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ASSESSING THE IMPACT OF THE SEPTEMBER 11 TERRORIST ATTACKS ON U.S. AIRLINE DEMAND*

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Abstract

This paper assesses the impact of the September 11th terrorist attacks and its after-effects on U.S. airline demand. Using monthly time-series data from 1986-2003, we find that September 11th resulted in both a negative transitory shock of over 30% and an ongoing negative demand shock amounting to roughly 7.4% of pre-September 11th demand. This ongoing demand shock has yet to dissipate (as of November 2003) and cannot be explained by economic, seasonal, or other factors.

JEL Classifications: R41, L16, L93

Keywords: Airlines, Structural Change, Attenuating Shock, September 11

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Abstract: This paper assesses the impact of the September 11th terrorist attacks and its after-effects on U.S. airline demand. Using monthly time-series data from 1986-2003, we find that September 11th resulted in both a negative transitory shock of over 30% and an ongoing negative demand shock amounting to roughly 7.4% of pre-September 11th demand. This ongoing demand shock has yet to dissipate (as of November 2003) and cannot be explained by economic, seasonal, or other factors.

1 Introduction

1 No industry has suffered greater economic damage from the terrorist attacks of September 11, 2001
2 than the U.S. airline industry. In addition to directly causing a temporary but complete shut-down
3 of the commercial aviation system, the attacks caused many travelers to reduce or avoid air travel,
4 weary of a newly-perceived risk associated with flying. Likewise, following September 11, many
5 businesses put temporary freezes on all but the most essential travel for their employees.¹ And
6 although the initial “panic” driven fear of flying immediately following September 11th appears to
7 have largely dissipated, the stringent new security requirements that were implemented as a direct
8 result of the terrorist attacks have made traveling by air more cumbersome and time-consuming
9 than prior to September 11th.² The purpose of this paper is to examine the impact of September
10 11th on U.S. airline demand and to determine whether or not September 11th and its after-effects
11 have resulted in a negative shift in the demand for air travel.

12 Since September 11, 2001, numerous airlines (both in the U.S. and abroad) have been experienc-
13 ing a financial crisis unlike any in modern aviation history. While United Airlines and US Airways
14 have already filed for Chapter 11 bankruptcy, many other large U.S. carriers have engaged in dra-
15 matic cost-cutting programs. The prospects for (or lack of) a recovery in passenger demand has been
16 the primary issue in the minds of aviation industry leaders and policymakers alike. In this paper,
17 we investigate the form and extent of the downturn in demand for domestic air travel following
18 September 11, 2001. While there is little doubt that September 11th and its after-effects resulted in
19 industry turmoil in the days and months directly following the attacks, there is controversy regarding
20 the longer term impact of September 11th on the airline industry. This controversy arises due to the
21 fact that weak economic conditions (particularly in the labor market) pre-dated—and have largely
22 persisted—since September 11, 2001.

23 Although the airline industry has always been highly cyclical, it has traditionally been able to
24 weather through temporary economic downturns. The impact of September 11th on airline demand
25 has been so severe, however, that demand still remains well below pre-attack levels more than two
26 years after the attacks. Our research purpose is to measure the magnitude of this ongoing shift in
27 demand by disentangling it from both the immediate downward spike following the terrorist attacks
28 (resulting from factors such as the temporary shutdown of the aviation system and the initial panic
29 driven fear of flying) as well as economic cycle effects. Measuring the magnitude of the ongoing

¹For example, a survey conducted by the National Business Travel Association shortly after the attacks found that 23% of corporations temporarily suspended domestic travel and 34% of corporations temporarily suspended international travel. Source: *NBTA Press Release*, September 19, 2001.

²See, for example “Hassle factor hurting airlines,” *Atlanta Business Chronicle*, April 15, 2002 or “Drive instead of fly? Maybe a good idea,” *Philadelphia Inquirer*, May 12, 2002.

1 demand shift is important for three reasons. First, since the terrorist attacks, there have been
2 and continue to be numerous arbitrations between airlines and their labor unions related to the
3 impact of September 11th on airline demand. Since many airline labor contracts expressly prohibit
4 laying off employees due to weak economic conditions (i.e., recessions), determining both the initial
5 and ongoing impact of the September 11th terrorist attacks has important ramifications on labor
6 negotiations within the industry. In particular, many contracts between airlines and their unions
7 have “no furlough” clauses that prohibit layoffs except in the case of extraordinary circumstances
8 beyond the control of the airline, known as *force majeure* events. Second, in the weeks and months
9 leading up to September 11th, one of the primary concerns of aviation policymakers was airport
10 and air traffic control congestion and delays.³ Consequently, understanding the ongoing impact
11 of September 11th on airline demand is important for aviation capacity planners. Finally, to the
12 extent that the demand for air travel has spill-over effects into other sectors of local economies
13 (Brueckner 2003, Button, Lall, Stough, and Trice 1999), the impact of lower demand for air travel
14 has much broader economic effects than those impacting solely the airline industry.

15 While the events of September 11th and its after-effects have been the focus of much industry and
16 policy attention (Masse 2001, Bureau of Transportation Statistics 2002, Air Transport Association
17 2003), it has thus far received little attention in the economics literature. One exception is Rupp,
18 Holmes, and DeSimone (2003), which studies airline schedule recoveries following airport closures
19 since September 11th.⁴

20 Our basic methodology is to estimate a reduced form model of demand for domestic air services
21 using monthly time-series data since 1986. After controlling for cyclical, seasonal and other unique
22 events impacting the industry, we model the post-September 11th period using an attenuating
23 shock process that has both a transitory component as well as an ongoing (as of November 2003)
24 component. After controlling for factors such as trend, seasonality and general macroeconomic
25 conditions, we find that the events of September 11th led to both an initial demand shock of more
26 than 30% as well as an ongoing downward shift in the demand for commercial air service of roughly
27 7.4%. We estimate that this ongoing demand shock accounts for over 90% of the current weakness
28 in domestic airline demand relative to its pre-September 11th peak.

29 The remainder of this paper is organized as follows. Section 2 provides a brief overview of U.S.
30 airline demand prior to and following September 11th and discusses some reasons why September

³For example, the Department of Transportation issued a *Notice of Market-based Actions to Relieve Airport Congestion and Delay*, (Docket No. OST-2001-9849) on August 21, 2001. See also Brueckner (2002) and Mayer and Sinai (2002).

⁴Rose (1992) studied general air safety concerns following the industry’s deregulation in 1978 and Borenstein and Zimmerman (1988) investigated the impact of fatal air accidents on airline’s profits and traffic. Likewise, Mitchell and Maloney (1989) analyzed the impact crashes on a carrier’s (and its competitors’) profits and insurance premia.

1 11th may have resulted in a longer-term structural change. Section 3 presents our model and
2 empirical analysis. A summary of our findings and concluding remarks are provided in Section 4.

3 **2 Analytical Framework**

4 The purpose of our investigation is to determine what—if any—structural impact the terrorist attacks
5 of September 11th has had on domestic airline demand. It is well known that the demand for
6 commercial airline service is both seasonal and cyclical. Thus, an integral part of our analysis of
7 the effects of September 11th requires that we effectively control for seasonal, economic and other
8 unique factors that are known to have impacted the demand for air service. After controlling for
9 these factors, we should be able to assess the degree to which the current industry malaise is related
10 to September 11th and its after-effects.

11 Figure 1 depicts monthly U.S. domestic airline industry revenue passenger miles (RPMs) in
12 addition to its 12-month moving average from January 1980 through December 2003. A revenue
13 passenger mile is defined as one paying passenger traveling one mile. Figure 1 demonstrates (a) the
14 seasonal component of airline demand (RPMs tend to peak in the summer and bottom during the
15 winter), (b) the cyclical component of airline demand, and (c) that prior to September 2001, industry
16 demand has been steadily trending upwards. Figure 1 also highlights a number of notable events
17 that have impacted the U.S. airline industry since 1980, such as the air traffic controller’s strike that
18 started in August 1981 and culminated with the firing of over 11,000 controllers.⁵ Likewise, the 1991
19 Gulf War and ensuing recession resulted in an industry-wide decline in RPMs for roughly eleven
20 months (compared to the same months of the previous year), after which point RPMs resumed their
21 upward trend.

22 Although Figure 1 illustrates that the U.S. airline industry has faced a number of negative
23 demand “shocks” throughout its history, airline demand—as measured by industry RPMs—has proven
24 to be quite resilient and most negative shocks have dissipated (on an industry-wide basis) within a
25 relatively short period of time. However, there are a number of reasons to suggest that September
26 11th and its aftermath may have imposed a more lasting impact on the demand for airline services.
27 First, September 11th likely caused more consumers to be unwilling to fly because of an increased fear
28 of flying. Another significant factor impacting demand has been the increased security measures that
29 have made traveling by air post-September 11th more time-consuming and far less convenient than
30 before the terrorist attacks. This effect, often referred to as the “hassle factor” has been especially

⁵The 1981 strike was unlike other labor disruptions among air traffic controllers in that President Reagan issued a directive prohibiting the FAA from re-hiring any of the fired controllers. This directive remained in effect until August 12, 1993.

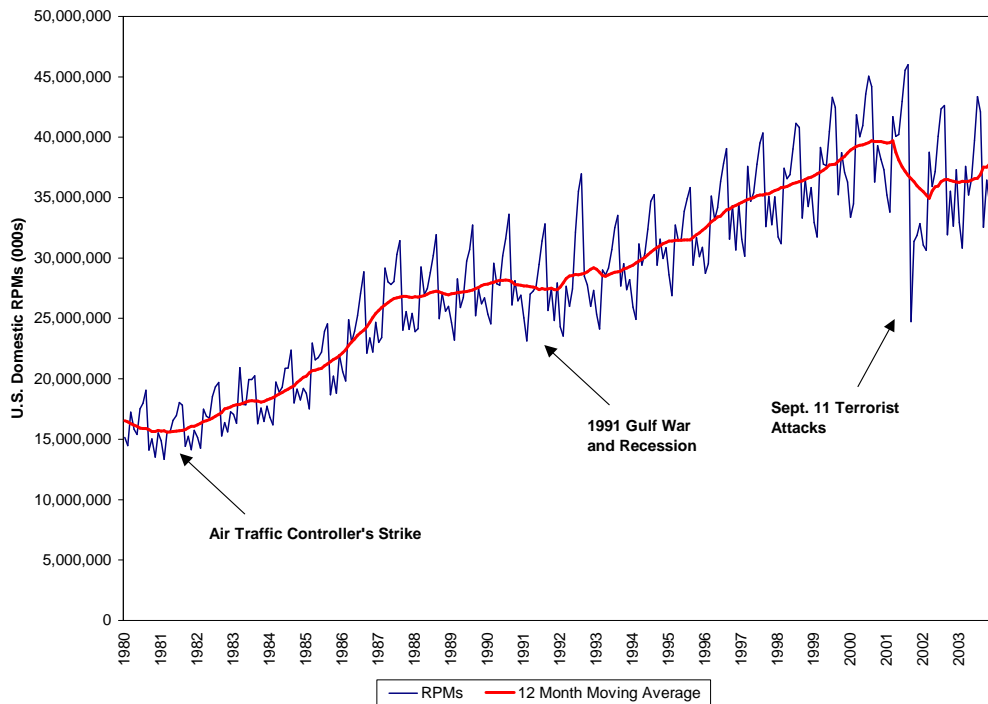
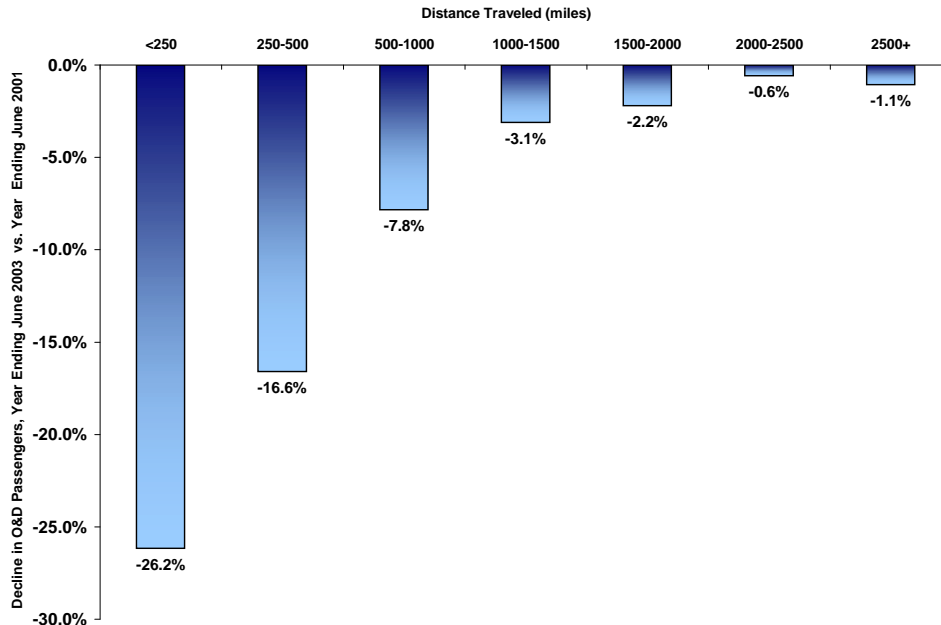


FIGURE 1: U.S. DOMESTIC RPMs, JANUARY 1980–DECEMBER 2003

1 noticeable on the demand for short-haul trips. Figure 2, for example, summarizes the percentage
 2 decline in the number of domestic origin and destination (O&D) passengers for the year ending
 3 June 2003 compared to the year ending June 2001.⁶ If the current weak demand for air services
 4 were solely related to cyclical factors, one would expect that the decline in passengers, by distance,
 5 would assume a fairly uniform pattern. Figure 2 demonstrates, however, that the drop in demand
 6 for domestic air service has been most pronounced in short-haul (less than 500 mile) markets, where
 7 increased elapsed travel times due to tighter security have made travel by alternative means such
 8 as driving or taking the train relatively more attractive following September 11th. As trip distance
 9 increases and traveling by air becomes the only viable form of transportation for most travelers, the
 10 percentage decline in O&D passengers pre and post-September 11th moderates substantially. And
 11 while the 26% drop in the less than 250 mile segment is likely also a result of weakened economic
 12 conditions (as a high proportion of passengers flying 250 miles or less tend to be business travelers
 13 on one-day trips), it is important to emphasize that such a dramatic decline in short-haul traffic is

⁶O&D passengers count travelers based on the starting and ending point of their journey, regardless of whether or not they make a connection. We compare these two time periods because the year ending June 2003 represents the most recent data available from the Department of Transportation's DB1A quarterly database of O&D passengers. Likewise, the year ending June 2001 represents the last four quarters of data unaffected by the events of September 11th.



Source: U.S. DOT DB1A Database. Notes: Domestic passengers only.

FIGURE 2: CHANGE IN DOMESTIC O&D PASSENGERS BEFORE AND AFTER SEPTEMBER 11, 2001

1 unprecedented. For example, we also compared two similar periods prior to and during the 1991
 2 Gulf War and ensuing recession and found that the decline in trips of 250 miles or less only decreased
 3 by 10.5%. Moreover, the percentage decline across all other flight distances was largely uniform.

4 In order to model the impact of September 11th on airline demand, we allow for the possibility of
 5 both a transitory as well as an ongoing shock component. The ongoing component (i.e., a downward
 6 shift in demand) attempts to capture both the post-September 11th “hassle” factor as well as an
 7 increased reluctance to fly based on concerns of further terrorist attacks (i.e., an increased fear of
 8 flying). We characterize such changes as “ongoing” since they are likely to persist at least until there
 9 have been significant improvements in the efficiency and perceived effectiveness of the passenger
 10 screening and security systems. The transitory component, in contrast, attempts to capture the
 11 relatively short term “panic” or uneasiness with air travel that kept many passengers from flying
 12 in the weeks and months directly following September 11th, but have now—for many passengers—
 13 subsided. Separating the persistent and ongoing components of the September 11th shock is the key
 14 component of our empirical analysis we develop in the next section.

3 The Data & The Model

Data for U.S. airline industry demand comes from the Air Transport Association's (ATA) monthly database of passenger traffic and represents all revenue (i.e. paying) passengers carried by ATA member carriers.⁷ In light of the dramatic change in the regulatory environment following deregulation, our analysis focusses on the post-deregulatory era.⁸ Moreover, within the post-deregulatory era, we focus our analysis on domestic travel from January 1986 until November 2003, due to data availability for some of our variables.

Our primary measure of airline demand is domestic RPMs. Although the number of O&D passengers is another possible measure, we chose RPMs as our proxy for demand since the average trip length of passengers has been steadily increasing over time.⁹ Our measure of the airline prices is the average monthly passenger yield (revenue per RPM) as reported by the ATA.¹⁰

Our baseline model is a reduced form estimation of the natural log of quantity (RPMs) and price (Yield):

Baseline Model

$$\ln(RPM_t) = \beta_0 + X_t'\beta_X + D_t'\beta_D + \varepsilon_t \quad (1)$$

$$\ln(Yield_t) = \gamma_0 + X_t'\gamma_X + D_t'\gamma_D + \nu_t \quad (2)$$

X_t represents a vector of exogenous variables, including both demand and supply shifters. D_t is a vector of dummy variables, accounting for seasonality and various events that may have impacted the market for passenger airline service. Finally, ε_t and ν_t are mean-zero error terms. We use OLS estimation and account for the auto-correlated nature of the errors by using Newey-West standard

⁷Carriers in the dataset include: Air Florida, Air New England, AirCal, Alaska, Aloha, America West, American, ATA, Best, Braniff, Capitol, Continental, Delta, Eastern, Hawaiian, Hughes Airwest, Jet America, JetBlue, Midwest, New York Air, Northeastern, Northwest, Ozark, Pacific Southwest, Pan Am, Piedmont, Reeve Aleutian, Republic, Southwest, Texas International, Trans World, United, US Airways, and Western. This data is available from the Air Transport Association at <http://airlines.org>.

⁸The U.S. domestic airline industry was deregulated in 1978, effectively eliminating regulatory constraints that governed route entry and pricing (Morrison and Winston 1986). A small number of airports in the U.S. are still subject to various regulatory restrictions. For example, Washington National (DCA), and New York's LaGuardia (LGA) and JFK airports are subject to the High Density Rule which limits the number of take-offs and landings; Dallas' Love Field (DAL) is subject to the Wright and Shelby Amendments, prohibiting carriers from flying between Love Field and airports in states other than Texas, Louisiana, Arkansas, Oklahoma, New Mexico, Mississippi, and Alabama; and DCA is subject to the Perimeter Rule, which prohibits most flights of more than 1,250 miles to and from this airport.

⁹While we feel that monthly RPMs provide a very good proxy for airline demand, it is important to note that RPMs actually represent the national market clearing level of quantity for commercial air service in any given month, and thus, incorporate elements of both demand and supply. However, to the extent that industry supply (as measured by available seat miles) responds to changes in industry demand (albeit, with a lag), RPMs should provide a good proxy for actual demand.

¹⁰It should be noted that the ATA's yield data represents the following subset of carriers: Alaska, American, America West, Continental, Delta, Northwest, United and US Airways. While this monthly data excludes several carriers—including the low cost carriers—it has been well established in the literature (Morrison 2001, Transportation Research Board 1999) that the prices of *all* carriers have fallen as a result of competition from low cost carriers.

1 error estimates. The descriptions of our independent variables, in addition to further details of
2 our modelling approach, are detailed below.

3 **Seasonality:** Airline demand is known to be highly seasonal, with the summer and holiday seasons
4 being the strongest. Therefore, we include monthly dummy variables to control for such
5 seasonality. In addition, we also control for some calendar irregularities such as Thanksgiving
6 holiday seasons that overflow into December and longer than average months of February due
7 to leap years.

8 **Economic Trend and Cyclicity:** Prior to September 2001, the demand for the air travel had
9 been growing rapidly (see Figure 1), fueled by steady economic growth and declining real
10 airfares. The demand for air travel is also known to be highly sensitive to business cycles.
11 To control for trend and cyclicity factors, we introduce two macroeconomic variables that
12 we consider to be major demand-shifters. Firstly, we use the national unemployment rate
13 as our business cycle indicator. Secondly, we use the domestic labor force to control for the
14 long-term growth of the overall economy.¹¹ While we recognize that gross domestic product is
15 the standard variable for measuring economic activity and its fluctuations, GDP statistics are
16 only available on a quarterly basis, which is not sufficient for our analysis.¹²

17 Figure 3 plots the national unemployment rate from 1986 through 2003. After reaching his-
18 torically low rates in 2000 and 2001, Figure 3 demonstrates that the onset of the economic
19 downturn is readily apparent prior to September 2001. Moreover, despite the fact that GDP
20 resumed growing in late 2001, Figure 3 illustrates that the labor market has remained relatively
21 weak.

22 One natural question that arises is the degree to which September 11th directly or indirectly re-
23 sulted in a weakened economy, and in turn, higher unemployment. Numerous researchers have
24 studied various economic effects of September 11th (i.e. Garner 2002, Hobijn 2002, Virgo 2001).
25 Moreover, it has been well documented that at least some mass layoffs following September
26 11th (especially those in the travel and tourism industries) were directly attributable to the ter-
27 rorist attacks rather than prevailing economic conditions.¹³ Determining aggregate job losses
28 at the national level attributable to September 11th, however, is almost impossible, since there

¹¹We also experimented with the level of non-farm employment as our macroeconomic variable, which yielded similar results. However, employment figures embody not only trend, but also cyclical fluctuations. Consequently, we elected to use two separate variables to account for them.

¹²We also experimented with average weekly earnings as a measure of business cycles. But, the results were not much different from those obtained with the unemployment rate.

¹³For example, in the 18 weeks following September 11th, employers reported 430 mass layoff (i.e. greater than 40 employees) events related to 9/11 to the Bureau of Labor Statistics. See *Impact of the Events of September 11, 2001, on Mass Layoff Statistics Data Series*, Bureau of Labor Statistics, March 1, 2002.

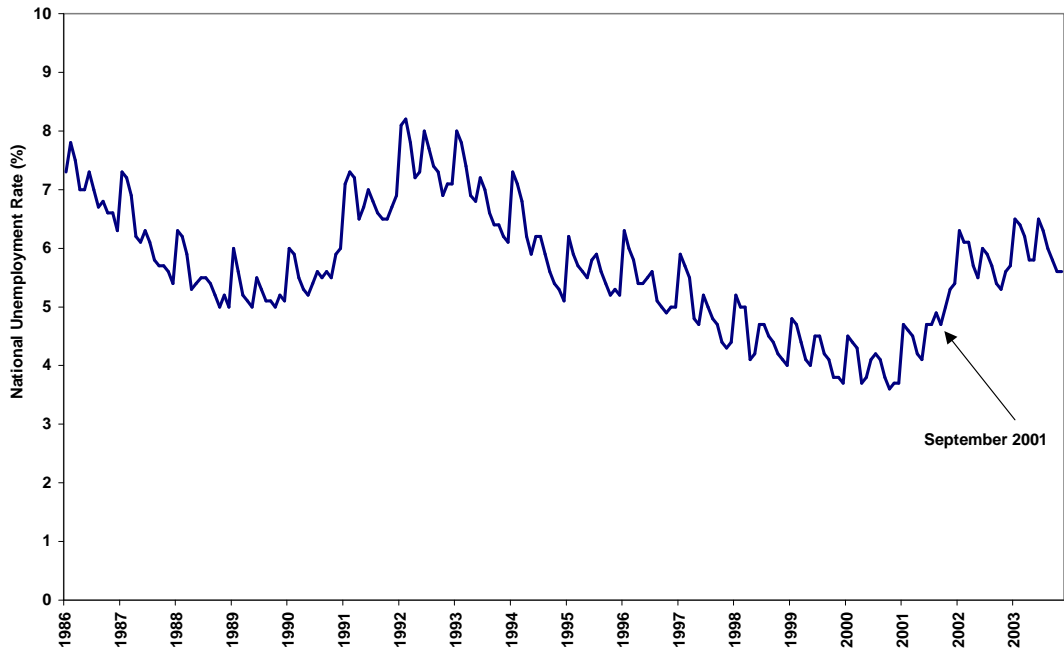


FIGURE 3: U.S. UNEMPLOYMENT RATE

1 are literally thousands of small firms whose layoffs would not be recorded by the Bureau of
 2 Labor Statistics. Thus, for the purposes of our analysis, we do not attempt to differentiate
 3 between the sources of job losses (i.e, general economic conditions versus September 11th).
 4 Consequently, to the extent that September 11th was directly or indirectly responsible for
 5 higher levels of national unemployment, our estimation results will underestimate September
 6 11's impact on airline demand.

7 In the quantity equation, the RPM and labor force variables are both upwardly trended, rais-
 8 ing the suspicion of a spurious regression. However, a Johansen test confirmed that these two
 9 variables are indeed co-integrated with a time trend.¹⁴ Consequently, the estimated coefficient
 10 on the labor force variable is superconsistent, while estimates on other variables remain unbi-
 11 ased (Davidson and MacKinnon 1993). An alternative model such as one using first differences
 12 with an error correction term may be able to specify the dynamic relationship between the
 13 co-integrated variables more precisely. However, the September 11th attack was a long-lag
 14 event, making the first different estimation problematic. Moreover, pinning down the precise

¹⁴We used Johansen's test in the EasyReg software package written by Bierens (2003).

1 dynamics of September 11th is not our main research focus. Rather, we would like to control
2 for the overall economic activity level while isolating the September 11th effect.

3 **Airline Fatalities:** Fear of flying is not a new phenomena. Since 1986, there have been thirty
4 fatal airline accidents involving U.S. scheduled commercial carriers—excluding the September
5 11th terrorist attacks—including one known terrorist attack (the Pan-Am Lockerbie bombing in
6 December 1988). It is reasonable to expect some travelers to experience increased apprehension
7 of flying, especially when there have been accidents involving a large number of fatalities. We
8 include a variable that measures the number of fatalities on U.S. carriers in order to control
9 for the generic demand impact of airline accidents. If fear of flying from the September 11th
10 terrorist attacks is comparable to that from other fatal accidents, we expect this variable to
11 pick up the generic fear effect. However, it is possible that travelers reacted more strongly to
12 the potential for greater “systematic risk” since September 11th than the “idiosyncratic risk”
13 inherent with air travel.

14 **Supply-Side Variables:** We also include two supply-side variables. The first is *LCCshare*, the
15 share of domestic industry RPMs serviced by low-cost carriers in each month. Many re-
16 searchers (i.e. Ito and Lee 2003, Morrison 2001, Bennett and Craun 1993) have documented
17 the impact of low cost carriers on the U.S. airline industry. Indeed, one recent, comprehensive
18 study (Transportation Research Board 1999, page 49) of the U.S. airline industry noted that
19 “Probably the most significant development in the U.S. airline industry during the past decade
20 [the 1990’s] has been the continued expansion of Southwest and the resurgence of low-fare en-
21 try generally.” The second supply-side variable is the cost per gallon of jet fuel, as reported
22 by the Department of Transportation. Since fuel accounts for approximately 10-15% of airline
23 operating costs, its exogenous fluctuation is likely to influence airline pricing.

24 **Some Extraordinary Events:** Although the post-deregulatory U.S. airline industry experienced
25 steady growth until 2001, a few events resulted in temporary negative “shocks” and require
26 special attention. Our model accounts for the 1991 Gulf War, the 2003 Iraq War, and the
27 Severe Acute Respiratory Syndrome (i.e. “SARS”) epidemic. Controlling for the last two
28 events is especially important because they may have imposed downward pressure on demand
29 during the post-September 2001 period. Failing to control for these events, therefore, would
30 result in over-estimating the impact of September 11.

31 Descriptive statistics for the variables described above are presented in Table 1 below.

TABLE 1: VARIABLE DEFINITIONS AND DESCRIPTIVE STATISTICS

Variable Name	Definition	Mean (Std. Dev)
$\ln(RPM_t)$	Natural log of domestic RPMs (000s) in month t	17.2580 (0.179)
$\ln(Yield_t)$	Natural log of domestic yield (CPI deflated) in month t	2.181 (0.145)
$\ln(labor_t)$	Natural log of national labor force in month t (000s)	11.790 (0.066)
$unemploy_t$	National unemployment rate (percent) in month t	5.671 (1.050)
$LCCshare_t$	Low cost carriers' share of domestic RPMs	0.095 (0.048)
$fuel_t$	Price per gallon of jet fuel (PPI deflated) in month t	3.939 (0.166)
$fatalities_t$	Airline fatalities on U.S. carriers in month t	9.808 (38.953)
$D(Leap)_t$	Dummy variable taking value 1 if period t is Feb. during leap year, and is 0 otherwise	0.019 (0.136)
$D(Thanks_{11})_t$	Dummy variable taking value 1 if period t is Nov. and the Sunday after Thanksgiving is in Dec., and is 0 otherwise	0.014 (0.118)
$D(Thanks_{12})_t$	Dummy variable taking value 1 if period t is Dec. and the Sunday after Thanksgiving is in Dec., and is 0 otherwise	0.014 (0.118)
$D(IraqWar)_t$	Dummy variable taking value 1 from February to April 2003, and is 0 otherwise	0.014 (0.118)
$D(GulfWar)_t$	Dummy variable taking value 1 if period t is between August 1990 and March 1991 and is 0 otherwise.	0.037 (0.190)
$D(SARS)_t$	Dummy variable taking value 1 from March to July 2003, and is 0 otherwise	0.023 (0.151)
N	Number of observations	215

1 3.1 Modelling The Impact of September 11th

2 Having described the baseline model, we now turn our attention to modelling the impact of Septem-
3 ber 11th. As a starting point, we first take a non-parametric approach by fitting twenty-seven dummy
4 variables—one for each month on and after September 2001—onto the baseline model we introduced
5 in the previous section. For this exercise, we also included the seasonality dummy variables but
6 excluded the Iraq War and SARS dummy variables. Figure 4 plots the coefficient estimates of those
7 twenty-seven monthly dummy variables across time. Each data point represents the gap between
8 the actual log of the RPMs/yield observation and what the baseline model predicts, after controlling
9 for economic fluctuations and other demand and supply factors. Figure 4 demonstrates that after
10 the sharp drop in September 2001, there was an initial recovery phase. By mid 2002 however, the
11 recovery began to taper off, and through November 2003, the gap for both RPMs and yield continues
12 to hover well below zero, without any apparent tendency of closing.

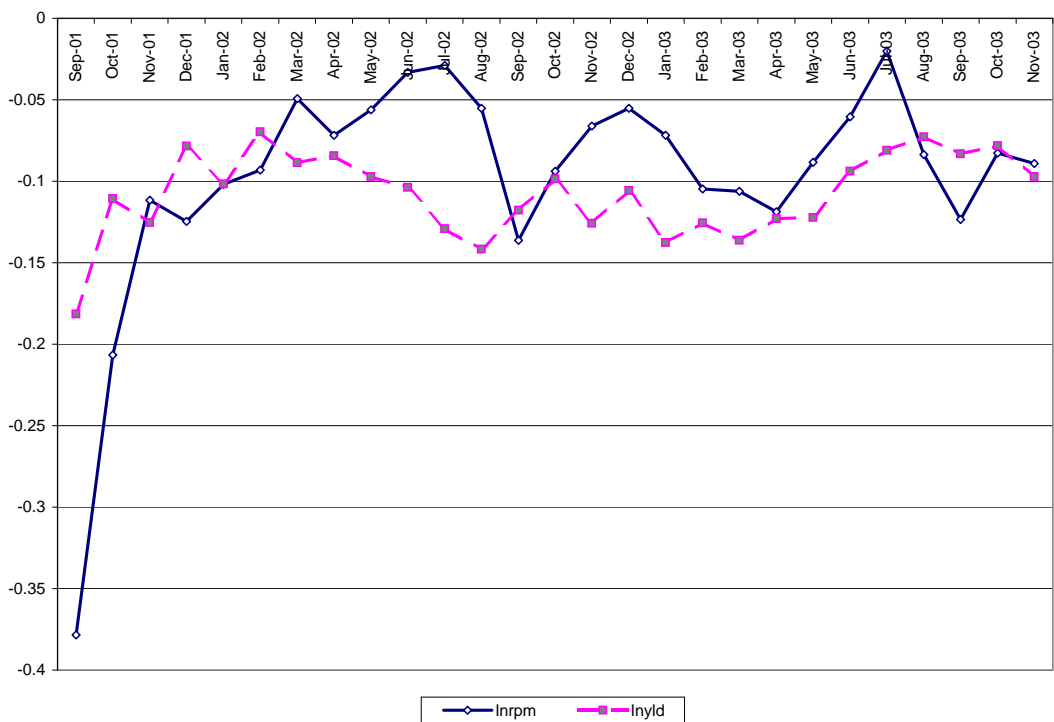


FIGURE 4: DUMMY VARIABLE ESTIMATES

13 Next, we construct two simple non-linear models that allow us to measure the magnitude of this
14 ongoing stagnation while controlling for the effects of concurrent events such as the recent Iraq War
15 and SARS epidemic (which are not isolated in Figure 4). Both models need to accommodate for

1 two different types of impacts from September 11th: (a) an ongoing downward shift in the demand
2 for air travel resulting from the increased apprehension of flying and inconveniences such as the
3 hassle factor, and (b) the initial panic driven fear of flying directly following September 11th. We
4 allow for the possibility of an ongoing downward shift in demand by including an dummy variable,
5 $D_{post911}$, that takes the value 0 for all observations before September 2001 and 1 thereafter. Thus,
6 the estimated coefficient on $D_{post911}$ will measure the relative magnitude in the downward shift in
7 demand following September 2001. To account for the sharp decline in demand following September
8 11th that was likely transitory in nature, we also include a shock component that attenuates over
9 time.

10 **Model 1:** Define T_{911} as the number of months since September 2001 plus one (for example, $T_{911} =$
11 2 in October 2001, 3 in November 2001, and so forth). In Model 1, we simply include the
12 inverse of $(T_{911})^2$ as an additional regressor. The implicit assumption is that the transitory
13 shock will decay at a rate equal to the squared reciprocal of time.¹⁵ Although this specification
14 is somewhat ad hoc, it has the advantage of being simple to estimate.

$$\beta_{shift}D_{post911} + \beta_{\frac{1}{t}}\frac{1}{(T_{911})^2} \quad (3)$$

15 We append this component to both the RPMs and yield equations in the baseline model. The
16 key parameter of interest is the magnitude of the estimate for β_{shift} , which represents the
17 portion of the demand decline that has not yet recovered since September 2001.

18 The dramatic decline (37.8%) in RPMs during September 2001 was an unprecedented event in
19 the history of U.S. aviation and was partly a result of the FAA's complete shutdown of com-
20 mercial air space for two and a half days.¹⁶ Thus, some of the decline in RPMs in September
21 2001 is likely due to the government imposed supply constraint. Moreover, we would like to
22 check for the possibility that such an extraordinary month becomes an influential observation,
23 pulling down the estimate of β_{shift} , our measure of the ongoing demand shift. In order to
24 investigate this issue, Model 2 isolates the September 2001 observation from the rest of the
25 data.¹⁷

26 **Model 2:** Define D_{911} as a dummy variable that takes value 1 for September 2001 and 0 for all
27 other months. Now, T_{911}^* is defined as the number of months since October 2001 (rather than

¹⁵We also ran the same regression using $1/T_{911}$ in place of $1/(T_{911})^2$ (not shown). The fit of the model was considerably better with $1/(T_{911})^2$.

¹⁶Although the FAA re-opened commercial airspace at 11 am on September 13th, most carriers did not resume flight operations—other than repositioning diverted aircraft—for another day or two.

¹⁷We thank an anonymous referee for suggesting this modelling approach.

1 September 2001) plus one. Similarly, $D_{post911}^*$ takes value 1 for all the months starting from
 2 October 2001 and 0 otherwise.

$$\beta_{911}D_{911} + \beta_{shift}D_{post911}^* + \beta_{\frac{1}{t}}\frac{1}{(T_{911}^*)^2} \quad (4)$$

3 If the extraordinary dip in September 2001 is indeed an influential observation, Model 2 will produce
 4 a smaller estimate for β_{shift} than Model 1.

5 It is important to emphasize that neither of our two models impose the presence of an ongoing
 6 shift in demand. If there has been no ongoing shift in demand as a result of September 11th, we
 7 would expect the estimated coefficients for $\hat{\beta}_{shift}$ to be close to zero. Thus, in both models, the
 8 possibility of an ongoing shift in demand can be empirically tested by performing the following
 9 hypothesis test:

$$H_0(\text{null hypothesis}) : \beta_{shift} = 0 \quad H_a(\text{alternative hypothesis}) : \beta_{shift} < 0 \quad (5)$$

10 Likewise, the presence of a transitory shock can be tested by performing appropriate hypothesis
 11 tests on $\beta_{\frac{1}{t}}$.

12 **3.2 Estimation Results**

13 The ordinary least squares estimates for Models 1 and 2 are presented in Table 2. Since the model
 14 is static and the regressors are identical in equations, there is no gain from estimating the two
 15 equations together. Table 2 also reports Newey-West robust standard errors in order to account for
 16 a non-spherical distribution of the error term.¹⁸

¹⁸We present the Newey-West standard errors in order to account for heteroscedasticity and auto-correlated errors, which are natural concerns because of the nature of the data and the reduced form analysis. We have also calculated the standard errors with a stationary bootstrap method and the results were almost identical to the regular OLS standard errors, except that the standard error of the β_{shift} coefficient became unusually large due to the extreme non-convexity of the $1/T^2$ variable.

1 Both the labor force and the unemployment rate are powerful and significant predictors of RPMs
2 (quantity), consistent with our *a priori* belief. A higher unemployment rate also reduces yields
3 (prices), which is intuitive.¹⁹ A larger labor force, however, also tends to reduce yields. This result
4 is somewhat counterintuitive, and we expect that this is probably due to the fact that the labor
5 force tends to be somewhat correlated with the growth of low cost carriers. Since the reduced form
6 estimates reflect the combined effects of the supply and demand, we caution the reader from drawing
7 too many inferences from these estimates. However, if the estimates in both the quantity and price
8 equation are significant and in the same direction for the same variable, we strongly suspect that it
9 reflects a demand change. Conversely, if the price and quantity effect move in opposite directions,
10 we suspect that it reflects a supply change.

11 Consistent with the previous literature, *LCCshare* has a powerful positive impact on RPMs and
12 a large negative effect on yield. The estimated coefficient on *fuel* is positive in the yield equation,
13 but is not statistically significant. *fatalities* showed almost no impact in either the quantity or price
14 equation. We suspect that this may reflect a temporary substitution away from the carrier involved
15 in the accident towards other carriers while leaving aggregate demand unchanged. This supports
16 our conjecture that the September 11th attacks were unique in the sense that they resulted in a
17 perceived increase in systematic (as opposed to idiosyncratic) risk.

18 The recent Iraq War had a negative and significant impact on both domestic RPMs and yield,
19 while the 1991 Gulf War did not. This result is likely a reflection of the fact that our analysis is
20 limited to domestic travel, as the 1991 Gulf War had a strong negative impact on international
21 traffic. Moreover, as noted by the NBER's business cycle dating committee, the downturn in the
22 U.S. economy coincided almost exactly with the timing of the our Gulf War variable.²⁰ Likewise, in
23 light of the September 11th terrorist attacks, there was a heightened awareness of the possibility of
24 additional terrorist attacks on domestic flights during the recent Iraq War. Finally, given that the
25 recent Iraq War largely overlapped with the SARS epidemic, it is possible that the model cannot
26 fully distinguish between these two events. Thus, the Iraq War coefficients likely reflect the combined
27 effect of these two events.

28 Turning our attention to the ongoing impact of September 11th, we see that the estimated
29 coefficients on β_{shift} are powerfully negative (and significant at the 1% level) in both the RPMs and
30 yield equations, suggesting a large demand contraction. The decline in RPMs is approximately 7.4%
31 while the yield decline was 10.0%. The negative impacts on both the quantity (RPMs) and price

¹⁹We also estimated the model with a simple linear trend in place of the labor force variable. The results show higher predicted RPMs for the post 9/11 period than the results with the labor force variable.

²⁰The peak of the business cycle began in July 1990 and reached its trough in March 1991. Source: <http://nber.org/cycles>.

TABLE 2: REDUCED FORM ESTIMATES

	Ln(RPMs)		Ln(Yield)	
	Model 1	Model 2	Model 1	Model 2
Constant	-6.603*	-6.505*	14.989 [†]	14.986 [†]
	(2.715)	(2.740)	(3.595)	(3.614)
$\ln(labor_t)$	2.029 [†]	2.021 [†]	-1.071 [†]	-1.071 [†]
	(0.227)	(0.229)	(0.299)	(0.301)
$unemploy_t$	-0.033 [†]	-0.033 [†]	-0.02*	-0.02*
	(0.007)	(0.007)	(0.010)	(0.010)
$LCCshare_t$	0.157	0.164	-0.969 [†]	-0.968 [†]
	(0.283)	(0.285)	(0.356)	(0.358)
$fuel_t$	0.012	0.011	0.019	0.020
	(0.018)	(0.018)	(0.027)	(0.028)
$fatalities_t$	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000
$D(Thanks_{11})_t$	-0.035 [†]	-0.035 [†]	-0.021	-0.021
	(0.008)	(0.008)	(0.013)	(0.013)
$D(Thanks_{12})_t$	0.061 [†]	0.061 [†]	0	0.001
	(0.011)	(0.010)	(0.019)	(0.019)
$D(Leap)_t$	0.033	0.034	0.008	0.007
	(0.019)	(0.019)	(0.032)	(0.032)
$D(GulfWar)_t$	-0.017	-0.017	0.008	0.007
	(0.015)	(0.015)	(0.017)	(0.017)
$D(IraqWar)_t$	-0.042 [†]	-0.043 [†]	-0.030 [†]	-0.029 [†]
	(0.011)	(0.011)	(0.011)	(0.011)
$D(SARS)_t$	0.013	0.013	0	0.001
	(0.015)	(0.015)	(0.010)	(0.010)
$\beta_{\frac{1}{t}}$	-0.313 [†]	-0.134 [†]	-0.073 [†]	-0.012
	(0.020)	(0.012)	(0.025)	(0.015)
β_{shift}	-0.075 [†]	-0.074 [†]	-0.101 [†]	-0.102 [†]
	(0.018)	(0.017)	(0.023)	(0.023)
β_{911}		-0.371 [†]		-0.176 [†]
		(0.020)		(0.026)
N	215	215	215	215
\bar{R}^2	.9674	.9677	.9235	.9231
Root MSE	0.0323	0.0322	0.0403	0.0404

Note: Monthly dummy variables have been suppressed.

*Significant at the 5% level. [†]Significant at the 1% level.

Newey-West autocorrelation-robust standard errors are reported.

1 (yields) indicate that 9/11 resulted in a negative demand shift, rather than a supply contraction.
2 Moreover, the estimated effect of the ongoing demand shift remains almost the same even after
3 we isolate the September 2001 observation from the remainder of the data in Model 2. Thus,
4 these results do not appear to be the outcome of one influential observation. If we assume the
5 estimated coefficients reflect a pure the demand shift—which, as discussed earlier, is consistent with
6 the simultaneous decline in both quantity and price—the implied elasticity of the airline supply is
7 0.74.

8 Given the limited number of observations after September 2001, it remains to be seen if this
9 ongoing shift in demand is a permanent one. It is possible, for example, that we are observing a
10 portion of a protracted non-linear response with long lags that have lasted more than twenty-seven
11 months. Such a protracted recovery, however, would also be unprecedented in the airline industry.
12 For example, we applied our model to the twenty seven months following the invasion of Kuwait and
13 subsequent 1991 Gulf War and found no evidence of a negative demand shift.

14 We also tested to see if the ongoing shift had any attenuating tendency by inserting a linear time
15 trend on post-September 2001 observations and allowing for a jackknife modification (the results
16 are not reported in Table 2). The estimated time trends were extremely small and statistically
17 insignificant while the other estimates remained mostly unchanged. This result suggests that the
18 ongoing shift has no apparent tendency to narrow its gap within the observed time period.

19 Finally, it is also important to note that we identify this ongoing shift separately from the tran-
20 sitory shock of September 11th and the estimation results also confirm that a substantial transitory
21 shock was present. In Model 1, the estimated coefficient on $\beta_{\frac{1}{t}}$ of -0.313 implies that the initial
22 shock of September 11th resulted in a 31% reduction in RPMs (in addition to the 7.5% ongoing
23 shift). Put differently, domestic RPMs reached a historical peak in August 2001 of approximately
24 46.0 billion miles and dropped precipitously to 24.7 billion miles in September 2001, then recovering
25 to 31.4 billion miles in October 2001. The transitory shock to yields of 7.3% was significantly smaller
26 than the corresponding shock to RPMs which makes sense since many airline tickets are purchased
27 well in advance.

28 Under Model 1, the transitory impact of September 11th diminishes to less than a 1% reduction
29 after 5 months (i.e., by February 2002) for RPMs and after 2 months (November 2002) for yields.
30 Thus, the estimated coefficients on β_{shift} apply mostly to the remaining 20 and 23 months of the
31 RPM and yield data respectively.

TABLE 3: GOODNESS-OF-FIT COMPARISON

	Ln(RPMs)		Ln(Yields)	
	Model 1	Benchmark	Model 1	Benchmark
Model Degree of Freedom	190	199	190	199
R^2	0.9726	0.8917	0.9331	0.8312
\bar{R}^2	0.9691	0.8835	0.9247	0.8185
RRS	0.1880	0.7422	0.3043	0.7679
TTS	6.8542	6.8542	4.5486	4.5486

RRS: Residual sum of squares.

TTS: Total sum of squares

Benchmark model employs a linear trend and seasonal dummies.

1 3.2.1 Goodness of Fit

2 The fit of both models is extremely good, with an \bar{R}^2 of .967 for RPMs and .923 for yields. Since
3 \bar{R}^2 s are often high in time-series data, we evaluate the fit of Model 1 relative to an alternative
4 benchmark model consisting only of a linear time trend and seasonal dummy variables. Table 3
5 compares the goodness-of-fit of the two models. While the benchmark model accounts for 89% and
6 83% of the variations in the RPMs and yield respectively, the improvements in fit from Model 1
7 are substantial. For the RPMs equation, the residual sum of squares are reduced by 74.7% and for
8 the yield equation, the reduction is 60.4%. Thus, we conclude that our model generates substantial
9 improvements over this alternative benchmark of a linear time trend and seasonal dummy variables.

10 Figure 5 plots the predicted RPM values of Model 1 along with their actual values (both series are
11 seasonally adjusted). The model's predictions appear to capture the post-September 11th demand
12 dynamics remarkably well.

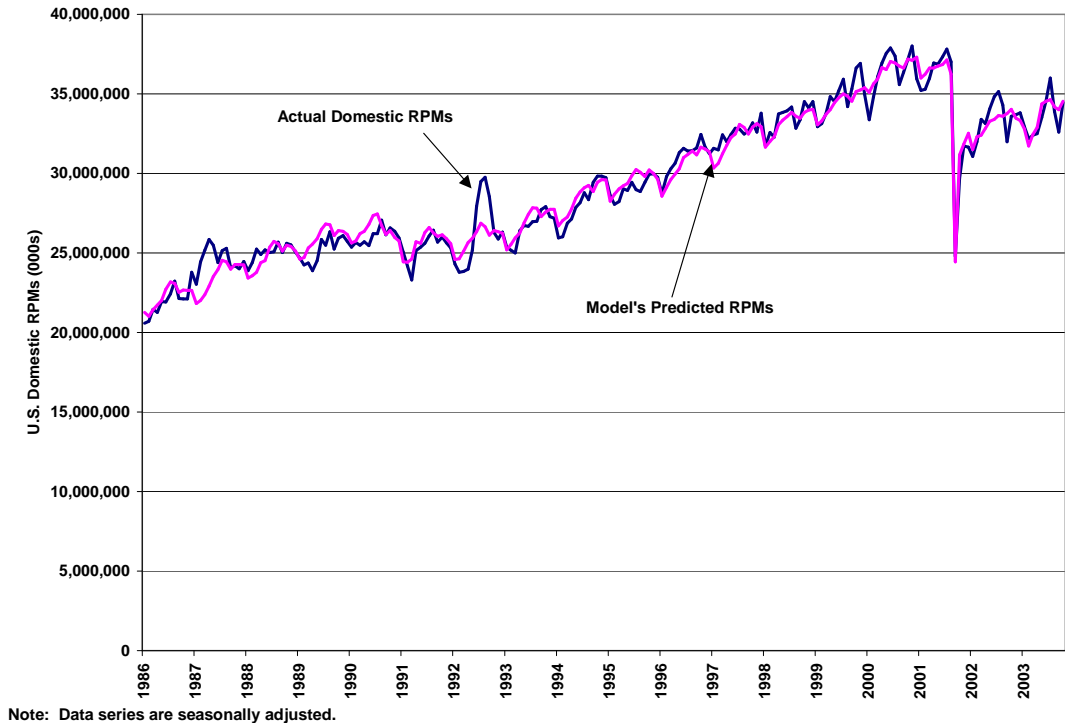


FIGURE 5: Domestic RPMs versus Model 1 Predictions

1 3.3 Analysis of Post-September 11th Airline Demand

2 Having estimated the impact of September 11th on U.S. airline demand, we now use our model's
 3 estimates to predict what demand would have been had it not been for the terrorist attacks. For
 4 our analysis in this section, we use the predicted values from Model 1.

5 Our methodology is as follows. From the predicted values of the regression model, we subtract
 6 both the ongoing and transitory estimated effects of September 11th, along with the seasonal fluctu-
 7 ation (series (b)). This counterfactual demand prediction is plotted in Figure 6, along with the
 8 actual (seasonally adjusted) level of RPMs (series (a)). As illustrated in Figure 6, the model pre-
 9 dicts a significantly higher level of demand had September 11th not occurred, notwithstanding the
 10 weakness in the labor market. Recall also that the immediate shock of September 11th is largely
 11 dissipated after five months. The difference between the counterfactual (b) and actual (a) RPMs
 12 after five months is the ongoing shift predicted by the model of roughly 7.4%.

13 To put this figure into context, domestic RPMs for the 12 month period ending November 2003
 14 (439.0 billion) were approximately 7.9% lower than their historical peak that occurred during the
 15 12 months ending August 2001 (476.6 billion). Thus, our analysis would suggest that the ongoing,

- 1 negative demand shock from September 11th accounts for roughly 94% of the decline in domestic
- 2 RPMs from this historical peak.

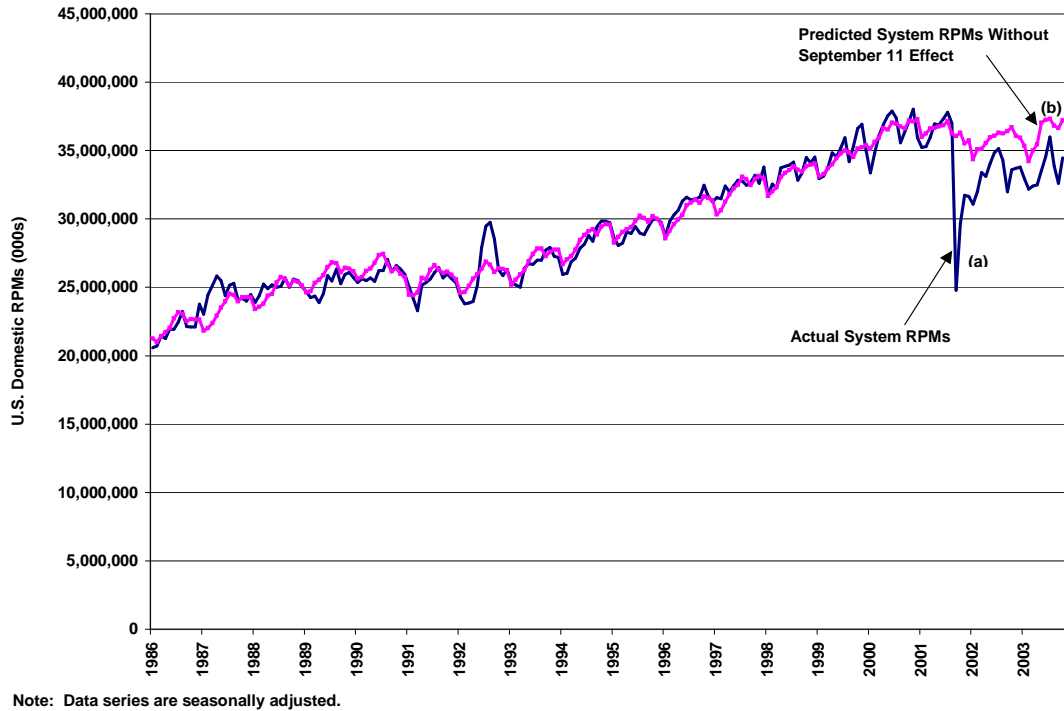


FIGURE 6: System RPMs versus Model 1 Predictions

3 3.4 Limitations of the Current Analysis

4 While our analysis provides strong evidence of a negative structural change in airline demand fol-
 5 lowing September 11th, we should emphasize that our analysis has some limitations. To begin with,
 6 at the time of our analysis, only 27 monthly observations since September 2001 are available, which
 7 limits the degrees of freedom for our analysis concerning the post-September 11 period. While the
 8 U.S. airline industry has typically recovered from other negative shocks considerably faster than
 9 27 months, a catastrophic event such as September 11th could obviously require a longer recovery
 10 period. If this is the case, we are still observing the recovery. Based on the data, one cannot rule
 11 out the possibility that we are still on the recovery trajectory from September 11th, especially when
 12 events such as the Iraq War and the SARS epidemic have put additional downward pressure on the
 13 demand for air travel. Consequently, it will be useful to repeat the current analysis as additional
 14 observations become available.

1 Moreover, it is possible that the industry adapts to the post-September 11th environment in
2 some unexpected way. For example, new technological innovations in security screening might
3 eliminate some of the waiting time at airports, thus reducing the hassle factor and making air travel
4 more convenient. Likewise, new forms of passenger screening (i.e., facial recognition) may become
5 widespread and improve passengers' sense of security.

6 Finally, we emphasize that our analysis does not attempt to account for any macroeconomic
7 effects caused by the terrorist attacks. Because it is probable that September 11th directly or indi-
8 rectly led to lower levels of macroeconomic activity—and in turn—increased unemployment, our results
9 likely understate the impact of September 11th on airline demand. Moreover, our macroeconomic
10 indicator variables, the labor force and unemployment rate, will tend to overstate the impact of
11 the negative economy on airline demand relative to other variables such as GDP. Nevertheless, we
12 believe that our analysis is useful in that it provides an approach to assist policymakers and industry
13 leaders evaluating the impact of major external shocks—such as the terrorist attacks of September
14 11th—on the U.S. airline industry.

15 **4 Conclusions**

16 The terrorist attacks of September 11th had a dramatic impact on the U.S. airline industry. Although
17 some of the initial panic and fear of flying directly following September 11th has dissipated, more
18 rigorous security screening and passengers' perceptions of the risk of flying have altered the demand
19 for and experience of air travel, especially in the United States.

20 While there is little doubt that September 11th and its after-effects resulted in industry turmoil
21 in the days and months directly following the attacks, there is controversy regarding the longer
22 term impact of September 11th on the airline industry. This controversy arises due to the fact that
23 weak economic conditions pre-dated—and persisted—past September 11, 2001. Our analysis attempts
24 to disentangle these macroeconomic effects on airline demand from the more direct effects of the
25 September 11th terrorist attacks. In addition, our analysis separates the effects of September 11th
26 into its effects temporary and ongoing components. In summary, we find that September 11th
27 resulted in both a transitory, negative demand shock of more than 30% in addition to an ongoing
28 negative demand shift of approximately 7.4% that cannot be explained by cyclical, seasonal or other
29 factors. Moreover, we estimate that this structural demand shock accounts for over 90% of the
30 current weakness in domestic airline demand relative to its pre-September 11th peak.

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