declines in seat offers in the domestic market appear to lag recessions by about one year. The recession that began in July 1990 is followed by a 1.6 percent decline in seat offers in 1991. The recession that begins in March 2001 (together with the extraordinary events of 9/11) precedes a 10 percent reduction in domestic seat offers in 2002. The recession that begins in December 2007 precedes a 1 percent reduction in seat offers for 2008, and a 7.9 percent reduction in 2009.

The 1990–1991 recession coincided with a relatively modest fuel spike when measured relative to unit revenue. The 2001 recession featured relatively modest fuel costs relative to revenue. The most recent recession, which began December 2007, featured a very large (unprecedented) fuel spike.

2.3 Changes in Air Services by Airport Type

This section describes changes in air service (as measured by domestic seat offers) at airports from 1989 through 2009. It is very difficult to tie observed changes in activity at a specific airport to changes in fuel prices; however, the analysis presented here focuses on airports grouped by the FAA's hub classification scheme—large, medium, small, and non-hub commercial airports—and shows how activity has varied over differing time frames and by airport size.

Exhibit I-14 shows the distribution of changes in seat offers for small, medium, and large hub airports in the period 2007 through 2009. The distributions illustrate the range and frequency of changes in seat offers in each year. The vertical lines on the chart are the average increase or decrease in seat offers for the particular year. So for example the blue distribution shows seat offers for 2007 with most of the small, medium, and large hub airports reporting increases over 2006. The recession began in December 2007, but the fuel spike had already been underway for two years. Most small, medium, and large hub airports reported a reduction in seat offers in 2008 relative to 2007, although some of these airports continued to grow rapidly, as illustrated by the long right-side tail of the red distribution. By 2009, the full brunt of the recession was being felt and the distribution shifted substantially to the left with virtually all of the airports reporting substantial reductions in seat offers.

What is most interesting about this chart is the leftward shift of the distribution as the economy deteriorated and the fuel spike took hold. On average, large, medium, and small hub airports reported a 3.7 percent increase in seat offers in 2007, 0 percent growth in 2008, and a strong 11.4 percent decrease on average in 2009. The distribution also spread out in 2009, with the standard deviation doubling versus 2008, suggesting a wider range of experiences.

Exhibit I-15 repeats the same distribution for changes in seat offers for non-hub airports in the period 2007 through 2009. The average response is very little different from that of large, medium, and small hub airports (once a few outlier airports are excluded from the analysis). What is distinguishing about non-hub airports is that the variability in response is much wider. In fact, even in 2009 there was a significant number of non-hub airports that showed positive growth, whereas there were no large, medium, or small hub airports that reported growth beyond 1 percent.

At a broader level, other interesting patterns emerge. Exhibit I-16 reports the average (in yellow) and the minimum and maximum (in red and blue) percentage changes in seat offers for large hub airports since 1989. Shown at the bottom of the chart are the average values as well as the identity of the airports reporting the maximum or minimum changes in seat

Exhibit I-14. Distribution of changes in seat offers at small, medium, and large hub airports, 2007–2009.

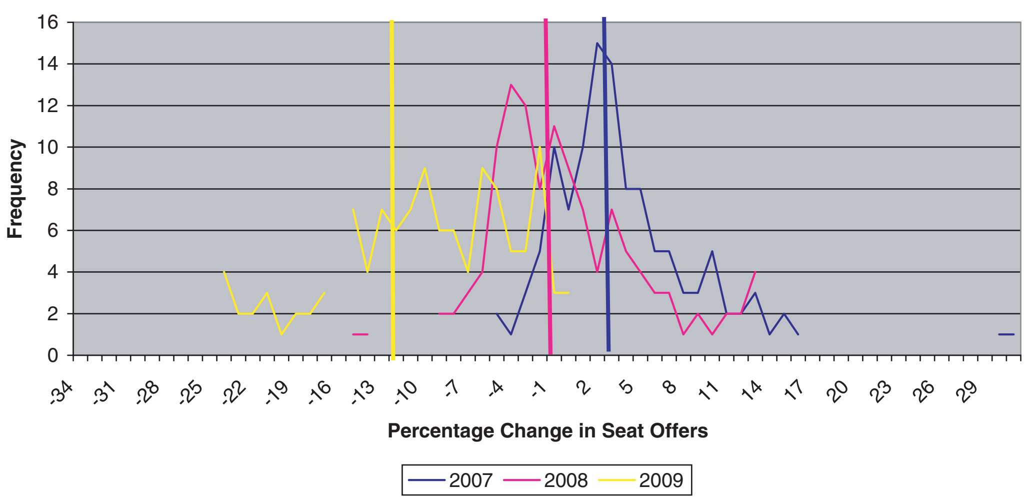
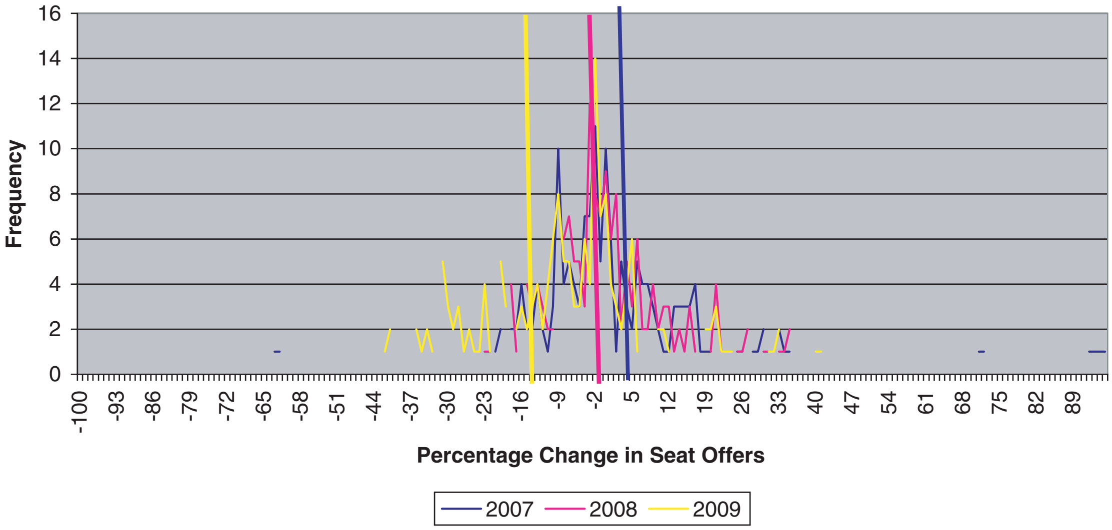


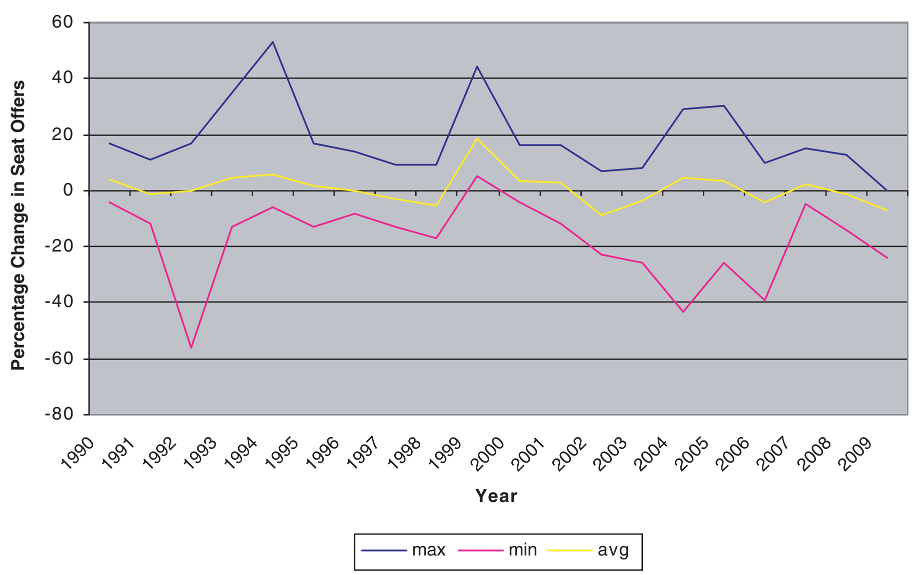
Exhibit I-15. Distribution of changes in seat offers at non-hub airports, 2007–2009.



offers in each year. Even at the largest airports, there is a relatively wide range of experience. For example, in 1992, the highest growth airport was Pittsburgh while Midway showed substantial falloff in air service. The following year, the two airports reversed roles. Midway continued to be the peak growth airport in 1994, 2000, 2002, and 2006. In contrast, Pittsburgh service fell off the most in 2003, 2005, 2007 and 2008, as US Airways continued to dismantle its hub there. What is perhaps most interesting about this chart is that the same airports that showed the maximum amount of growth in one or more years also reported the lowest level of growth in other years. This suggests that the level of activity at some airports will vary substantially from year to year as carriers seek to establish new air services, some of which will succeed while others will not.

The same pattern is shown in Exhibits 17 and 18 for medium and small hub airports, respectively. Again, the same airports

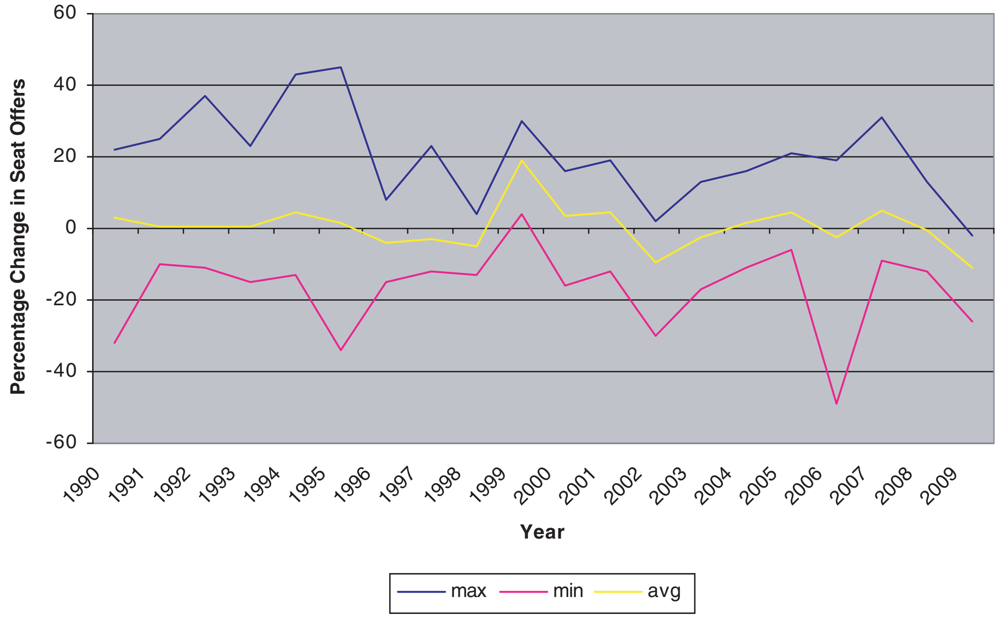
Exhibit I-16. Percentage change in seat offers at large hub airports.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
max	PHL	LAS	PIT	MDW	MDW	LAS	CVG	PHL	IAD	IAD	MDW	FLL	MDW	JFK	IAD	IAD	MDW	JFK	SFO	DEN
min	IAD	PHL	MDW	PIT	DEN	TPA	DFW	MDW	JFK	SLC	EWR	IAD	BOS	PIT	STL	PIT	CVG	PIT	PIT	CVG
avg	4	-1	0	4	6	1	0	-3	-5	19	4	3	-9	-4	4	4	-4	2	-1	-7

airports that have been max and min

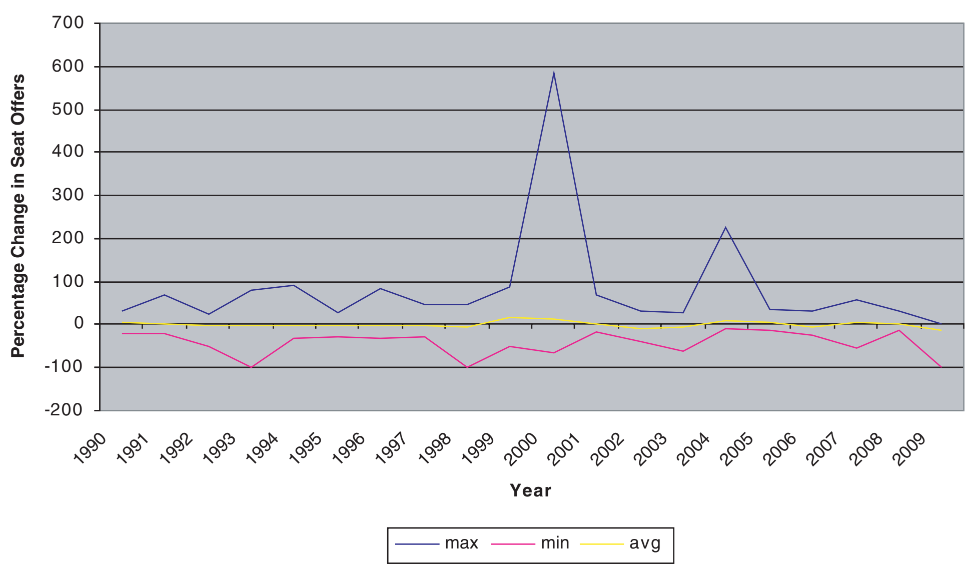
Exhibit I-17. Percentage change in seat offers at medium hub airports.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
max	OAK	SNA	CMH	RNO	JAX	OAK	OMA	PVD	BNA	BUF	BUF	SJC	SMF	DCA	RSW	RSW	DAL	MSY	MSY	BUF
min	MCI	CLE	SDF	IND	BNA	RDU	BUR	OAK	CLE	RNO	RNO	RNO	DCA	MCI	MEM	DAL	MSY	BDL	OAK	ONT
avg	3	0	1	0	5	2	-4	-3	-5	19	3	4	-10	-3	2	5	-3	5	-1	-11

airports that have been max and min

Exhibit I-18. Percentage change in seat offers at small hub airports.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
max	ACY	ACY	MSN	GCN	GSO	BIL	COS	GCN	MHT	GPT	SFB	SFB	SFB	ACY	SFB	SFB	BTR	HPN	SFB	MLI
min	DSM	CAE	DAY	SFB	EUG	ACY	BIL	GSO	SFB	GCN	GCN	SRQ	EUG	SFB	LIT	SBN	GSO	GCN	ISP	SFB
avg	4	0	-2	-2	-1	-3	-1	-2	-7	15	14	2	-11	-5	8	5	-7	4	1	-14

airports that have been max and min

that report very high growth in one year often show the lowest growth in following years.

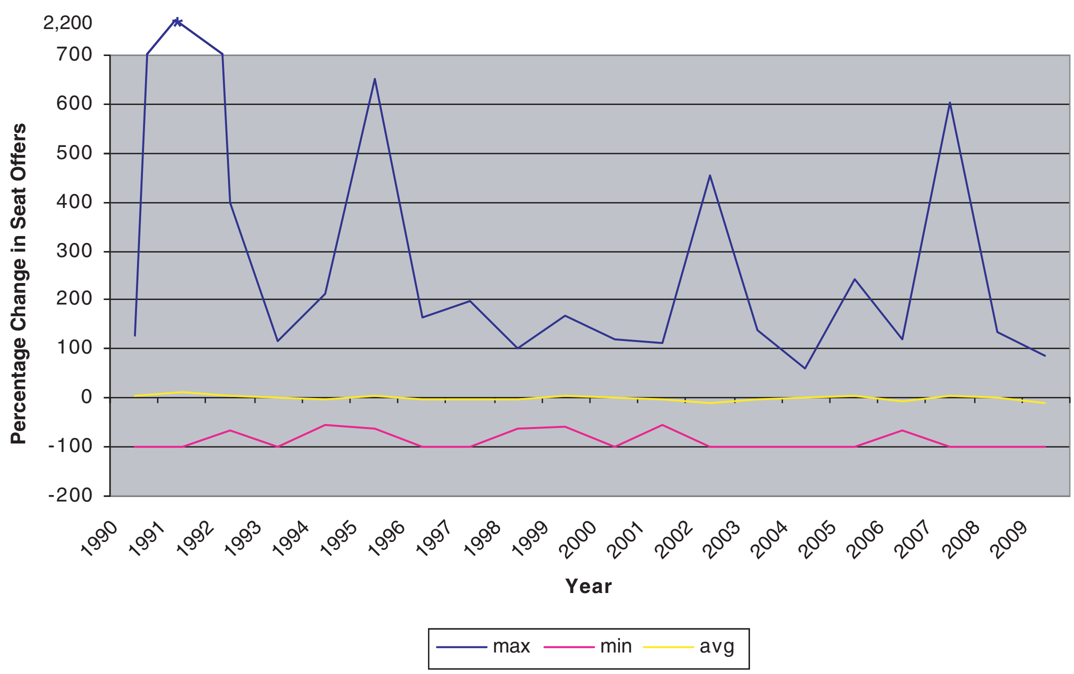
Exhibit I-19 shows the same type of information regarding changes in air service for non-hub airports. Here the variation in air service is very wide with some airports growing off a very small base by more than a factor in a single year. Some airports in this group also have lost air service entirely over the analysis period. Again, the same airports are repeated as both showing maximum and minimum growth as carriers experiment with new air services at non-hub airports.

Exhibit I-20 makes clear that there have been really two epochs in the last 20 years. In the first, comprising the period up to about 1997, the large hub airports reported the greatest variation in changes in air service as measured by the coefficient of variation (defined as the standard deviation of a sample divided by its mean). In this first epoch, legacy carriers were completing the buildup of their connecting hubs and there was a substantial amount of consolidation within the industry. As a result, these large hub airports reported very substantial change in air service from year to year. Once the large hubs were established, the variation in air service from year to year became relatively stable at these airports while smaller airports experienced relatively larger variations in activity. In the second epoch, after 1997, the smallest airports (the non-hubs) showed the highest coefficients of variations, followed by the small and medium hub airports, respectively.

2.4 Changes in Development Programs and Budgets at Specific Airports

Exhibit I-21 summarizes recent announced changes in capital programs and budget reductions at airports of all sizes resulting from the current recession and recent fuel spike. A short perusal of the exhibit shows that airports of all sizes have been affected, sometimes dramatically so, by the economic environment. Even the very large hub airports like Atlanta, Orlando, and Fort Lauderdale show substantial cuts in discretionary programs and/or budgets. Changes in levels of air service generally are more dramatic at smaller airports and seem to have larger impacts on capital programs and budgets. The dramatic changes in air service would be expected because smaller airports have less air service as measured both in the

Exhibit I-19. Percentage change in seat offers at non-hub airports.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
max	OXR	EFD	PIE	LAF	VGT	BFI	TTN	BFI	PDT	MKL	ORH	UIN	IFP	LGB	IPT	APF	RDD	TTN	ROW	ALW
min	STC	BED	LAF	BFI	ALW	LGB	SCK	BED	SMX	VGT	VGT	PIR	STS	SOP	ORH	EFD	BED	BFI	HGR	APF
avg	5	12	5	2	-4	6	-2	-2	-1	5	1	-4	-12	-4	0	5	-5	6	-1	-11

(highlighted) airports that have been max and min

Exhibit I-20. Variability among airports in change in seat offers within hub type.

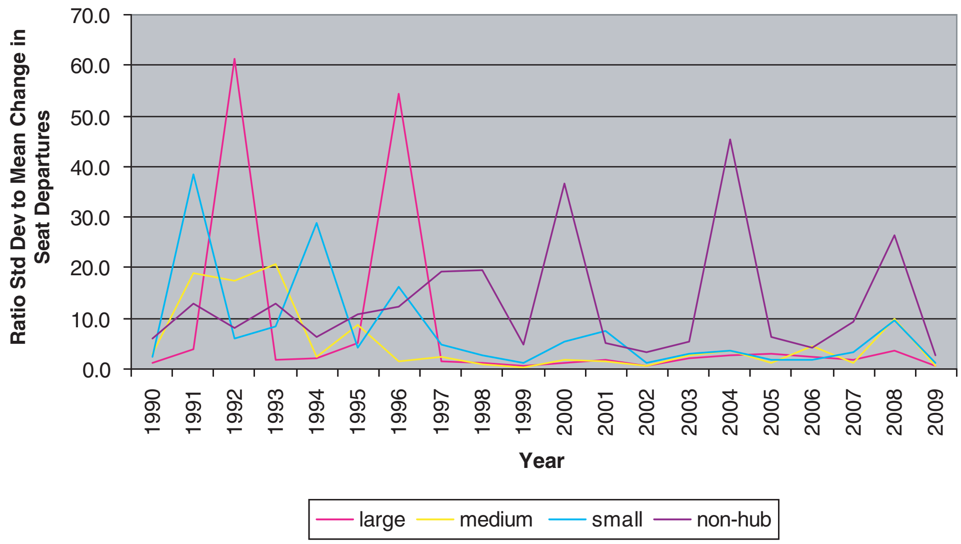


Exhibit I-21. Airport capital development projects and operating budgets 2008–2009.

Airport	FAA Hub Category	Project	Action	Budget Change	Change in Seat Offers	
					2008	2009
Atlanta	L	Capital program	Budget cut	-$225M; may cut $50M more	-1%	-2%
Butte	N	Additional runway lighting ($2.5M) Terminal renovation to increase energy efficiency ($5-7M) Overall capital projects	Delayed Delayed Budget cut	-30%	-7%	-61%
Dulles Int'l	L	Terminal replacement ($2B) Car rental center ($400M)	Halted Halted		-3%	-7%
Ft. Lauderdale Int'l	L	Discretionary projects	Delayed		1%	-13%
Green Bay	S	Parking lot and exit road expansion ($2.2M) Overall capital projects	Canceled Budget cut	-11.6%	-1%	-23%
Kansas City	M	Overall capital projects	Budget cut	-6.3%	-4%	-15%
Louisville Int'l	S	Some capital projects	Delayed		1%	-13%
McCarran Int'l	L	Capital improvement plan ($3.7B) Runway reconstruction; new signage, baggage handling upgrade ($215M) Escalator expansion at baggage claim	Budget cut Delayed Canceled	-9.7%	-1%	-15%
Missoula Int'l (Montana)	N	Small capital projects not funded by AIP	Delayed		-3%	-26%
Oakland	M	Overall capital projects Build third terminal, cargo and passenger airline tenant support centers, pavement rehabilitation ($1B)	Budget cut Canceled	-5.5%	-12%	-24%
Orlando Int'l	L	Expansion including ticket lobby overhaul	Delayed		-1%	-15%
Pensacola	S	New gates and boarding bridges	Delayed		0%	-15%
Reno-Tahoe	S	Capital projects	Budget cut		-6%	-21%
Richmond	S	Capital program	Budget cut		-4%	-2%
San Luis Obispo	N	Capital projects	Delayed		-4%	-34%
Sioux City	N	Overall capital projects Terminal renovation ($1.8M) Runway reconstruction ($12M)	Budget cut Delayed Delayed	-5%	75%	-34%
Toledo	N	Overall capital projects	Budget cut	-12.5%	-11%	-54%
Tucson	S	Overall capital projects Gate expansion	Budget cut Canceled	-0.4%	6%	-23%

Sources: Trade and General Press Reports absolute number of seat offers and also in the diversity of service in city pairs.

To summarize this chapter:

- The recent fuel spike really began in 2004 and reached unprecedented levels relative to unit revenues in 2008.
- The other large fuel spike in the analysis period was in 1991 and coincided with the Gulf War and a recession.
- There is a wide variation in air service, with recent history showing that the size of annual changes is inversely related to airport size.
- Airlines appear to react to fuel spikes and recessions with a lag, as they are unable to adjust their fixed schedules and fleets instantly.
- Many airports evidence wide swings in annual service in some years showing the highest level of growth followed by years with the lowest performance in their hub group, as carriers seek to establish new services at these airports with varying levels of success.
- While changes in air service are likely to be affected by fuel spikes and recessions, there are many local factors that also affect changes in air services.
- Airport capital development programs were adversely affected by the severe recession and fuel spike.

The discussion now turns to the development of models and software to assess the risk of fuel and economic uncertainty in air service forecasting.

CHAPTER 3

Statistical Model Development

The Airport Forecasting Risk Assessment Program is software designed to assist airports with anticipating changes in air service due to external shocks (particularly fuel price and income changes). Because every airport is different, this software is meant to assess risk in existing forecasts. Such a forecast might be an internal projection made by or for airport staff or it could be from an external source such as the FAA's TAF, which provides long-term projections of operations and enplanements for over 3,000 U.S. airports. The latest available TAF for air carrier/air taxi operations and enplanements are used as baseline projections for the next five years in the software described here, but the user may replace the TAF with his or her own baseline forecast (or adjust the TAF), if desired.

The software program is based on statistical air service models that are intended to provide a plausible description of the major factors that may affect observed changes in activity at U.S. airports. As will be discussed, the activity metric used in the models is actually seat departures; the resulting predictions of seat departures then are translated into predictions of operations and enplanements to match the metrics used in the TAF or user-supplied forecast. An overview of the logic behind the software is provided in Exhibit I-22. The findings from earlier tasks described in Chapter 2 formed the basis for designing the overall structure of, and inputs to, the air service models.

It is important to understand that the results from the air service models are used only to project *changes to an existing forecast* that may be expected to result from user-specified variations in the explanatory variables of the models. So, for example, suppose an existing baseline forecast projected 100,000 operations in 2010 and 105,000 operations in 2011, and was based on the underlying assumption that fuel oil prices would increase by 3 percent. The user could input these baseline assumptions and forecasts into the software, and then run a scenario where fuel oil prices increase by, say, 10 percent instead. The software then will forecast what the change in operations from 2010 to 2011 would be based on the air service models and apply that percentage change to the user forecast. If, for example, the air service models show only a 2 percent increase in operations due to the 10 percent fuel oil price increase, then the scenario 2011 forecast for the existing user model would be 102,000 operations. In this way, the user can assess various "what-if" scenarios and how they might affect the baseline forecast.

3.1 Air Service Models

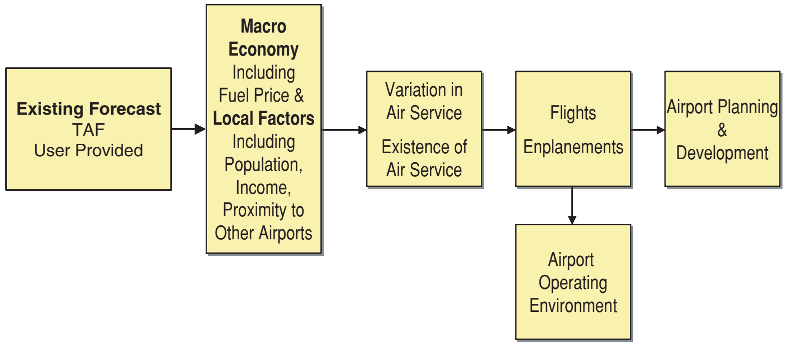
To develop the air service models, annual airport-level data from 1990 through 2009 have been collected and analyzed. The data vary both cross sectionally (across airports) and longitudinally (over time), resulting in a "panel" set of data. The FAA's hub classification system was used to categorize airports into the following groups:[1]

- Large hub airports
- Medium hub airports
- Small hub airports
- Non-hub airports
- Non-primary commercial service airports
- General aviation airports and other airports

Based upon feedback from the ACRP Project 03-15 panel, the scope of the analysis was limited to the first four categories, which together comprise over 99 percent of scheduled commercial service; airports in Alaska and Hawaii were also excluded from the analysis. In addition, large hub airports that serve as primary connecting hubs for major airlines were broken out and treated separately from other large hub airports because their observed activity levels will depend not only on fuel prices, income changes, and other determinants of air

[1] The analysis accounted for the possibility that an airport could change hub classification over the 20-year period.

Exhibit I-22. Overview of how the software works.



service in local markets but also on carriers' decisions about how to flow traffic through the hubs and across their networks.

Through the modeling development process and subsequent statistical testing, the non-connecting large hub airports were combined with medium hub airports into a single category. Minimum activity requirements were also imposed for the non-hub airport category,[2] resulting in a total of 271 airports that were included in the final analysis, broken out as follows (as of 2009):

- Large connecting hub airports: 17
- Other large/medium hub airports: 43
- Small hub airports: 63
- Non-hub airports: 148

Some consideration was given to how best to measure and define air service levels at these airports. For modeling purposes, average daily scheduled domestic seat departures were utilized as the appropriate measure. It is recognized that changes in seat offers may be accomplished either by changing frequency or aircraft gauge, and that the impacts of such changes, particularly at small airports, may be quite different between the two alternatives. As mentioned previously, results from the air service models then are translated into predictions of operations and enplanements to match the metrics used in the TAF or user-supplied baseline forecast.

The software only considers the effects of external impacts on domestic scheduled operations and enplanements. Any international activity at an airport is accounted for but held constant throughout the analysis. Because most scheduled international activity is affected by bilateral or multilateral agreements between countries, the likely response to external shocks would be difficult to assess.

Consideration was given to modeling changes in both seat offers and flight offers simultaneously; however, such an approach would be fairly sophisticated econometrically and difficult to model successfully from a statistical standpoint. Instead, a simpler approach was pursued that incorporates airport-specific average seat size as an exogenous variable that may help to explain variations in total seat offers. This approach is discussed in more detail below.

To moderate the data collection effort, Official Airline Guide–scheduled seat departures for the combined months of February and July for each year between 1990 and 2009 were utilized as reasonable measures of average daily seat offers at each airport included in the analysis. There will be a wide variation of activity levels at individual facilities within each airport category over time. Given this background, a large airport-level database was assembled that includes many data items that may help to explain the observed changes in airport-level domestic seat departures over the past 20 years. Exhibit I-23 provides a description of the explanatory variables examined in the work program and their expected effects on seat offers at individual airports.[3,4]

Standard statistical regression techniques for panel data were utilized to assess how some or all of these variables may help explain variations in airport-level domestic seat departures over the past 20 years. To help account for trend effects, a one-year lag of the dependent variable (daily seat departures) was also included as an explanatory variable. As will be seen, not all of the variables listed in Exhibit I-23 were statistically significant contributors to the estimating equations.

[2] Any Essential Air Service (EAS) locations, airports without at least three years of three or more flights per day, or airports where average daily seats were less than 100 averaged over the entire time period were excluded from the analysis.

[3] As seen in Exhibit 23, an attempt was made to account for variations in technology and fleet mix that might help explain activity variations across airports. Admittedly, the metric used for this (average seat size) is a crude measure. Also, the Leisure Destination Index was defined based on the notion that resort areas (such as Las Vegas and Florida airports) will likely have a much higher percentage of traffic that originates elsewhere with the airport as a final destination, as opposed to non-leisure areas where the traffic would exhibit a more even split between origin-destination trips that either start or end at the airport.

[4] The initial exploratory analysis also incorporated other efforts to improve the model, including testing for time dependence (so-called "autocorrelation"), alternative formulations of the explanatory variables (including different time lag structures), separating out fuel price and airline cost impacts (since, as discussed above, airlines may undertake measures to mitigate the effects of fuel price increases), and capturing additional airport-specific effects.

Exhibit I-23. Possible explanatory variables.

Type	Variable	Measure	Expected Impact on Seat Offers
Macro	Total Cost	Real (adjusted for inflation) annual ATA Composite Cost Index	Negative
	Jet Fuel Cost	Real (adjusted for inflation) annual ATA Jet Fuel Cost Index	Negative
	Jet Fuel Cost Volatility	ATA Jet Fuel Cost coefficient of variation (monthly variation around annual mean)	?
	Oil Price Volatility	ATA Oil Price coefficient of variation (monthly variation around annual mean)	?
	9-11 Shock	Separate dummy variables for 2002 and 2003	Negative
Airport-Specific	Population	Population in the Census metropolitan or micropolitan area where airport is located	Positive
	Income	Per capita real income in the Census metropolitan or micropolitan area where airport is located	Positive
	Changes in Technology and Fleet Mix	Average seat size at airport (larger aircraft have lower costs per seat)	Positive
	Leisure Destination Index	100 - Percent O-D passengers originating at airport calculated from DOT ticket sample	Positive
	Demand/Supply Balance	Airport load factor calculated from FAA T-100 reports	Positive
	Inter-Airport Competition	Domestic seat-departures at large or medium hubs within 50 miles of airport	Negative
	Low Cost Carrier (LCC) Presence	Percentage of seats flown by LCCs at airport	Positive
	Airline Concentration	HHI (sum of squared market shares) at airport calculated from OAG seats	Negative
	Pricing Strategy	Average O-D yield at airport from DOT ticket sample (high fares could reflect high service levels or weak competition)	?

For the large connecting hub group, two separate equations were estimated—one for local traffic and one for connecting traffic. The observed seat levels at each connecting hub were broken into local and connecting categories based on observed local passenger shares on flight segments from the Data Bank 1B (DB1B) ticket sample published each year by U.S. DOT.

A total of five panel equations were estimated—two for the connecting hub group and one each for the remaining large/medium hub group, the small hub group, and the non-hub group.[5] For all but the non-hub group, a so-called "one-way fixed effects" model with airport-specific effects was estimated.[6]

In addition to directly testing the variables listed in Exhibit I-23, an effort was made to consider interaction terms involving combinations of the variables (which would allow the effects of one variable to change depending on the magnitude of another), as well as other categorizations of the airports. An analysis was undertaken to assess whether airports with access to only a small number of major carrier hubs may be affected differently by fuel price spikes (e.g., down-gauging vs. flight reductions). This effort did not result in any significant findings, other than the revelation that even very small airports typically have service to several hubs. For example, among airports with an average of at least 100 daily seats over the past 20 years, there are only nine that have an average of three or fewer hub connections over the same time period. While overall service from hubs indeed has declined over time since the 1990s for many smaller airports, many still have service to multiple connecting locations.

3.2 Statistical Results

The regression analysis for the 271 airports included in the database led to statistical models that explain between 86 and 98 percent of the variation in seat offers over 20 years. Summary results for the five models are shown in Exhibit I-24.

Among the potential macro variables, jet fuel cost (lagged by one year) and the 9-11 dummy variables for 2002 and 2003 have statistically significant negative impacts on observed seat offers. The oil price/fuel cost volatility variables did not show to be

[5] From a technical standpoint, an important consideration is that within each category there is much more seat variation between airports at any given time than there is variation at a given airport over time. Thus it would not be prudent to expect that changes in the level of a given explanatory variable would have the same impact on the level of seats at a small airport as at a larger one. Consequently our regression models utilize log values of the dependent and independent (explanatory) variables, which is equivalent to modeling percentage changes rather than raw differences. This ties in directly with the plan to apply percentage changes from the model predictions to the TAF or user-supplied baseline forecasts.

[6] An airport-specific fixed effects specification would have been preferred for the non-hub group as well, but given the focus in this study on fuel prices and income effects, more reasonable results were obtained using simple ordinary least squares in this case.

Exhibit I-24. Equation estimates for daily domestic seat departures.

Coefficients
(t-statistics)

Model: / *Explanatory Variable*	Connecting Hubs Local Traffic	Connecting Hubs Connecting Traffic	Other Large-Medium Hubs	Small Hubs	Non-Hubs
Daily Seat-Departures[-1]	0.75240 (123.76***)	0.06815 (4.15***)	0.66652 (25.08***)	0.54409 (35.57***)	0.74530 (97.99***)
Real Jet Fuel Cost[-1]	-0.09112 (-8.58***)	-0.09876 (-3.79***)	-0.09863 (-9.75***)	-0.08764 (-6.44***)	-0.06185 (-4.52***)
Real Per Capita Local Income[-1]	0.34308 (7.38***)	0.75304 (8.06***)	0.39448 (10.56***)	0.05269 (1.05)	0.13843 (5.23***)
Average Seat Size[-1]	0.14261 (2.82***)		0.18217 (4.45***)		
HHI Index	-0.12085 (-5.03***)		-0.06322 (-3.68***)	-0.08060 (-3.66***)	-0.30011 (-20.96***)
Seat-Departures at Lrg/Med Hubs within 50 miles	-0.04466 (-1.36)	-0.28266 (-3.87***)	-0.10383 (-2.81***)	-0.32717 (-3.31***)	
9-11 Dummy for 2002	-0.14957 (-8.86***)	-0.06643 (-1.62)	-0.12500 (-8.32***)	-0.12362 (-5.91***)	-0.14252 (-5.95***)
9-11 Dummy for 2003	-0.10640 (-6.38***)	-0.08462 (-2.09**)	-0.09004 (-6.02***)	-0.10150 (-4.93***)	-0.06242 (-2.54**)
Adjusted R^2	0.98206	0.94698	0.97599	0.93836	0.86654

Note: [-1] indicates one-year lag
***Significant at 99% level
**Significant at 95% level

The numbers in parentheses of Exhibit I-24 are "t-statistics," which relate directly to the degree of statistical significance indicated in the exhibit. In the current context, a variable that is "statistically significant" means that the researchers are confident that the impact of the variable is not zero; the higher the t-statistic (in absolute value), the more confident the researchers are that the effect is not zero. A t-statistic of around 1.65 in absolute value correlates to a 90 percent confidence level; a t-statistic of around 1.96 in absolute value correlates to 95 percent confidence. Note that in a few instances in Exhibit I-24, the estimated significance level is less than 90 percent (indicated by no asterisk next to the t-statistic). These variables were nevertheless kept in the analysis so that the equations are relatively parsimonious with each other.

It is important to understand that just because an explanatory variable is statistically significant does not necessarily mean that it is "important" in the sense that a given change in the variable will lead to a large change in projected seat departures. The impact could be small, but from a statistical standpoint it is "significantly" different from zero. A measure of the relative impact of an explanatory variable is given by its elasticity, which is briefly discussed in Section 3.2.

significant in any of the model specifications tested and so are not included in the equation estimates shown in Exhibit I-24. As for airport-specific effects, variables measuring local income, average seat size, airport concentration [Herfindahl–Hirschman index (HHI)], and inter-airport competition (seat departures at neighboring airports) all showed statistically significant impacts with the expected signs in most of the models.[7]

Given the functional form used, the coefficients can be interpreted as elasticities, meaning that a 1 percent change in the variable indicated would lead to a percentage change in airport seat departures equal to the coefficient value. For example, the model representing local traffic at connecting hubs projects that a 1 percent increase in the real price of jet fuel would lead to a 0.091 percent decrease in the number of seat departures offered at a given airport (holding all else constant).

It is interesting to compare the results across the five different airport groupings. Not surprisingly, the trend component measured by the lagged value of daily seat-departures is much smaller for the connecting hubs' connecting traffic relative to their local traffic; this is consistent with the notion that there is significant random year-to-year variation in how traffic flows over carrier hubs.[8] The impact of jet fuel costs and the 9-11 dummies are fairly consistent across airports, while local income effects are smaller at the small hub and non-hub airports. In addition, the effect of airline concentration (mea-

[7] As noted earlier, except for the non-hub model, the equations also include a separate constant term estimated for each airport (not shown in Exhibit I-24).

[8] But some of this apparent random variation may simply reflect data sampling variation from the DB1B data, which by its design does not accurately depict through routings.

sured by the HHI) is much higher at very small non-hub airports. This latter effect also is not surprising since many such airports in fact have only a single scheduled carrier.

The statistical modeling for non-hub airports proved to be somewhat more difficult compared to the other groupings; this was expected due to the more stochastic nature of carrier scheduling decisions at very small airports. Aside from the sorts of variables considered here, scheduled service at such airports may be heavily influenced by carrier network considerations, the availability of specific aircraft equipment types, the status of dominant local employers, etc. None of these sorts of influences can be easily measured for use in a statistical model; thus, they are considered "stochastic" (i.e., random) and outside of the framework of the models used here.

3.3 Airport Impact Models

This section provides a description of the airport impact models used to translate projections from the air service models into airport impacts. There are two categories of impacts that are considered: operational and financial. The operational impacts are a direct function of the air service models and the definitions in the software. The financial impacts depend on statistical models developed with FAA 5100-127 data, which are financial statements reported by each airport annually. The two types of impacts are described in the following subsections.

3.3.1 Operational Impacts

The air service models explain percentage changes in annual seat offers. For projection purposes, seat offers must be translated into operations and enplanements, which are the two most commonly used activity measures at airports and form the basis for many airport forecasting and planning functions. Seats offers from the air service models are translated into operations and enplanements using the following identities:

- Operations = (seat offers) / (average seat size)
- Enplanements = (load factor) × (seat offers)

The default values for seat size and load factor are taken to be the average at the airport in question for 2009. In the software, the user can alter the average seat size variable, which in turn will alter the operations forecast.

3.3.2 Financial Impacts

The estimates of airport operations and enplanements provide a basis for estimating airport revenues. Unlike the air service models that were distinguished by airport hub size, there is a single model employed to estimate operating revenue encompassing all 271 airports in the analysis. Total operating revenue data for FY 2008 were collected from FAA 5100-127 filings that are available online. A log-linear regression was estimated for 2008 revenues as a function of 2008 TAF air carrier and air taxi operations, domestic enplanements, and international enplanements; the results are shown in Exhibit I-25.

The results indicate a particularly strong correlation between domestic enplanements and airport operating revenues. As with the air service models, in the software this model is used solely to calculate *percentage changes* in revenue to the baseline forecast over time (TAF or user input) and/or for scenario forecasts based on the air service models described earlier.

Exhibit I-25. Equation estimate for annual airport operating revenues.

	Coefficients (t-statistics)
Intercept	6.77147 (11.92***)
Air Carrier + Air Taxi Operations	0.28207 (2.63***)
Domestic Enplanements	0.52448 (6.63***)
International Enplanements	0.05396 (3.04***)
Adjusted R^2	0.82942

***Significant at 99% level

CHAPTER 4

Software Approach and Design

The objective of this work effort was to provide a practical mechanism for airports to assess the risk of fuel price uncertainty and other economic factors to their future development programs and operations. Early on, it was determined that the software to be developed for this project should allow a user to analyze either their own customized forecast of future airport activity, or a default baseline forecast. In either case, the goal is to assess how such forecasts may be affected by changes in fuel prices and other sources of uncertainty. To make this assessment, key assumptions that underlie the forecast, including expectations about fuel prices, economic growth, and other factors, must be considered. Then, the program should allow the user to undertake sensitivity studies by varying assumptions about the key drivers, with the software generating a range of likely outcomes based on these assumptions.

An important feature of the software that was developed is the creation of confidence bands for the forecast, which are generated using an analysis based on the historic range of errors in expectations of jet fuel prices and GDP growth. This approach answers a fundamental question: How might an airport forecast be affected given the historic errors in expected future jet fuel prices and economic growth?

The software uses information from the heating oil futures market (which has a close correspondence to jet fuel prices) and data on GDP forecast errors to create confidence bands that reflect the risk to an airport's forecast due to these very-difficult-to-forecast variables.[9] The software also generates a one-page report that summarizes key inputs and the results of the risk analysis. The overall process is illustrated in Exhibit I-26, showing how the inputs to the statistical model developed earlier tie into an airport's assessment of the uncertainty associated with its activity forecasts.

[9] Again, it is important to emphasize that there may be other major factors driving any given forecast that are unknown to the software and are not accounted for in the confidence bands.

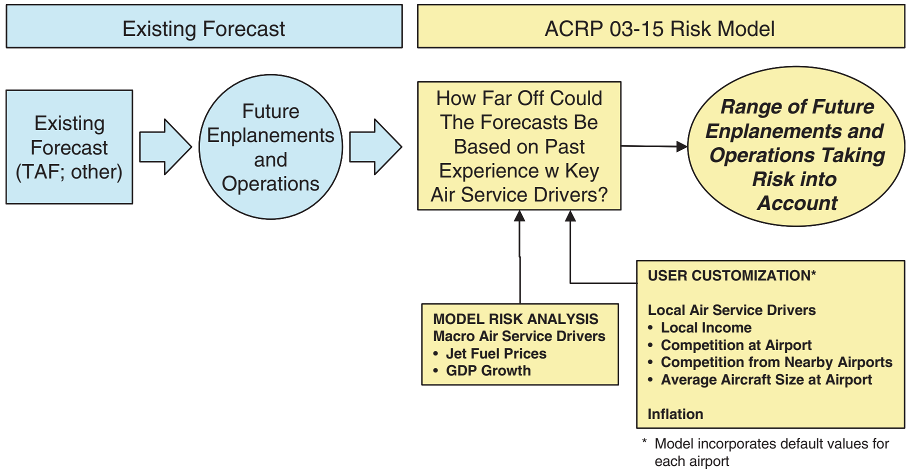
This approach is designed to produce useful information for airport users. If there have been significant changes in expectations about the economy or jet fuel prices in the recent past, some airport sponsors may be asked questions or have concerns about future air service, which in turn would have important implications for their operating budgets and for their development programs. For example, the recession that began in December 2007 and the fuel spike of 2008 were not well-anticipated by airlines or by airports. As information on these events became apparent, many airports were forced to alter development plans or cut operating budgets (examples of these impacts are discussed in the following subsection). Airport sponsors would benefit if they could quickly assess the impacts of these unanticipated events on their operations and development plans. Perhaps more important, the sponsors would be able to anticipate questions and concerns from business partners (e.g., airlines, financial intermediaries) and provide useful information in their continuing dialogues.

This approach focuses on the impacts of unanticipated events on *existing* forecasts. This makes sense because no single, overarching model will be capable of considering the many details that determine air service at specific airports. Airport sponsors themselves are better positioned to know their local markets and develop local forecasts, and are also in the business of interacting with their partners (including airlines) to anticipate changes in air services.

4.1 Embedding Uncertainty into Forecasts

While the air service statistical models explain a high percentage of the variation in observed seat offers over the past 20 years, their primary purpose is to aid airport decision makers in projecting future activity at their airport. The software developed for this project allows users to employ these models to project activity five years out (through 2014) from the end of the historical data in 2009, and then to apply the pre-

Exhibit I-26. Combining existing forecasts with the risk model.



dicted changes in activity to a baseline TAF or user-supplied forecast.

The underlying motivation for such an approach is that all forecasts are inherently uncertain, and it can be useful to be able to measure that uncertainty by placing confidence bands around the baseline projection. To get a better feel for such uncertainty, consider the annual TAF forecasts produced by the FAA. The latest 2009 forecasts make long-term projections of operations and enplanements out to 2030. Like any forecast, inaccuracies in the TAF tend to increase with the number of future years. But even over a much shorter time frame, the TAF forecasts can be somewhat inaccurate.

An analysis of the TAF was conducted for each year from 2003 through 2008 that measured the accuracy of the airport forecasts relative to actuals for domestic operations and total enplanements from one to five years out.[10] The results, broken out by airport hub type, are shown in Exhibit I-27.

As expected, the projections become less accurate the further out the projection period and the smaller the airport. But for airports of any size, the results suggest that it is important to be able to assess the uncertainty associated with airport activity forecasts; that is the major motivation for the software described here.

To use the air service models to help address this issue, it is necessary to provide expected future values of the models' explanatory variables. Looking back to Exhibit I-23, for some variables such as average seat size and the HHI, a reasonable default assumption may be that next period's value will be the same as the latest current period value. But others, in particular the jet fuel cost and income variables, can be quite volatile and/or difficult to predict even one or two years ahead. The software provides default values for projections of the explanatory variables out to 2014, but the user can override these values and has full control over what values to assign to future variables.

In the current context, it is important to focus on the jet fuel cost and income variables, both of which are difficult to predict. Given that air carrier schedules are set well in advance, the lagged representation for fuel price is consistent with the notion that airlines use current fuel prices to help make decisions about future service offers. In practical terms, however, it is important to note that airlines typically make scheduling decisions more often than once per year. Most U.S. carriers set seasonal schedules approximately six months in advance.

However, given the volatility in world oil prices, relying only on current or recent historic fuel prices as guides to what

[10] Thus, six years of data (from 2003 through 2008) were used for the one-year ahead analysis, five years (from 2003 through 2007) for the two-year ahead analysis, etc.

Exhibit I-27. TAF accuracy one to five years out.

Based on 2003-2008 Forecasts
(Mean Absolute Percentage Error)

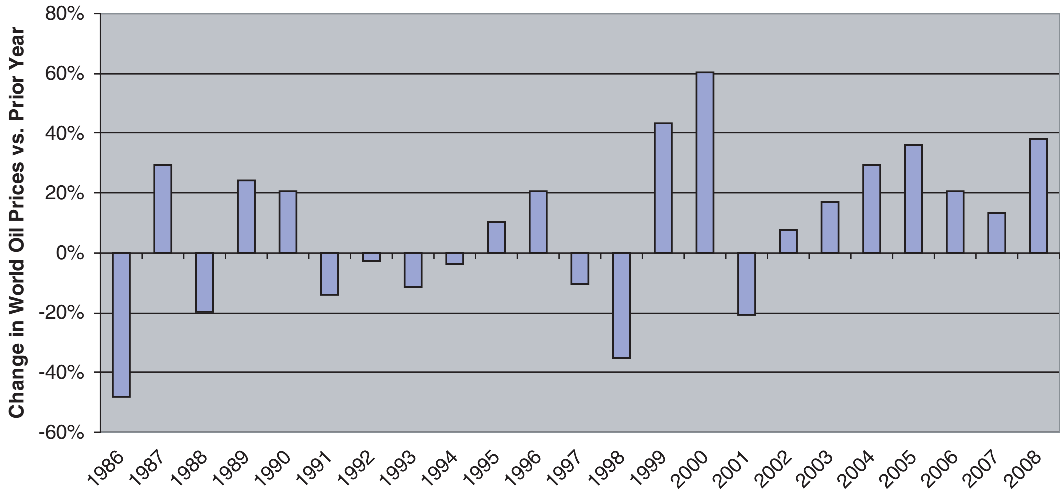
Domestic Operations

Hub Type	Years Ahead Forecast				
	1	2	3	4	5
Large	3.4%	10.2%	13.9%	18.4%	25.5%
Medium	5.3%	12.5%	17.3%	22.0%	25.7%
Small	8.0%	13.9%	17.9%	22.7%	26.0%
Non-Hub	14.0%	20.4%	25.3%	31.9%	38.7%
All	10.4%	16.8%	21.4%	27.1%	32.8%

Enplanements

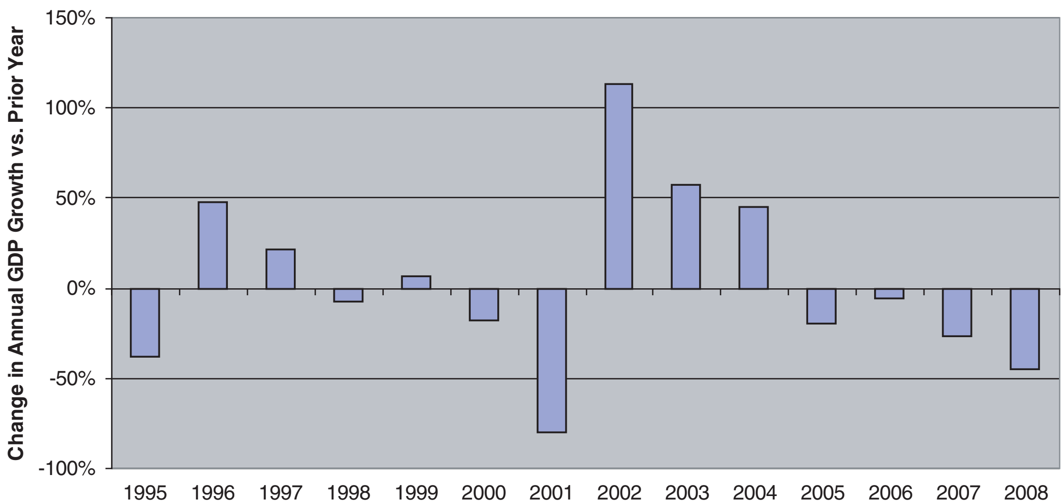
Hub Type	Years Ahead Forecast				
	1	2	3	4	5
Large	3.9%	9.3%	12.4%	15.7%	20.4%
Medium	5.5%	11.3%	14.5%	17.9%	19.3%
Small	8.7%	12.3%	14.4%	17.1%	18.6%
Non-Hub	15.6%	20.2%	23.9%	26.3%	27.9%
All	11.5%	16.1%	19.3%	22.0%	23.9%

Exhibit I-28. Historical volatility in oil prices.



Source: EIA, Annual Energy Outlook Retrospective Review, 2009 Report

Exhibit I-29. Historical volatility in GDP growth.



Source: EIA, Annual Energy Outlook Retrospective Review, 2009 Report

they may be several months ahead can lead to large projected errors.[11] Exhibit I-28 shows how recent volatility could cause large misses in predicting future fuel prices.

One possible way to obtain more accurate predictions of future fuel prices would be to utilize the financial futures market for crude oil or related commodities. Many U.S. airlines engage in fuel hedging strategies using heating oil futures contracts. Heating oil prices are closely correlated with jet fuel prices, and the futures market for heating oil is large and very liquid.[12]

The described annual models would indicate that one should use today's jet fuel price to help project next year's seat departures at a given airport, but for practical purposes it is suggested that users consider looking at current prices for heating oil futures contracts at least several months out in order to get a better understanding of where jet fuel prices may be headed.

An assessment of average national income growth suggests similar findings; as shown in Exhibit I-29, the historic data series is quite volatile. This volatility can become significantly more pronounced if one considers variations in *local* income, which is the metric actually used in the air service models.

One of the major objectives of the modeling effort is to obtain reasonable estimates of the uncertainty in airport-level operations and enplanement forecasts by providing likely

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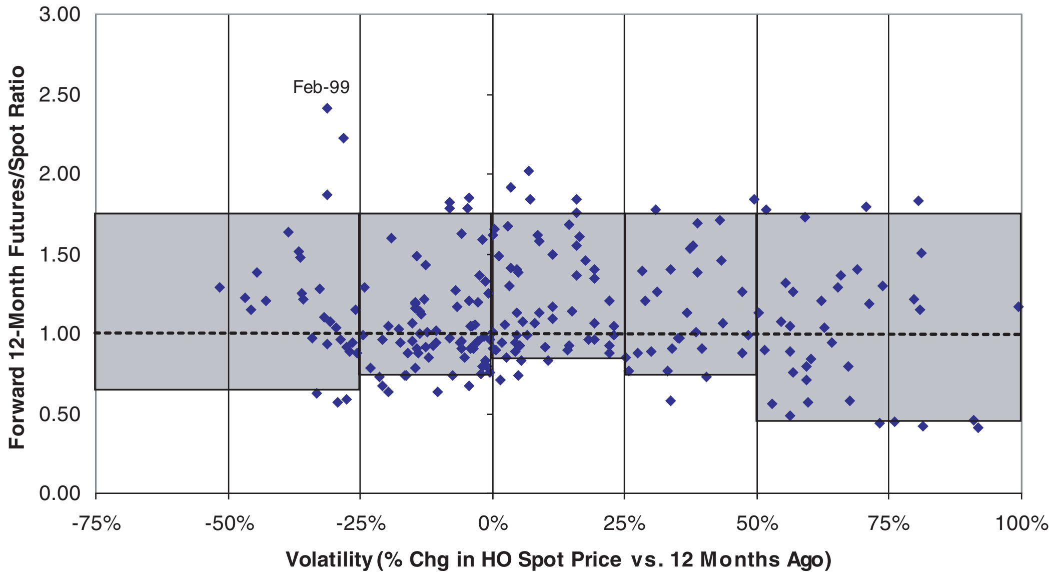
[11] This is the "random walk" theory of prices, which states that this period's price is simply equal to last period's price plus a random error.

[12] Although there is a futures contract for kerosene (which is the primary component of jet fuel) that trades on the Tokyo Commodities Exchange, it is denominated in Japanese yen, which would introduce foreign exchange risk for U.S. companies.

Exhibit I-30. Accuracy of heating oil futures prices as a function of volatility.



upper and lower bounds based on the range of observed historical changes in the models' explanatory variables. Focusing on heating oil futures and Energy Information Administration (EIA) projections of future GDP, an analysis was undertaken to assess how prior volatility affects the accuracy of futures projections over the past 20 years.

For heating oil futures, monthly data of 12-month-ahead futures prices from August 1990 through February 2009 were examined.[13] Exhibit I-30 relates the accuracy of these futures prices (relative to the actual spot prices 12 months later) to recent volatility as measured by the percentage change in the spot price over the prior 12 months. A futures price exactly hitting the 12-month-ahead spot price would be indicated by points exactly at 1.00 on the vertical axis.

On the horizontal axis, points to the left of zero indicate falling spot heating oil prices over the past 12 months, and points to the right indicate rising prices. For example, the point identified as February 1999 on the chart reflects a year-ahead spot price (for February 2000) that significantly exceeded the February 1999 12-month futures price as measured on the vertical axis (93.72 cents per gallon vs. 38.83 cents); this was partially a reflection of the fact that spot prices had declined by more than 31 percent (measured on the horizontal axis) between the 12-month period from February 1998 to February 1999.

The shaded area represents an approximate 90 percent confidence band based on the observed data points and indicates that the range of uncertainty for heating oil futures projections is somewhat smaller when (absolute) volatility is smaller (in the –25% to +25% range). During times of high volatility, the shaded confidence band gets larger, as would be expected (beyond –25% and +25%). The empirical confidence bands shown in Exhibit I-30 are embedded in the software to allow the user to quickly define lower and upper bound scenarios for the price of jet fuel based on recent observed price volatility.

A corresponding analysis was undertaken for EIA projections of GDP growth.[14] But in this case, there are many fewer projections compared to the heating oil projections (annual only from 1994 on), and they are spread out over one to five years ahead. An analysis of these data indicated that the overall error range of the projections relative to the actual was fairly evenly spread within ±2 percentage points regardless of the number of years ahead being forecast or the magnitude of recent volatility in the data series. Consequently, the ±2 point range is embedded in the software for purposes of defining lower and upper bound scenarios for local income growth for all future projection years.

4.2 Airport Outreach

An important part of the research project was to reach out to airport sponsors and operators to get feedback about how useful the software might be to their activity forecast–dependent

[13] Until 2007, futures contracts for heating oil were traded only for periods of 18 months ahead and shorter. Currently the maximum forward period is 36 months. The analysis described here is based on 12-month-ahead contracts, which have been actively traded for many years.

[14] Projections of local per capita income (the metric used in the air service models) for the five-year period from 2010 through 2014 could not be obtained. Instead, it is assumed that local income changes are likely to follow national trends as measured by the EIA national projections of GDP. But unlike the monthly heating oil projections, EIA's annual GDP projections are available for several years into the future; thus, the analysis for GDP is based on projections from one to five years ahead.

decision making and how the software tool itself could be improved. Valuable feedback was obtained from representatives of five different airports—two medium hub commercial airports, two small hub airports, and one non-hub airport. In addition, the project panel included several industry professionals who provided direct feedback from presentations made during the work effort. Finally, the project team made a presentation at the Airport Finance and Administration Conference held by the Southeast Chapter of the American Association of Airport Executives (AAAE) held in February 2010.

The feedback fell into two major categories:

- Overall usefulness of assessing how airports deal with uncertainty
  - How can a simple model accurately gauge uncertainty at specific airports? (Every airport is different.)
  - In practice, airport decision making is often reactive, not proactive or forward-looking.
  - Effect of fuel prices on airports depends primarily on airline reactions, which in turn are very dependent on many factors, including carrier financial strength, market competition, fleet composition, network effects, fuel hedging strategies, etc.
  - Institutional factors are very important, particularly for smaller airports (e.g., AIP funding).
  - Impacts may be different at airports that have significant non-aviation–related revenue sources.
- Practical usefulness of the software that was developed
  - Program appears to be easy to use, given its relatively narrow focus.
  - Ability to view and compare historical data is useful.
  - User should be reminded that many other factors may affect airport activity and revenues.
  - Results appear to come from a black box; user would have to read report to understand how the underlying statistical model works.
  - Limitations of TAF are shown clearly, which is useful to airport planners.

A number of useful revisions and enhancements were made to the software based on this feedback, which also led the project panel to recommend that the scope and focus of the software be kept fairly narrow and straightforward. For the software to be truly useful to its intended audience, a fine line had to be followed to ensure that it did not overwhelm the end user or require a significant learning curve.

CHAPTER 5

Areas for Future Research

This project undertook an analysis of how large changes in fuel prices may affect future projections of airport activity. A statistical model tying these and other economic elements together was developed and embedded inside a user-friendly software program in order to allow airport planners and sponsors to accurately assess how fuel, economic, and other uncertainties might affect their own airport forecasts.

Great care was taken to develop a statistically sound and defensible model of how airport activity may be affected by fuel price changes and other factors. By design, the model was then embedded in a software program to assist airport planners with anticipating changes to *existing forecasts* of air services. It accomplishes this by calculating percentage changes in seat departures based on a defined set of explanatory variables and then applying those percentages to the chosen existing forecast. This approach is less than perfect because these existing forecasts have their own embedded statistical relationships and uncertainties which the model developed here cannot fully account for. At best, it is hoped that the projected percentage changes from the model are reasonably similar to what would be obtained if the existing forecasts themselves were to be re-estimated with the same user-specified changes in explanatory variables that appear in the software.

With this limitation in mind, additional research could involve a so-called “meta-analysis” of airport forecasts. Such an approach would focus on combining the results of different forecasts in the hopes of finding more accurate measures of the impacts (“effect sizes”) of specific factors such as oil prices on airport activities. If carried out properly, a meta-analysis may be able to assess the reasons behind variations between forecasts and expose any biases or weaknesses that may exist in specific forecasts.

Another area for fruitful research may be in focusing on a more direct assessment of how airport aviation activity fits into the overall macro-economy. The demand for travel and, therefore, the demand for aviation services, is primarily a derived demand—most people consume scheduled aviation services not because they like to fly *per se,* but because it enables them to engage in desirable or necessary activities such as vacations and business meetings at remote locations. So it makes sense to assess how energy price shocks may affect overall consumer demand, and then try to ascertain how that translates into changes in the demand for air travel.

A common theme in some recent academic studies is that the effects of rises in energy prices are felt mainly as reductions in consumer purchasing power. Because many of the primary demand uses for energy are relatively price-inelastic (for example, commuter travel to work and home heating and electricity use), rising energy prices result in consumers spending more on energy consumption, thereby leaving less discretionary income for purchases of other goods and services. This scenario is primarily how oil price shocks would be expected to affect aviation demand, with the impacts on discretionary leisure travel likely to be greater than the impacts on business travel. This and related issues are discussed further in the literature review contained in the appendix.

Another feature of the current analysis is that it was designed to be relevant for hundreds of different-sized airports. While this feature means that the findings and potential usefulness of the software may be fairly widespread, it also means that the analysis was quite restrictive in terms of how variations in local conditions and factors could be accounted for. Perhaps future analyses could focus on one specific type of airport (e.g., large reliever airports) in order to gain more insight into how oil prices and other economic shocks are likely to affect facilities with similar roles and uses.

APPENDIX

Literature Review

This literature review was conducted as part of the effort to create a tool to assist airports with anticipating changes in air service due to external shocks (particularly fuel price changes) that have important implications for airport development and finance. Because the mandate is practical, particular attention was focused on empirically based literature that attempts to model quantitatively air traffic flows.

Overview

Exhibit A-1 provides an overview of study objectives and the major findings of the empirical literature we have reviewed. Many of these studies attempt to explain the structure of the commercial airline industry—how the airline network system evolved, the nature of completion among carriers including strategic entry into markets, and the role that scale and density economies play. Two issues have received special attention: the emergence of the hub and spoke system, and strategic entry by low-cost carriers like Southwest Airlines.

Arguments have been made in the literature that the hub and spoke system confers both cost and demand-side advantages to carriers. Berry (1990), for example, notes that hub and spoke systems reduce the number of round-trips needed to transport a given number of passengers and, given economies of flying large planes, can produce cost savings sufficient to overcome the costs of flying more miles (on connecting spokes). At the same time, he argues that hubbing is a form of product differentiation that allows airlines to offer services for which passengers are willing to pay premiums. The demand-side advantages include superior gate and ticketing services, higher flight frequency, and frequent flyer programs. In a later study, Berry et al. (1997) find evidence that hubbing airlines are able to charge fare premium to relatively price-inelastic (business) travelers for such services, and that hubbing confers cost advantages related to economies of spoke density.[15] Aguirregabiria and Ho (2008) report evidence in a study that the cost of entering new connecting routes declines with a carrier's scale of operations at airports and that hubbing serves as a deterrent to entry by potential competitors.

Several studies have attempted to explain the market entry patterns of low-cost carriers (LCCs), who generally do not set up hub and spoke systems. Boguslaski et al. (2004) finds that Southwest initially entered dense, short-haul markets and later entered longer-haul markets, partly motivated by network effects. Ito and Lee (2003) report similar results, and also find that LCCs tend to enter markets with above-average prices. Oliveira (2008) presents evidence that Gol Airlines, an LCC in Brazil, engaged in entry strategies similar to those of Southwest. Both Oliveira (2008) in a study of the U.S. market and Alderighi et al. (2004) find that full-service carriers lower prices in response to market entry by LCCs.

Virtually all of the studies listed in Exhibit A-1 define products as route-specific trips between airport pairs. In this sense, these studies address, at least indirectly, the issue of modeling airport-specific traffic patterns. However, most of these studies do not model traffic volumes (either the number of flights or the number of passengers) explicitly. For example, those studies that focus on carrier entry patterns typically model discrete outcomes (i.e., an airline either does or does not offer service at a particular airport).[16] While carrier presence and traffic volumes are related, it is not always possible to distinguish one from the other because of variations in aircraft size, load factors, and flight frequency. One exception is Borenstein and Rose (2003) who model the effects carrier bankruptcies have on airport-specific service levels. They find no significant bankruptcy effects on service levels at large and small airports,

[15] Spoke density confers cost advantages in that it allows carriers to use larger planes that have lower costs per seat than smaller aircraft.

[16] Tamer and Ciliberto (2007) and Sugawara and Omori (2008) make probabilistic estimates of carrier service entry into specific airports. Morrison and Winston (1995) make similar estimates at the route level (entry and exit from specific airport pairs).

Exhibit A-1. Literature summary—study objectives and major findings.

Study	Study Objective	Major Findings
Alder et al. (2008)	Assess European transport infrastructure investments.	Investments in rail infrastructure will improve social welfare.
Aguirregabiria & Ho (2008)	Effects of demand, costs, and strategic factors on adoption of hub–spoke networks.	Cost of entry into a route declines with scale of airline's operations at connecting airports. Also, hub–spoke networks deter strategic entry by rivals.
Alderighi et al. (2004)	Response of full-service carriers to entry of low-cost carriers in Europe.	Incumbent carriers lower fares for both business and leisure travelers when low-cost carriers enter markets.
Berry (1992)	Effects of airlines' scale of operations on profits, as indicated by entry decisions.	Within-market competition limits the number of entering firms, even if airport access restrictions are eased.
Berry et al. (1997)	Estimate the effects of hubs on airline costs and price markups.	Hubbing airlines' ability to raise fares limited mainly to price-inelastic travelers. Find evidence of economies of spoke density.
Berry (1990)	Test hypothesis that airport presence (e.g., better service related to hub–spoke system) affect demand as well as costs.	Airport presence by carriers increases demand for air travel and explains, in part, pricing practices by hubbing airlines.
Boguslaski et al. (2004)	Explain entry patterns of Southwest Airlines.	Initially, Southwest entered dense short-haul markets, then entered long-haul markets, partially motivated by network effects.
Borenstein & Rose (2003)	Estimate the effect of airline bankruptcies on air service.	No substantial effects of bankruptcies on large and small airports, but some impacts on medium-sized airports.
Goolsbee and Syverson (2008)	Analyze how incumbents respond to threat of entry (by Southwest).	Incumbents decrease fares substantially on threatened routes.
Ito & Lee (2003)	Identify market characteristics affecting entry of nonstop, low-cost carriers.	Low-cost carriers enter dense markets with above-average prices; entry no longer limited to short- and medium-haul markets.
Lederman (2003)	Investigate the effects of frequent flyer programs and product differentiation on airline demand and pricing.	Frequent flyer programs affect airline demand and pricing strategies. Low-cost carrier entry is a form of product differentiation.
Morrison and Winston (1995)	Explain route entry and exit decisions of U.S. carriers from 1988–1992.	Carrier entry decisions depend on own and other carriers' hub status, expected fare, and presence of Southwest. Exit decisions are influenced similarly, but carriers more likely to exit long-haul markets.
Oliveira (2008)	Explain entry patterns of low-cost carrier Gol Airlines in Brazilian domestic market.	Initially, Gol focused on high-density, short-haul markets, but then diversified into longer-haul markets.
Pai (2007)	Identify the determinants of aircraft size and flight frequency on airline routes.	Aircraft size and flight frequency increase with market population, income, and runway length.
Sugawara & Omori (2008)	Model airline entry decisions.	Predict entry probabilities for two airlines at new Shizuoka airport.
Tamer & Ciliberto (2007)	Investigate impacts of firm characteristics on market structure of U.S. airline industry.	Competitive effects of low-cost carriers are different from large airlines and are increasing in airport presence, and repealing Wright Amendment would increase markets served out of Dallas Love by 20%.
Yan et al. (2008)	Explain point-to-point network effects and entry patterns of Southwest Airlines.	Main network effects are airport and regional presence, and substitutability of markets.

and small effects on medium-sized airports. Pai (2007) models traffic volume measured as flight frequency and finds that frequency increases with market population, income levels, and maximum airport runway length.

Demand-Side Modeling

Before discussing the details of demand-side modeling, a brief digression on market structure is worthwhile. It is fair to say that there is a consensus in the recent literature that domestic air carriers participate in "oligopolistic" markets (meaning markets with a small number of sellers, each of whom may influence the decisions of the other sellers). In this setting, passengers are assumed to be so-called "utility maximizers" and firms engage in strategies that they believe are consistent with profit maximization. The demand facing any single carrier depends on the pricing, output/capacity, and market entry decisions of its rivals. Indeed, several authors make explicit assumptions about the nature of the strategic "games" that rivals play in markets.[17]

[17] As we explain later in this review, some authors incorporate assumptions about strategic gaming explicitly in their econometric models.

Exhibit A-2 summarizes market/product definitions and demand-side control factors that are used in the studies that have been reviewed. Most of the studies define a "product" as a non-directional one-way or round-trip route between airport pairs. Aguirregabiria and Ho (2008) define a product as a round-trip, but distinguish direction.

The demand-side control variables generally fit into three categories: controls for buyer (passenger) characteristics, controls for site (origin/destination) characteristics, and controls for product differentiation. Two commonly used types of controls for buyer characteristics are:

- Passenger income in airport market areas—measures used in the literature include average per capita income for city/airport pairs, per capita GDP at the departing airport, the minimum and maximum per capita GDP in city pairs, and changes in state-level income and employment.
- Number of potential passengers in airport market areas—measures include average population for city pairs, and the geometric mean of population at market endpoints.

Also, some researchers have attempted to capture differential pricing strategies by airlines by distinguishing from business (relatively price-inelastic) travelers and leisure (relatively price-elastic) travelers. Berry et al. (1997) and Lederman (2003) model differential pricing explicitly by assigning passengers to "business" and "leisure" groups from fare distributions observed in the samples they use. Boguslaski et al. (2004) include controls for the fraction of leisure travelers in their model. Finally, Pai (2007) controls for the percentage of managerial workers in airport market area workforces.

Several studies distinguish origin/destinations characteristics by controlling for so-called vacation sites. For example, Ito and Lee (2003) include dummy variables for Sunbelt states; Pai (2007) includes dummy variables for Las Vegas and Orlando; Yan et al. (2008) include dummy variables for Nevada and Florida trips, and Berry et al. (1997) include mean temperature differences between city pairs.

Several authors recognize and attempt to control for product differentiation in their studies. The following are commonly used controls:

- Nonstop verses connecting flights
- Hub presence, captured as dummy variables or measures of hub size
- Trip length
- Flight frequency between airport pairs

As noted earlier, these factors are also likely to affect carrier costs in addition to affecting service quality, and hence demand. Some authors have characterized these factors as demand-side controls; others interpret them as cost/supply-side controls; and some, for example, Berry (1990) and Aguirregabiria and Ho (2008), specify structural models in which these factors appear in both demand and cost equations.

Supply/Cost Modeling

Exhibit A-3 describes the flight cost/supply factors and cost economy measures used in the reviewed studies. Perhaps the most important feature of supply-side modeling is the absence of cost data that can be linked to route-level demand-side data. Moreover, no study that was reviewed controlled explicitly for fuel costs.

Because of the lack of data, researchers have generally adopted one of two strategies for controlling for carrier costs:

- Impute costs from fully specified structural models
- Include proxies or instrumental variables as controls for costs

Two studies, Aguirregabiria and Ho (2008) and Berry et al. (1997) adopt the first strategy. Both specify full structural models, assume strategic behavior on the part of air carriers, and find market equilibria as solutions to N-person games. They then compute imputed costs as the difference between observed prices and optimal (profit-maximizing) markups, which are independent of costs.[18]

Most of the studies reviewed adopt the second strategy and control for cost variables through the use of proxy variables. These proxy variables include:

- Trip distance
- Hub presence, measured as hub size or dummy variables indicating the existence of hubs
- Airport congestion (e.g., average delay, slot constraint indicators, airport volume)
- Maximum runway length
- New carrier verses legacy carrier indicators

Also, Oliveira (2008) uses city-specific fixed effects to control for cost differences across airports.

Some studies (particularly those focused on entry decisions) also include, as supply-side variables, indicators of the degree of competition at airports. Several compute Herfindahl-Hirschman indices at airports to control for competition levels, and Goolsbee and Syverson (2008) and Boguslaski et al. (2004) include dummy variables for Southwest Airlines' presence at airports as an indicator of entry threat potential.

[18] The optimal markup depends only on price elasticity, and not the level of marginal cost.

Exhibit A-2. Literature summary—demand modeling.

Study	Market and Product Definitions	Demand Control Factors
Alder et al. (2008)	Business and leisure trips on hub–spoke and low-cost air, and rail transport. Business and leisure differential pricing.	Trip time, transport alternatives.
Aguirregabiria and Ho (2008)	Directional round-trip between cities.	Hub size at origin–destination and connecting airports, distance, and nonstop flight indicator.
Alderighi et al. (2004)	City pair trips for various passenger subclasses (promotional, discounted economy, unrestricted).	Per capita GDP in area of departing airport.
Berry (1992)	Dependent variable is entry into city pair markets. Market characteristics, proxies for profit, include distance, population (product of city pair populations), tourist cite indicator, and measures of airport presence.	Market characteristics, proxies for profitability, include distance, population (product of city pair populations), tourist site indicator, and measures of airport presence.
Berry et al. (1997)	Directional round-trip between city pairs. Distinguish between high- and low-elasticity passengers.	Trip distance, direct flight indicator, airport congestion indicator, population of end-point cities (geometric mean), temperature difference between city pairs (tourism indicator), flight frequency proxy.
Berry (1990)	Round-trip itineraries between city pairs.	Population (product of city pair populations), trip distance, airport presence (number of top 50 cities served by airline from airport).
Boguslaski et al. (2004)	City pair trip, regardless of direction.	Density (daily number of passengers on all flights), geometric mean of population in city pair, per capita income at origin and destination, maximum fraction of leisure travelers among the city pairs, trip distance.
Borenstein and Rose (2003)	Two different measures of service: total nonstop domestic flights to and from airport; total number of domestic locations served nonstop from airport.	Seasonal and time-period fixed effects, changes in state-level employment, and changes in state-level income.
Goolsbee and Syverson (2008)	Airport to airport trip.	Demand controls not identified.
Ito and Lee (2003)	Round-trip and one-way itineraries.	Route density (average daily number of passengers carried by all passengers), distance, population at endpoint cities, per capita income at endpoint cities, "vacation" cite indicator (sunbelt states).
Lederman (2003)	Carrier-specific round-trips.	Airline-route fixed effects, airline-quarter (time) fixed effects, fare distributions (percentiles), hub presence, airline flight shares.
Morrison and Winston (1995)	Carrier-specific route between two airports.	Slots, distance, density, relative fares, population and real per capita income at origin and destination.
Oliveira (2008)	Non-directional origin and destination routes aggregated to city levels.	City-specific dummy variables intended to capture geographic idiosyncrasies such as income, wealth, and propensities for business and leisure travel, trip distance.
Pai (2007)	Dependent variables are aircraft size and flight frequency between airport pairs.	Percentage of households with income greater than $75,000, percentage of managerial workers in labor force, percentage of population under age 25, in airports' MSAs; route distance, leisure travel indicator (Las Vegas and Orlando).
Sugawara and Omori (2008)	Route between two airports.	Population at airports.
Tamer and Ciliberto (2007)	Non-directional trip between two airports.	Average population, average per capita income, average rates of income growth at market endpoints, distance to closest competing airport, trip distance, and distance form market endpoints to the geographic center of the United States.
Yan et al. (2008)	Airport pair routes.	Distance between airports, average population, average per capita income, and vacation site (Nevada and Florida).

Exhibit A-3. Literature summary—supply/cost modeling.

Study	Flight Cost/Supply Factors	Hub/Spoke Density Economies
Alder et al. (2008)	Function of great circle distance and number of seats for short and long haul.	Not measured.
Aguirregabiria and Ho (2008)	Costs not modeled explicitly. Hub size, trip distance, nonstop, and airline-specific effects; airport effects. Model distinguishes variable flights costs, fixed flight costs, and entry costs imputed from price markups.	Estimate economies of hub size.
Alderighi et al. (2004)	Trip distance, Herfindahl-Hirschman index computed over all full-service carriers serving market, presence of low-cost carrier in market.	Not measured.
Berry (1992)	Costs not modeled explicitly. Distance between city pairs, airport presence used as proxies.	Not measured explicitly, but measures of airport presence (city pair market shares, number of routes served out of airport) included in models.
Berry et al. (1997)	Costs not modeled explicitly (computed as difference between fares and markups). Cost instruments include airport congestion, segment distance, and trip frequency proxy.	Spoke density economies imputed from differences between fares and markups.
Berry (1990)	Costs not modeled explicitly. Distance between city pairs, airport presence (number of top 50 cities served by airline from airport), and instruments for new versus legacy carriers used as proxies.	Airport presence used as proxy for hub density.
Boguslaski et al. (2004)	Costs not modeled explicitly. Supply-side proxies include number of cities served at trip endpoints, Southwest share of O&D passengers, and several indicators of competiveness including presence of competing hub and Herfindahl-Hirschman indices at end point cities.	Not measured directly, but measures of Southwest presence at airports interpreted as measures of network effects.
Borenstein and Rose (2003)	Costs not modeled explicitly. Market share of airline filing for bankruptcy included as supply-side variable.	Not measured.
Goolsbee and Syverson (2008)	Costs not modeled explicitly. Southwest presence at airports included as supply-side entry threat variables.	Not measured.
Ito and Lee (2003)	Costs not modeled explicitly. Supply-side indicators include hub presence, delays (dummy variable for 10 airports with highest delays), multiple airport cities, Herfindahl-Hirschman indices for endpoint cities.	Not measured.
Lederman (2003)	Costs not modeled.	Not measured.
Morrison and Winston (1995)	Costs not modeled. Other carriers' presence at airports included as supply-side entry-threat variables.	Not measured.
Oliveira (2008)	Costs not modeled explicitly. Gol presence at airports included as supply-side entry threat variables. City-specific dummy variables interpreted proxies for cost and air travel service support differences across airports.	Not measured directly, but city-specific dummy variables interpreted as proxies for network effects.
Pai (2007)	Costs not modeled explicitly. Supply-side variables include number of nearby airports, maximum runway length, airport delays, and slot constraint indicator.	Not measured directly, but number of destinations served and proportion of passengers with connecting flights used as hub presence proxies.
Sugawara and Omori (2008)	Costs not modeled explicitly. Distance used as a measure of travel cost. Availability of high-speed train used as air travel alternative.	Not measured.
Tamer and Ciliberto (2007)	Costs not modeled explicitly. Geographic distance between airlines' closest hub and market endpoints used as proxy for cost.	Not measured directly, but cost proxy variable used to control for hub effects.
Yan et al. (2008)	Costs not modeled explicitly. Supply-side proxies include Herfindahl-Hirschman index (maximum of airport pair), airport volume (maximum of airport pair), and dummy variables for full-service hub presence.	Not measured directly, hub presence variables used to control for hub effects.

Econometric Methods

Exhibit A-4 identifies the econometric methods employed in the recent literature. Generally, these methods can be classified into the following three groups:

- Multivariate regression models
- Discrete choice models—logit and probit estimators
- Structural models—simulation estimators

The choice of estimators depends primarily on model specifications.

The multivariate regression models have been employed to estimate reduced form models when the dependent variable of interest is continuous. For example, Borenstein and Rose (2003) use this technique to explain traffic volumes at airports at which bankruptcies have occurred. Goolsbee and Syverson (2008) is primarily interested in explaining variations in air fares, and Pai (2007) models two continuous variables—aircraft size and flight frequency.

Many authors employ logit and probit models that are suitable for use when the dependent variable of interest is discrete. Many of the studies reviewed have used these estimators to model market entry decisions including, for example, Berry (1992), Boguslaski et al. (2004), Ito and Lee (2003), Morrison and Winston (1995), and Oliveira (2008).

Several studies, including Aguirregabiria and Ho (2008), Berry (1992), Berry et al. (1997), and Sugawara and Omori (2008), employ structural models in their work. These models have been developed, in part, out of empirical work in the field of industrial organization. In these models, consumers are assumed to behave consistently with utility maximization, and firms attempt to maximize profits while playing strategic (oligopolistic) games. Given assumptions about the structure and distributions of model error terms, estimates of parameters are then drawn iteratively (using simulation estimators) until the values of observed variables (e.g., prices) can be retrieved. Estimating these models is typically very computationally intensive.

Concluding Remarks

Demand-side models in the recent literature are relatively rich, primarily because data on passenger, site, and product characteristics can be married with detailed, route-specific DOT data on U.S. domestic air travel. The cost or supply-side modeling in the literature is much less rich because of lack of data. Most researchers have resorted to controlling for costs through proxies and instruments. Two of the structural models reviewed impute detailed cost estimates as differences between observed prices and optimal markups. However, neither of these models incorporates the effects of exogenous shocks such as changes in fuel prices.

Many of the studies reviewed attempt to explain the evolution of the structure of airline markets, and several of these focus on market entry decisions. While these models provide useful insights, they fall short as tools for modeling airport-specific traffic and revenue streams. While carrier entry (and exit) decisions are linked to airport traffic volumes, modeling these is not sufficient to predict airport traffic flows. Also, most of these studies employ discrete choice estimators (logit and probit). These models are well suited for identifying patterns of behavior for populations (i.e., the industry as a whole), but typically have weak predictive power for individual observations (i.e., specific airports).

The structural models are the most sophisticated of those reviewed. These models are capable of dealing with

Exhibit A-4. Literature summary—econometric methods.

Study	Econometric/Statistical Methods
Alder et al. (2008)	Nested multinomial logit model.
Aguirregabiria and Ho (2008)	Recursive pseudo maximum likelihood estimator [See Aguirregabiria and Mira (2007)].
Alderighi et al. (2004)	Multivariate regression model.
Berry (1992)	Probit model, simulation estimator.
Berry et al. (1997)	Simulation estimator.
Berry (1990)	Simulation estimator.
Boguslaski et al. (2004)	Probit model.
Borenstein and Rose (2003)	Multivariate regression model.
Goolsbee and Syverson (2008)	Multivariate regression model.
Ito and Lee (2003)	Probit model.
Lederman (2003)	Nested logit model.
Morrison and Winston (1995)	Probit model.
Oliveira (2008)	Amemiya Generalized Least Squares (AGLS); probit model.
Pai (2007)	Multivariate regression models.
Sugawara and Omori (2008)	Bayesian estimation using Markov chain Monte Carlo Simulation.
Tamer and Ciliberto (2007)	Multinomial logit model.
Yan et al. (2008)	Spatial probit model.

endogeneity and strategic behavior and in two cases have permitted researchers to make inferences about underlying cost structures. However, estimating and using these models is very computationally intensive. This drawback would appear to rule out these types of models as good candidates for practical tools for predicting airport-specific traffic flows.

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PART II

Documentation for Airport Forecasting Risk Assessment Program

Software Quick Start

The Airport Forecasting Risk Assessment Program is a Microsoft® Excel spreadsheet; the user will need Microsoft Excel 2000 or later to run the software, and Excel macros must be enabled.

Open the spreadsheet.

Go to the ***SelectLOCID*** worksheet, and select an airport from the pull-down menu (Exhibit II-1).

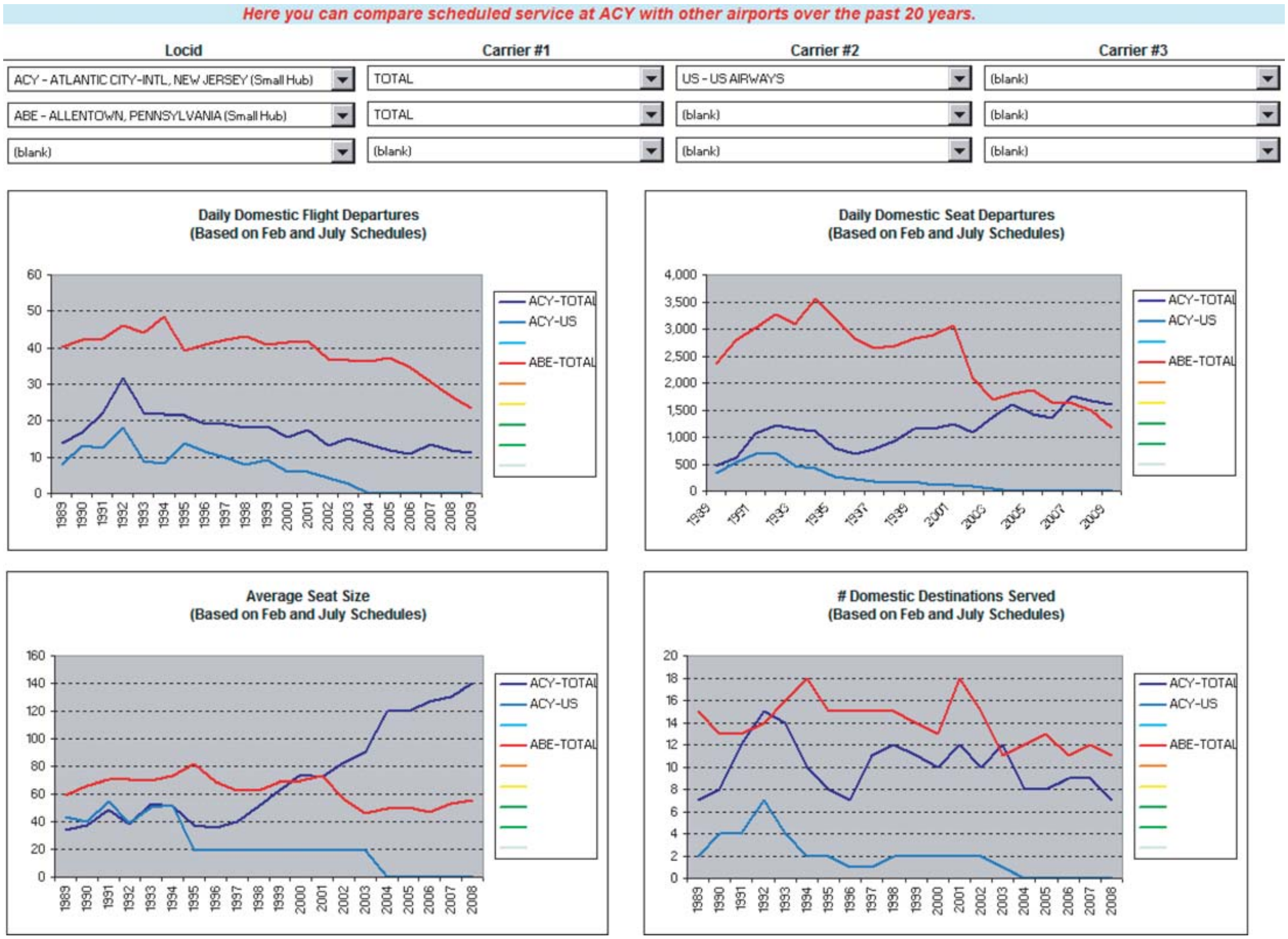
Press Update Tables .

The program takes the user to the ***OAGHistory*** worksheet (Exhibit II-2) where he or she can view 20-year trends for the airport including average domestic flight departures, domestic seat departures, average seat size, and number of domestic destinations served. The pull-down menu is used to focus on specific airlines at the airport or to compare the airport to others.

The user should also examine the ***TAFHistory*** worksheet (Exhibit II-3), which shows how accurate recent TAF forecasts have been for the subject airport.

Exhibit II-1. *SelectLOCID* worksheet.

Exhibit II-2. ***OAGHistory*** **worksheet.**



The ***CurrentService*** worksheet (Exhibit II-4) shows the air services available in individual domestic markets by identified airlines in 2009. The user can modify this information by adding new cities in the first two columns and new average weekly departures and average seat size in the last two columns labeled User Updates.

The user can also modify existing services information in the last two columns. All of the modifications will show up in **red font**. To take account of these modifications in a new Baseline Forecast, press *Update Tables*.

The software will then take the user to the ***Baseline&Scenarios*** worksheet (Exhibit II-5). If modifications were made in the ***CurrentService*** worksheet, the Baseline Forecast at the top of the page will reflect those changes. If modifications were not made in the ***CurrentService*** worksheet, the Baseline Forecast at the top of the page will be the TAF forecast.

The user can further modify the forecast directly in the columns labeled User Updates by typing in the numbers or using standard Excel commands. For the ACY example shown in Exhibit II-5, the results of increasing future activity by 5 percent across the board (relative to the default TAF baseline) are shown in Exhibit II-6. Changes will be shown in **red font**.

Exhibit II-3. ***TAFHistory*** **worksheet.**

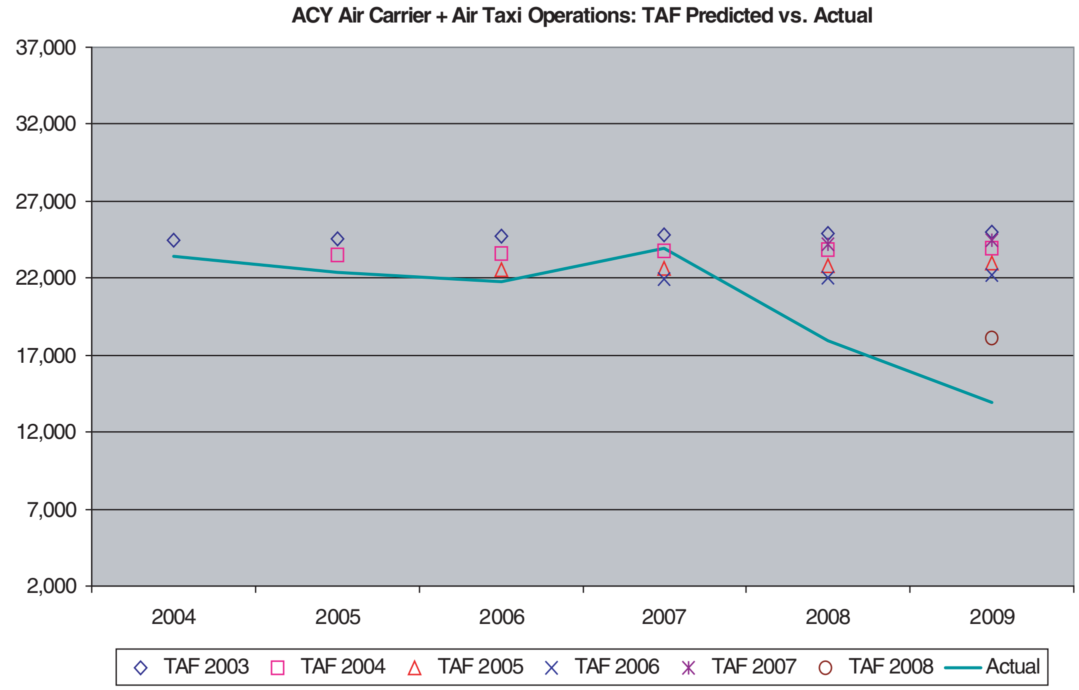


Exhibit II-4. ***CurrentService*** **worksheet.**

Here you can review current scheduled domestic service. You may update the schedule by editing the User Update columns. You can also add service to new domestic cities by filling in the Arrival and User Update columns below the last OAG record.
After you update or add service, please click the "Update Tables" button below.

Update Tables

Reset User Updates to OAG Defaults

OAG Scheduled Domestic Departures from ACY for YE Dec 2009					User Updates (changes in red)	
Arrival	Name	Carriers	Weekly Departures	Avg Seat Size	Weekly Departures	Avg Seat Size
ATL	ATLANTA, GEORGIA	FL	7.79	117.0	7.79	117.0
BOS	BOSTON, MASSACHUSETTS	NK	4.70	145.0	4.70	145.0
FLL	FT. LAUDERDALE, FLORIDA	NK	19.29	145.0	19.29	145.0
MCO	ORLANDO, FLORIDA	FL-NK	23.49	142.3	23.49	142.3
MYR	MYRTLE BEACH, SOUTH CAROLINA	NK	8.00	145.0	8.00	145.0
PBI	WEST PALM BEACH, FLORIDA	NK	3.26	145.0	3.26	145.0
RSW	FORT MYERS-REGIONAL, FLORIDA	NK	8.53	145.0	8.53	145.0
TPA	TAMPA/ST. PETERSBURG, FLORIDA	NK	7.00	145.0	10.00	145.0

Exhibit II-5. Upper portion of ***Baseline&Scenarios*** **worksheet.**

Baseline Forecast for ACY
(Based on TAF Air Carrier/Air Taxi Forecast and User Updates of Current Domestic Service)
You can change the Default Baseline forecasts by entering new numbers in the User Update columns.

Reset User Updates to Baseline Defaults

	Default Baseline Domestic Forecast		User Updates (changes in red)	
Year	Domestic Operations	Domestic Enplanements	Domestic Operations	Domestic Enplanements
2009	14,406	520,470	14,406	520,470
2010	14,548	527,543	14,548	527,543
2011	14,692	534,712	14,692	534,712
2012	14,836	541,979	14,836	541,979
2013	14,983	549,350	14,983	549,350
2014	15,133	556,821	15,133	556,821

	Default Baseline International Forecast		User Updates (changes in red)	
Year	International Operations	International Enplanements	International Operations	International Enplanements
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	0	0	0	0

Exhibit II-6. Results of user updates to ACY example scenario.

	Default Baseline Domestic Forecast		User Updates (changes in red)	
Year	Domestic Operations	Domestic Enplanements	Domestic Operations	Domestic Enplanements
2009	14,406	520,470	14,406	520,470
2010	14,548	527,543	15,275	553,920
2011	14,692	534,712	15,427	561,448
2012	14,836	541,979	15,578	569,078
2013	14,983	549,350	15,732	576,818
2014	15,133	556,821	15,890	584,662

In the lower portion of the ***Baseline&Scenarios*** worksheet (Exhibit II-7), the user can input ranges for key air service drivers, which in turn will create scenarios for the Baseline Forecast.

In general, increases in these drivers will have the following impacts on air services:

- Jet fuel price: (–)
- Economic growth: +
- Inflation:[19] +
- Average seats:[20] +
- Airport concentration: (–)
- Other airport competition:[21] (–)

The Herfindahl–Hirschman airport concentration index (shown at the bottom left of the worksheet) is a measure of the level of market competition at the airport. It is computed as the sum of the squared seat-departure shares of all the carriers at the airport, and ranges from 0 to 10,000, with higher values reflecting less competition. If an airport were served by only a single monopoly carrier, the index would equal 10,000 (= 100 percent seat share squared).

This driver has a negative impact on air services, reflecting the fact that the higher the index, the lower is the level of competition and therefore the lower the level of overall air service. The user can compute the index for a given set of market shares by using the calculator shown at the bottom of the ***Baseline&Scenarios*** worksheet.

The user can also create Confidence Bands around the Baseline Forecast taking account of jet fuel price and economic uncertainty by pressing the buttons:

Set Jet Fuel Scenarios based on Futures Uncertainty

Set Income Scenarios based on EIA GDP Uncertainty

[19] In the air services model, inflation is used to adjust nominal jet fuel prices to real prices; so high inflation results in lower real prices for jet fuel and thus more air service.

[20] Average seat size is a proxy for the cost of producing a seat departure; larger aircraft produce lower seat costs, which in competitive markets result in lower prices and thus more air service.

[21] Competition from large or medium hub airports within 50 miles tends to reduce air service.

Exhibit II-7. Lower portion of *Baseline&Scenarios* worksheet.

Forecast Drivers for Domestic Scenarios (International Forecast is Fixed)
2005-2009 data are fixed; you may change the Baseline and/or Scenario assumptions below for 2010-2014.
If you entered updates to the Baseline Domestic Forecast above,
you should ensure that the Baseline assumptions below are consistent with those updates.

View the latest Heating Oil futures prices by clicking here

Set Jet Fuel Scenarios based on Futures Uncertainty

Year	Baseline Price of Jet Fuel (Current Yr $/gal)	Scenario 1	Scenario 2
2005	$1.622		
2006	$1.906		
2007	$2.025		
2008	$2.938		
2009	$1.844		
2010	$2.174	**$1.500**	**$4.000**
2011	$2.258	$2.258	$2.258
2012	$2.499	$2.499	$2.499
2013	$2.719	$2.719	$2.719
2014	$2.888	$2.888	$2.888

(Default baseline from 2010 forward based on change in projected price of jet fuel from EIA Annual Energy Outlook 2010.)

Year	Baseline Inflation Rate	Scenario 1	Scenario 2
2005	3.34%		
2006	3.25%		
2007	2.87%		
2008	2.14%		
2009	1.18%		
2010	1.47%	**0.00%**	**0.00%**
2011	1.31%	1.31%	1.31%
2012	1.43%	1.43%	1.43%
2013	1.76%	1.76%	1.76%
2014	1.73%	1.73%	1.73%

(Default baseline from 2010 forward based on projected GDP Implicit Price Deflator from EIA Annual Energy Outlook 2010.)

Set Income Scenarios based on EIA GDP Uncertainty

Year	Baseline Local Real Income Growth	Scenario 1	Scenario 2
2005	0.43%		
2006	0.73%		
2007	0.27%		
2008	0.34%		
2009	-2.83%		
2010	1.07%	**4.00%**	**-1.00%**
2011	3.52%	3.52%	3.52%
2012	3.64%	3.64%	3.64%
2013	2.80%	2.80%	2.80%
2014	2.46%	2.46%	2.46%

(Default baseline from 2010 forward based on projected US GDP from EIA Annual Energy Outlook 2010; 2009 value equal to US GDP growth.)

Not relevant for Small Hubs

Year	Baseline Airport Avg Seatsize	Scenario 1	Scenario 2
2005	119.9		
2006	126.7		
2007	130.1		
2008	140.2		
2009	141.9		
2010	141.9	141.9	141.9
2011	141.9	141.9	141.9
2012	141.9	141.9	141.9
2013	141.9	141.9	141.9
2014	141.9	141.9	141.9

(Default baseline from 2010 forward equal to 2009 value.)

Year	Baseline Airport Concentration Index - HHI (0-10,000)	Scenario 1	Scenario 2
2005	8,189		
2006	8,450		
2007	8,804		
2008	9,715		
2009	8,333		
2010	8,333	8,333	8,333
2011	8,333	8,333	8,333
2012	8,333	8,333	8,333
2013	8,333	8,333	8,333
2014	8,333	8,333	8,333

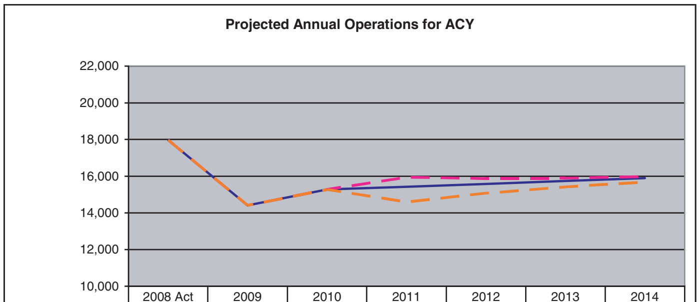
(Default baseline from 2010 forward equal to 2009 value.)

Year	Baseline Domestic Daily Seat-Departures at Lrg/Med Hubs within 50 Miles	Scenario 1	Scenario 2
2005	0		
2006	0		
2007	0		
2008	0		
2009	0		
2010	0	0	0
2011	0	0	0
2012	0	0	0
2013	0	0	0
2014	0	0	0

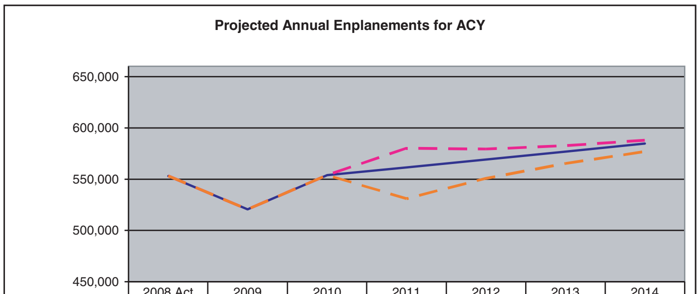
(Default baseline from 2010 forward derived from TAF.)

The Baseline and Sensitivity Cases will be shown in the ***Projections*** and ***One-Page Report*** worksheets (Exhibits II-8 and II-9).

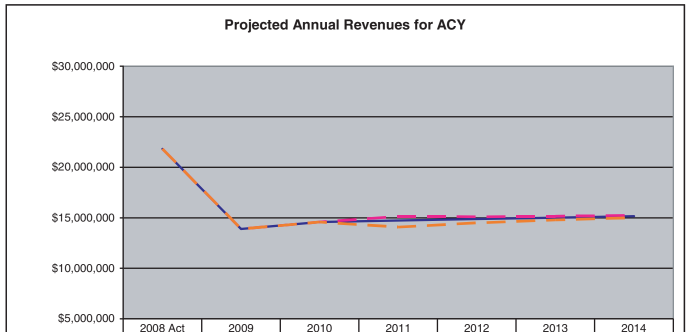
Exhibit II-8. *Projections* worksheet.



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	17,962	14,406	15,275	15,427	15,578	15,732	15,890
Scenario 1	17,962	14,406	15,275	15,940	15,861	15,891	15,980
Scenario 2	17,962	14,406	15,275	14,589	15,076	15,418	15,679



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	553,177	520,470	553,920	561,448	569,078	576,818	584,662
Scenario 1	553,177	520,470	553,920	580,140	579,441	582,641	588,000
Scenario 2	553,177	520,470	553,920	530,975	550,752	565,295	576,911



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	$21,809,615	$13,886,975	$14,587,270	$14,731,777	$14,877,321	$15,024,827	$15,174,229
Scenario 1	$21,809,615	$13,886,975	$14,587,270	$15,126,114	$15,095,449	$15,147,055	$15,244,057
Scenario 2	$21,809,615	$13,886,975	$14,587,270	$14,083,422	$14,489,700	$14,782,287	$15,011,764

Exhibit II-9. ***One-Page Report*** **worksheet.**

Airport Forecasting Risk Assessment Model

Forecast Generated:	August 27, 2010

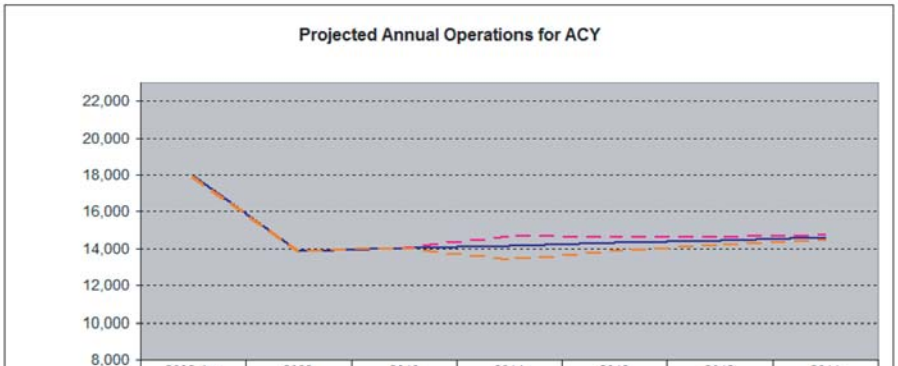
Local Income Projections (% change)

	Baseline	Scenario 1	Scenario 2
2010:	1.07%	4.00%	-1.00%
2011:	3.52%	3.52%	3.52%
2012:	3.64%	3.64%	3.64%
2013:	2.80%	2.80%	2.80%
2014:	2.46%	2.46%	2.46%

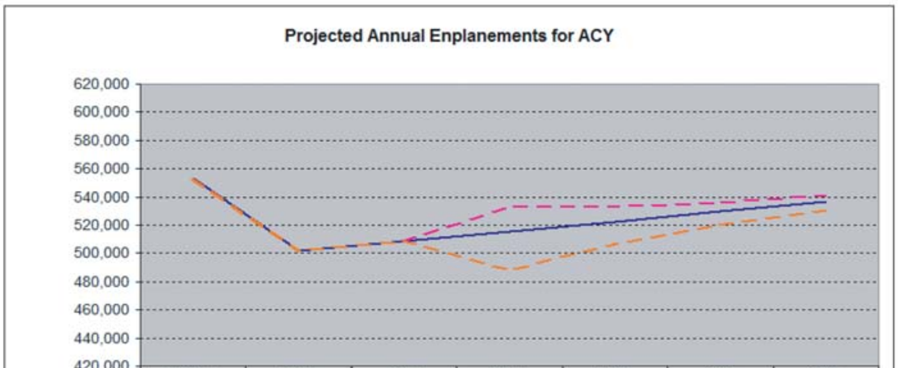
Jet Fuel Price Projections ($ per gallon)

	Baseline	Scenario 1	Scenario 2
2010:	$2.17	$1.50	$4.00
2011:	$2.26	$2.26	$2.26
2012:	$2.50	$2.50	$2.50
2013:	$2.72	$2.72	$2.72
2014:	$2.89	$2.89	$2.89

ACY - ATLANTIC CITY-INTL, NEW JERSEY (Small Hub)



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	17,962	13,898	14,035	14,174	14,313	14,455	14,600
Scenario 1	17,962	13,898	14,035	14,665	14,602	14,635	14,721
Scenario 2	17,962	13,898	14,035	13,422	13,879	14,200	14,443



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	553,177	501,686	508,504	515,415	522,419	529,524	536,726
Scenario 1	553,177	501,686	508,504	533,255	532,983	536,129	541,171
Scenario 2	553,177	501,686	508,504	488,064	506,595	520,168	530,966

In creating the sensitivity cases, the user should keep in mind how the drivers affect air services at an airport. Exhibit II-10 summarizes these impacts.

As with any forecasting process, the user is ultimately responsible for the assumptions used in the analysis. The software provides a structured way to improve airport forecasts and create sensitivity cases, but it is not a substitute for a well-thought-out analysis.

Exhibit II-10. Impact of drivers on air services.

Driver	Effect on Air Service if Driver is		Explanation
	Higher	Lower	
Jet Fuel Prices	−	+	If nominal fuel prices rise, air services decline, and vice versa.
Real Local Income	+	−	If real local income increases, air services increase, and vice versa.
Inflation	+	−	If inflation increases, it reduces real jet fuel prices and air services rise, and vice versa.
Average Seat Size at Airport	+	−	If average seat size increases, airline costs fall and air services rise, and vice versa.
Airport Concentration Index	−	+	If one or a few carriers dominate seat departures, air services decline, and vice versa.
Competition from Large/Medium Hubs	−	+	If average daily seat departures from an FAA large or medium hub airport within 50 miles grow, air services decline and vice versa.

Software User Manual

This user manual is presented in the form of a guided tour of the software, using Atlantic City International Airport (ACY) as an example. The steps to running the program are in **bold** and **highlighted**.

SelectLOCID Worksheet

The first worksheet shown in the software (Exhibit II-11) asks to the user to select from a list of 271 commercial service airports in the United States (excluding Hawaii and Alaska).

In this example, select **ACY**. To run the program, press the **Update Tables** button. This erases all previous information run through the model and loads data for the selected airport.

The user can also get access to information on the program; to do so, press **Help and Program Information**.

Exhibit II-11. Selecting an airport of interest in the *SelectLOCID* worksheet.

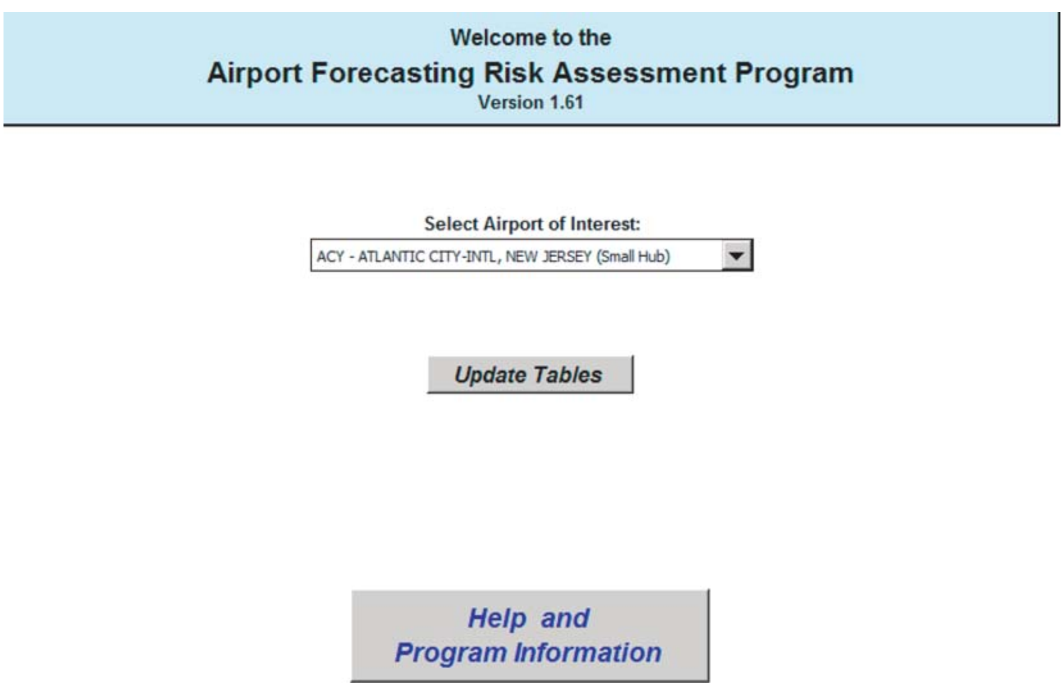


Exhibit II-12. Selecting airlines and comparison airports in the *OAGHistory* worksheet.

Locid	Carrier #1	Carrier #2	Carrier #3
ACY - ATLANTIC CITY-INTL, NEW JERSEY (Small Hub)	TOTAL	NK - SPIRIT AIRLINES	FL - AIRTRAN AIRWAYS
ABE - ALLENTOWN, PENNSYLVANIA (Small Hub)	TOTAL	(blank)	(blank)
(blank)	(blank)	(blank)	(blank)

OAGHistory Worksheet

Once the **Update Tables** button is pushed, the software sends the user to the *OAGHistory* worksheet. At the top of the worksheet, the user can select:

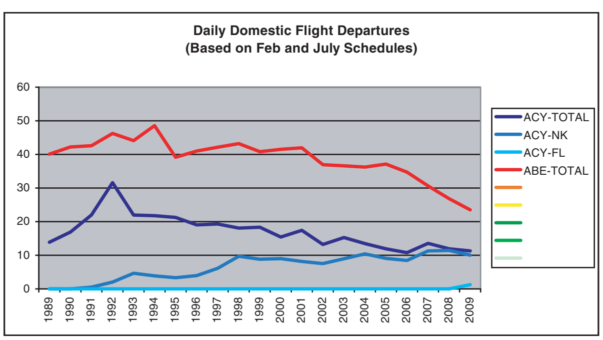
- Air service by individual carriers at the subject airport
- Air service history at comparison airports (including by individual carriers)

This information may be helpful in creating a customized forecast and in reviewing the reasonableness of any forecast relative to history.

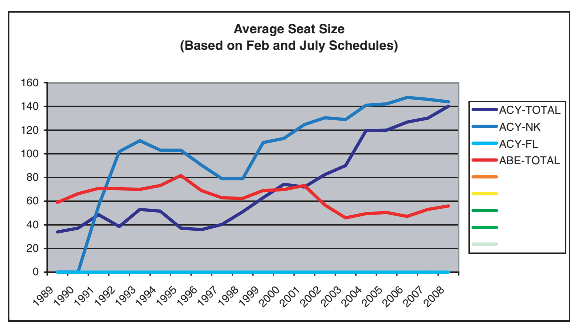
In this example, select **NK (Spirit) and FL (Airtran)** from the pull-down boxes for ACY (shown in Exhibit II-12). Select **ABE (Allentown, PA)** for a comparison airport. When an airport is first selected, airport totals are shown, but the user may select individual carriers in any or all of the three carrier selection boxes.

The graphics (shown in Exhibit II-13) provide an interesting history of air service at the subject airports. A user might test his or her own customized forecast against this history, or use a comparison airport to examine the possible future for the subject airport. In the following discussion, sample observations that might be drawn from the data are provided for illustrative purposes. These observations do not represent any formal conclusions about the airports shown.

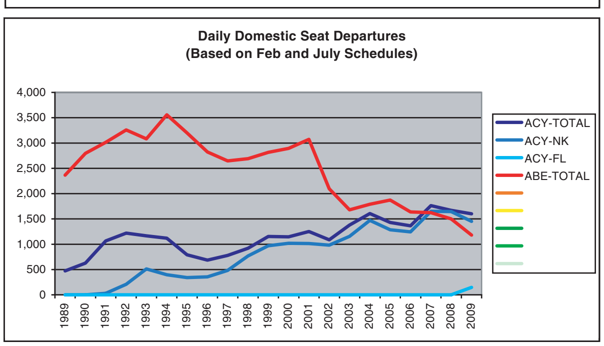
Exhibit II-13. Twenty-year air service history graphs in the *OAGHistory* worksheet.



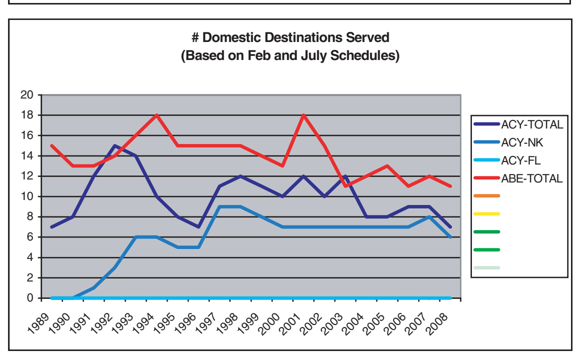
Flight departures at ABE have fallen off dramatically, while they have been more stable at ACY over the past 8 years.



Average seats per departure at ABE has varied between 80 and 45 seats. Average seats at ACY are on an upward trend.



Seat departures at ABE have fallen dramatically since the early 1990's, and accelerated after 9/11. ACY is on an upward trend, again due to NK.



Number of points served has been trending down at both airports, with ACY very dependent on NK.

Exhibit II-14. *CurrentService* worksheet.

Here you can review current scheduled domestic service. You may update the schedule by editing the User Update columns. You can also add service to new domestic cities by filling in the Arrival and User Update columns below the last OAG record.
After you update or add service, please click the "Update Tables" button below.

Update Tables

Reset User Updates to OAG Defaults

OAG Scheduled Domestic Departures from ACY for YE Dec 2009					User Updates (changes in red)	
Arrival	Name	Carriers	Weekly Departures	Avg Seat Size	Weekly Departures	Avg Seat Size
ATL	ATLANTA, GEORGIA	FL	7.79	117.0	7.79	117.0
BOS	BOSTON, MASSACHUSETTS	NK	4.70	145.0	4.70	145.0
FLL	FT. LAUDERDALE, FLORIDA	NK	19.29	145.0	19.29	145.0
MCO	ORLANDO, FLORIDA	FL-NK	23.49	142.3	23.49	142.3
MYR	MYRTLE BEACH, SOUTH CAROLINA	NK	8.00	145.0	8.00	145.0
PBI	WEST PALM BEACH, FLORIDA	NK	3.26	145.0	3.26	145.0
RSW	FORT MYERS-REGIONAL, FLORIDA	NK	8.53	145.0	8.53	145.0
TPA	TAMPA/ST. PETERSBURG, FLORIDA	NK	7.00	145.0	7.00	145.0

CurrentService Worksheet

This worksheet shows the average weekly departures and average seat size for 2009 for each domestic market served nonstop at the airport. Exhibit II-14 is an example for ACY.

This worksheet is consistent with the embedded TAF forecast, which is the default used in the model. The Baseline TAF forecast for ACY is found at the top of the ***Baseline&Scenarios*** worksheet, and shown in Exhibit II-15.

Updating the Baseline Forecast in the *CurrentService* Worksheet

In the ***CurrentService*** worksheet, an important feature allows users to update air service information by adding service to new cities and/or changing the number of weekly departures and average seat size in existing markets (in the right two columns).

Caution: It is very important to note that whatever changes are made in the ***CurrentService*** worksheet will become the Baseline Domestic Forecast in the ***Baseline&Scenarios*** worksheet. In effect the user is creating an updated Baseline using more current information.

Exhibit II-15. Baseline forecast from the *Baseline&Scenarios* worksheet.

Baseline Forecast for ACY
(Based on TAF Air Carrier/Air Taxi Forecast and User Updates of Current Domestic Service)
You can change the Default Baseline forecasts by entering new numbers in the User Update columns.

Reset User Updates to Baseline Defaults

	Default Baseline Domestic Forecast		User Updates (changes in red)	
Year	Domestic Operations	Domestic Enplanements	Domestic Operations	Domestic Enplanements
2009	14,406	520,470	14,406	520,470
2010	14,548	527,543	14,548	527,543
2011	14,692	534,712	14,692	534,712
2012	14,836	541,979	14,836	541,979
2013	14,983	549,350	14,983	549,350
2014	15,133	556,821	15,133	556,821

	Default Baseline International Forecast		User Updates (changes in red)	
Year	International Operations	International Enplanements	International Operations	International Enplanements
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	0	0	0	0

Exhibit II-16. User-revised *CurrentService* worksheet.

Here you can review current scheduled domestic service. You may update the schedule by editing the User Update columns. You can also add service to new domestic cities by filling in the Arrival and User Update columns below the last OAG record.
After you update or add service, please click the "Update Tables" button below.

Update Tables

Reset User Updates to OAG Defaults

OAG Scheduled Domestic Departures from ACY for YE Dec 2009					User Updates (changes in red)	
Arrival	Name	Carriers	Weekly Departures	Avg Seat Size	Weekly Departures	Avg Seat Size
ATL	ATLANTA, GEORGIA	FL	7.79	117.0	7.79	117.0
BOS	BOSTON, MASSACHUSETTS	NK	4.70	145.0	4.70	145.0
FLL	FT. LAUDERDALE, FLORIDA	NK	19.29	145.0	19.29	145.0
MCO	ORLANDO, FLORIDA	FL-NK	23.49	142.3	23.49	142.3
MYR	MYRTLE BEACH, SOUTH CAROLINA	NK	8.00	145.0	8.00	145.0
PBI	WEST PALM BEACH, FLORIDA	NK	3.26	145.0	3.26	145.0
RSW	FORT MYERS-REGIONAL, FLORIDA	NK	8.53	145.0	8.53	145.0
TPA	TAMPA/ST. PETERSBURG, FLORIDA	NK	7.00	145.0	7.00	145.0
DTW	Detroit				7.00	145.0

So, for example, at ACY, Spirit started once-daily service to Detroit with 145-seat aircraft after December 2009, the last month of OAG data in the model.

To update air service at ACY, input the city OAG code and name in the first two columns, and weekly departures and average seat size in the last two columns. Then press **Update Tables**. The revised ***CurrentService*** worksheet is shown in Exhibit II-16.

Notice that changes in the ***CurrentService*** worksheet are in red. As noted previously, these changes in air service are automatically translated into a new Baseline Scenario in the ***Baseline&Scenarios*** worksheet. Once the **Update Tables** button is pressed in the ***CurrentService*** worksheet, the software automatically moves to the ***Baseline&Scenarios*** worksheet shown in Exhibit II-17.

Notice that the Default Baseline Forecast is now higher than it was before the new service to Detroit was added.

Caution: When updating the ***CurrentService*** worksheet, it is important to reflect all of the changes in air service, which will then be reflected in the New Baseline Forecast.

Exhibit II-17. User-revised *Baseline&Scenarios* worksheet.

Baseline Forecast for ACY
(Based on TAF Air Carrier/Air Taxi Forecast and User Updates of Current Domestic Service)
You can change the Default Baseline forecasts by entering new numbers in the User Update columns

Reset User Updates to Baseline Defaults

	Default Baseline Domestic Forecast		User Updates (changes in red)	
Year	Domestic Operations	Domestic Enplanements	Domestic Operations	Domestic Enplanements
2009	15,084	545,516	15,084	545,516
2010	15,233	552,930	15,233	552,930
2011	15,384	560,444	15,384	560,444
2012	15,535	568,060	15,535	568,060
2013	15,689	575,786	15,689	575,786
2014	15,846	583,617	15,846	583,617

	Default Baseline International Forecast		User Updates (changes in red)	
Year	International Operations	International Enplanements	International Operations	International Enplanements
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	0	0	0	0

Baseline&Scenarios Worksheet

In this worksheet, the user can make further changes to the Baseline Forecast and create two different sensitivity cases. Also by selecting the buttons on this worksheet, the user can create confidence bands around the Baseline Forecast that reflect the historic range of error in expectations for jet fuel prices and economic growth (based on national GDP). Each of these functionalities is exercised below.

Creating a User-Defined Scenario

In the ***Baseline&Scenarios*** worksheet, the user can create alternative forecasts by simply inputting the data at the top of the worksheet in the columns labeled User Updates. For example, assume that, starting in 2010, domestic operations and enplanements at ACY were going to grow 5 percent more than indicated by the TAF. The user can easily modify the Baseline Forecast by using simple commands. For instance, in the Domestic Operations column for 2010, the user could input:

= 1.05 * B11

which would cause domestic operations in 2010 to be 5 percent higher than the TAF projection. The same type of command could be used in following years to increase operations by 5 percent each year. Repeating the same command in the Domestic Enplanements column will cause domestic enplanements to also increase by 5 percent compared to the TAF.

The result is a new User-Defined Baseline Forecast as shown in Exhibit II-18 taken from the ***Baseline&Scenarios*** worksheet.

Notice that the user updates are highlighted in red. These changes in red are now the Baseline Forecast around which sensitivity cases can be created.

> The user updates created in the ***Baseline&Scenarios*** worksheet are the new Baseline Forecast for the model. Any sensitivity cases created subsequently will be based on the user-defined scenario.

Exhibit II-18. User updates in the *Baseline&Scenarios* worksheet.

Baseline Forecast for ACY
(Based on TAF Air Carrier/Air Taxi Forecast and User Updates of Current Domestic Service)
You can change the Default Baseline forecasts by entering new numbers in the User Update columns

Reset User Updates to Baseline Defaults

	Default Baseline Domestic Forecast		User Updates (changes in red)	
Year	Domestic Operations	Domestic Enplanements	Domestic Operations	Domestic Enplanements
2009	15,084	545,516	15,084	545,516
2010	15,233	552,930	**15,995**	**580,577**
2011	15,384	560,444	**16,153**	**588,466**
2012	15,535	568,060	**16,312**	**596,463**
2013	15,689	575,786	**16,473**	**604,575**
2014	15,846	583,617	**16,638**	**612,798**

	Default Baseline International Forecast		User Updates (changes in red)	
Year	International Operations	International Enplanements	International Operations	International Enplanements
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	0	0	0	0

Creating a Sensitivity Case Using User-Defined Ranges for Key Air Service Drivers

In the ***Baseline&Scenarios*** worksheet, the user creates sensitivity cases for a forecast. This is the central reason for the creation of the software. The models embedded in the software (described in detail in the following paragraphs) are designed to show how air service may be affected depending on future values for not only key drivers like jet fuel prices and income growth, but also other drivers. The user is free to input whatever range of values for drivers that seems appropriate.

> When creating scenarios, care should be taken to keep assumptions internally consistent for each sensitivity case. For example, a High Case should reflect an optimistic view of the future, which usually will mean low jet fuel prices, higher income growth, less competition from nearby hubs, and lower inflation. Drivers would move in the opposite direction for a Low Case.

Jet Fuel Prices and Local Income

The spike in jet fuel prices in 2007–2008 was largely unanticipated and caused a substantial reduction in air services (measured by average daily seat departures); the impact was compounded by a severe recession that began in 2008. Creating a Low scenario that anticipates both high fuel prices and low income growth is one of the logical sensitivity tests for any air service forecast. A High scenario would have relatively low jet fuel prices and high income growth.

Up-to-date information on oil market expectations is available from the Chicago Mercantile Exchange website link embedded in the software and illustrated in Exhibit II-19.

Exhibit II-19. Link to oil futures market in the *Baseline&Scenarios* worksheet.

To get an up-to-the minute view of likely future jet fuel prices, press the link:

View the latest Heating Oil futures prices by clicking here

This link takes the user to the Chicago Mercantile Exchange (CME) page for heating oil futures prices. These prices are highly correlated with jet fuel prices. Following is a sample page taken from the site on June 28, 2010.

Month	Last	Change	Prior Settle	Open	High	Low	Volume
Jul-10	2.0909	-0.0213	2.1122	2.11	2.1148	2.0801	4,733
Aug-10	2.1144	-0.019	2.1334	2.1386	2.1386	2.1034	14,238
Sep-10	2.1395	-0.0167	2.1562	2.1578	2.1597	2.1293	5,114
Oct-10	2.1646	-0.0158	2.1804	2.1826	2.1826	2.1562	1,688
Nov-10	2.1881	-0.0167	2.2048	2.1858	2.1907	2.1812	556
Dec-10	2.2129	-0.015	2.2279	2.2312	2.2336	2.2039	2,962
Jan-11	2.2368	-0.0142	2.251	2.2325	2.2365	2.2324	377

Exhibit II-20. Range of values for jet fuel prices and real GDP.

Jet Fuel Prices Gallon (nominal)					
Time Period		Average	Median	High	Low
1Q 2000	3Q 2009	$ 1.43	$ 1.33	$ 3.51	$ 0.59
1Q 2005	3Q 2009	$ 2.07	$ 1.94	$ 3.51	$ 1.33
US Real GDP					
2000	2009	1.79%	2.27%	3.66%	-2.40%
2005	2009	1.15%	2.03%	2.94%	-2.40%

Sources: ATA and US BEA; EIA

The model embedded in the software uses local income growth (measured as the change in real per capita income in the metro- or micropolitan area where the airport of interest is located) as a key economic driver for airport activity. For projections into the future, however, such local income measures may be difficult to obtain, so the baseline projections are based on estimates of national GDP growth. If the user has access to local projections, they can be used in place of the national GDP projections.

To assist the user in defining sensitivity cases, Exhibit II-20 reports the high, low, and average values for jet fuel prices and national GDP growth over the past decade.

Baseline Inflation Rate

The air services model embedded in the software operates on real jet fuel prices. The model takes whatever jet fuel price assumptions are made and converts them to real dollars using the assumed Baseline Inflation Rate forecast. The higher the inflation rate, the *lower* the real jet fuel price will be; since a lower real price of jet fuel will cause an *increase* in air services, higher inflation is consistent with more air services in the model.

Exhibit II-21 reports on the range of annual inflation reported by the GDP deflator in the past decade.

Average Aircraft Size

In the air services model embedded in the software, aircraft size has a positive effect on seat departures. Aircraft size is a proxy for the cost of producing air services per seat. Because larger aircraft tend to produce lower seat mile costs (all else being the same), in competitive markets these lower costs would be passed onto consumers resulting in more demand and therefore air service. In developing scenarios, users would want to input any known changes in future fleet types used by carriers. Or, it might be appropriate to input a trend in average seat size if it is likely to continue.

Seat-Departures from Nearby Large or Medium Hub Airports

In the air services model, this variable has a negative impact on air services. An airport operating in the shadow of a large or medium hub airport would tend to have fewer air services

Exhibit II-21. Range of annual inflation.

US GDP Deflator

Time Period		Average	Median	High	Low
2000	2009	2.4%	2.9%	3.3%	1.2%
2005	2009	2.6%	2.9%	3.3%	1.2%

Source: US BEA

than would be the case in the absence of such competition. The software provides information on the average daily seat-departures at large and medium hubs within 50 miles of the subject facility.

> **Caution:** The software is NOT designed to accommodate very large changes in seat-departures at nearby large or medium hubs. Doubling the figures for a nearby hub or setting them to zero may produce nonsensical results. Scenarios showing changes of ±10% should be easily accommodated and produce reasonable results.

Airport Concentration Index

The Herfindahl-Hirschman Index (HHI) is a measure of the level of competition in a defined market. It takes into account the relative size of competitors as well as how many of them there are. As applied in the software, market shares measure the percentage of domestic seat-departures at the airport accounted for by marketing carriers. The HHI is the sum of squares of these shares (measured in percentage points). The equation for the HHI is:

$$\text{HHI} = (\text{share}_1)^2 + (\text{share}_2)^2 + (\text{share}_3)^2 + \cdots + (\text{share}_n)^2$$

A monopoly carrier with 100 percent of the seats at an airport would have an HHI of 10,000 ($= 100^2$). Five competitors with equal 20 percent shares would have an HHI of 2,000. As the HHI increases, air services decline.

The user should input any expected or feasible changes in competitive conditions. For example, an airport with five competitors that might lose one of them may see a decline in air services. Adding one or more competitors may cause an improvement in air services. To calculate a new HHI, the user can enter carrier seat-departures in the section at the bottom left of the ***Baseline&Scenarios*** worksheet (Exhibit II-22).

Exhibit II-23 reports some additional HHI calculations for hypothetical situations ranging from monopoly to equal shares among five carriers.

Exhibit II-22. HHI calculator on *Baseline&Scenarios* worksheet.

Airport Concentration Index Calculator

Input seat-departures by all carriers at the airport (per day, per week, etc.)

Airline	Seat-Departures
A	10,000
B	5,000
C	2,000
D	500
E	
F	
G	
H	
I	
J	
TOTAL	17,500

Airport Concentration Index:
4,220

Exhibit II-23. HHI hypothetical market share calculations.

Number of Carriers	Shares of Seat Departures Airline A	B	C	D	E	HHI
1	100%					10,000
2	90%	10%				8,200
2	80%	20%				6,800
2	70%	30%				5,800
2	60%	40%				5,200
2	50%	50%				5,000
3	90%	5%	5%			8,150
3	80%	10%	10%			6,600
3	70%	15%	15%			5,350
3	60%	20%	20%			4,400
3	50%	25%	25%			3,750
3	40%	30%	30%			3,400
3	33%	33%	33%			3,327
4	90%	3%	3%	3%		8,133
4	80%	7%	7%	7%		6,533
4	70%	10%	10%	10%		5,200
4	60%	13%	13%	13%		4,133
4	50%	17%	17%	17%		3,333
4	40%	20%	20%	20%		2,800
4	30%	23%	23%	23%		2,533
4	25%	25%	25%	25%		2,500
5	90%	3%	3%	3%	3%	8,125
5	80%	5%	5%	5%	5%	6,500
5	70%	8%	8%	8%	8%	5,125
5	60%	10%	10%	10%	10%	4,000
5	50%	13%	13%	13%	13%	3,125
5	40%	15%	15%	15%	15%	2,500
5	30%	18%	18%	18%	18%	2,125
5	20%	20%	20%	20%	20%	2,000

Sample Sensitivity Case for ACY

Returning to the sample runs for ACY, recall that we had input a forecast that assumes that both enplanements and operations will increase 5 percent per year for the five years following 2009. To assess the sensitivity of that new forecast to unforeseen economic circumstances, create a Low case that assumes $3.50 jet fuel and zero income growth for all five years. For the High case, assume $2.00 jet fuel and 3 percent annual income growth for all five years. Leave the other variables unchanged. **To implement this sensitivity case, input the assumptions (shown in Exhibit II-24 in red) into the *Baseline&Scenarios* worksheet**.

Examining the Baseline and Sensitivity Cases

The new Baseline and Sensitivity cases can be viewed in the ***Projections*** worksheet and in the ***One-Page Report*** worksheet. The former shows graphs and data for operations and enplanements as well as estimates of airport operating revenues; Exhibit II-25 shows the results for the assumptions input in Exhibit II-24. By 2014, both operations and enplanements would be about 7 percent lower in the Low case than in the Baseline, while the High case would be about 4 percent higher. By 2014, ACY operating revenues are estimated to be 5 percent lower in the Low case and 3 percent higher in the High case.

The ***One-Page Report*** worksheet shown in Exhibit II-26 was designed to be viewed in combination with the embedded risk analysis options discussed in the following section; it shows the same enplanements and operations graphs as in Exhibit II-25, along with the implied High and Low cases for jet fuel and income in the pre-defined risk analysis (see the next section).

Exhibit II-24. Inputting sensitivity assumptions in the *Baseline&Scenarios* worksheet.

Baseline Forecast for ACY

(Based on TAF Air Carrier/Air Taxi Forecast and User Updates of Current Domestic Service)

You can change the Default Baseline forecasts by entering new numbers in the User Update columns

Reset User Updates to Baseline Defaults

	Default Baseline Domestic Forecast		User Updates (changes in red)	
Year	Domestic Operations	Domestic Enplanements	Domestic Operations	Domestic Enplanements
2009	15,084	545,516	15,084	545,516
2010	15,233	552,930	**15,995**	**580,577**
2011	15,384	560,444	**16,153**	**588,466**
2012	15,535	568,060	**16,312**	**596,463**
2013	15,689	575,786	**16,473**	**604,575**
2014	15,846	583,617	**16,638**	**612,798**

	Default Baseline International Forecast		User Updates (changes in red)	
Year	International Operations	International Enplanements	International Operations	International Enplanements
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	0	0	0	0

Forecast Drivers for Domestic Scenarios (International Forecast is Fixed)

2005-2009 data are fixed; you may change the Baseline and/or Scenario assumptions below for 2010-2014.
If you entered updates to the Baseline Domestic Forecast above,
you should ensure that the Baseline assumptions below are consistent with those updates.

Reset All Scenarios to Baseline Defaults

View the latest Heating Oil futures prices by clicking here

Set Jet Fuel Scenarios based on Futures Uncertainty

Year	Baseline Price of Jet Fuel (Current Yr $/gal)	Scenario 1	Scenario 2
2005	$1.622		
2006	$1.906		
2007	$2.025		
2008	$2.938		
2009	$1.844		
2010	$2.174	**$3.500**	**$2.000**
2011	$2.258	**$3.500**	**$2.000**
2012	$2.499	**$3.500**	**$2.000**
2013	$2.719	**$3.500**	**$2.000**
2014	$2.888	**$3.500**	**$2.000**

(Default baseline from 2010 forward based on change in projected price of jet fuel from EIA Annual Energy Outlook 2010.)

Year	Baseline Inflation Rate	Scenario 1	Scenario 2
2005	3.34%		
2006	3.25%		
2007	2.87%		
2008	2.14%		
2009	1.18%		
2010	1.47%	1.47%	1.47%
2011	1.31%	1.31%	1.31%
2012	1.43%	1.43%	1.43%
2013	1.76%	1.76%	1.76%
2014	1.73%	1.73%	1.73%

(Default baseline from 2010 forward based on projected GDP Implicit Price Deflator from EIA Annual Energy Outlook 2010.)

Set Income Scenarios based on EIA GDP Uncertainty

Year	Baseline Local Real Income Growth	Scenario 1	Scenario 2
2005	0.43%		
2006	0.73%		
2007	0.27%		
2008	0.34%		
2009	-2.83%		
2010	1.07%	**0.00%**	**3.00%**
2011	3.52%	**0.00%**	**3.00%**
2012	3.64%	**0.00%**	**3.00%**
2013	2.80%	**0.00%**	**3.00%**
2014	2.46%	**0.00%**	**3.00%**

(Default baseline from 2010 forward based on projected US GDP from EIA Annual Energy Outlook 2010; 2009 value equal to US GDP growth.)

Not relevant for Small Hubs

Year	Baseline Airport Avg Seatsize	Scenario 1	Scenario 2
2005	119.9		
2006	126.7		
2007	130.1		
2008	140.2		
2009	141.9		
2010	141.9	141.9	141.9
2011	141.9	141.9	141.9
2012	141.9	141.9	141.9
2013	141.9	141.9	141.9
2014	141.9	141.9	141.9

(Default baseline from 2010 forward equal to 2009 value.)

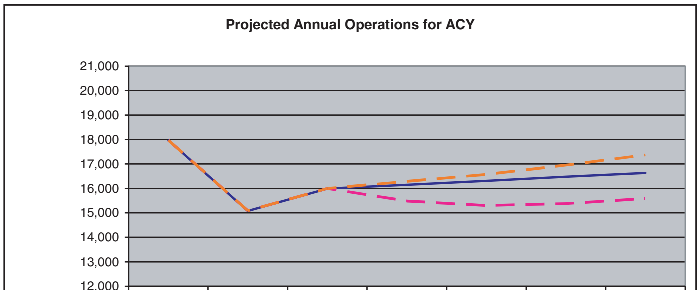
Year	Baseline Airport Concentration Index - HHI (0-10,000)	Scenario 1	Scenario 2
2005	8,189		
2006	8,450		
2007	8,804		
2008	9,715		
2009	8,333		
2010	8,333	8,333	8,333
2011	8,333	8,333	8,333
2012	8,333	8,333	8,333
2013	8,333	8,333	8,333
2014	8,333	8,333	8,333

(Default baseline from 2010 forward equal to 2009 value.)

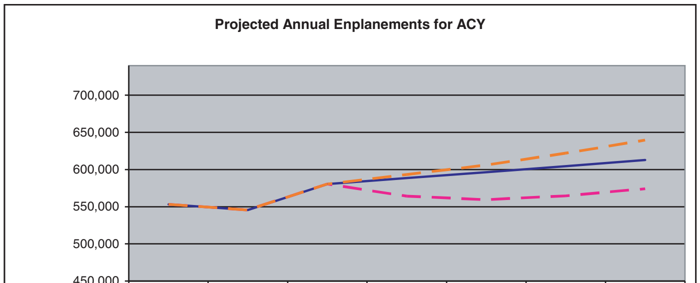
Year	Baseline Domestic Daily Seat-Departures at Lrg/Med Hubs within 50 Miles	Scenario 1	Scenario 2
2005	0		
2006	0		
2007	0		
2008	0		
2009	0		
2010	0	0	0
2011	0	0	0
2012	0	0	0
2013	0	0	0
2014	0	0	0

(Default baseline from 2010 forward derived from TAF.)

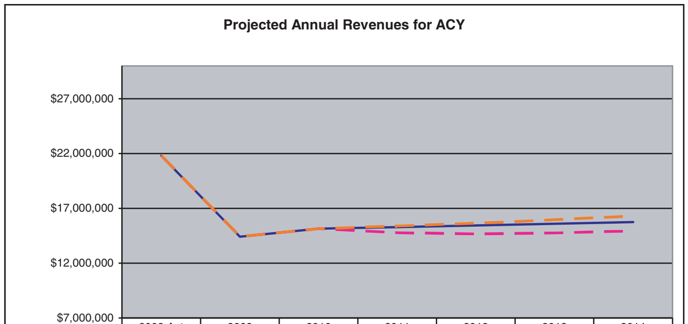
Exhibit II-25. Revised baseline and sensitivity example from the *Projections* worksheet.



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	17,962	15,084	15,995	16,153	16,312	16,473	16,638
Scenario 1	17,962	15,084	15,995	15,484	15,303	15,383	15,589
Scenario 2	17,962	15,084	15,995	16,288	16,573	16,951	17,369



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	553,177	545,516	580,577	588,466	596,463	604,575	612,798
Scenario 1	553,177	545,516	580,577	564,097	559,593	564,544	574,160
Scenario 2	553,177	545,516	580,577	593,376	606,014	622,098	639,704



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	$21,809,615	$14,419,394	$15,146,637	$15,296,747	$15,447,923	$15,601,112	$15,756,232
Scenario 1	$21,809,615	$14,419,394	$15,146,637	$14,783,759	$14,673,023	$14,762,465	$14,949,958
Scenario 2	$21,809,615	$14,419,394	$15,146,637	$15,399,595	$15,647,118	$15,964,795	$16,311,881

Exhibit II-26. ***One-Page Report*** **worksheet showing confidence bands.**

Airport Forecasting Risk Assessment Model

Forecast Generated: August 27, 2010

Local Income Projections (% change)

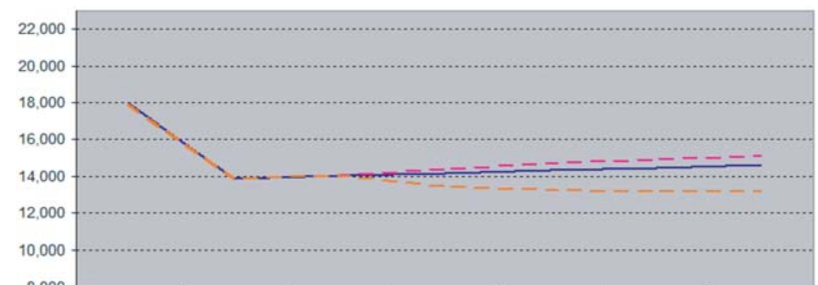
	Baseline	Scenario 1	Scenario 2
2010:	1.07%	3.07%	-0.93%
2011:	3.52%	5.52%	1.52%
2012:	3.64%	5.64%	1.64%
2013:	2.80%	4.80%	0.80%
2014:	2.46%	4.46%	0.46%

Jet Fuel Price Projections ($ per gallon)

	Baseline	Scenario 1	Scenario 2
2010:	$2.17	$1.85	$3.81
2011:	$2.26	$1.92	$3.95
2012:	$2.50	$2.12	$4.37
2013:	$2.72	$2.31	$4.76
2014:	$2.89	$2.46	$5.05

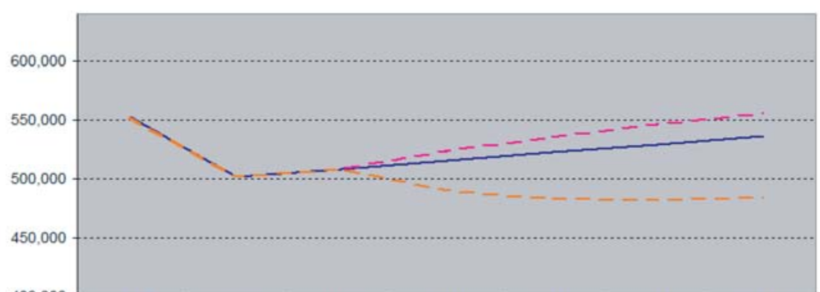
ACY - ATLANTIC CITY-INTL, NEW JERSEY (Small Hub)

Projected Annual Operations for ACY



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	17,962	13,898	14,035	14,174	14,313	14,455	14,600
Scenario 1	17,962	13,898	14,035	14,392	14,670	14,905	15,120
Scenario 2	17,962	13,898	14,035	13,481	13,234	13,148	13,148

Projected Annual Enplanements for ACY



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	553,177	501,686	508,504	515,415	522,419	529,524	536,726
Scenario 1	553,177	501,686	508,504	523,346	535,431	546,023	555,847
Scenario 2	553,177	501,686	508,504	490,225	483,024	481,628	483,342

Risk Analysis Features of the Software

One of the most important features of the software is an embedded risk analysis, which places confidence bands around a forecast designed to capture the uncertainty of future jet fuel prices and income growth. The objective is to provide airports with a way to undertake a formal risk analysis for their forecast designed to capture the range of values for these very uncertain drivers of air service. The risk analysis answers the following question:

> Given my current expectations about jet fuel prices and economic growth, I have created a forecast of enplanements and commercial operations for my airport; what are the High and Low forecasts if I define a range of future jet fuel prices and income growth likely to occur about 90 percent of the time?

The embedded risk analysis looks at how accurately jet fuel prices and economic growth have been forecast over the past 20 years. To create an approximate 90 percent confidence band, an analysis was undertaken that compares actual to forecast values and identifies the percentage range of error (high and low) that occurs 90 percent of the time.

So for example, monthly heating oil futures prices for a period 12 months forward were compared to actual jet fuel prices and the percentage error was measured. A confidence band was constructed, defined as the percentage range (high and low) likely to encompass the error in forecasting the price of jet fuel 12 months into the future about 90 percent of the time. The same type of confidence band was created for errors in forecasting GDP growth. Further discussion of these embedded analyses is contained in Chapter 4.

To apply the embedded risk analysis into the forecast for ACY, recall that the baseline TAF was already modified by assuming that both operations and enplanements would grow by an additional 5 percent per year. What is the confidence band around this forecast given uncertainty of jet fuel prices and income growth?

To create the confidence band, **go to the *Baseline&Scenarios* worksheet and press the two buttons**:

Set Jet Fuel Scenarios based on Futures Uncertainty | *Set Income Scenarios based on EIA GDP Uncertainty*

This will overwrite any other assumptions that have been made about future jet fuel prices and income growth, and automatically create Low and High Cases that correspond to a 90 percent confidence band for these two drivers. Other drivers can be modified as well, if desired.

The new Baseline and Sensitivity cases can be viewed in the ***Projections*** worksheet and in the ***One-Page Report*** worksheet. The latter combines the data elements of the implied High and Low cases for jet fuel and income with the enplanements and operations graphs so the user can see the overall results on a single page. However, the graphs also reflect any other Base case or Scenario changes the user may have entered in the ***Baseline&Scenarios*** worksheet.

Exhibit II-27 shows the ***One-Page Report*** for the scenario created for ACY. Interestingly, the Low case in the risk analysis shows a downside for both operations and enplanements that is 10 percent of the Baseline by 2014. The upside is far more modest—on the order of 3.5 percent.

Interpreting Results

Like any modeling exercise, interpreting results from the software depends almost exclusively on the assumptions the user makes. The software is designed to be a supplement to existing forecasts. It provides a structured way to:

- Modify an existing forecast with updated information on existing air services
- Modify an existing forecast with new growth assumptions

Exhibit II-27. Sample risk analysis for ACY.

Airport Forecasting Risk Assessment Model

Forecast Generated:	August 27, 2010

Local Income Projections (% change)

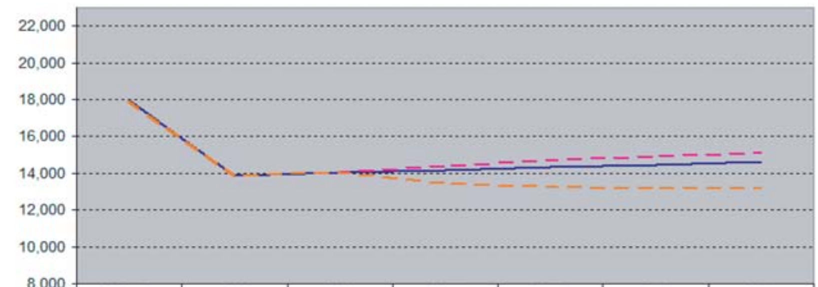
	Baseline	Scenario 1	Scenario 2
2010:	1.07%	3.07%	-0.93%
2011:	3.52%	5.52%	1.52%
2012:	3.64%	5.64%	1.64%
2013:	2.80%	4.80%	0.80%
2014:	2.46%	4.46%	0.46%

Jet Fuel Price Projections ($ per gallon)

	Baseline	Scenario 1	Scenario 2
2010:	$2.17	$1.85	$3.81
2011:	$2.26	$1.92	$3.95
2012:	$2.50	$2.12	$4.37
2013:	$2.72	$2.31	$4.76
2014:	$2.89	$2.46	$5.05

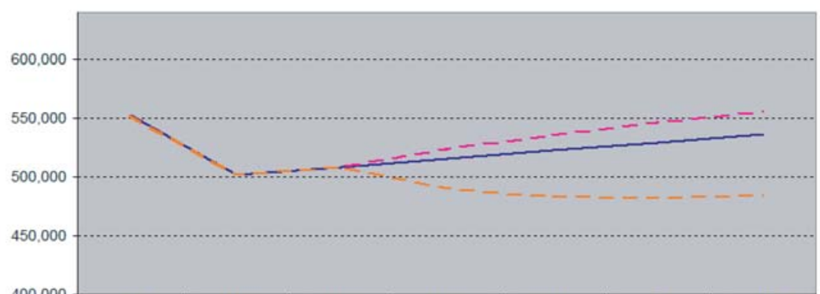
ACY - ATLANTIC CITY-INTL, NEW JERSEY (Small Hub)

Projected Annual Operations for ACY



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	17,962	13,898	14,035	14,174	14,313	14,455	14,600
Scenario 1	17,962	13,898	14,035	14,392	14,670	14,905	15,120
Scenario 2	17,962	13,898	14,035	13,481	13,234	13,148	13,148

Projected Annual Enplanements for ACY



	2008 Act	2009	2010	2011	2012	2013	2014
Baseline	553,177	501,686	508,504	515,415	522,419	529,524	536,726
Scenario 1	553,177	501,686	508,504	523,346	535,431	546,023	555,847
Scenario 2	553,177	501,686	508,504	490,225	483,024	481,628	483,342

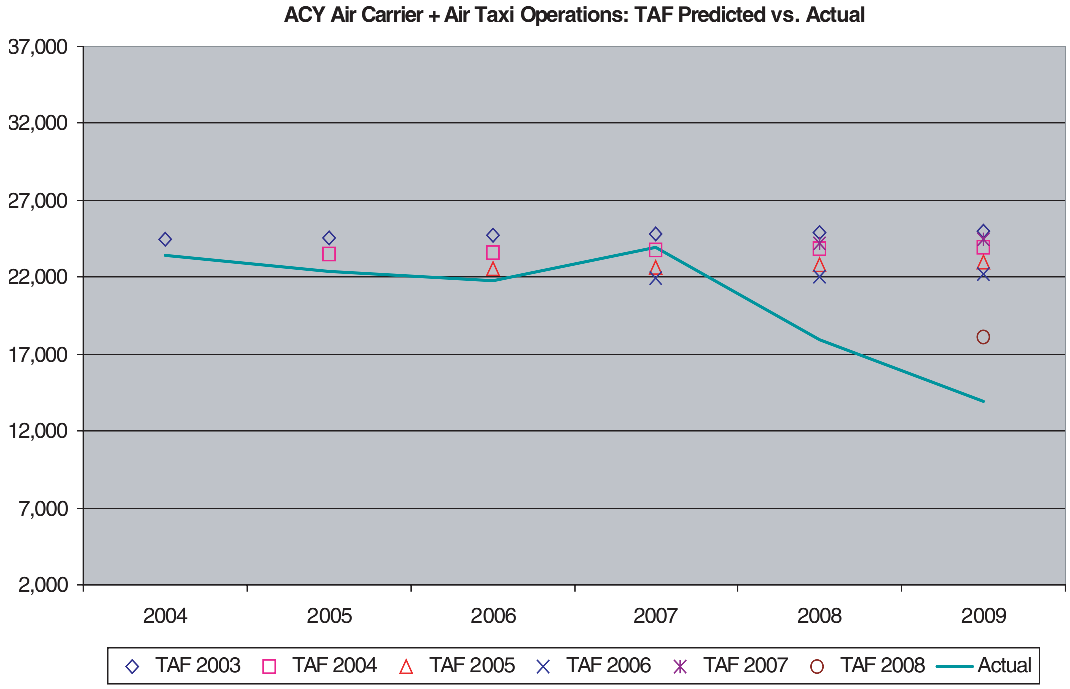
- Create sensitivity cases by defining ranges for key drivers of air service including jet fuel prices, income growth, inflation, the cost of producing air service (using seat size as a proxy), competition at the airport, and competition from nearby large and medium hub airports
- Utilize a more formal risk analysis of the forecast based on the likely range of error in forecasting two key air service drivers: jet fuel prices and income growth

The software will produce useful results when reasonable and consistent assumptions are applied. In such cases, it may be a useful tool for airport sponsors to examine the downside and upside of their future air services and the implications for airport finances and future development.

One way to judge the results of the analysis is to compare it to the accuracy of the TAF in recent years. On the ***TAFHistory*** worksheet, the user will find a comparison of forecast and actual operations for the TAF beginning in 2003. The summary for ACY is shown in Exhibit II-28.

The example for ACY illustrates one of the key motivations for the creation of the software: unanticipated spikes in jet fuel prices accompanied by sudden and unanticipated slow-down in the economy can produce dramatic and unanticipated reductions in air services. Thus, examining the potential impact of sudden changes in jet fuel prices and in income growth is prudent for those interested in the consequences of changes in air services at airports.

Exhibit II-28. *TAFHistory* worksheet.



Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation