

**Applying Intervention Analysis to Financial Performance Data:
The Case of U.S. Airlines and September 11th.**

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Abstract

Using intervention analysis I assess the effect of the September 11 terrorist attack on the performance of the U.S. airline industry. The estimated initial effect supports the U.S. federal government decision to provide a \$5 billion cash compensation to the airlines. However, the long-run effect is found to be much smaller than the losses reported by the industry in 2001 and 2002. Also, the analysis suggests that not all of the airlines were equally affected by the terrorist act and that investors were fairly rational pricing major airline stocks, but were less accurate with the stocks of smaller regional carriers.

1. Introduction

The tragic events of September 11, 2001 provide researchers with the natural experiment settings to study the effect of an unanticipated large-scale catastrophic event on the U.S. economy and society. U.S. airlines have been placed in the most vulnerable position by this devastating terrorist act. Immediately after the attack the Federal Aviation Administration shut down the National Airspace System and all air traffic in the United States remained grounded for several days. U.S. airlines have experienced substantial losses after the attack as a result of flight restrictions, enhanced security procedures and the abrupt decline in passenger traffic. Even though \$5 billion in cash compensation and up to an additional \$10 billion in loan guarantees were provided to the airlines by the federal government, U.S. airlines posted total losses of \$17.7 billion in 2001 and 2002¹.

I assess the impact of the September 11 terrorist attack on the performance of U.S. airlines using intervention analysis first suggested by Box and Tiao (1965, 1975) and further developed by Larcker, Gordon, and Pinches (1980), Enders, Sandler, and Parise (1992) and others. Intervention analysis has advantages over the standard event study method first introduced by Ball and Brown (1968) and Fama et al. (1969). It allows the observed autocorrelation in the model residuals to be removed thus providing improved estimates for reliable statistical testing, and requires considering each time series on a case-by-case basis instead of forcing one model on all series when examining events that simultaneously affect several firms (Larcker, Gordon, and Pinches, 1980). Also,

¹ Arndt and Zellner (2003) report U.S. airline losses of \$17.7 billion in 2001 and 2002. The airline financial statements indicate \$17.5 billion of operating losses and \$17 billion of net losses in 2001 and 2002 combined. If 2003 losses are added, the figures become \$21.3 and \$19.5 billion for operating and net losses respectively.

intervention analysis can provide an impulse response function to study the transitional effects of an event.

Guzhva and Pagiavlas (2004) utilize Vector Autoregression (VAR) model to separate the effect of the attack on U.S. airline performance from downturn in general economic conditions. They confirm the U.S. government assessment that U.S. airlines lost about \$5 billion due to the attack in September – December 2001. While VAR is very useful in decomposing the effect of the attack from macroeconomic influences, it does not provide long-run effect, which can be estimated through intervention analysis as the change in the long-run mean of a series of financial data.

I examine monthly revenue passenger miles (RPM) series to objectively assess the effect of the terrorist attack on the financial performance of U.S. airlines. RPM are considered to be the industry standard for the airlines' financial performance evaluation and have an advantage over typical accounting and financial statements as they provide unbiased performance information and are not influenced by creative accounting techniques. I perform intervention analysis with the aggregate industry data and with individual monthly RPM series for U.S. major and regional airlines to detect if the terrorist act resulted in different effects for individual air carriers. As expected, the intervention analysis of the industry data reveals a statistically and economically significant effect of the attack on the performance of U.S. airlines. The magnitude of the effect, however, is much smaller than losses reported by the U.S. airline industry. The initial effect of the attack is found to be around \$1.5 billion a month, while the long-run effect is estimated to be \$7 billion. The magnitude of the initial effect confirms Guzhva and Pagiavlas (2004) findings and supports the federal government decision to provide a

\$5 billion cash compensation to the airlines, as \$1.5 billion a month sums to around \$5 billion in 3 months and 20 days. However, the long-run effect of \$7 billion, which can be compared with the annual performance data of the industry, is much smaller than reported losses, suggesting that not all of the losses can be explained by the attack of September 11, 2001². Probably, the airlines' failure to profitably operate in times of increased competition and slow economic recovery can be accountable for the rest of U.S. airline industry losses after September 11, 2001.

The analysis at the individual air carrier level shows that not all of the U.S. airlines were significantly hurt by the terrorist attack. Two out of seven major airlines and eight out of ten regional airlines managed to minimize the impact. Moreover, three regional airlines have demonstrated significant improvements in performance after the September 11 attack. The comparison of the results of the intervention analysis with the market reaction reported by Carter and Simkins (2004) reveals that investors were fairly rational with pricing major airline stocks on September 17, 2001, but the market was not completely right for many of regional airline stocks.

2. September 11, 2001 and the U.S. airline industry

On September 22, 2001 President Bush signed into law the Air Transportation Safety and System Stabilization Act. The Act makes available to the President funds to compensate air carriers for direct losses suffered as a result of any flight-grounding orders of the federal government and incremental losses resulting from the September 11 terrorist attack on the United States. Under the Act a total of \$5 billion in cash compensation was provided to the airlines along with an additional \$10 billion in loan

² \$17.7 billion reported losses in 2001 and 2002 plus \$5 billion in cash compensation sum to \$22.7 billion.

guarantees. Despite such substantial government assistance, U.S. airlines posted total losses in excess of \$17 billion in 2001 and 2002. However, U.S. airlines were not alone in their devastating experience from the terrorist attack. The whole U.S. economy including industries, such as hotels and insurance, was seriously affected (Buckler, Meyer, and Lucas, 2002). The government's assistance to one industry and denial of assistance to others has caused a great deal of controversy in the business community. This controversy has been intensified by the fact that the airlines have seemingly stayed in a permanent crisis mode since deregulation in 1978 (Arndt and Zellner, 2003; Will, 2002).

The Bush administration has become increasingly concerned that the government bailout to the airlines may disappear without an improvement in the situation (Economist, 2003). If the federal government continues to provide cash or taxpayer-backed loans to the airlines, it could reduce their incentive to solve their own problems, which include high and uncompetitive costs for older companies³, particularly those related to union contracts (Arndt and Zellner, 2003).

3. Data

The airline performance measurement literature is well developed. Feng and Wang (2000) utilize 63 performance indicators covering production, marketing and execution. Baldanza (1999) and Schefczyk (1993) argue that typical accounting and financial statements do not provide relevant data and recommend the use of published non-financial information to objectively assess the airlines' performance. A measure of financial performance in the airline industry that combines financial and operational

³ American Airlines, United, Northwest, etc.

information and has become the industry standard is revenue passenger miles (RPM) per period of time. It is calculated as the number of revenue passengers⁴ carried by an airline for a mile per period of time. One can obtain generated revenues by multiplying RPM by average yield⁵. Also, using RPM and yield analysis, the revenue and subsequent profitability of a route, segment, or market can be assessed. Combinations of RPM, yield, available seat miles (ASM), and cost per ASM provide a great deal of information for operational and financial analyses of airlines.

In this paper I employ monthly RPM series from Form 41 Financial Data and 298C Summary Data of the U.S. Department of Transportation⁶. The industry sample consists of 374 monthly RPM and ASM observations from March 1974 through April 2005. Individual air carrier RPM series consist of 374 observations for older companies and fewer than 374 observations for younger airlines with the shortest series of 94 observations for the youngest airline (Mesaba Aviation) in the sample. There are seven major and ten non-major airlines in the sample⁷. A graph of monthly RPM of the U.S. airline industry is presented in Figure 1.

Operating and net loss data and the information about the federal grants are obtained from the airline financial statements.

****Insert Figure 1 About Here****

⁴ Revenue passengers are those who actually pay for the flight. Some passengers are not paying (or not paying in full) such as airline employees, air marshals, etc.

⁵ Yield in this case is revenue per one RPM.

⁶ Form 41 contains financial information on large U.S. certified air carriers including balance sheets, income statements, cash flows, aircraft inventory, operating expenses, RPM, yield, ASM, costs per ASM, etc. Form 41 Financial Data and 298C Summary Data are available through Database Product, Inc.

⁷ Major airlines have annual revenues greater than \$1 billion and a nationwide network. Non-major airlines have annual revenues less than \$1 billion and a regional network.

4. September 11 and U.S. airlines' performance

4.1. Methodology

I utilize the following econometric model:

$$RPM_t = \alpha + \gamma(t) + \sum_{i=1}^{11} \delta_i D_i + \sum_{j=1}^{\infty} \beta_j RPM_{t-j} + \sum_{j=0}^{\infty} \varphi_j \varepsilon_{t-j} + \omega SEP11_t \quad (1)$$

where RPM_t is the RPM in period t ; α is a constant; $\gamma(t)$ is a time trend; D_i is a dummy variable where i represents a calendar month; ε_{t-j} is a normal i.i.d. disturbance; $SEP11_t$ is a dummy variable that takes value of 0 before September 2001, 0.67^8 in September 2001, and 1 thereafter; δ_i , β_j , φ_j , and ω are coefficients.

Since the September 11 dummy remains equal to unity until the end of the sample period, I arguably model the effect of the September 11 attack as the permanent change to the airline industry RPM. Probably, the prolonged impulse model with the decaying function would be more appropriate in the case of a terrorist threat as the fear of flying would dissipate over time and people would begin to move back to their original patterns of airline travel. However, this requires arbitrarily setting the September 11 dummy to zero at some point of time after the attack while the terrorist threat is still a significant factor in airline travel decisions. Some flights were canceled by the authorities even in 2005 and the airports are still struggling with the enhanced security, which significantly affects the airlines operations. Hence, the September 11 dummy that stays equal to one through April 2005 is a reasonable modeling assumption.

Equation (1) can be expressed as:

⁸ Since the tragic events in September 2001 occurred on 11 day of the month, the dummy was calculated as a ratio 20/30.

$$B(L)RPM_t = \alpha + \gamma(t) + \sum_{i=1}^{11} \delta_i D_i + \Gamma(L)\varepsilon_t + \omega SEP11_t \quad (2)$$

where $B(L)$ and $\Gamma(L)$ are polynomials in the lag operator L . The coefficients of $B(L)$ are the autoregressive (AR) components, and the coefficients of $\Gamma(L)$ are the moving average (MA) components of the ARMA model. The coefficient ω is of special interest to the analysis as it provides the information about the impact of the September 11 attack on the performance of the U.S. airline industry.

An augmented Dickey-Fuller (ADF) test was performed on detrended RPM series to ensure that it did not contain a unit root. Sequential t-tests beginning with lag 12 were utilized to determine the appropriate number of lags for the unit root test (Campbell and Perron, 1991; Ng and Perron, 1995). September 11 was assumed to be an exogenous structural break for the RPM series. As proposed by Perron (1989), failure to allow for an existing structural break decreases the ability to reject a false unit root. The unit root tests were performed with and without allowing for the structural break. Both tests rejected the null hypotheses of the unit root. Without the structural break dummy the unit root hypothesis was rejected at the 5% level, whereas with the structural break dummy the test provided much stronger results and the unit root hypothesis was rejected at the less than 1% level. The absence of a unit root means that the effect of the terrorist attack will eventually die out. The data exhibit strong seasonal patterns, which I control for by using eleven dummy variables representing calendar months from January to November.

The estimation procedure was conducted using the standard Box-Jenkins method. In choosing among alternative plausible ARMA models, the lowest Akaike Information Criterion (AIC) method was utilized; ARMA (3, 2) model was selected. Diagnostic

checking was performed by plotting the correlogram of residuals squared to insure that they are characterized by a white noise process. Also, the ARCH (autoregressive heteroskedasticity) Lagrange multiplier test was performed and it resulted in non-significant statistics, which implies the absence of the ARCH effect.

The best fitting ARMA model can be written as:

$$RPM_t = \sum_{j=1}^3 \beta_j RPM_{t-j} + \sum_{j=0}^2 \varphi_j \varepsilon_{t-j} + \omega SEP11_t \quad (3)$$

where RPM_t is a seasonally adjusted and detrended RPM series⁹.

Also, the above procedures were conducted for monthly ASM series and the best fitting ARMA (3,2) model can be expressed as:

$$ASM_t = \sum_{j=1}^3 \beta_j ASM_{t-j} + \sum_{j=0}^2 \varphi_j \varepsilon_{t-j} + \omega SEP11_t \quad (4)$$

4.2. Empirical Results

The empirical results of the effect of September 11, 2001 on the U.S. Airline industry are reported in Table 1. The statistically significant coefficient of the September 11 dummy represents the initial, or impact, effect of the terrorist attack on the U.S. airline industry. The coefficient indicates the initial reduction of 7,466.375 million RPM per month. To provide the economic sense of the decrease in the airline performance, I compare this number with the average RPM per month for the U.S. airlines in 2000: it represents a 12.86% drop in RPM. The monetary equivalent of the initial effect of the September 11 events on the U.S. airline industry can be obtained by multiplying the

⁹ The intercept was not included here because it was already included in the trend and seasonal patterns equation and therefore was assumed to be zero in ARMA model.

estimated decrease in RPM by \$0.1351, the average yield of the U.S. airlines in 2000 according to the Air Transport Association (ATA) of America. It turns out to be about \$1.009 billion. According to the U.S. Bureau of Transportation Statistics, in 2000 86.2% of operating revenues of U.S. airlines were from the passenger service. Assuming equal decline in freight operations and reported extra costs on enhanced security of about \$4 billion per year¹⁰ (Arndt and Zellner, 2003) the initial impact of the terrorist attack on the U.S. airlines is calculated to be around \$1.504 billion in the first month after the attack¹¹. The figure of \$1.5 billion a month confirms finding of Guzhva and Pagiavlas (2004) and supports the federal government decision to provide a \$5 billion cash compensation to cover the airlines' losses that occurred before December 31st, 2001¹².

****Insert Table 1 About Here****

Obviously, the decline in airline revenues cannot be equal to the losses the airlines suffered as a result of September 11 since the corresponding cost reductions implemented by the airlines should be considered. However, given that airlines have high fixed costs¹³ and most variable operating costs¹⁴ cannot be cut instantaneously (Werner, 1999) the airlines' losses from September to December 2001 should be reasonably close to \$5.45 billion. In an attempt to assess the effect of airline cost reduction I utilize ARMA (3,2) model with monthly ASM series. The results of the estimation are presented in Table 1.

¹⁰ These costs are attributed to securing cockpit doors, paying extra tax for adding federal security employees at airports, new baggage screening equipment, etc.

¹¹ Calculated as \$1,009 mln / 0.862 + \$4,000 mln / 12

¹² 1.5 bln multiplied by 3.63 months equals to 5.45 bln

¹³ Airliners, ground equipment, etc.

¹⁴ Labor costs, for instance.

Even though the estimation shows the initial significant drop in the airlines ASM (about 8.15%), the airlines were still accountable for almost all expenses associated with flight operations. They were still responsible for the aircraft lease payments, pilots, flight attendants and maintenance personnel wages, etc. Utilizing costs data for 2000 published by ATA I approximate the partial reduction in direct operating costs of U.S. airlines for the period of 2001 following the terrorist attack. Assuming that the airlines were not paying for fuel and passenger services, but were still accountable for other services associated with flight operation, their savings would be \$0.0224 per ASM. Using the estimated initial effect of negative 6,533.338 million ASM per month, the airlines were saving about \$146 million a month. The total cost reduction for 20 days of September and fourth quarter 2001 turns out to be \$537 million¹⁵. Subtracting \$537 million from previously estimated \$5.45 billion loss in revenues I almost exactly match the government assessment of the initial impact of the terrorist attack. Hence, even though the airlines trimmed their schedules as a result of the attack, their losses were in the magnitude of \$5 billion. As one can see, the September 11 terrorist act resulted in a statistically and economically significant *initial* decline in U.S. airlines performance.

The long-run effect of the terrorist attack can be assessed by calculating the change in the long-run mean of the RPM series. The long-run effect (*LRE*) of intervention is given by the following equation:

$$LRE = \frac{\omega}{(1 - \beta_1 - \beta_2 - \beta_3)} \quad (5)$$

¹⁵ Calculated as \$146 mln * 3.67

where β_1 , β_2 , and β_3 are AR term coefficients of ARMA (3,2) model presented in equation (3).

After substituting the coefficients in equation (5) I find that *LRE* equals to negative 17,095.761 million RPM, which represents 2.45% of the total number of RPM for the U.S. scheduled airlines in 2000. By using 13.51 cents per RPM yield, 86.2% ratio of passengers' revenue to total revenue, and \$4 billion a year of extra security costs, the monetary value of the *LRE* is calculated to be \$7.91 billion in the post-September 11 period of 2001 and 2002 combined.¹⁶ This amount represents the decline in revenues and extra security costs for U.S. airlines. As mentioned earlier, the specifics of the airline costs structure do not permit rapid cost reductions. However, as many airlines trimmed their schedules after September 11, 2001, they were able to reduce the costs of operations over the long-run. To approximate the cost reduction, I divide total flying operation expenses in 2000, reported in Form 41 of the U.S. Department of Transportation, by total number of ASM in 2000. The resulting number is \$0.0391 per ASM. By taking *LRE* number of ASM, subtracting from it 3.67 months of initial effect ASM, and multiplying by \$0.0391, one can estimate the cost reduction for the airlines in 2002. This figure turns out to be \$403 million¹⁷. Hence, even after accounting for trimmed airline schedules over the long run, U.S. airlines' 2001 and 2002 losses due to the terrorist attack amount to about \$7 billion¹⁸. While statistically significant, *LRE* yields much smaller economic significance (in relative terms) than the initial effect. The magnitude of the impact is much smaller than \$22.7 billion in cumulative losses of the airline industry allegedly caused by the September 11 attack.

¹⁶ Calculated as $\$2,310 \text{ mln}/0.862 + \$4,000 \text{ mln}/3.26 + \$4,000 \text{ mln}$ for 2001 and 2002 years

¹⁷ Calculated as $(34,247.342 \text{ mln} - 3.67 * 6,533.338 \text{ mln}) * \0.0391

¹⁸ Calculated as $7.91 \text{ bln} - 0.537 \text{ bln} - 0.403 \text{ bln}$

One of the legitimate concerns of utilizing ARMA models to assess the effect of the attack on U.S. airlines' performance is that the airline industry is quite cyclical and the macroeconomic environment may affect passenger traffic, while there is no place for "fundamental" variables in the model. For instance, if the model's residuals are consistently negative during periods of recession, it may be indicative that the model overestimates the airlines' performance from March to November 2001, when, according to the National Bureau of Economic Research, the U.S. economy was in recession. However, after examining the residuals during five business cycles that occurred during the sample period, I conclude that the model does not demonstrate consistent overestimation in recessions¹⁹. This is also confirmed by the residuals for the September – December 2001 observations that are reasonably sized in the context of other observations. In addition, the estimated initial effect matches the findings of Guzhva and Pagiavlas (2004) that suggests that the intervention analysis provides reliable results even without considering macroeconomic variables.

4.3. Impulse response function

One of the advantages of the intervention analysis is that the model can provide researchers with additional information such as transitional effects of an event. Obviously, the \$1.5 billion monthly loss is not a permanent one. As implied by the unit root test the effect of the terrorist attack will eventually die out. Hence, the monthly losses will dampen and eventually disappear. The reduction rate of monthly losses that are attributable to the terrorist attack can be provided by the impulse response function.

¹⁹ According to the National Bureau of Economic Research the U.S. economy was in contraction from November 1973 to March 1975, from January 1980 to July 1980, from July 1981 to November 1982, from July 1990 to March 1991, and from March 2001 to November 2001.

Unfortunately, the estimated ARMA (3,2) model cannot be inverted to obtain the impulse response function. A more detailed discussion of the impulse response function is contained in the appendix.

Without the impulse response function there is no empirical way to determine at what point the airline monthly losses diminish. The estimated *LRE*, however, suggests that in any case the total impact of the terrorist attack on U.S. airlines should not surpass \$7 billion and the losses that exceed *LRE* cannot be attributed to the September 11 attack.

5. Impact on individual air carriers and market reaction.

Several studies assess the effect of the September 11, 2001 attack on the airlines. Drakos (2004) focuses on the effect on the airline stocks traded in various stock markets and reports a structural break in systematic and idiosyncratic risks of airline stocks. Carter and Simkins (2004) investigate the reaction of airline stock prices to the attack using the multivariate regression model methodology. They argue that the terrorist attack resulted in the unprecedented effect on the U.S economy and society. Their findings support the conception of rational pricing and suggest that the market differentiated among various airlines. Carter and Simkins conclude that the market believed the long-term consequences of the attack were much more significant for U.S airlines than for either international carriers or airfreight firms. Also, they report that market distinguished between airlines based on the level of their cash reserves penalizing those with lower levels of cash and equivalents. It seems that the market was concerned about the airlines' ability to survive a prolonged downturn in air travel. Was the market right? How rational were investors on September 17, 2001 when they tried to assess the effect the attack

would have on U.S. airlines? I attempt to answer this question by comparing the market reaction reported by Carter and Simkins for U.S major and regional airlines to the results of the intervention analysis at the individual air carrier level.

Utilizing the procedure described in Section 4, I examine monthly RPM series for U.S. major and regional (non-major) airlines. All time series were detrended, checked for unit roots and presence of ARCH effects, and seasonally adjusted. As noted by Larcker, Gordon and Pinches (1980), one of the advantages of intervention analysis is the necessity to consider each time series individually instead of forcing one model on all time series. Thus, for each airline time series the best ARMA(n,m) model was identified as:

$$RPM_{it} = \sum_{j=1}^n \beta_{ij} RPM_{it-j} + \sum_{j=0}^m \phi_{ij} \varepsilon_{t-j} + \omega_i SEP11_t \quad (6)$$

where i indicates an individual airline in the sample. The results of the estimation are presented in Table 2.

****Insert Table 2 About Here****

The analysis reveals some surprising results. Only five out of seven major airlines show that their performance was significantly affected by the terrorist attack. One of the airlines, whose airplanes were used in the attack, American Airlines, and Southwest Airlines were able to minimize the impact of the terrorist act on their performance. The coefficient of the September 11 dummy is not significant for these two airlines. While the market reacted less dramatically with the stock of Southwest Airlines, investors penalized

the stock of American Airlines almost as much as the stock of United Airlines – the air carrier that has large and significant decline in performance due to the attack in the short and long runs. The market was not completely right in this case. However, investors correctly assessed the impact of September 11 on future performance of Continental Airlines and US Airways. Both airlines’ stock prices declined by almost 50 percent, which is in line with large drops in their performance. Interestingly, the intervention analysis estimates two largest statistically significant declines in RPM due to the attack for United Airlines and US Airways – two major airlines that filed for bankruptcy in the post-September 11 period²⁰. Overall, on September 17, 2001 the stock market demonstrated rationality and priced the major U.S. airlines stocks almost correctly differentiating the effects of the attack on individual air carriers.

Panel B of Table 2 presents the findings for non-major (regional) airlines. Only two out of ten airlines demonstrate statistically significant declines in performance due to the attack – America West and Midwest Express Airlines. The market reacted very pessimistically pushing the stock price of America West down with a negative abnormal return of more than 60 percent. With Midwest Express, however, investors’ reaction was less dramatic – its stock had a negative abnormal return of “only” 34.4 percent.

Surprisingly, three non-major airlines: Alaska, Aloha, and Atlantic Southeast Airlines exhibit statistically significant increase in performance after the September 11 attack. Unfortunately, the market reaction for two of these airlines is not available. The stock price of the third carrier – Alaska Airlines demonstrated negative abnormal return of 26.38 percent. The analyses for the remaining five non-major airlines do not reveal statistically significant change in performance due to the attack. Investors, however,

²⁰ United Airlines filed on 12/09/2002; US Airways filed on 8/11/2002.

penalized stocks of all of them with negative abnormal returns ranging from 18.55 to 46.2 percent. Interestingly, only one non-major airline in the sample that filed for bankruptcy after September 11, 2001 – Hawaiian Airlines was not significantly affected by the terrorist attack, suggesting that it had different reasons to file for bankruptcy²¹.

Comparing the results of the intervention analysis of monthly RPM series of U.S. airlines to the market reaction reveals that the investors were less rational with pricing non-major airline stocks than the stocks of large and well-known major air carriers.

Table 2 also presents losses reported by U.S. airlines in their financial statements in 2001 and 2002 and the federal grants received by the airlines. For major airlines the relative sizes of the individual federal grants are approximately in line with the reductions in RPM that can be attributed to the attack with the exception of American Airlines and Southwest. On the other hand, among non-major airlines only America West and Midwest Express airlines were significantly affected, while almost all of the airlines received the grants.

6. Conclusion

In this paper I utilize intervention analysis to examine financial performance data of U.S. airlines. Revenue passenger miles series are inspected to objectively assess the effect of the September 11, 2001 terrorist attack on the performance of the industry. Intervention analysis with the industry data shows that the terrorist attack resulted in a statistically and economically significant effect. While supporting the federal government evaluation of the initial impact of the attack that led to a \$5 billion in cash compensation to the airlines, the cause of the overwhelming losses reported by the U.S. airlines in 2001

²¹ Hawaiian Airlines filed for bankruptcy on 3/21/03.

and 2002 is questioned. The analysis suggests that only \$7 billion out of reported \$22.7 billion in losses can be attributed to the terrorist attack. Probably, the U.S airline industry excess loss of \$15.7 billion can be explained by the inability of the traditional airline business model to profitably operate in times of unfavorable economic conditions, increasing competition and decreasing yields²².

The examination of RPM series at the individual air carrier level reveals that not all of the airlines were equally hurt by the terrorist act. Two major and five regional airlines managed to minimize the effect of the attack and three regional carriers were able to significantly improve their performance following September 11, 2001. Comparing the results of the intervention analysis at the individual air carrier level with the market reaction reported by Carter and Simkins (2004) reveals that investors in general correctly assessed the impact of the attack on large and well-known major airlines, but were less accurate with pricing the stocks of smaller regional carriers.

²² According to the Air Transport Association of America the average yield of the U.S. airlines was \$0.1351 in 2000, \$0.1242 in 2001, \$0.1145 in 2002, \$0.1178 in 2003, and \$0.1170 in 2004.

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Appendix

The transitional effects of the attack can be obtained from the impulse response function. Using a lag operator I rewrite (3) as:

$$(1 - \beta_1 L - \beta_2 L^2 - \beta_3 L^3)RPM_t = \omega SEP11_t + \sum_{j=0}^2 \varphi_j \varepsilon_{t-j}$$

and

$$RPM_t = \frac{1}{(1 - \beta_1 L - \beta_2 L^2 - \beta_3 L^3)} \left(\omega SEP11_t + \sum_{j=0}^2 \varphi_j \varepsilon_{t-j} \right)$$

Theoretically, we should be able to substitute

$$\frac{1}{(1 - \beta_1 L - \beta_2 L^2 - \beta_3 L^3)} \quad \text{with} \quad \frac{1}{(1 - \lambda_1 L)(1 - \lambda_2 L)(1 - \lambda_3 L)}$$

where λ_1, λ_2 , and λ_3 are characteristic roots of the polynomial $B(L) = 0$. With the characteristic roots, the ARMA model can be inverted to obtain the impulse response function. We can trace the response of the U.S. airlines' performance to a large-scale terrorist act by differentiating the impulse response function and updating by j periods. Unfortunately, with the AR coefficients presented in Table 1, there is no solution for λ_1 , λ_2 , and λ_3 . Without such a substitution the model cannot be inverted to calculate the impulse response function for the identified ARMA model.

In an attempt to obtain an approximate impulse response function, I estimate the second best model with industry RPM series. The initial intention was to approximate the ARMA (3,2) model with an AR(p) model for the impulse response function's estimation. Eighteen models, from AR(1) to AR(18) were examined and all of them were of "bad

quality” substitutes for ARMA (3,2) (the estimated coefficients were not statistically significant at conventional levels, AICs were much higher, etc.) The ARMA (1,12) model was the second best choice after ARMA (3,2) for the RPM series. Also, ARMA (1,12) model is somewhat similar to ARMA (3,2) in terms of explanatory power and is invertible. ARMA (1,12) also provides a significant coefficient for the September 11th dummy.

ARMA (1, 12) model can be written as:

$$y_t = \beta_1 y_{t-1} + \sum_{j=0}^{12} \varphi_j \varepsilon_{t-j} + \omega Z_t \quad (7)$$

or

$$(1 - \beta_1 L) y_t = \omega Z_t + \sum_{j=0}^2 \varphi_j \varepsilon_{t-j}, \quad (8)$$

Hence,

$$y_t = \omega \sum_{i=0}^{\infty} \beta_1^i Z_{t-1} + \sum_{i=0}^{\infty} \beta_1^i \sum_{j=0}^2 \varphi_j \varepsilon_{t-j} \quad (9)$$

Equation (9) is an impulse response function. By differentiating (9) and updating by j periods one can trace the response of the airlines’ performance on the terrorist act:

$$\frac{dy_{t+j}}{dZ_t} = \omega(1 + \beta_1 + \beta_1^2 + \dots + \beta_1^j) \quad (10)$$

Since in the limit $j \rightarrow \infty$, the *LRE* of the intervention:

$$LRE = \frac{\omega}{(1 - \beta_1)} \quad (11)$$

Equation (10) can be utilized to calculate the effect of the terrorist attack in a predetermined period of time after the occurrence. For instance, if an attack happens in period t , one can expect the decrease in monthly RPM in period $t+3$ by:

$$\frac{dy_{t+3}}{dZ_t} = \omega(1 + \beta_1 + \beta_1^2 + \beta_1^3) = \omega + \omega\beta_1 + \omega\beta_1^2 + \omega\beta_1^3$$

where ω reflects the direct impact of the attack on the airlines' performance, the following terms reflect the effect of the attack multiplied by the effect of y_{t+2} , y_{t+1} , and y_t respectively.

Figure 2 shows the impulse response of the U.S. airlines' performance to the terrorist attack (for ARMA (1,12) model). The area above the curve represents the cumulative effect on the industry's aggregate RPM. Because $0 < \beta_1 < 1$, the absolute value of the magnitude of the impact is increasing as we move further away from the impact period but the relative impact on the airlines performance is decreasing with time and is less than 1% in ten months after the attack. One should remember, however, that ARMA (1,12) model cannot be used to assess the impact since it is not the first choice model for the examined time series.

****Insert Figure 2 About Here****

Table 1. The impact of the September 11, 2001 terrorist attack on monthly aggregate RPM and ASM of U.S. scheduled airlines.

This table presents maximum likelihood estimates of the intervention analysis of monthly revenue passenger miles (RPM) and available seat miles (ASM) of the U.S. scheduled airlines to assess the impact of the terrorist attack of September 11, 2001 using ARMA(3,2) models below:

$$RPM_t = \sum_{j=1}^3 \beta_j RPM_{t-j} + \sum_{j=0}^2 \varphi_j \varepsilon_{t-j} + \omega SEP11_t$$

$$ASM_t = \sum_{j=1}^3 \beta_j ASM_{t-j} + \sum_{j=0}^2 \varphi_j \varepsilon_{t-j} + \omega SEP11_t$$

RPM and *ASM* are deseasoned and detrended monthly RPM and ASM series (in thousand) of the U.S. scheduled airlines, ε_{t-j} is a normal i.i.d. disturbance;

SEP11_t is a dummy variable that takes value of 0 before September 2001, 0.67 in September 2001, and 1 thereafter; β_j , φ_j , and ω are coefficients.

$LRE = \frac{\omega}{(1 - \beta_1 - \beta_2 - \beta_3)}$ is the long run effect of the terrorist attack calculated as the change in the long-run mean of the RPM series. Percent of change indicates

an increase or decrease in RPM and ASM due to the terrorist attack. The initial impact effect (coefficient of *SEP11*) is compared with average monthly RPM and ASM in 2000, while the long-run effect (*LRE*) is compared with total annual RPM and ASM in 2000. Statistical significance at the 10%, 5%, and 1% level is indicated by *, **, or ***, respectively. Standard errors are in parentheses.

<i>RPM model</i>	<i>RPM</i> _{<i>t</i>-1}	<i>RPM</i> _{<i>t</i>-2}	<i>RPM</i> _{<i>t</i>-3}	ε_{t-1}	ε_{t-2}	<i>SEP11</i>	% of change	<i>LRE</i>	% of change	Adj. R-sq.
	-0.8428*** (0.0175)	0.5402*** (0.0353)	0.8659*** (0.0239)	1.7037*** (0.0180)	0.9492*** (0.0204)	-7466375*** (1307925)	-12.86%	-17095761	-2.45%	0.86
<i>ASM model</i>	<i>ASM</i> _{<i>t</i>-1}	<i>ASM</i> _{<i>t</i>-2}	<i>ASM</i> _{<i>t</i>-3}	ε_{t-1}	ε_{t-2}	<i>SEP11</i>	% of change	<i>LRE</i>	% of change	Adj. R-sq.
	-0.7532*** (0.0204)	0.6325*** (0.0258)	0.9299*** (0.0199)	1.6553*** (0.0288)	0.9386*** (0.0237)	-6533338*** (1415452)	-8.15%	-34247342	-3.56%	0.93

Table 2. The impact of the September 11, 2001 terrorist attack on monthly RPM of U.S. scheduled airlines, stock market reaction and federal grants.

This table presents maximum likelihood estimates of the intervention analysis of monthly revenue passenger miles (RPM) of the U.S. scheduled airlines to assess

the impact of the terrorist attack of September 11, 2001 using ARMA(n,m) model: $RPM_{it} = \sum_{j=1}^n \beta_{ij} RPM_{it-j} + \sum_{j=0}^m \varphi_{ij} \varepsilon_{it-j} + \omega_i SEP11_t$,

and market reaction on September 17th, 2001 estimated as the abnormal return for a firm on event day by Carter and Simkins (C&S) (2004) using the multivariate regression model methodology.

RPM_t is deseasoned and detrended monthly RPM series (in thousand) of the U.S. scheduled airlines, ε_{t-j} is a normal i.i.d. disturbance; $SEP11_t$ is a dummy variable that takes value of 0 before September 2001, 0.67 in September 2001, and 1 thereafter; β_j , φ_j , and ω are coefficients.

$LRE = \frac{\omega}{(1 - \beta_1 - \dots - \beta_n)}$ is long-run effect of the terrorist attack calculated as the change in the long-run mean of the RPM series. Percent of change indicates an

increase or decrease in RPM due to the terrorist attack. The initial impact effect (coefficient of $SEP11$) is compared with average monthly RPM in 2000, while the long-run effect (LRE) is compared with total annual RPM in 2000. Statistical significance at the 10%, 5%, and 1% level is indicated by *, **, or ***, respectively. Standard errors are in parentheses.

Airline	Order of ARMA model	Adj. R-sq	SEP11 (RPM)	SEP11 (%)	LRE (RPM)	LRE (%)	Sept. 17 Market Reaction (C&S)	Reported Operating & Net(°) Profit/Loss in 2001-2002 (\$ mln)	Received Federal Grant (\$ mln)
<i>Panel A. Major Airlines</i>									
American Airlines	(4,4)	0.78	-2688 (7004)	-0.03%	-169519	-0.15%	-0.3551	(5,194.1) (4,321.0)'	866
Continental Airlines	(3,2)	0.89	-529420*** (124979)	-10.19%	-2581056	-4.14%	-0.4601	(788.2) (597.1)'	417
Delta Air Lines	(3,2)	0.87	-1229123*** (95558)	-13.68%	-3974884	-3.69%	-0.3999	(1,899.4) (2,237.8)'	654
Northwest Airlines	(3,2)	0.68	-745746*** (25442)	-11.30%	-1444737	-1.82%	-0.3331	(1,329.8) (937.1)'	461
Southwest Airlines	(4,3)	0.78	-4720 (4888)	-0.13%	-278539	-0.66%	-0.2022	547.8 455.4'	235
United Airlines ^	(3,4)	0.80	-2000612*** (296950)	-18.91%	-4165327	-3.28%	-0.3988	(5,982.0) (4,820.9)'	652
US Airways ^	(4,3)	0.87	-559784*** (100713)	-14.33%	-1733778	-3.70%	-0.4797	(1,937.5) (3,468.8)'	264

Note: ^ indicates the airline filed for bankruptcy: United Airlines filed on 12/09/02; US Airways filed on 8/11/02.

Table 2. Continued

Airline	Order of ARMA model	Adj. R-sq	SEP11 (RPM)	SEP11 (%)	LRE (RPM)	LRE (%)	Sept. 17 Market Reaction (C&S)	Reported Operating & Net(*) Profit/(Loss) 2001-2002 (\$ mln)	Received Federal Grant (\$ mln)
<i>Panel B.</i>									
<i>None-Major Airlines</i>									
Airtran	(3,3)	0.53	713 (2471)	0.21%	7568	0.18%	-0.3865	28.0 (14.1)'	29
Alaska Airlines	(3,3)	0.87	23634* (13925)	2.37%	234475	1.96%	-0.2638	(125.4) (68.2)'	71.6
Aloha Airlines	(4,4)	0.95	3491*** (1005)	4.39%	244897	25.64%	N/A	(41.2) (50.2)'	N/A
America West Airlines	(3,2)	0.72	-133459*** (41911)	-8.38%	-241824	-1.27%	-0.6217	(506.5) (563.8)'	108.2
American Trans Air	(3,4)	0.73	14790 (10593)	1.79%	85236	0.86%	-0.4620	(242.9) (247.4)'	66.3
Atlantic Southeast Airlines	(4,3)	0.91	1700*** (635)	0.96%	159152	7.52%	N/A	63.8 15.6'	N/A
Frontier Airlines	(4,2)	0.57	1484 (949)	0.67%	204083	7.64%	-0.3113	(9.4) (4.3)'	12.7
Hawaiian Airlines ^	(3,3)	0.70	-594 (6981)	-0.13%	-5893	-0.11%	-0.1855	(62.9) (56.4)'	22
Mesaba Aviation	(3,4)	0.70	-7092 (4487)	-5.03%	-19059	-1.13%	-0.2106	7.9 6.3'	12.5
Midwest Express Airlines	(3,4)	0.65	-21488*** (4579)	-13.03%	-32125	-1.62%	-0.3440	(35.2) (35.4)'	16.3

Note: ^ indicates the airline filed for bankruptcy: Hawaiian Airlines filed on 3/21/03.

Figure 1. U.S. airlines revenue passenger miles

Monthly revenue passenger miles from March 1974 to April 2005.

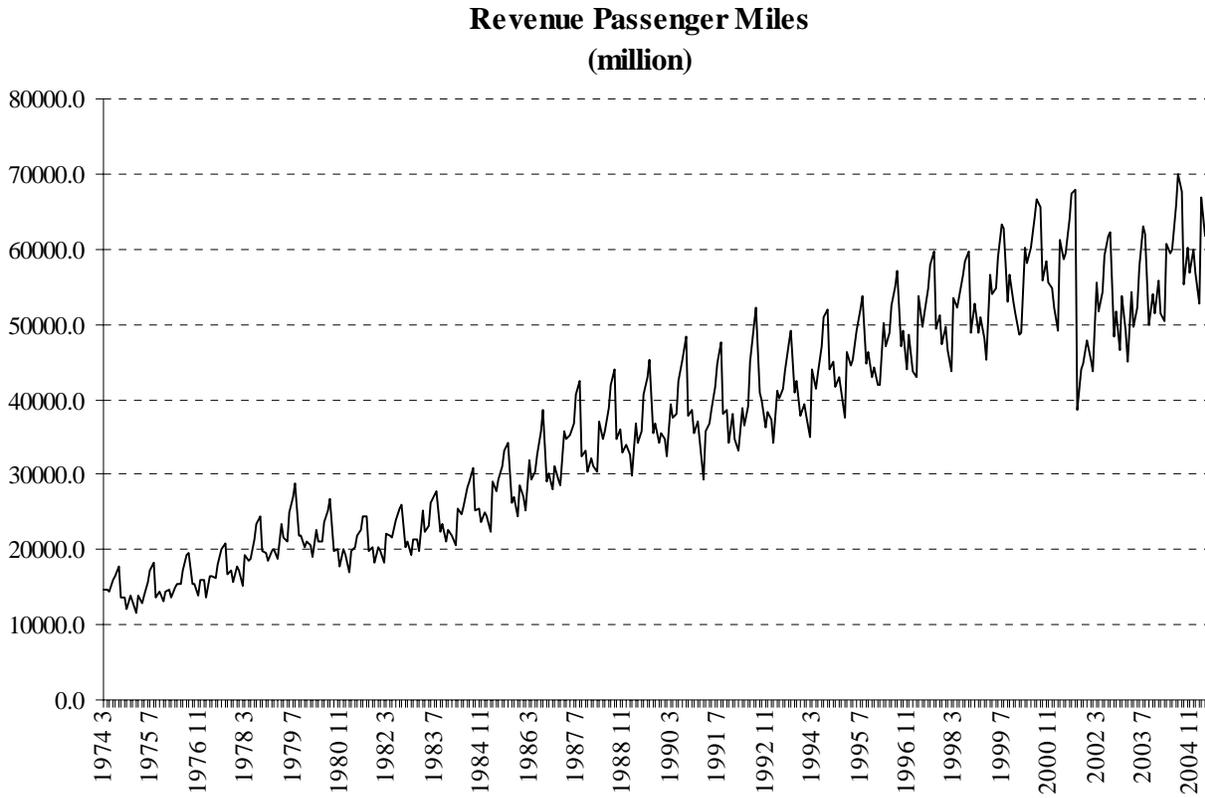


Figure 2. Impulse response of the U.S. airlines performance on a large scale terrorist attack

The impact is calculated using impulse response function of ARMA (1,12) model as a ratio of the absolute value of the magnitude of the impact to the cumulative RPM using average monthly performance of the U.S. scheduled airlines in 2000. The impact continues slowly decreasing beyond the 24th month after the attack and equals to -0.22% in 48 months, -0.17% in 60 months, -0.11% in 96 months, etc.

