Estimated Impacts of September 11th on US Travel

U.S. Department of Transportation
Research and Innovative Technology Administration
Bureau of Transportation Statistics

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U.S. Department of Transportation

Maria Cino
Deputy Secretary

Research and Innovative Technology Administration

John Bobo
Acting Administrator

Bureau of Transportation Statistics

Terry T. Shelton
Acting Director

Produced under the direction of:
William Bannister
Assistant Director for Advanced Studies

Project Manager
Ivy Harrison

Editor
William Moore

Major Contributors
David Chien
Jeffery Memmott
Peg Young

Cover Design & Report Layout
Alpha Glass Wingfield

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EXECUTIVE SUMMARY

The terrorist attacks of September 11, 2001, had an immediate and visible impact on U.S. transportation. While the obvious impacts were temporary, there may have been less obvious yet longer lasting changes in U.S. travel patterns. The Research and Innovative Technology Administration's Bureau of Transportation Statistics analyzed the impacts in three different ways. All three analyses found these post-9/11 travel trends:

- Immediate and continuing impact in air travel,
- Immediate but temporary decline in highway travel,
- No impact on rail travel, and
- Travelers switched from air to highway.

RESULTS

1. NHTS Data: A comparison of 2001-2002 National Household Travel Survey (NHTS) long-distance travel data for pre-9/11 and post-9/11 yielded the following initial findings:

- Reduction in the amount of long-distance travel,
- Decrease in the rate of international trip taking,
- Reduction in the rate of personal business travel, and
- Changes in mode of travel depending on distance traveled.

2. Time Series Analysis: Forecasts using travel data from 1990 to 2001 were compared to what actually took place after 9/11. The comparisons found:

- Actual Airline Revenue Passenger-Miles began in December 2004 to approach the forecasted values. Otherwise, up to then, Airline Revenue Passenger-Miles were significantly lower than forecast.

- Rail Passenger-Miles showed no evidence of impact from 9/11.
- Vehicle-Miles Traveled dropped for one month – September 2001 – compared to the expected level. In addition, the actual VMT level for September 2002 – one year later – was significantly lower than expected, while the 11 months between September 2001 and September 2002 did not show any unexpected deviations.

3. Econometric Analysis: A statistical analysis of economic data produced the following conclusions:

- There was a strong statistical relationship between the events of 9/11 and aviation and highway travel, but not rail travel.
- Air travel dropped quickly after 9/11 and then continued to drop for the following six months.
- Highway travel also dropped quickly immediately after 9/11 but then leveled off in the following four months.
- People switched from air travel to highway travel over the six-month period after 9/1l.

EXPECTED CHANGES THAT DIDN'T HAPPEN

The comparison of pre-9/11 and post 9/11 NHTS data did not find the following expected results:

- No significant decline in the percent of business travel,
- No significant decline in overall trips by older Americans,
- No change in the percent of air trips from individuals living in urban areas.

THE METHODOLOGY

1. NHTS Data: To assess the near-term impact on travel, we split the 2001-2002 National Household Travel Survey (NHTS) long-distance travel data collection into pre-9/11 and post-9/11 datasets. Each was then weighted to produce an annual estimate of long-distance travel—one based on survey responses before 9/11 and the other based on responses after 9/11. The two new datasets have some limitations that impact our ability to draw comparisons: seasonality effects that are unknown and we do not know how economic changes affected travel behavior after 9/11. Therefore, we conducted additional time-series and econometric data analysis to help assess the before and after 9/11 travel picture.

Based on the entire data collection, there were an estimated 2.6 billion long-distance trips taken in 2001. Privately owned vehicles (POV) accounted for the largest portion of trips, 90 percent, followed by air at 7 percent. Bus was used for only 2 percent of the trips and "other," which includes trains, ferries, and other transportation means, collectively accounted for only 1 percent.

The NHTS analysis focuses on long-distance trips because this type of travel was most impacted by 9/11 and is where measurable effects would most likely be found. The NHTS is a national survey with data on 45,000 long-distance trips of 50 miles or more from home.

Because the time period of the NHTS overlapped September 11, 2001, the data collected were divided into two files: a pre-9/11 file and a post-9/11 file, with both files weighted to produce estimates of a year's worth of travel.

2. Time Series Analysis of Long-Distance Passenger Data: Differences due to seasonality could be confounding the measurement of the 9/11 impact in the NHTS data. To understand the seasonality characteristics of the passenger data, we analyzed three different sets of monthly data: air revenue passenger miles (RPM), rail passenger miles (PM), and highway vehicle miles traveled (VMT). To acquire a base from which to measure the 9/11 effect, we forecast these three series beyond September 2001 based on data from January 1990 through August 2001.

3. Econometric Analysis of Travel by Mode: Monthly seasonally adjusted modal data from January 2000 through June 2003 were used to estimate travel equations with a 9/11 dummy variable in order to measure the effects of 9/11 on travel by mode. Air, highway, and rail travel equations were econometrically estimated.

There was a statistically significant substitution relationship over the estimation period between air travel and highway travel, although the cross elasticity is small at -0.041. This cross elasticity was derived from the air travel coefficient and indicates that for any given 10 percent drop in air travel, highway travel will increase at approximately 0.41 percent.

CHAPTER 1
Results of National Household Travel Survey

INTRODUCTION

The terrorist attacks in the United States in September 2001 had an immediate and visible impact on transportation. While the obvious impacts were temporary, there may have been less obvious yet longer lasting changes in U.S. travel patterns. The purpose of this study is to provide a greater understanding of the passenger travel behavior patterns of persons making long-distance trips before and after 9/11.

The 2001 National Household Travel Survey (NHTS) provides an opportunity to explore some of those changes in travel patterns. The survey was conducted between March 2001 and May 2002. The tragic events of 9/11 happened to occur during the data collection period. As such, even though the survey was not designed to capture 9/11 impacts, it can be used to look at some of the changes that occurred with travel patterns during that period. To examine the changes in travel patterns, the dataset was divided up into a pre-9/11 dataset and a post-9/11 dataset. These datasets were each reweighted by the U.S. population to produce nationally representative annual datasets. These datasets were then analyzed and the results compared to determine what, if any, interesting changes in travel patterns could be identified.

However, there are two major difficulties in using these datasets to estimate the impacts of 9/11 on travel patterns. First, the datasets are not seasonally adjusted. Because the two datasets cover trips for only a portion of the year, seasonal travel patterns can affect the number of trips and trip characteristics within each dataset. Because NHTS data are not collected on an annual basis, there is no way to use previous survey data to adjust for those seasonal patterns. The second difficulty is the changing economic environment during the time the survey was conducted. These changing economic conditions also likely affected the number of trips and trip characteristics when comparing the pre-9/11 and post-9/11 datasets. As a result of these limitations in the NHTS data, this report also contains two additional 9/11 analyses, a time series analysis using seasonally adjusted historical and forecast data by mode, and an econometric analysis looking at the impact by mode of 9/11 and several economic variables.

PRE- AND POST- 9/11 ENVIRONMENT

As discussed above, economic changes can have positive or negative effects on travel, making it hard to isolate the impacts of 9/11. And different economic factors can simultaneously influence changes in opposite directions for different types of travel, as can be surmised from the following discussion.

Prior to September 2001, the economy was experiencing flat or slightly declining growth as real Gross Domestic Product (GDP) remained around the $9.87 trillion to $9.90 trillion range (in chained real 2000 dollars) for over five quarters, from the second quarter of 2000 through the third quarter of 2001. An official recession started from the economic peak in March 2001 until the economic trough in November 2001, according to the National Bureau of Economic Research (NBER).[1] After 9/11, from the fourth quarter of 2001 to the second quarter of 2003, GDP showed a steady growth (figure 1). From these data, one might predict an increase in travel after 9/11, commensurate with the recovering economy. Travel did start to recover after 9/11, but it did not quickly return to previous levels. For example, the number of airline passengers did not surpass its 2001 peak until July 2004.

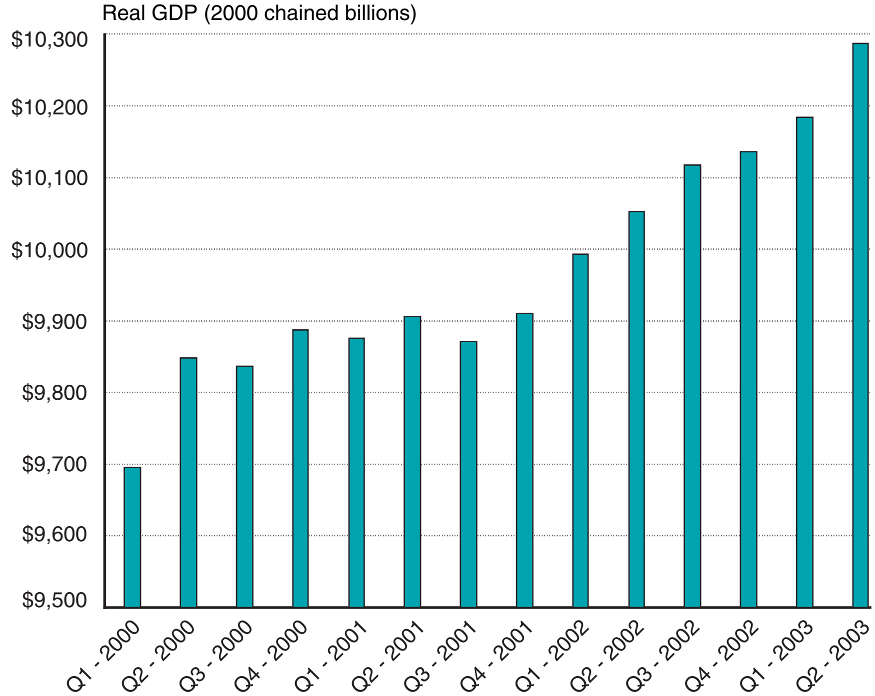
Besides the economic downturn identified by the NBER, there were other signs that the economy had started to weaken prior to 9/11. Industrial production is a good indicator of business activity and reflects the level of business travel and overall production of the economy. The economic downturn is reflected in the rapid decline of the Industrial Production Index (figure 2), which had fallen from a high of 115 in July 2000 to 110.6 by September 2001 as business inventories began to accumulate. Therefore, declining industrial production prior to 9/11 may have contributed to an overall drop in travel. However, after January 2002, the index began to rise and, although it did not reach the levels seen in 2000, it did indicate an economic upturn, which might have contributed to a predicted increase in travel after 9/11.

Beginning in January 2000, the unemployment rate steadily increased from just below 4 percent to almost 5 percent by September 2001, and by May of 2003 had risen above 6 percent (figure 3). It might reasonably be expected that rising unemployment would lead to reductions in personal travel throughout the period covered by the 2001 NHTS.

Even though the air travel price index (ATPI) (figure 4) indicates that real ticket prices were already declining from the first quarter of 2001 through the third quarter

[1] National Bureau of Economic Research, Department of Commerce, The NBER Business-Cycle Dating Procedure, October 21, 2003, available at http://www.nber.org/cycles.

Figure 1



SOURCE: U.S. Department of Commerce, Bureau of 51. Business Economic Analysis, Current-Dollar and "Real" Gross Domestic Product, seasonally adjusted, www.bea.gov.

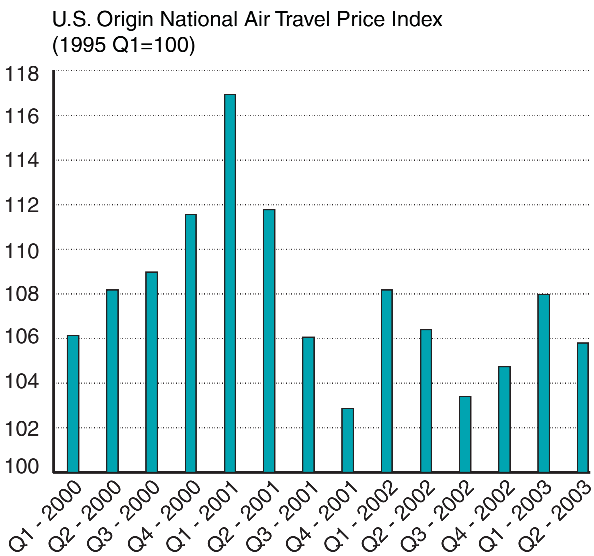
Figure 2

SOURCE: Economic Report of the President, TABLE B-Industrial production indexes, major industry divisions 1955-2002.

Figure 3

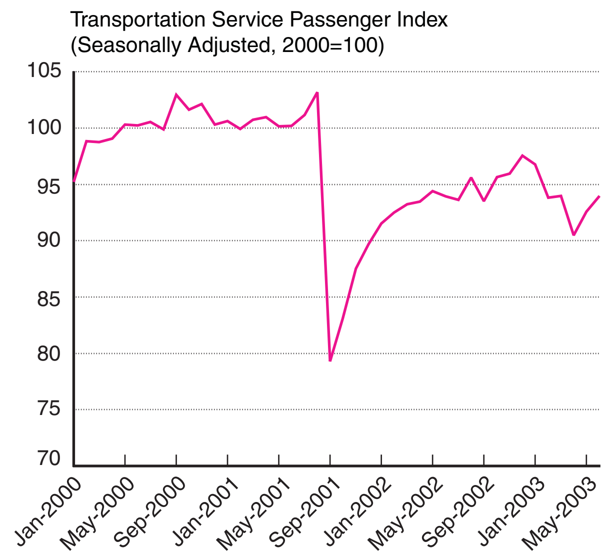
SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Unemployment Rate, seasonally adjusted, LNS14000000, www.bls.gov.

Figure 4



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, National-Level ATPI Series (1995 Q1 to 2005 Q4), seasonally adjusted, www.bts.gov.

Figure 5



SOURCE: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Services Index, Jan 1990 - Dec 2005, seasonally adjusted, www.bts.gov.

of 2001, travel had just begun to respond to lower ticket prices prior to 9/11. The transportation service passenger index (figure 5), a measure of transportation activity strongly influenced by airline travel, was rising in July and August of 2001, from 101.2 to 103.2. After 9/11 the index fell significantly to 79.3. After 9/11, ticket prices, as measured by the ATPI, continued to fall almost to 1995 price levels in the fourth quarter of 2001 and rose slightly thereafter with some volatility, but has not reached the levels of the first two quarters of 2001. With these relatively lower ticket prices after 9/11, the transportation service passenger index began to increase slowly (with a small dip in March 2003 corresponding with the beginning of the Iraq war), but has not reached the levels prior to 9/11. Therefore, it appears that travel was influenced by factors other than just changes in airline ticket prices. Some of these factors will be discussed in the econometric analysis in chapter 3.

NHTS BACKGROUND

This section of the study examines results from the 2001 National Household Travel Survey (NHTS). NHTS 2001 is a national household survey of both daily and long-distance travel, providing the most recent comprehensive look at travel by Americans. The NHTS data collection occurred from March 2001 to May 2002. The long-distance components of the NHTS 2001 data were divided and reweighted into two nationally representative annual datasets to compare pre-and post-9/11 travel patterns because 9/11 occurred during the NHTS data collection.

Changes in trip volumes, mode choice, and the characteristics of individuals traveling in the United States before and after 9/11 are examined to see if any general patterns can be noted. Also, changes in the proportion of long-distance trips made domestically versus internationally are investigated. Some of the topics covered by mode choice for both the pre-and post-datasets include trip purpose, age, gender, income, trip distance, and trip location.

Long-Distance Travel

Long-distance trips in the 2001 NHTS are defined as trips of 50 miles or more from home to the farthest destination traveled. A long-distance trip includes the outbound portion of the trip to reach the farthest destination as well as the return trip home and any stops made along the way to change transportation modes or for an overnight stay. Long-distance travel includes trips made by all modes, including privately owned vehicle (POV), airplane, bus, train, and ship; and for all purposes, such as commuting, business, pleasure, and personal and family business. Train and ship long-distance travel are combined into an "other" category due to the small number of observations.

NHTS PRE- AND POST-9/11 COMPARISONS [2]

The annualized full NHTS 2001 data indicate that there were more than 2.6 billion long-distance trips taken in 2001. Approxi-

[2] Not all figures display the same modes. Only the modes that were found to have statistically significant differences between pre- and post- 9/11 data for a particular variable are shown.

mately 90 percent were by privately owned vehicle (POV). Trips by airplane accounted for 7 percent of long-distance trips. Travel by bus accounted for 2 percent of these trips, and train trips represented less than 1 percent.

The total estimated number of yearly trips was lower using the post-9/11 sample as compared to the pre-9/11 sample – 2.7 billion trips from the pre-9/11 file and 2.4 billion trips from the post-9/11 file, an 11 percent decline. The POV trips were estimated to be 2.4 billion trips from the pre-9/11 file and 2.2 billion trips from the post-9/11 file, an 8 percent decline. Air trips were estimated to be 216 million from the pre-9/11 file and 169 million from the post-9/11 file, the largest decline of all the modes at nearly 22 percent. Further analysis of the two datasets to identify changes in long-distance travel patterns before and after provides additional insight into the possible effects of 9/11.

International Travel Down

Prior to 9/11, international travel (originating from the United States) represented 3 percent of all long-distance trips, but after 9/11 that travel dropped to 2 percent of all trips, a statistically significant decline. The mode with the largest decrease in international travel was air, which fell from 16 to 12 percent of all air trips after 9/11. Air travel accounts for approximately one-half of all international trips. POV long-distance trips for international travel experienced a small decline after 9/11 (figure 6). POV travel accounts for slightly more than 40 percent of international trips.

Personal Business Travel Decreased

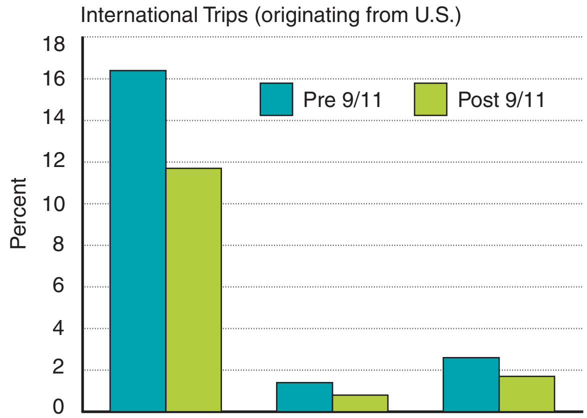
Long-distance trips for personal business also experienced a statistically significant decline after 9/11, from nearly 14 percent of all trips to 12 percent. Personal business trips include medical visits, shopping trips, and trips to attend weddings and funerals. POV accounts for approximately 90 percent of all long-distance personal business trips. Air travel, which accounts for only about 5 percent of all personal business trips, experienced a 3 percent decrease from 9 to 6 percent of air trips (figure 7).

More Shorter Distance Trips Taken

The only trip distance that showed a significant increase after 9/11 was in the shortest distance category of between 50 to 99 miles. All modes combined in this distance category showed an increase from 45 to 50 percent of total trips after 9/11 (figure 8). POV trips, which account for more than 95 percent of all trips between 50 to 99 miles, increased from 49 to 54 percent after 9/11, bus trips increased from 23 to 36 percent, and the "other" category increased from 44 to 65 percent. Air was the only mode not to register a significant increase, but air travel accounts for a negligible portion (nearly zero percent) of the trips in the 50 to 99 mile range. Modes that were not statistically significant were not included in the figures.

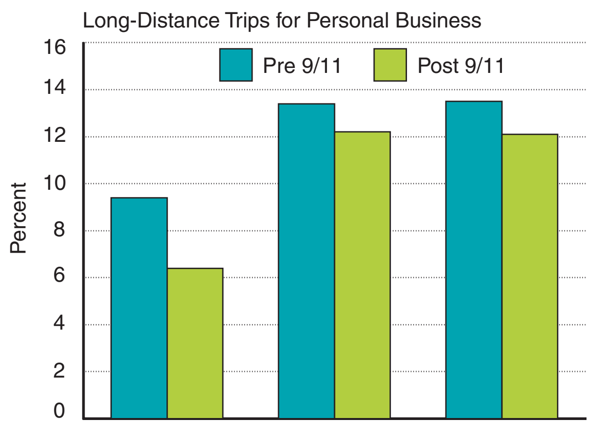
Appendix A describes the methodology of the NHTS and how the pre-9/11 and post-9/11 data files were created. Appendix B contains tables with the data estimates used in this report and their standard errors. Standard errors are in the same metric as the estimates. All comparisons in the text and graphics are statistically significant at a 0.05 level unless otherwise noted.

Figure 6



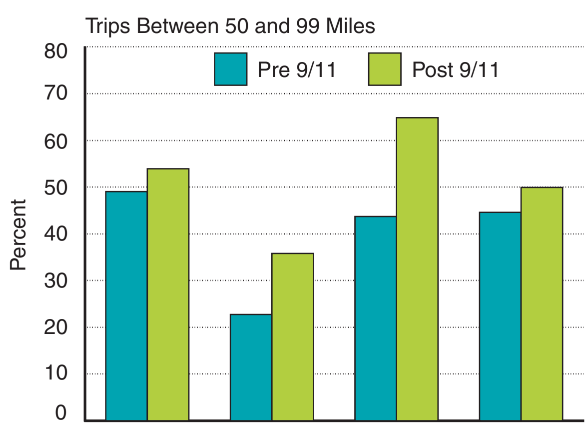
SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, NHTS 2001 Long Distance Pre-9/11 and Post-9/11 Files.

Figure 7



SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, NHTS 2001 Long Distance Pre-9/11 and Post-9/11 Files.

Figure 8



SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, NHTS 2001 Long Distance Pre-9/11 and Post-9/11 Files.

Expected Results Not Observed

Immediately following the 9/11 terrorist attack, experts were trying to determine how these attacks would impact our economy, business and leisure travel, and the attitudes of Americans. The terrorist attack was expected to have a different degree of impact on the various travel markets. Here are some of the expected repercussions that were not borne out by the NHTS data:

- No significant decline in the percent of business air travel. This can be seen in table B1, appendix B, as the difference in pre-9/11 and post-9/11 business air travel was not statistically significant at the 0.05 level. There was no significant decline in the percent of business travel in general. The Pre- and Post-9/11 Econometric Analysis section discusses economic factors consistent with this finding.
- No significant decline in overall trips by older Americans. Older Americans are more risk averse and might be expected to travel proportionately less than other age groups when faced with the risk of terrorist attacks. However, those 65 and older did not show any statistically significant difference between pre-9/11 and post-9/11 when all modes were combined (table B2, appendix B).
- Little reduction in female long-distance travel patterns. It was hypothesized that females tend to be more risk averse than males and thus might show a decline in their proportion of long-distance travel after 9/11. However, female travel as a portion of all long-distance travel, with the exception of bus trips, showed no significant reduction (table B3, appendix B).
- No change in the percent of air trips from individuals living in urban areas, potentially the most affected by the 9/11 attacks, as compared to the percent of air trips from individuals living in rural areas. See table B7, appendix B, which shows urban travel by mode for pre-and post-9/11 travel. No significant change in percent of air trips from individuals living in urban areas was noted.

CONCLUSIONS

Without controlling for seasonality and economic effects, the NHTS data indicate that there was a decline in long-distance travel after 9/11. There was a decrease in the percentage of travelers traveling for international travel and personal business after 9/11. The decrease in travel for international and personal business occurred for both air and all modes combined. In addition, the proportion of trips under 100 miles increased after 9/11.

CHAPTER 2
Time Series Analysis of Passenger Data: Pre- and Post-September 11, 2001

INTRODUCTION

In the previous chapter, we noted that some of the differences between the pre- and post-September 2001 data could be attributed to the nature of time series data. Differences due to seasonality confound the measurement of the September 2001 impact. In order to understand the time series characteristics of the passenger data, we turn our attention to different sets of data that measure monthly passenger movement. The following sections will analyze three sets of monthly data: air revenue passenger miles, rail passenger miles, and vehicle miles traveled. The data do not separate local and long-distance travel.

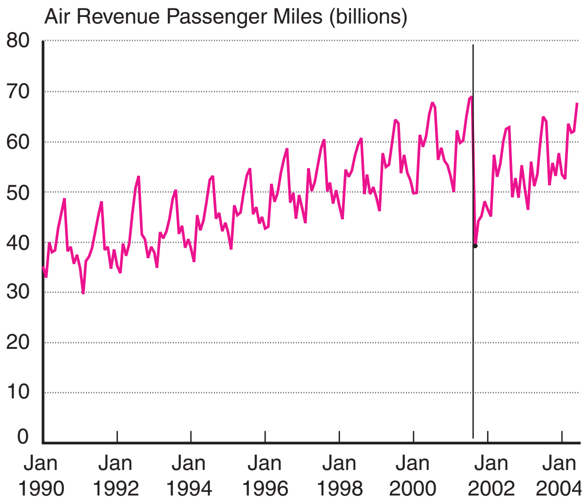
To measure the effect of September 11, 2001, we will forecast these three series based on the data from January 1990 through August 2001. The forecasts are then compared to what actually occurred in the data. Air showed the greatest differences: the values of the aviation time series began to enter the prediction intervals in December 2003, indicating that the aviation miles only began to approach in 2004 the previously expected values. Rail miles did not appear to experience an immediate impact from September 11, 2001. Vehicle miles experienced a one-month drop for September 2001, and an additional one-month drop was also experienced for September 2002.

The following sections provide the details behind these findings.

ABOUT THE DATA

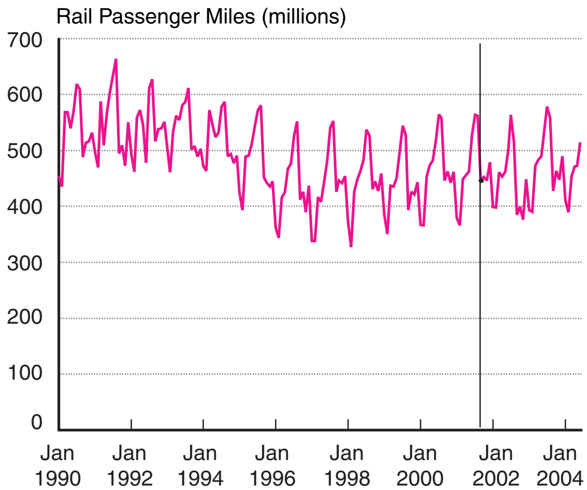
The first three figures (figures 9, 10, and 11) provide graphs of the passenger time series data: air revenue passenger miles (RPM), rail passenger miles (PM),

Figure 9



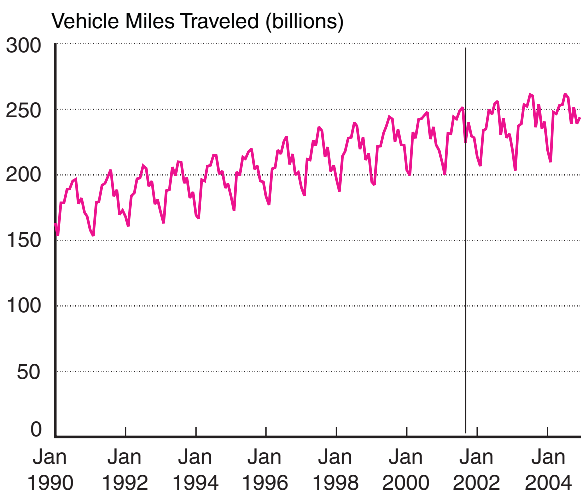
SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, Office of Airline Information, Air Carrier Traffic Statistics (Monthly T-100).

Figure 10



SOURCE: FRA, Office of Safety website, Table 1.02 Operational Data Tables, available at http://safetydata.fra.dot.gov/OfficeofSafety/

Figure 11



SOURCE: USDOT / Federal Highway Administration, Traffic Volume Trends report available at http://www.fhwa.dot.gov/policy/ohpi/travel/index.htm and vehicle miles traveled (VMT). The air RPM are found in the T-1 dataset compiled for the T-100 database, taken from the U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics (BTS), Office of Airline Information (OAI). The data for rail PM are compiled from the U.S. Department of Transportation, Federal Railroad Administration (FRA), Office of Safety. VMT data are taken from the *Traffic Volume Trends* reports from the Federal Highway Administration, Office of Highway Policy Information.[3] The datasets to be studied are all monthly, and each time series initiates at January 1990. The data values for the three series are through June 2004. Each of the three graphs contains a vertical line indicating September 2001. (Appendix C provides a table with all the data.)

SEASONAL ANALYSIS

A quick perusal of the three passenger datasets reveals that the data are strongly seasonal. But it is difficult to compare the degree of seasonality across the three time series. The next three graphs attempt to simplify the comparison. Figures 12, 13, and 14 provide histograms of the seasonality of each series, which required an additional assumption that the seasonality of each series does not change much over time to justify averaging the monthly components. The seasonality is measured as the percent deviation from the underlying trend and consists of the average for the five years of monthly data prior to September 2001, that is, September 1996 through August 2001. The method for decomposing the seasonality and the trend will be dealt with in the next section.

Note that the vertical axis for each graph runs from +25% to -25% deviation. In this way, the degree of deviation is comparable across the figures. While the patterns of seasonality are comparable (less travel in winter, and more travel in summer), we note that rail PM tends to vary the most and VMT the least. Part of this may be accounted for by the fact that rail deals with fewer miles, while VMT incorporates more; extreme values have less of an impact when the number of observations is large.

The next section describes how the seasonal and trend components were created.

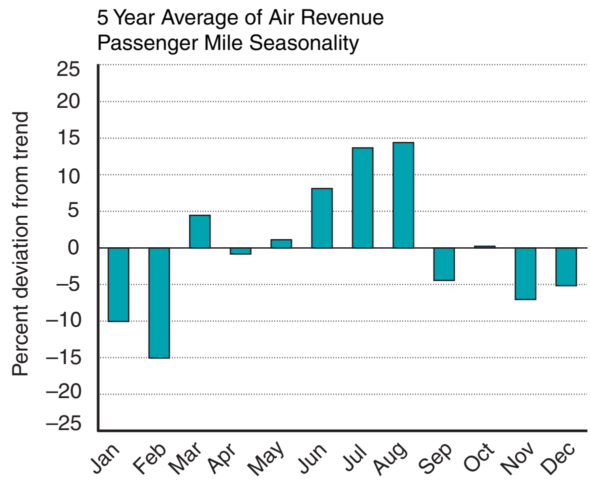
STAMP MODELING

One approach to studying seasonality is to decompose a time series into three components: the trend, the seasonal factors, and the irregular components. STAMP, which stands for Structural Time Series Analyser, Modeller and Predictor,[4] allows us to take a set of time series data and break that dataset down (or "decompose" it) into components that cannot be observed directly, but have intuitive appeal. Most readers have an understanding that a trend component will represent the long-term direction of the data; a seasonal component will reflect changes due

[3] Quality information on the air RPM and rail PM can be found at: http://www.bts.gov/programs/economics_and_finance/transportation_services_index/html/source_and_documentation_and_data_quality.html. Information on the quality of the VMT data can be found at: http://www.fhwa.dot.gov/ohim/tvtw/tvtpage.htm.

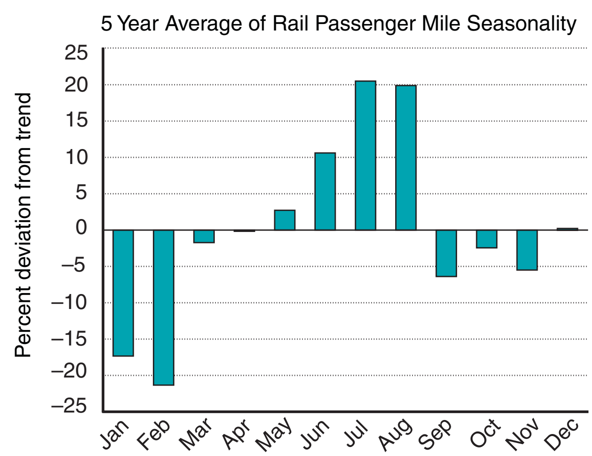
[4] See Koopman et al. (2000) for more detail on STAMP.

Figure 12



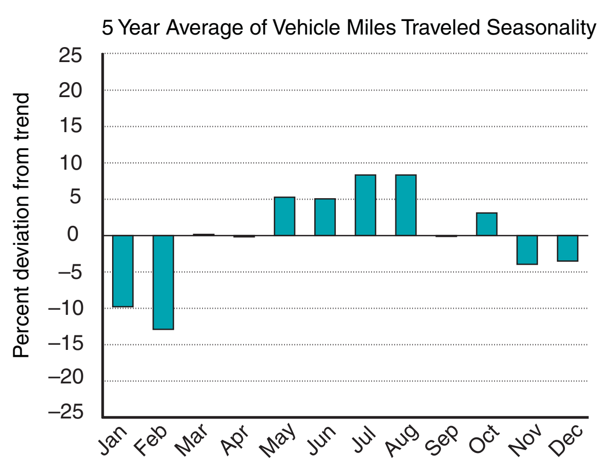
SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

Figure 13



SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

Figure 14



SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

to the time within the year; and the irregular component will illustrate what is "left-over" or not explained by the trend or seasonal behavior. (For an explanation of the theory, the reader can obtain the details in appendix D.) These three components can be stochastic, or changing over time (S); fixed, or unchanging over time (F); or nonexistent (N). Through statistical testing, we ascertained the best fitting model for each time series for the time period of January 1990 through August 2001 (see table 1). By fitting the data prior to September 2001, we can then forecast that model out through the current time and compare the results of these pre-September 2001 forecasts to the actual data.

Table 1: STAMP Model Specifications for Passenger Time Series.

Passenger Mode	Level S/F/N	Slope S/F/N	Season S/F/N
Air RPM	S	F	S
Rail PM	S	N	S
VMT	S	F	S

NOTE: S = stochastic, F =fixed, N = nonexistent

While all three series have models with levels and seasonality changing stochastically over time, the air RPM and VMT exhibit fixed underlying trends. The rail PM has no long-term trend for the period under study.

Using the above models, we forecast from September 2001 through December 2004 to help us understand the changes that occurred over that forecast period. We next provide the graphs of the three sets of data, with forecasts from September 2001 through December 2004 (figures 15, 16, and 17). The prediction intervals for the forecasts are also provided.

The following three graphs (figures 18, 19, and 20) provide a comparison of the forecasts based on the pre-September 2001 data with the actual data from September 2001 forward. The large Is on the graphs indicate the values within the prediction interval.

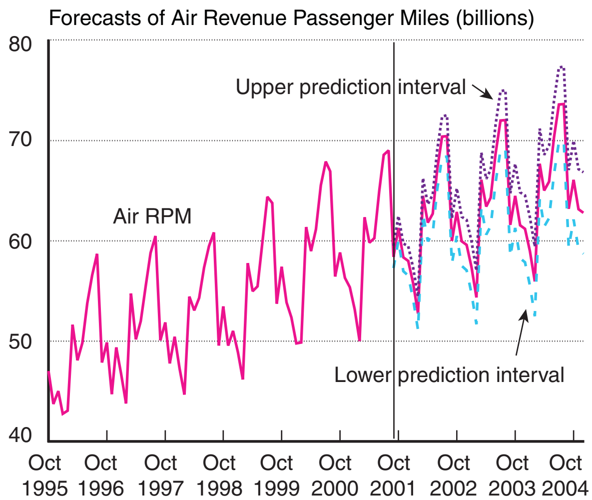
As was expected, air RPM experienced the greatest impact. The forecasted RPMs and the actual RPMs have yet to match one another; only in 2004 did the actual air RPMs cross over into and remain in the 95 percent prediction interval, which indicates that aviation only began to return to what would have been the expected set of RPMs in 2004. Rail PM actuals tended to be close to the forecasted values. VMT seems to show little difference between the actuals and the forecasts, with the exception of the months of September 2001 and September 2002, thereby indicating little long-term impact on overall VMT levels.

In order to more accurately define the impact of September 2001 on the actual data, we attempted to model the impact of September 11, 2001, using the full set of data (January 1990 to June 2004), with the three-step intervention procedure developed by Ord and Young (2004). Three components of the intervention are tested: an additive outlier (AO) on September 2001, a temporary decay (TC) starting October 2001, and a level shift (LS) starting November 2001.

For air RPM, the AO was significant, as was expected; the TC of 8 percent [5] also proved to be significant. The LS term was not significant – indicating that there may not be a permanent shift downward in the trend of the time series.

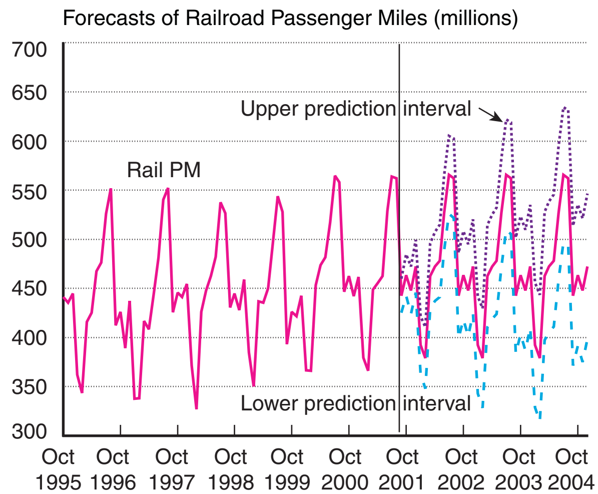
[5] Four decay rates were tested: 6, 7, 8, and 9 percent. For air RPM, the best fitting decay rate was 8 percent, which results in a half-life of 3 months beyond September, or December 2001.

Figure 15



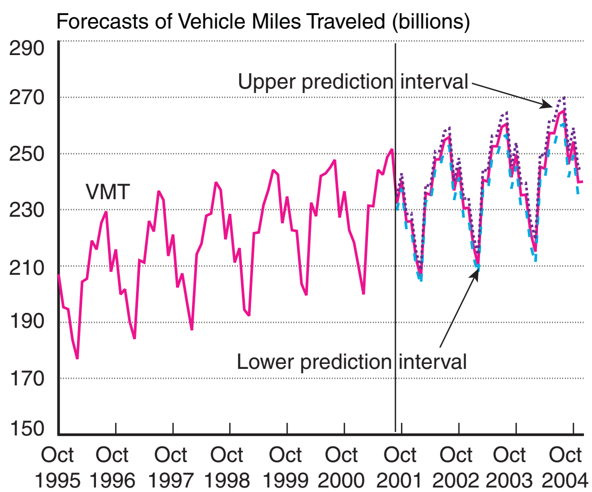
SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

Figure 16



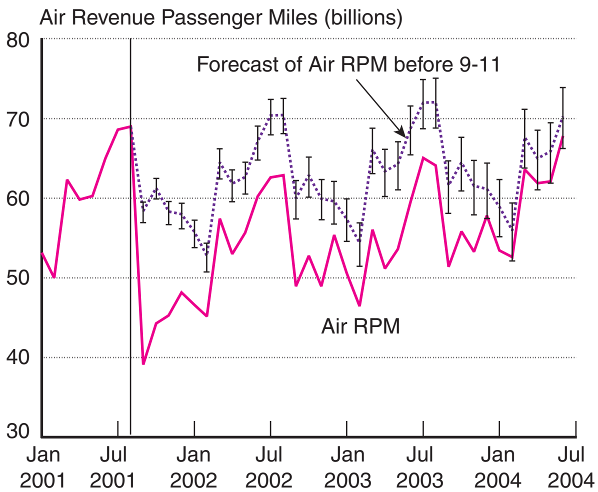
SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

Figure 17



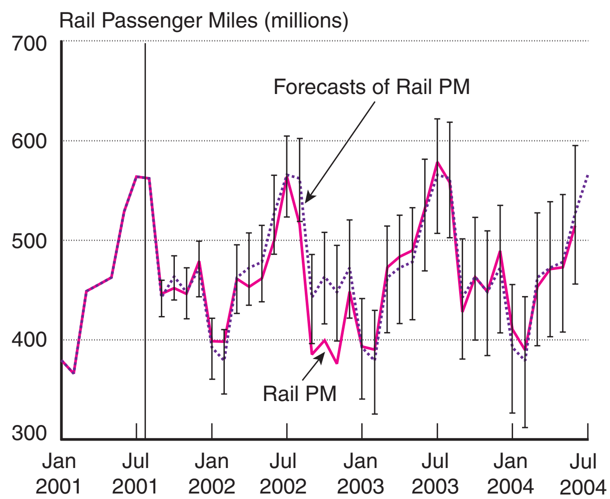
SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

Figure 18



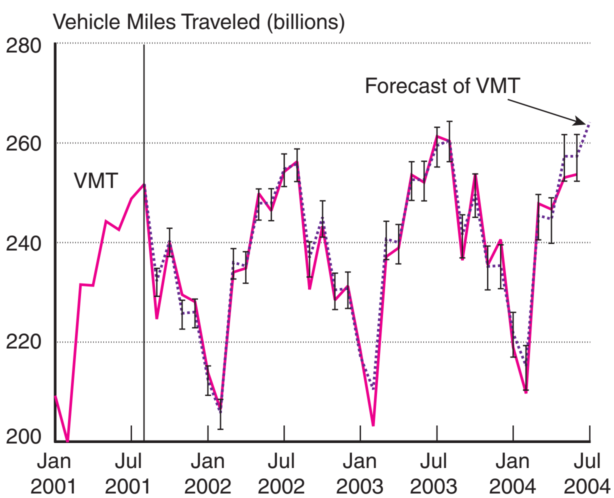
SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

Figure 19



SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

Figure 20



SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

For rail RPM, none of the three-step intervention terms were significant, indicating that September 2001 did not have a significant impact on the series. However, as can be seen in the graph, there was an unexpected short-term drop in the rail PM the following year (September through November), which may indicate an avoidance of travel on the one-year anniversary.

For VMT, the AO at September 2001 was significant, but then the data returned to the expected pattern. So it may be that people avoided car travel in September 2001, but then returned to their usual driving behavior the following month. The summary of these intervention results are provided in table 2.

The next section conducts an analysis comparing the NHTS data with the time series analysis; the time series summaries used in the analysis are available in appendix E.

COMPARISON OF PRE- AND POST- 9/11 MONTHLY TRIPS

In order to simplify the comparison between the time series analysis and the NHTS data, only the forecast results from the time series analysis for the months of the NHTS data collection are considered. The three tables in appendix E show, according to the time series forecasting, both the actual values and the forecasts, along with the corresponding calculated forecast errors.

The travel estimates by mode presented in appendix E can be compared to the NHTS trip estimates to indicate what portion, if any, of the changes in the number of trips between the NHTS pre-and post-9/11 datasets can be attributed to the events of 9/11 and the following months covered by the NHTS survey.

Both the pre-and post-9/11 NHTS datasets were reweighted to give annual trip estimates for the U.S. population. However, the survey periods covered by each dataset do not give equivalent time periods before and after September 11, 2001. The NHTS survey was conducted from March 2001 to May 2002. The pre-and post-9/11 datasets divide the persons surveyed during that period into two groups, March 2001 to September 11, 2001 in the pre-9/11 dataset, and September 12, 2001 to May 2002 in the post-9/11 dataset. The pre-9/11 dataset covers three full months and parts of four other months. The post-9/11 dataset covers 5 full months and parts of 4 other months. The repeated months between the two datasets include March 2001 and March 2002, April 2001 and April 2002, May 2001 and May 2002, and the pre-and post-9/11 portions of September 2001. As a consequence of the unequal time periods covered in each dataset, the total number of estimated trips from each dataset cannot be compared to each other. However, it is possible to compare the trip estimates by calculating a monthly average number of trips from each dataset to adjust for the unequal time periods. Table 3 gives the comparison of NHTS monthly trip estimates to the travel estimates by mode in tables E1 through E3.

Unfortunately the comparisons are very rough. For highways, vehicle miles traveled includes all personal vehicle, public transit, and freight travel over all public highways in the United States. This is compared to NHTS trip estimates that include only long-

Table 2: Intervention Analysis in STAMP on Passenger Time Series.

Passenger mode	Additive Outlier (AO) Sep-01	Temporary Change (TC) Oct-01	Level Shift (LS) Nov-01
Air RPM	Significant	Significant (decay rate = 8%)	Not Significant
Rail PM	Not Significant	Not Significant	Not Significant
VMT	Significant	Not Significant	Not Significant

SOURCE: STAMP analysis, U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

Table 3: Comparison of NHTS Trip Estimates to Other Travel Data

	Monthly average pre-9/11 period (Mar. 2001-Sept. 11 2001)	Monthly average post-9/11 period (Sept. 12, 2001 - May 2002)	Percent change
Vehicle Miles Traveled			
Actual	242.3	225.1	-7.1
Forecast in absence of 9/11	242.3	225	-7.2
NHTS Personal Vehicle Trips (millions)			
Estimated	201.8	181.2	-10.2
Air RPM (millions.)			
Actual	63.1	46.4	-26.4
Forecast in absence of 9/11	63.1	58.1	-7.8
NHTS Air Trips (millions)			
Estimated	18.0	14.1	-21.7
Rail RPM (millions.)			
Actual	508.3	439.1	-13.6
Forecast in absence of 9/11	508.3	436.4	-14.1
NHTS Train Trips (millions.)			
Estimated	1.7	1.6	-5.5
NHTS Bus Trips (millions.)			
Estimated	5.1	4.5	-12.1

SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

NOTE: Shaded difference not significant at a 0.05 level. Pre- and Post-9/11 monthly estimates of VMT are prorated for the NHTS survey overlap months of March, April, and May 2001 and 2002, using NHTS pre-and post-9/11 datasets. The weights for the overlap months are calculated using the proportion of trips taken in those months from the pre-and post-9/11 datasets. September 2001 is prorated using 0.33 for the pre-9/11 weight, and 0.67 for the post-9/11 weight.

distance personal vehicle trips. For passenger rail, Amtrak passenger data is compared to the NHTS long-distance trips by rail, which likely includes some commuter rail trips. There are no long-distance bus data available for comparison to the NHTS bus trip estimates.

Air trips provide the most interesting comparison. Average monthly air RPM experienced a drop of 26.4 percent between the pre-9/11 time period and the post-9/11 time period. When the post-9/11 time period was forecast using previous historical trends, the drop was only 7.8 percent. The difference between those two percentage decreases, about 18.6 percent, can be viewed as the additional decrease in air travel beyond normal historical seasonal trends. The estimated decline from NHTS data of about 22 percent is roughly comparable to the 26 percent decline in air RPM. While the 22 percent cannot be divided up into seasonal and non-seasonal components, using the proportional change in air RPM as a proxy, this gives roughly about a 6 to 7 percent decline for normal seasonal trends and the rest, about 15 to 16 percent, can be attributed to other factors, including 9/11.

CHAPTER 3
Pre- and Post-9/11 Econometric Analysis of Travel by Mode

PREFACE

The following analysis supplements the previous chapters, which initially reviewed the NHTS datasets and then developed seasonally adjusted time series travel estimates. The econometric analysis to follow includes equation estimates for three modes of travel: air, highway, and rail passenger. Each equation will be reviewed for statistical qualities, followed by a discussion that will establish a relationship between travel by mode and the catastrophic events of 9/11.

DATA

The seasonally adjusted monthly travel data used in the econometric analysis spans the period of January 2000 through June 2003, and is identical to the data used in the time series analysis. The exponential weights for the dummy variable used in the VMT equation for the 5-month period from September 2001 to January 2002 are: 1.000, 0.6494, 0.4217, 0.2738, and 0.1778. These weights were approximated by applying a standard natural exponential curve to the data, which would result in a function ranging from 1.0 to 0. These 5 months were chosen based on their proximity to 9/11 and appeared to be the time frame when travel appeared to be most affected by 9/11. Other time periods were chosen and were not found to be statistically significant.

The economic data comes from the Economic Report of the President, which was obtained from the web.[6] The fuel price data originates from the U.S. Department of Energy, Energy Information Administration. Revenue Passenger Miles per Departure data came from the Bureau of Transportation Statistics,

[6] http://www.gpoaccess.gov/eop/

Office of Airline Information. Although the equations listed in the tables below contain only those variables that were statistically significant, several variables were tested, but did not meet the statistical significance tests at either the 5 or 10 percent probability levels. The variables that were excluded in the equations consisted of industrial production and wholesale and retail sales. However, all variables were tried in logarithmic and lagged conversions, and equation specifications were estimated in linear and nonlinear formats.

METHODOLOGY

Travel was econometrically estimated for aviation, highway, and rail passenger modes from monthly data. Both linear and log specifications were tested with combinations of the following economic variables: unemployment, wholesale and retail sales, industrial production, income per driver, fuel prices by mode and fuel type or fuel cost per mile. Two types of dummy variables were used, a typical 0,1 value for September 2001 through February 2002, and another with an exponential decay curve. Corrective procedures were also implemented when needed, such as those associated with serial or time dependent correlation over several periods. Lagged variables through two time periods were also used, and in cases where serial correlation were present, AR(1) (auto-regressive terms of one period) were then included in the estimations. Other independent variables were also used, such as the airline revenue passenger miles per departure. In all, over 30 estimations per mode were attempted with varying combinations of variables and equation specifications.

RESULTS AND STATISTICAL ANALYSIS

Aviation

The results of the aviation estimation (table 4) indicate that there was a statistically significant negative impact of 9/11 on air travel per person above age 16. Other relevant variables such as income per person above age 16, jet fuel price, and the unemployment rate were significant as well, with all variables statistically significant at the $\alpha = 0.01$ level. All variables have the correct a priori mathematical sign. For example, income has a positive effect on travel, while both unemployment and jet fuel price negatively impact travel.

Overall, the statistical fit accounts for 51 percent of the variation from the dependent

Table 4: Seasonally Adjusted Aviation Revenue Passenger-Miles per Driving Age 16+ Population Equation Estimation with Unemployment Variable

Dependent Variable: Aviation Revenue Passenger Miles (seasonally adjusted) per Population Driving Age 16+

Method: Least Squares

Sample: January 2000 to June 2003

Included observations: 42

Variable	Coefficient	Standard error	t-statistic	Probability
Income per population age 16+	0.014	0.002	9.171	0.000
Jet fuel price	-0.195	0.064	-3.018	0.005
Dummy 9/11	-105.270	20.604	-5.109	0.000
Unemployment	-26.308	8.148	-3.229	0.003
R-squared	0.512			
Adjusted R-squared	0.474			

SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

variable mean. The Durbin-Watson test is inconclusive for autocorrelation among error terms, so no adjustments were made to the original equation.

Where:

Income per population aged 16+ = income[7] per population aged 16+[8] (in real 1996 dollars per population aged 16 and over)

Jet fuel price = kero-jet fuel price[9] (1/10th cent per bbl in nominal dollars)

Dummy 9/11 = dummy variable, where value equals 1 for September 2001 through February 2002

Unemployment = unemployment (percent)[10]

Highway

The highway vehicle-miles traveled (VMT) equation estimation (table 5) has an R-squared value of 74.8 percent, which is much higher than the aviation or rail equations. The premise for using the revenue-passenger miles variable (RPM_DEPART) was to capture the effect of travel declining as a result of 9/11, especially very short air flights (100 miles or less), which may be leading to more highway travel. The RPM variable is significant at $\alpha = 0.05$ level, while all other variables are significant at the $\alpha = 0.01$ level. This indicates that there is a strong relationship between the events of 9/11 on highway travel. All of the variables also have the proper sign, such as when air travel declines, VMT increases, indicating that they are substitutes. Travel increases with rising income as well. The EXP_9/11 variable consists of a weighted dummy variable for 9/11, in which the weights decline exponentially over a 4-month period after 9/11. The exponential form of the dummy variable was found to be statistically significant, but the (0,1) dummy was not statistically significant. The original Durbin-Watson statistic tested positive for positive serial correlation ($\alpha = 0.01$), so an adjustment was made to include an autoregressive (AR) period 1 error term variable.

Table 5: Highway Vehicle-Miles Traveled per Driving Age 16+ Population Equation Estimation

Dependent variable: vehicle miles traveled per driver
Method: least squares
Sample (adjusted): February 2000 to June 2003
Included observations: 41 after adjustments

Variable	Coefficient	Standard error	t-statistic	Probability
RPM per departure	-0.989	0.398	-2.483	0.018
Income per population 16+	0.035	0.001	58.356	0.000
Exponential Dummy 9/11	-44.820	13.488	-3.323	0.002
AR(1)	0.797	0.107	7.415	0.000
R-squared	0.748			
Adjusted R-squared	0.727			

SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

Where:

RPM per departure = Revenue passenger miles[11] per departure

[7] U.S. Department of Commerce, Bureau of Economic Analysis, table 2.6, Personal Income and Its Disposition, Monthly, seasonally adjusted, www.bea.gov.

[8] Economic Report of the President, Table B–35, Civilian population and labor force, 1929–2001, monthly data seasonally adjusted, 2004.

[9] U.S. Department of Energy, Energy Information, State Energy Price and Expenditure Report, 2004. http://www.eia.doe.gov.

[10] U.S. Department of Labor, Bureau of Labor Statistics, Unemployment Rate, seasonally adjusted, LNS14000000, www.bls.gov.

[11] U.S. Department of Transportation, Research and Innovative Technology Administration (RITA), Bureau of Transportation Statistics, Transportation Services Index (TSI), http://www.bts.gov/xml/tsi/

Exponential Dummy 9/11 = exponentially weighted dummy variable, where value exponentially decays through 4 time periods.

AR(1) = Auto-regressive error terms of time period one[12]

Rail

Only the logarithmic equation specification (table 6) was found to be statistically acceptable, in terms of fit and statistical significance. Notice that the equation has no 9/11 variable, because it was found to not be statistically significant in all combinations of log and linear specifications as well as combinations of all variables. Both the log of the time period lag of one for the dependent variable and the log of the income per driver were found to be statistically significant. Each variable has the proper positive sign indicating that rail passenger travel rises as a result of the effects of the previous time period and the effects of increases in income per driver. The Durbin-Watson statistic revealed no serial correlation.

Table 6: Log of Seasonally Adjusted Passenger-Miles for Rail per Driving Age 16+ Population Equation Estimation

Dependent variable: Log Rail Passenger-miles per Population Aged 16+ (seasonally adjusted)
Method: Least Squares
Sample (adjusted): February 2000 to June 2003
Included observations: 41 after adjustments

Variable	Coefficient	Standard error	t-statistic	Probability
Log of seasonally adjusted rail passenger miles per population aged 16+ lagged one period	0.767	0.105	7.301	0.000
Log of income per population aged 16+	0.175	0.079	2.223	0.032
R-squared	0.537			
Adjusted R-squared	0.525			

SOURCE: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

DISCUSSION

Economic Demand Elasticities Comparison

Often an evaluation of econometric equations includes comparisons to other estimates using the estimated coefficients to develop economic elasticities. Demand elasticities measure the degree, in percentage change, to which one economic variable changes based on the percentage change of another economic variable. Table 7 shows a comparison between demand elasticities from the BTS study versus Carol Dahl's compilation of various model elasticities.[13] All of the BTS elasticities were calculated at the mean and are very close or within the range of Carol Dahl's findings, possibly with the exception of the aviation income elasticity, which appears to be larger than the

src/index.xml and National Transportation Statistics, http://www.bts.gov/publiications/national_transportation_statistics//2005/index.html, 2005.

[12] See William Greene, *Econometric Analysis*, 2003.

[13] Carol Dahl, Professor, Director of CSM/IFP Joint International Degree Program in Petroleum Economics and Management, Colorado School of Mines, Golden, Colorado. Dahl has compiled demand equation elasticities for 20 authors, many with multiple estimations over time. They are categorized according to equation specifications and type of data used. Elasticities are derived from equation coefficients in the form of a percentage change in demand for a percentage change in price or income.

higher range of the estimates (Dahl, 1995). It should also be noted that Dahl's elasticities are measured with respect to transportation fuel consumption and are not as specific to a particular mode as the BTS study. Therefore, the elasticities should be judged in a more general manner than viewed as exact comparisons by mode.

Table 7: Economic Demand Elasticities

	Aviation	Highway	Rail	Dahl
Income elasticity	1.74	1.04	0.18	0.09 to 0.85
Fuel price elasticity	-0.38	-	-	-0.01 to -0.36

SOURCE: Dahl, Carol A. "Demand for Transportation Fuels: A Survey of Demand Elasticities and Their Components," Journal of Energy Literature, 1(2), Fall, 1995. and U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.

The results indicate that there is a strong statistical relationship between the events of 9/11 and aviation and highway travel, but not rail revenue passenger miles. Given that the 9/11 dummy variables are statistically significant, it can be concluded that the negative effect of 9/11 on travel declines in a more arithmetic fashion for air travel over a 6 month period, in which there is a decline in the intercept. Similarly, highway travel has a tendency to decline in a more exponential pattern over a 4-month period. These conclusions do not attempt to determine when travel will return to a more normal historical level, but rather only the declining portion of the travel. Furthermore, it can be concluded that there is a statistically significant substitution relationship between air travel and highway travel, although the cross elasticity is small at -0.041. This cross elasticity was derived from the air travel coefficient and indicates that for each 100 percent drop in air travel, highway travel will increase at approximately 4.1 percent.

The conclusions of this study do not equate to assuming that future catastrophic events would yield the same results because the degree of damage and the impending effect on behavior may not be the same for future events. The severity of catastrophic events and their impact on future behavior is not easily quantifiable, and yet is essential for future analysis of catastrophic events. Hopefully future research and analysis will lead to some kind of indicator of the degree of severity of catastrophes.

APPENDIX A
Methodology

SOURCE AND ACCURACY

The findings from the 2001 NHTS survey are based on travel data collected from a random digit dial sample of telephone interviews conducted with over 60,000 individuals in approximately 26,000 nationally representative households. Interviews were conducted between March 2001 and May 2002. Individuals in the NHTS sample were asked to complete a travel diary for a specified day, known as the *travel day,* and were also asked to report on the characteristics of long-distance trips of 50 miles or more from home made during a 4-week period, known as the *travel period.*

Estimates reported here are based on weighted data to account for selection probabilities at the household and individual level, and are further adjusted for household and individual nonresponse. Comparisons made in this report are statistically significant at a 0.05 level.

CREATION OF PRE-9/11 AND POST-9/11 DATA FILES

The 2001 NHTS was conducted from March 2001 through May 2002. The NHTS person-level dataset was divided into two parts: pre-9/11 data and post-9/11 data. The pre-9/11 dataset includes trips taken in the period from March 2001 to September 2001, a period of 5 1/2 months, and includes the summer season in which a large proportion of long-distance trips are taken. There were approximately 22,000 persons responding about travel prior to 9/11. The post-9/11 dataset includes trips taken in the period from September 2001 to May 2002, a period of roughly 8 months, and includes Thanksgiving and Christmas—a traditionally heavy season for long-distance trips. The survey had responses from approximately 38,000 persons on their long-distance trips after 9/11. The composition of persons who took long-distance trips prior to 9/11 and those that took long-distance trips following 9/11 was not the same. A more detailed description of how the pre-9/11 and post-

9/11 data files were created is contained in Chapter 1 of "National Household Travel Survey—Pre- and Post-Data Documentation" found on www.bts.gov.

Additional steps were taken to make each of the pre-9/11 and post-9/11 groups a nationally representative sample. This is achieved by constructing new weights using statistically sound methods briefly described below.

REWEIGHTING OF PRE-9/11 AND POST-9/11 DATA FILES

Weights are needed to produce valid population-level estimates so that the results of a survey of the population are representative of the population as a whole. For example, if in the survey 47 percent of the respondents were male and in the U.S. population 49 percent of the population was known to be male, then the male survey respondents would be weighted stronger so that their data and travel information would count for 49 percent of the population's travel patterns. Adjustment and post-stratification are performed on collected data to reduce bias of estimates. Post-stratification reweights the data so that the characteristics of the respondents are the same as the characteristics of the population.

To see whether the pre- and post- 9/11 groups were representative samples of the national population it was necessary to construct population control totals for key survey variables using Census 2000 numbers. Tolerance levels were used in the final reweighting program to determine which combination of variables to keep. An example of a tolerance level would be for Hispanics to be within 4 persons of a census generated control total that would represent the total Hispanics in the United States for a designated timeframe. A more detailed description of how the pre-9/11 and post-9/11 data files were reweighted is contained in chapter 2 of "National Household Travel Survey- Pre- and Post-Data Documentation" found on www.bts.gov.

APPENDIX B
NHTS Tables

NOTE: Cells with a small sample size (< 30) or that have a covariance or c.v. (> 0.3) are shaded blue to indicate that the weighted estimates are not reliable. Cells with bold type indicate significant differences (p<0.05) between pre-9/11 and post-9/11 estimates.

Table B1: Distribution of Pre- and Post-9/11 Long-Distance Trips by Trip Purpose, for Each Mode

	Percentage trips (standard error)									
	Personal vehicle		**Air**		**Bus**		**Other**		**All modes**	
Trip purpose	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Commute	13.3	13.8	2.6	3.6	0.7	4.3	6.2	30.1	12.1	13.1
	(1.47)	(0.88)	(0.73)	(1.49)	(0.46)	(2.25)	(3.66)	(11.05)	(1.34)	(0.82)
Business	13.2	15.0	37.0	41.1	6.7	6.6	36.6	30.3	15.1	16.8
	(0.87)	(0.74)	(2.05)	(1.92)	(2.21)	(2.47)	(6.70)	(10.18)	(0.82)	(0.68)
Pleasure	56.4	56.0	49.5	48.4	55.0	58.7	46.4	31.9	55.7	55.2
	(1.13)	(0.84)	(1.95)	(1.78)	(5.08)	(3.31)	(6.40)	(7.06)	(1.01)	(0.78)
Personal business	13.4	12.2	**9.4**	**6.4**	37.3	29.4	6.9	5.2	**13.5**	**12.1**
	(0.45)	(0.45)	(0.97)	(0.86)	(4.51)	(3.11)	(2.47)	(2.09)	(0.43)	(0.43)
Other	**3.8**	**3.1**	1.5	0.6	0.4	1.1	3.9	2.5	**3.5**	**2.8**
	(0.26)	(0.16)	(0.80)	(0.20)	(0.26)	(0.74)	(2.61)	(1.83)	(0.23)	(0.15)
All trips	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table B2: Distribution of Pre- and Post-9/11 Long-Distance Trips by Age Group, for Each Mode

	Percentage trips (standard error)									
	Personal vehicle		Air		Bus		Other		All modes	
Age group	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
0 - 24	**26.6**	**24.6**	**20.5**	**14.5**	46.2	51.9	6.8	25.0	**26.4**	**24.5**
	(0.75)	(0.68)	(1.38)	(1.23)	(5.05)	(3.44)	(2.44)	(10.50)	(0.70)	(0.63)
25 - 54	53.6	55.4	**61.7**	**70.0**	21.4	26.8	75.4	58.4	53.8	55.8
	(0.99)	(0.84)	(1.70)	(1.50)	(3.68)	(3.34)	(4.72)	(10.03)	(0.91)	(0.76)
55 - 64	11.7	11.0	11.7	9.6	7.0	8.7	8.0	10.7	11.6	10.8
	(0.72)	(0.44)	(1.03)	(0.80)	(2.45)	(2.19)	(2.52)	(4.51)	(0.65)	(0.42)
65 - 74	5.6	6.4	4.2	3.5	16.0	8.2	8.0	4.6	5.8	6.2
	(0.26)	(0.34)	(0.87)	(0.47)	(7.03)	(1.74)	(2.76)	(1.61)	(0.29)	(0.31)
75 +	2.4	2.7	2.0	2.5	**9.4**	**4.5**	1.8	1.2	2.5	2.7
	(0.18)	(0.22)	(0.42)	(0.45)	(1.88)	(0.97)	(0.91)	(0.66)	(0.17)	(0.21)
All trips	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table B3: Distribution of Pre- and Post-9/11 Long-Distance Trips by Gender, for Each Mode

	Percentage trips (standard error)									
	Personal vehicle		Air		Bus		Other		All modes	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Male	57.2	57.6	56.6	60.1	**35.9**	**54.8**	52.3	67.0	56.6	57.8
	(1.00)	(0.88)	(2.14)	(1.60)	(4.50)	(3.63)	(7.87)	(7.50)	(0.91)	(0.82)
Female	42.8	42.4	43.5	40.0	**64.1**	**45.2**	47.7	33.0	43.4	42.2
	(1.00)	(0.88)	(2.14)	(1.60)	(4.50)	(3.63)	(7.87)	(7.50)	(0.91)	(0.82)
All trips	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table B4: Distribution of Pre- and Post-9/11 Long-Distance Trips by Income, for Each Mode

	Percentage trips (standard error)									
	Personal vehicle		Air		Bus		Other		All modes	
Household income ($)	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
0-24,999	13.1	13.6	5.9	4.4	32.1	18.5	11.0	19.3	12.9	13.1
	(0.79)	(0.60)	(0.87)	(0.63)	(6.92)	(3.00)	(5.18)	(11.24)	(0.76)	(0.55)
25-49,999	32.7	30.5	14.3	15.8	30.3	28.6	**35.6**	**15.5**	31.2	29.3
	(1.00)	(0.87)	(1.27)	(1.29)	(4.51)	(3.06)	(7.59)	(4.61)	(0.91)	(0.82)
50,000+	54.3	55.9	79.7	79.8	**37.6**	**52.9**	53.4	65.2	55.9	57.6
	(1.04)	(1.00)	(1.55)	(1.39)	(4.88)	(3.85)	(8.57)	(10.49)	(0.97)	(0.92)
All trips	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table B5: Distribution of Pre- and Post-9/11 Long-Distance Trips by Trip Length, for Each Mode

Trip length one-way (miles)	Personal vehicle Pre	Personal vehicle Post	Air Pre	Air Post	Bus Pre	Bus Post	Other Pre	Other Post	All modes Pre	All modes Post
	Percentage trips (standard error)									
50 - 99	**49.0**	**53.9**	0.5	0.3	**22.7**	**35.8**	**43.6**	**64.8**	**44.6**	**49.9**
	(1.04)	(0.77)	(0.32)	(0.17)	(3.22)	(3.96)	(7.41)	(7.14)	(0.99)	(0.73)
100 - 249	35.3	33.3	**5.1**	**2.4**	47.0	40.2	33.1	18.9	33.1	31.1
	(0.96)	(0.65)	(1.16)	(0.51)	(3.97)	(3.28)	(6.53)	(4.05)	(0.88)	(0.58)
250 - 499	**10.9**	**8.9**	13.8	16.1	15.1	17.2	5.8	5.9	**11.1**	**9.5**
	(0.38)	(0.37)	(1.61)	(1.43)	(2.52)	(2.82)	(1.81)	(2.67)	(0.39)	(0.36)
500 - 999	**3.3**	**2.6**	30.4	27.9	10.0	3.5	7.0	2.3	**5.6**	**4.4**
	(0.21)	(0.15)	(1.92)	(1.35)	(2.22)	(0.90)	(4.08)	(0.89)	(0.26)	(0.16)
1,000+	1.6	1.3	50.1	53.4	5.1	3.2	10.4	8.1	5.6	5.0
	(0.14)	(0.11)	(1.95)	(1.57)	(2.11)	(1.13)	(3.67)	(2.48)	(0.26)	(0.19)
All trips	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table B6: Distribution of Pre- and Post-9/11 Long-Distance Trips by Trip Destination, for Each Mode

Trip destination category	Personal vehicle Pre	Personal vehicle Post	Air Pre	Air Post	Bus Pre	Bus Post	Other Pre	Other Post	All modes Pre	All modes Post
	Percentage trips (standard error)									
Same state	66.8	68.1	**9.6**	**5.5**	**43.9**	**62.7**	33.4	33.3	61.5	63.2
	(0.87)	(0.71)	(1.73)	(0.66)	(4.94)	(3.92)	(6.90)	(7.53)	(0.86)	(0.65)
Same census division	16.8	18.0	10.2	8.9	18.8	21.6	31.6	45.7	16.4	17.8
	(0.59)	(0.63)	(1.29)	(0.91)	(3.06)	(3.38)	(7.39)	(10.50)	(0.55)	(0.58)
Same census region	7.5	6.4	**11.5**	**17.6**	10.5	7.3	7.9	4.7	7.9	7.1
	(0.63)	(0.30)	(1.37)	(1.28)	(2.83)	(1.57)	(2.60)	(1.58)	(0.59)	(0.28)
Different region	7.5	6.7	52.3	56.4	**24.5**	**6.7**	19.7	8.6	**11.6**	**10.2**
	(0.34)	(0.32)	(1.95)	(1.72)	(6.78)	(1.51)	(4.64)	(3.21)	(0.44)	(0.30)
International	**1.4**	**0.8**	**16.4**	**11.7**	2.3	1.7	7.4	7.8	**2.6**	**1.7**
	(0.14)	(0.09)	(1.52)	(0.97)	(0.74)	(0.80)	(2.63)	(2.36)	(0.17)	(0.11)
All trips	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table B7: Distribution of Pre- and Post-9/11 Long-Distance Trips by Area Type, for Each Mode

Percentage trips (standard error)

Area type	Personal vehicle Pre	Personal vehicle Post	Air Pre	Air Post	Bus Pre	Bus Post	Other Pre	Other Post	All modes Pre	All modes Post
Urban	72.0	69.8	89.7	90.5	**83.5**	**72.4**	91.8	73.9	73.9	71.3
	(1.08)	(0.97)	(1.03)	(0.81)	(2.80)	(3.01)	(4.54)	(8.45)	(0.97)	(0.88)
Rural	28.0	30.2	10.3	9.5	**16.5**	**27.6**	8.2	26.1	26.2	28.7
	(1.08)	(0.97)	(1.03)	(0.81)	(2.80)	(3.01)	(4.54)	(8.45)	(0.97)	(0.88)
All trips	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table B8: Distribution of Pre- and Post-9/11 Long-Distance Trips by Mode, for Each Trip Purpose

Percentage trips (standard error)

Trip purpose	Personal vehicle Pre	Personal vehicle Post	Air Pre	Air Post	Bus Pre	Bus Post	Other Pre	Other Post	All modes Pre	All modes Post
Commute	**97.7**	**94.7**	1.7	1.9	0.1	0.7	0.5	2.6	100.0	100.0
	(0.56)	(1.37)	(0.52)	(0.81)	(0.09)	(0.40)	(0.28)	(1.12)		
Business	77.3	80.1	19.4	17.0	1.0	0.9	2.3	2.1	100.0	100.0
	(1.80)	(1.48)	(1.72)	(1.36)	(0.33)	(0.33)	(0.59)	(0.78)		
Pleasure	89.9	90.9	**7.0**	**6.1**	2.2	2.4	0.8	0.7	100.0	100.0
	(0.49)	(0.31)	(0.32)	(0.22)	(0.35)	(0.21)	(0.12)	(0.09)		
Personal business	**87.7**	**90.4**	**5.5**	**3.7**	6.3	5.4	0.5	0.5	100.0	100.0
	(0.88)	(0.73)	(0.55)	(0.49)	(0.66)	(0.56)	(0.16)	(0.18)		
Other	95.4	96.8	3.3	1.4	0.2	0.8	1.0	1.0	100.0	100.0
	(1.89)	(1.02)	(1.80)	(0.48)	(0.17)	(0.59)	(0.70)	(0.72)		
All trips	88.9	89.7	**7.9**	**7.0**	2.3	2.2	0.9	1.1	100.0	100.0
	(0.45)	(0.37)	(0.35)	(0.25)	(0.22)	(0.15)	(0.13)	(0.20)		

Table B9: Distribution of Pre- and Post-9/11 Long-Distance Trips by Mode, for Each Age Group

Percentage trips (standard error)

Age group	Personal vehicle Pre	Personal vehicle Post	Air Pre	Air Post	Bus Pre	Bus Post	Other Pre	Other Post	All modes Pre	All modes Post
0 - 24	89.6	90.0	**6.2**	**4.1**	4.0	4.7	0.2	1.2	100.0	100.0
	(0.62)	(0.84)	(0.47)	(0.37)	(0.39)	(0.37)	(0.08)	(0.54)		
25 - 54	88.7	89.0	9.1	8.8	0.9	1.1	1.3	1.2	100.0	100.0
	(0.64)	(0.53)	(0.53)	(0.41)	(0.16)	(0.16)	(0.23)	(0.26)		
55 - 64	90.0	90.9	8.0	6.2	1.4	1.8	0.7	1.1	100.0	100.0
	(1.08)	(0.89)	(0.89)	(0.51)	(0.48)	(0.48)	(0.18)	(0.46)		
65 - 74	86.7	92.3	5.7	3.9	6.3	2.9	1.3	0.9	100.0	100.0
	(2.88)	(0.96)	(1.19)	(0.54)	(2.90)	(0.64)	(0.42)	(0.24)		
75 +	**84.6**	**89.4**	6.3	6.4	**8.4**	**3.7**	0.7	0.5	100.0	100.0
	(1.90)	(1.41)	(1.29)	(1.13)	(1.57)	(0.86)	(0.34)	(0.26)		
All trips	88.9	89.7	**7.9**	**7.0**	2.3	2.2	0.9	1.1	100.0	100.0
	(0.45)	(0.37)	(0.35)	(0.25)	(0.21)	(0.15)	(0.13)	(0.20)		

Table B10: Distribution of Pre- and Post-9/11 Long-Distance Trips by Mode, for Each Gender

Percentage trips (standard error)

	Personal vehicle		Air		Bus		Other		All modes	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Male	89.8	89.3	7.9	7.2	**1.4**	**2.1**	0.9	1.3	100.0	100.0
	(0.64)	(0.52)	(0.55)	(0.34)	(0.18)	(0.20)	(0.18)	(0.33)		
Female	**87.7**	**90.1**	**8.0**	**6.6**	3.4	2.4	1.0	0.9	100.0	100.0
	(0.67)	(0.45)	(0.43)	(0.35)	(0.45)	(0.25)	(0.20)	(0.15)		
All trips	88.9	89.7	**7.9**	**7.0**	2.3	2.2	0.9	1.1	100.0	100.0
	(0.45)	(0.37)	(0.35)	(0.25)	(0.21)	(0.15)	(0.13)	(0.20)		

Table B11: Distribution of Pre- and Post-9/11 Long-Distance Trips by Mode, for Each Income Group

Percentage trips (standard error)

Household	Personal vehicle		Air		Bus		Other		All modes	
income ($)	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
0-24,999	90.2	93.1	3.6	2.4	5.5	3.1	0.8	1.4	100.0	100.0
	(1.69)	(1.00)	(0.51)	(0.35)	(1.45)	(0.54)	(0.39)	(0.87)		
25-49,999	93.2	93.5	3.6	3.8	2.2	2.2	1.1	0.5	100.0	100.0
	(0.53)	(0.38)	(0.35)	(0.29)	(0.33)	(0.26)	(0.28)	(0.13)		
50,000+	86.6	87.2	11.1	9.7	1.5	2.0	0.9	1.1	100.0	100.0
	(0.64)	(0.56)	(0.58)	(0.44)	(0.17)	(0.22)	(0.16)	(0.21)		
All trips	89.1	89.8	7.8	7.0	2.2	2.2	0.9	1.0	100.0	100.0
	(0.46)	(0.36)	(0.36)	(0.26)	(0.22)	(0.16)	(0.14)	(0.16)		

Table B12: Distribution of Pre- and Post-9/11 Long-Distance Trips by Mode, for Each Trip Distance

Percentage trips (standard error)

Trip length one-way	Personal vehicle		Air		Bus		Other		All modes	
(miles)	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
50 - 99	**98.0**	**96.9**	0.1	0.0	**1.1**	**1.6**	0.9	1.5	100.0	100.0
	(0.22)	(0.46)	(0.06)	(0.02)	(0.15)	(0.23)	(0.18)	(0.38)		
100 - 249	94.9	95.9	**1.2**	**0.5**	3.0	2.9	0.9	0.7	100.0	100.0
	(0.47)	(0.33)	(0.29)	(0.12)	(0.36)	(0.28)	(0.23)	(0.12)		
250 - 499	86.9	83.5	9.8	11.7	2.8	4.0	0.5	0.7	100.0	100.0
	(1.22)	(1.29)	(1.14)	(1.14)	(0.53)	(0.67)	(0.15)	(0.29)		
500 - 999	52.1	53.5	43.1	44.2	3.7	1.8	1.1	0.6	100.0	100.0
	(2.70)	(2.07)	(2.60)	(2.07)	(0.83)	(0.44)	(0.68)	(0.20)		
1,000+	24.9	22.9	71.5	73.9	1.9	1.4	1.7	1.8	100.0	100.0
	(1.81)	(1.67)	(1.81)	(1.82)	(0.80)	(0.49)	(0.57)	(0.41)		
All trips	89.1	89.7	**7.9**	**7.0**	2.1	2.2	0.9	1.1	100.0	100.0
	(0.43)	(0.37)	(0.36)	(0.25)	(0.16)	(0.15)	(0.13)	(0.20)		

Table B13: Distribution of Pre- and Post-9/11 Long-Distance Trips by Mode, for Each Trip Destination

Percentage trips (standard error)

Trip destination category	Personal vehicle		Air		Bus		Other		All modes	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Same state	96.6	96.6	**1.3**	**0.6**	**1.6**	**2.2**	0.5	0.6	100.0	100.0
	(0.32)	(0.26)	(0.25)	(0.07)	(0.17)	(0.20)	(0.12)	(0.12)		
Same census division	90.7	90.9	4.9	3.5	2.6	2.7	1.8	2.9	100.0	100.0
	(0.91)	(1.24)	(0.67)	(0.40)	(0.40)	(0.46)	(0.54)	(1.03)		
Same census region	**84.4**	**79.8**	**11.6**	**17.2**	3.0	2.3	0.9	0.8	100.0	100.0
	(1.69)	(1.43)	(1.38)	(1.33)	(0.87)	(0.52)	(0.29)	(0.22)		
Different region	57.8	59.1	35.8	38.5	4.8	1.5	1.6	1.0	100.0	100.0
	(1.72)	(1.87)	(1.60)	(1.76)	(1.50)	(0.35)	(0.41)	(0.33)		
International	46.0	43.7	49.4	48.7	2.0	2.3	2.6	5.3	100.0	100.0
	(3.55)	(3.23)	(3.69)	(3.34)	(0.61)	(1.05)	(0.91)	(1.22)		
All trips	88.9	89.7	**7.9**	**7.0**	2.3	2.2	0.9	1.1	100.0	100.0
	(0.45)	(0.37)	(0.35)	(0.25)	(0.21)	(0.15)	(0.13)	(0.20)		

Table B14: Distribution of Pre- and Post-9/11 Long-Distance Trips by Mode, for Each Area Type

Percentage trips (standard error)

Area type	Personal vehicle		Air		Bus		Other		All modes	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Urban	86.6	87.7	9.6	8.8	2.6	2.3	1.2	1.2	100.0	100.0
	(0.61)	(0.50)	(0.48)	(0.36)	(0.29)	(0.18)	(0.17)	(0.25)		
Rural	95.2	94.5	**3.1**	**2.3**	**1.4**	**2.2**	0.3	1.0	100.0	100.0
	(0.44)	(0.53)	(0.33)	(0.20)	(0.21)	(0.28)	(0.16)	(0.36)		
All trips	88.9	89.7	**7.9**	**7.0**	2.3	2.2	0.9	1.1	100.0	100.0
	(0.45)	(0.37)	(0.35)	(0.25)	(0.21)	(0.15)	(0.13)	(0.20)		

APPENDIX C
The Time Series Data

Table C1: Raw Data for Time Series Analysis

	Air RPM (000s)	Rail PM	VMT (billions)
Jan-90	35,153,577	454,115,779	163.28
Feb-90	32,965,187	435,086,002	153.25
Mar-90	39,993,913	568,289,732	178.42
Apr-90	37,981,886	568,101,697	178.68
May-90	38,419,672	539,628,385	188.88
Jun-90	42,819,023	570,694,457	189.16
Jul-90	45,770,315	618,571,581	195.09
Aug-90	48,763,670	609,210,368	196.67
Sep-90	38,173,223	488,444,939	178.07
Oct-90	39,051,877	514,253,920	182.27
Nov-90	35,699,216	516,429,873	171.23
Dec-90	37,444,088	531,619,395	168.29
Jan-91	34,848,290	496,467,387	157.88
Feb-91	29,672,427	469,504,489	153.34
Mar-91	36,202,993	587,905,914	179.06
Apr-91	37,146,602	509,488,334	179.52
May-91	38,869,421	566,342,448	191.91
Jun-91	42,199,760	603,845,247	193.45
Jul-91	45,384,965	633,450,001	198.37
Aug-91	48,164,550	664,013,874	204.05
Sep-91	38,481,957	494,557,648	183.58
Oct-91	39,062,110	509,037,626	188.43
Nov-91	34,688,141	472,359,118	169.68
Dec-91	38,575,165	550,795,984	172.77
Jan-92	35,265,807	493,541,137	167.89
Feb-92	33,868,884	462,084,011	160.43
Mar-92	39,724,539	559,205,172	184.03

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Table C1 (*continued*)

Raw Data for Time Series Analysis

	Air RPM (000s)	Rail PM	VMT (billions)
Apr-92	37,294,373	572,122,965	186.32
May-92	39,728,367	546,043,825	196.99
Jun-92	45,754,460	478,204,759	197.49
Jul-92	50,807,813	610,774,196	206.88
Aug-92	53,219,046	627,359,211	205.02
Sep-92	41,564,915	516,516,158	191.16
Oct-92	40,578,092	538,313,763	195.10
Nov-92	36,863,415	539,769,246	177.62
Dec-92	39,045,016	551,397,116	181.25
Jan-93	37,911,556	500,349,189	171.66
Feb-93	34,902,869	461,280,157	162.82
Mar-93	42,058,882	534,476,186	187.84
Apr-93	40,814,097	562,429,065	188.71
May-93	42,133,943	554,039,017	205.95
Jun-93	44,679,864	580,500,717	199.39
Jul-93	48,622,037	586,861,727	209.81
Sep-93	41,677,832	501,353,952	193.74
Oct-93	43,264,475	507,702,230	197.76
Nov-93	38,868,799	489,299,178	182.30
Dec-93	40,610,043	503,041,903	186.80
Jan-94	38,863,562	472,917,856	169.31
Feb-94	36,068,535	463,567,851	166.44
Mar-94	45,433,842	572,167,273	196.19
Apr-94	42,418,163	546,898,075	195.41
May-94	44,297,210	524,008,197	206.60
Jun-94	48,169,096	531,971,149	207.28
Jul-94	52,410,979	578,257,564	214.78
Aug-94	53,235,052	587,229,076	215.05
Sep-94	44,677,623	490,032,783	200.51
Oct-94	45,845,403	493,619,903	202.86
Nov-94	42,230,318	477,594,716	190.07
Dec-94	43,868,116	490,779,357	193.09
Jan-95	42,050,940	425,207,429	183.62
Feb-95	38,580,784	393,268,412	172.52
Mar-95	47,390,145	489,360,683	202.41
Apr-95	45,427,499	490,903,635	199.53
May-95	45,915,722	511,120,586	213.56
Jun-95	49,992,583	542,693,418	212.28
Jul-95	53,345,749	571,259,638	217.72

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Table C1 (*continued*)

Raw Data for Time Series Analysis

	Air RPM (000s)	Rail PM	VMT (billions)
Aug-95	54,776,466	580,982,161	219.87
Sep-95	45,589,237	451,385,426	204.32
Oct-95	46,993,036	441,202,778	206.99
Nov-95	43,703,386	435,470,011	195.41
Dec-95	45,015,358	444,598,571	194.59
Jan-96	42,734,234	362,022,328	183.74
Feb-96	43,056,589	343,413,949	176.82
Mar-96	51,646,570	416,042,895	204.47
Apr-96	48,063,492	425,092,726	205.56
May-96	49,808,809	467,573,082	219.00
Jun-96	53,774,378	476,554,648	215.87
Jul-96	56,576,582	525,954,361	225.44
Aug-96	58,714,135	551,695,523	229.38
Sep-96	47,857,913	412,344,840	207.91
Oct-96	49,873,317	425,991,795	215.97
Nov-96	44,696,485	389,249,720	199.94
Dec-96	49,361,193	437,256,586	201.75
Jan-97	46,692,784	337,798,678	190.13
Feb-97	43,761,932	337,893,100	183.95
Mar-97	54,755,166	416,925,515	211.95
Apr-97	50,182,894	408,488,665	211.29
May-97	51,979,543	444,032,624	226.08
Jun-97	55,462,027	481,053,743	222.25
Jul-97	58,771,317	540,293,509	236.71
Aug-97	60,496,856	552,486,079	233.50
Sep-97	50,076,953	425,814,893	213.55
Oct-97	51,846,329	445,858,326	221.22
Nov-97	47,743,798	441,249,575	202.42
Dec-97	50,414,361	454,400,575	207.32
Jan-98	47,290,992	371,355,589	196.87
Feb-98	44,641,209	326,874,247	187.17
Mar-98	54,453,961	426,172,239	214.22
Apr-98	53,044,174	447,877,815	217.92
May-98	54,302,581	462,341,914	227.90
Jun-98	57,335,447	482,325,897	228.73
Jul-98	59,441,840	537,481,124	239.94
Aug-98	60,813,085	526,444,502	237.14
Sep-98	49,560,508	430,364,874	219.46
Oct-98	53,463,147	444,719,403	228.52
Nov-98	49,561,082	427,669,956	211.18

Table continues on the next page

Table C1 (*continued*)

Raw Data for Time Series Analysis

	Air RPM (000s)	Rail PM	VMT (billions)
Dec-98	51,024,977	459,051,399	216.30
Jan-99	48,861,094	384,824,724	194.44
Feb-99	46,158,194	350,270,063	192.33
Mar-99	57,761,057	436,837,107	221.74
Apr-99	54,968,382	435,360,347	221.98
May-99	55,469,960	450,054,655	231.81
Jun-99	59,918,608	496,553,598	237.02
Jul-99	64,397,523	543,923,323	244.20
Aug-99	63,752,132	528,001,216	242.57
Sep-99	53,733,696	393,137,094	225.30
Oct-99	57,407,208	425,897,553	234.66
Nov-99	53,866,781	421,595,015	222.83
Dec-99	52,331,272	442,742,459	222.46
Jan-00	49,745,428	366,607,410	203.58
Feb-00	49,876,910	366,139,276	199.64
Mar-00	61,378,569	453,096,388	232.63
Apr-00	58,981,617	473,751,011	227.81
May-00	61,165,486	481,725,263	242.11
Jun-00	65,524,091	517,102,460	243.01
Jul-00	67,883,256	564,747,276	245.08
Aug-00	66,924,512	558,060,051	247.77
Sep-00	56,441,629	446,489,429	227.33
Oct-00	58,834,210	462,329,685	236.55
Nov-00	56,283,261	442,268,378	222.80
Dec-00	55,380,280	461,651,082	218.44
Jan-01	53,129,922	379,458,113	209.26
Feb-01	49,992,995	366,288,212	199.91
Mar-01	62,323,049	448,912,584	231.49
Apr-01	59,801,562	455,496,342	231.37
May-01	60,246,477	462,376,555	244.25
Jun-01	64,987,625	528,690,495	242.58
Jul-01	68,573,410	564,037,290	248.79
Aug-01	69,003,617	562,266,005	251.69
Sep-01	39,106,905	446,266,947	224.57
Oct-01	44,271,037	452,095,235	240.00
Nov-01	45,245,063	446,094,295	229.48
Dec-01	48,167,518	479,188,434	228.09
Jan-02	46,587,818	398,440,459	213.81
Feb-02	45,157,533	397,948,828	206.46
Mar-02	57,423,155	461,087,451	234.01

Table continues on the next page

Table C1 (*continued*)

Raw Data for Time Series Analysis

	Air RPM (000s)	Rail PM	VMT (billions)
Apr-02	53,013,066	453,147,413	234.81
May-02	55,663,570	461,648,459	249.89
Jun-02	60,224,150	499,751,748	246.39
Jul-02	62,570,110	564,046,073	254.19
Aug-02	62,881,793	516,103,068	256.24
Sep-02	48,925,997	385,097,846	230.60
Oct-02	52,779,975	399,248,774	243.29
Nov-02	48,902,677	375,996,408	228.39
Dec-02	55,355,434	448,246,102	231.26
Jan-03	50,602,700	393,287,373	216.60
Feb-03	46,455,943	390,041,481	201.90
Mar-03	56,033,121	472,573,962	236.70
Apr-03	51,146,721	483,653,074	238.10
May-03	53,591,384	489,484,678	253.20
Jun-03	59,426,357	531,138,943	252.00
Jul-03	65,041,408	578,767,927	261.30
Aug-03	64,095,456	557,897,322	259.60
Sep-03	51,347,366	427,807,444	236.00
Oct-03	55,810,667	463,025,617	253.40
Nov-03	53,249,129	448,181,812	233.30
Dec-03	57,795,908	489,403,554	237.60
Jan-04	53,447,972	410,338,691	217.30
Feb-04	52,608,801	389,778,365	210.40
Mar-04	63,600,019	453,014,590	247.50
Apr-04	61,887,720	471,116,666	245.40
May-04	62,074,299	472,861,212	253.00
Jun-04	67,833,476	514,365,919	253.70

APPENDIX D
The Structural Time Series Model

Although terms such as "trend" and "seasonal" are intuitively appealing, they are mental constructs as we cannot observe them directly. Therefore, we use a structural modeling approach that treats them as *unobserved components* (Harvey, 1989; Harvey and Shephard, 1993). In the empirical work we used the STAMP (Structural Time Series Analyser, Modeller and Predictor) software in conjunction with GiveWin; for details, see Koopman et al. (2000).

We define the components at time *t* as follows: trend = μ_t; slope = β_t; seasonal component = γ_t; and irregular component = ε_t. We assume that the process is observed at unit time intervals *(t, t+1,…)* and that there are *s* such intervals in a year (e.g. s=12 for monthly data). We then allow each component to evolve over time according to the specifications:

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \quad (1)$$

$$\beta_t = \beta_{t-1} + \varsigma_t \quad (2)$$

and

$$\gamma_t + \gamma_{t-1} + ... + \gamma_{t-s+1} = \omega_t \quad (3)$$

The quantities η_t, ζ_t, and ω_t represent zero mean, random shifts in the corresponding component. We assume such shifts to be independent of one another and uncorrelated over time; we also assume that they are independent of the "irregular" component, ε_t, seen in Equation (4) below. Equations (1)–(3) are known as the *state* or *transition* equations since they describe the underlying states of the process, or the transition of the components from one time period to the next.

Equations (1) and (2) provide a general framework for describing the evolution of the trend. If the process being modeled does not require all of these components, they can be dropped from the specification. The components are tested in sequential fashion as follows (Harvey, 1989, pp. 248-56):

- Does the slope disturbance term have positive variance? [Zero variance corresponds to the slope being fixed over time]
- Does the level disturbance have positive variance? [Zero variance corresponds to the mean level being fixed over time]
- If the slope disturbance is dropped, does the slope differ from zero?

If all three statistical tests produced negative outcomes, the trend term would be reduced to a constant.

When the time series is seasonal, we check:

- Does the seasonal disturbance term have positive variance? [Zero variance corresponds to a stable seasonal pattern]
- If the seasonal disturbance is dropped, are the seasonal components significantly different from zero? [Is there any seasonal pattern?]

If we drop the seasonal disturbance term, we are left with a "classical" model with fixed seasonal components. If the seasonal pattern is rejected completely, we reduce the model purely to its trend components.

The observed series is related to the states of the system by the *observation (or measurement) equation*:

$$y_t = \mu_t + \gamma_t + \varepsilon_t \qquad (4)$$

where ε_t denotes the 'irregular' component. The irregular component has zero mean and is assumed to be serially uncorrelated (i.e., not predictable) and independent of the disturbances in the state equations.

Estimation proceeds by maximum likelihood (Harvey, 1989, pp. 125-128). Operational details are provided in Koopman et al. (2000, section 8.3). The key parameters are the four variances corresponding to the disturbance terms [σ_ε^2, σ_η^2, σ_ζ^2 and σ_ω^2]. Note that we assume these variances are constant over time; the time series may need to be transformed to justify this assumption, at least to a reasonable degree of approximation. The four variance terms control the form of the model, allowing each of level, slope and seasonal to be stochastic or fixed; slope and seasonal elements may be present or absent. Table D1 illustrates the principal variations. If fixed components are included in a model, the corresponding terms appear in the state equations (e.g. fixed seasonal coefficients) but the variance term is zero. If the components are stochastic, the same terms appear in the model, but the variance is strictly positive. The most general form is the Basic Structural Model (BSM), in which all components are stochastic. The BSM forms the starting point for the model development process, and is the standard form employed in STAMP. The program then "tests down" to eliminate any components that are not required.

Table D1: Some of the Principal Models in the Structural Framework

Type of model	σ_{ε}^{2}	σ_{η}^{2}	σ_{ζ}^{2}	σ_{ω}^{2}
Level only				
Constant mean	yes	0	0	0
Local level (LL)	yes	yes	0	0
Random walk (RW)	0	yes	0	0
Trend only				
Deterministic	yes	0	0	0
Local level with fixed slope	yes	yes	0	0
Random walk with fixed drift	0	yes	0	0
Local linear trend (Holt)	yes	yes	yes	0
Smooth trend	yes	0	yes	0
Second difference	0	0	yes	0
Seasonal (with selected trend)				
Fixed seasonals	(yes or 0)	(yes or 0)	(yes or 0)	0
Varying seasonals	(yes or 0)	(yes or 0)	(yes or 0)	yes
Basic Structural Model (BSM)	yes	yes	yes	yes

NOTE: Based on Koopman et al. (2000), page 141.

APPENDIX E
Summary of Monthly Forecasts

Table E1: Forecasts and Forecast Errors for Air RPM

	Air RPM	Forecast of Air RPM before 9/11-01	Forecast error	Absolute percent error
Mar-01	62,323,049			
Apr-01	59,801,562			
May-01	60,246,477			
Jun-01	64,987,625			
Jul-01	68,573,410			
Aug-01	69,003,617			
Sep-01	39,106,905	58,390,903.80	19,283,998.80	49.31%
Oct-01	44,271,037	61,261,140.50	16,990,103.50	38.38%
Nov-01	45,245,063	58,337,950.00	13,092,887.00	28.94%
Dec-01	48,167,518	57,977,550.10	9,810,032.10	20.37%
Jan-02	46,587,818	55,752,782.90	9,164,964.90	19.67%
Feb-02	45,157,533	52,754,058.80	7,596,525.80	16.82%
Mar-02	57,423,155	64,478,755.60	7,055,600.60	12.29%
Apr-02	53,013,066	61,791,637.40	8,778,571.40	16.56%
May-02	55,663,570	62,679,059.30	7,015,489.30	12.60%

Table E2: Forecasts and Forecast Errors for Rail RPM

	Rail PM	Forecasts of Rail PM before 9-11-01	Forecast error	Absolute percent error
Mar-01	448,912,584			
Apr-01	455,496,342			
May-01	462,376,555			
Jun-01	528,690,495			
Jul-01	564,037,290			
Aug-01	562,266,005			
Sep-01	446,266,947	442,469,757.70	-3,797,189.30	0.85%
Oct-01	452,095,235	463,447,212.30	11,351,977.30	2.51%
Nov-01	446,094,295	448,090,467.10	1,996,172.10	0.45%
Dec-01	479,188,434	472,451,381.90	-6,737,052.10	1.41%
Jan-02	398,440,459	392,260,011.50	-6,180,447.50	1.55%
Feb-02	397,948,828	379,067,383.20	-18,881,444.80	4.74%
Mar-02	461,087,451	462,607,735.60	1,520,284.60	0.33%
Apr-02	453,147,413	472,183,198.80	19,035,785.80	4.20%
May-02	461,648,459	478,159,689.20	16,511,230.20	3.58%

Table E3: Forecasts and Forecast Errors for VMT

	VMT	Forecast of VMT prior to 9-11-01	Forecast error	Absolute percent error
Mar-01	231.49			
Apr-01	231.37			
May-01	244.25			
Jun-01	242.58			
Jul-01	248.79			
Aug-01	251.69			
Sep-01	224.57	232.25	7.67	3.42%
Oct-01	240.00	240.33	0.33	0.14%
Nov-01	229.48	225.79	-3.69	1.61%
Dec-01	228.09	226.04	-2.05	0.90%
Jan-02	213.81	212.42	-1.38	0.65%
Feb-02	206.46	205.80	-0.67	0.32%
Mar-02	234.01	236.01	2.01	0.86%
Apr-02	234.81	235.29	0.48	0.21%
May-02	249.89	247.92	-1.97	0.79%

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