Exploration of Sequestration Impacts on U.S. Air Traffic Delays

Susan Kelly Archer, Ed.D.

Casey Richardson

Embry Riddle Aeronautical University
College of Aviation
PhD in Aviation Program
Daytona Beach, Florida
USA

Abstract

This research project examined flight delays data to determine if the span of time when air traffic controller furloughs were implemented due to government sequestration coincided with an increase in recorded flight delays. The Reducing Flight Delays Act of 2013 was enacted into law in the U.S., based on reports suggesting that the month of April 2013was the time period during which the significant increase in delays occurred. The related research question was: Do the Bureau of Transportation Statistics (BTS) data support the statement made in aJournal of Transportation (2013) article that furloughs caused flight delays to triple? Through a mixed-method design, incorporating an initial qualitative analysis and subsequent quantitative analysis, the researchers examined the assertion that the time period during which air traffic control employees were furloughed due to government sequester had significantly more flight delays. In all cases, the analysis results supported the assertion.

Keywords: sequestration, aviation, flight delays, air traffic control, furlough

1.Problem Statement and Purpose

There are a number of reasons why commercial aircraft experience delays. Some of these reasons, such as a weather delay, are beyond human control. Other reasons are specifically based on human control. In late 2012 and early 2013, Congressional differences over budget issues led to sequestration and government shutdown. When these events occurred, non-essential government employees were furloughed and the resulting impact was experienced in a number of venues. One such venue was commercial aviation. According to a May 2013 *Journal of Transportation* article, commercial aviation "helps drive more than $1 trillion in U.S. economic activity and more than 10 million U.S. jobs" (p.33). Thus, government action that resulted in possible flight delays could have had a significant effect on the Nation's economy and jobs. Flight delays are defined by the FAA as occurring when a flight arrives at its destination at least 15 minutes later than its scheduled arrival time. The *Journal of Transportation* article presented the opinions of leadership from the industry trade organization, Airlines for America, who opined that the Reducing Flight Delays Act of 2013, when enacted, would protect air traffic controllers from budget cut-based furloughs, allowing for more efficient operations in moving passengers throughout the country. Prior to the Act's becoming law in May 2013, air traffic controller furloughs had caused flight delays to triple (*Journal of Transportation,* 2013, p. 33). The repercussions from a continuation of these flight delays, if left uncorrected, could have caused extremely negative consequences for air carriers and air travel, with ripple effects throughout the U.S. economy.

The purpose of this research project was to examine flight delays data to determine if the span of time when furloughs were implemented due to sequestration coincided with an increase in recorded flight delays. Information that was used to support creation and implementation of the Reducing Flight Delays Act of 2013 suggested that the month of April 2013, prior to the Act's enactment, was the time period during which the significant increase in delays occurred.The FAA classification of flight delays uses seven major categories for why aircraft are not on time: Air Carrier, Weather, National Aviation System, Security, Aircraft Arriving Late, Cancelled, and Diverted.

Within the National Aviation System category, there are five subcategories: Weather, Volume, Equipment, Closed Runway, and Other.Delays related to air traffic control fall within the Othersubcategory of the major classification of National Aviation System.

The research question investigated in this study was: Do the BTS data support the statement made in the *Journal of Transportation* (2013) article that furloughs caused flight delays to triple?

2. Review of Related Literature

The related literature seemed to naturally fall into groups of articles describing reasons for flight delays and the various impacts of flight delays. This review also included a report and an article regarding the sequestration events and the related effect.

2.1 Reasons for Flight Delays

There are fewer formal studies of the reasons for flight delays than of the subsequent impact of the flight delays on the commercial aviation industry. This section includes descriptions of what has been described in the existing body of research on reasons for flight delays. In a 2009 study of European airports, Santos and Robin found underlying factors in flight delays were market concentration, slot coordination, hub airports, and hub airlines. Their findings suggested that airlines internalized the effects of self-imposed congestion, but the hub system had higher delays at airports for hub airlines. Laskey, Xu, and Chen (2012) studied factors leading to flight delays to develop a stochastic model using Bayesian Networks that represented the relationships between those factors and their underlying causes. The model could be used to infer expected values and distributions of various delay variables based on changes to the value of a different specific variable.

Pyrgiotis (2011) and Wong and Tsai (2012) studied flight delay propagation. Pyrgiotis (2011) developed an analytical model to study the ripple effect of one delay through the network. The model was designed to be effective for the busiest airports, to "explore at a macroscopic level the implications of a large number of policy alternatives and future scenarios on system-wide delays and associated costs" (pg. 69). Wong and Tsai (2012) used the Cox proportional hazards model to investigate the ripple effect of departure and arrival delay models for a Taiwanese domestic airline. Their resulting hazard ratios produced probabilities of reversing flight delays if different sets of contributing factors were applied. Jungai and Hongjun (2012) used a simulated annealing algorithm to develop an optimization model that would provide information on reducing serious air traffic flight delays, by minimizing an objective function of delay cost.

2.2 Impact of Flight Delays

Researchers across the globe have investigated the effect of flight delays from multiple perspectives. According to Peterson, Neels, Barczi and Graham, almost 25 percent of all U.S. commercial flights were delayed by more than 15 minutes in 2007 (2013, pg. 107). The U.S. Department of Transportation reported the same result for 2011 (Ferrer, et al., 2012). Peterson, et al. (2013) focused on economic costs of flight delays, which they separated into direct and indirect effects. The direct consequences were measured in increased costs for airlines. Indirect impacts were measured in lost labor productivity for business passengers, opportunity cost of time for leisure passengers, and resultant differences in consumer spending on travel and tourism goods and services. They developed a model to estimate increases to U.S. financial welfare based on reductions in the number of delayed flights. For instance, reducing delays by 30 percent estimated increasing U.S. welfare by $38.5 billion (Peterson, et al., 2013).

Lubbe and Victor (2012) also studied the cost of flight delays to corporations, using business travelers from one corporation in South Africa, in which the units measured were man-hours lost. The researchers examined the possibility that a relationship might exist between flight delays and types of travelers (frequent vs. infrequent) as well as flight delays and time periods by month, week, day, and time. Although the findings indicated that the value of the time lost due to flight delays was not considered substantial to the corporation, there were significant relationships between "substantial delays and month, day and time period flown" (2012, pg. 9). Lubbe and Victor (2012) found that 24.3% of the corporate population could be classified as frequent travelers; they experienced 63.5% of the significant flight delays. Ferrer, Oliveira, and Parasuraman (2012) and Britto, Dresner, and Voltes (2012) examined the indirect cost of delayed flights on passengers' flight behavior. Britto, et al. (2012) found that flight delays lead to diminished passenger demand which can, in turn, lead to increased airfares. They suggested that cycle of decreased demand and increased fares would cripple the industry.

2.3 Sequestration

In a May 7, 2013 report for the Congressional Research Service, Elias, Brass, and Kirk explained the reason for sequestration and described its impact on the aviation community. The Congressional budget process of fiscal year (FY) 2013 forced "across-the-board" cuts in funding federal programs via sequestration, based on the Budget Control Act of 2011 (BCA; P.L. 112-25). This Act required automatic reductions to federal discretionary spending whenever the Congressional Joint Select Committee on Deficit Reduction cannot reach an agreement on deficit reduction. Such was the case in the second quarter of FY 2013, and in accordance with the American Taxpayer Relief Act of 2012 (ATRA; P.L. 112-240), nondefense discretionary account spending was reduced by 5.3%. As the largest Federal Aviation Administration (FAA) account is for operations, which includes salaries and benefits for employees, the FAA accomplished its debt reduction by furloughing personnel, including air traffic controllers in April of 2013. FAA efforts to diminish the severity of the impact of the air traffic controller reductions, including rolling furloughs to maintain the air traffic control system and increased aircraft spacing that reduced the number of flights at airports over specific time periods, caused approximately 3% to 4% of flights to be delayed (Elias, et al., 2013). The greatest proportion of these delays was felt in locations where the airspace is most congested, such as New York City. When the rolling furloughs and increased spacing were implemented, major airports in Los Angeles and New York reported flight delays of more than an hour on weekend flights and up to 80 minutes during the workweek (Martin & Flores, 2013). Elias, et al. (2013) shared that the Reducing Flight Delays Act of 2013 (P.L. 113-9) allowed the FAA to suspend employee furloughs and restore air traffic control operations. Elias, et al. (2013) did compare the sequestration-based furloughs to the 2011 FAA furloughs due to the expiration of federal trust and other program expenditure authorities.

2.4 Research Direction

This research study examined the reported reasons for flight delays in various U.S. airports using multiple methods. Preliminary analysis determined if there were any significant differences in the distribution of flight delays by month. More in-depth analysis examined when an increase in flight delays might have occurred, with the intent of determining if a specific cause for flight delays had some association with the given timeframe – April 2013 when air traffic control employees were furloughed due to sequestration.The basis for the research was the question: Do the Bureau of Transportation Statistics data support reported quotes that sequestration led to significant delays in air travel?

3. Method

3.1 Mixed Method Research Design

To explore the potential impacts of sequestration on U.S. airline traffic delays, a mixed methods research design was chosen which combines qualitative and quantitative analysis of data retrieved from the Bureau of Transportation Statistics (BTS). A summary of this simple research design choice is shown in figure 1.

3.2 Sample Design

The Bureau of Transportation Statistics website is a free public website hosted by the Research and Innovative Technology Administration, a subgroup of the U.S. Department of Transportation. Airline delays statistics are presented in calendar month categorized summary data. Data were readily available for all months from June 2003 through August 2013. In addition to categorizing the data in monthly intervals, the data were also organized around common causal categories including: weather, volume, equipment, closed runways, and*other*. The primary causal variable of interest to this research project was the longitudinal data in the National Aviation System (NAS) category, using the Other subcategory. The researchers selected the "other" category, because this variable, more than any other subcategory, was likely to capture the effects of personnel shortfalls in air traffic control facilities (Office of Secretary DOT, 2002).

Data from the BTS website are widely considered reliable. For the purposes of this research project the data from the BTS website will be assumed to be free of bias or skew with regard to airline delay information.

3.3 Qualitative Data Analysis

This research study examined the data by month, focusing on number of delays, to see if there was consistency in the distribution of number of delays over the months of the years used in the sample.

The test used for this analysis was the chi-squared test for homogeneity, testing the relative similarity of the annual distributions of delays. In order to have equal numbers of cells in columns and equal numbers of cells in rows, the monthly frequencies had to be manipulated into year groups that were not associated with a typical calendar. The BTS database did not provide information for months after August 2013, so the months were separated into year groups from September through August (i.e., September 2012 through August 2013).

The conditions required for this test are:

1. The data are multinomial and can be presented in a contingency table.
2. All expected values (within the individual cells of the contingency table) are at least five.
3. The cells have counts (frequencies) rather than percentages.
4. Either row totals or column totals are fixed.
5. The data come from multiple groups and the groups are independent.

The BTS data were able to be manipulated to create a contingency table with rows of year groups and columns of months. The observed cell values and resultant row and column totals were very large compared to five, so all expected values were greater than five. The observed cells included frequencies or actual counts, with both row and column totals fixed (expected row and column totals matched observed), and the year groups were independent of each other.

The hypotheses used for this chi-squared test were:

H_0: The annual distributions of numbers of delays per month were the same.
H_a: The annual distributions of numbers of delays per month were not the same. At least one annual distribution included observed counts (in at least one cell) that were significantly different from the expected frequencies.

A chi-squared test of homogeneity for all year groups from September 2003/August 2004 through September 2012/August 2013 yielded a chi-squared statistic of 19903.24 and corresponding *p*-value less than 0.001, with degrees of freedom equal to 99. Based on these results, the null hypothesis was rejected. There was sufficient evidence at the 0.001 significance level to suggest at least one month in one of the year groups had a significantly different number of delays. Subsequent tests comparing the most recent year group, September 2012 through August 2013, with each other year group individually continued to show a significant difference between the distributions. The hypotheses were modified slightly to match the actual years being tested in each subsequent test. These qualitative results indicated that a quantitative analysis to determine the individual month that might be significantly different should be completed.

3.4 Quantitative Data Analysis

The data coding used by the BTS for airline traffic delays was unmodified during retrieval, handling, and analysis. The data were already well-organized and the coding constructs appeared robust enough for early exploratory research of the impacts of sequestration on delays. The numbers of monthly delays due to NAS Other from June 2003 through August 2013 were downloaded from the BTS website. The monthly delay numbers were sorted chronologically and examined graphicallyin figures 2 and 3.

The dataset distribution appeared to be approximately normal, based on the normal probability plot shown in figure 4. When the overall graph of points in the normal probability plot appears to have some curvature, the researcher can examine the middle 50 percent of the data points for linearity. In figure 4, the middle 50 percent of the normal probability plot appeared very linear, with the elements of curvature at the far ends of the distribution of points. Additionally, if confidence bands were available on the program used to create the plot, it is likely that data points would have been contained within them.

As such, the grand mean and standard deviation were used as the test model for exploration of system variation and effect variation. The mean of the number of NAS Other delays was 1494.033 delays per month with a standard deviation of 907.78. Each individual month of delay data was then tested against the total distribution using a student-t distribution test, using the following hypotheses:

H_0:The monthly number of delays is not significantly different from μ of 1494.033.
H_a: The monthly number of delays is significantly different from μ of 1494.033.

The conditions required for this test are randomization, independence, and normality. Normality was addressed through examination of the graphical displays.

Because data were available from 2003 through 2013 for all air carriers, the researchers opted to use all of the data rather than drawing a random sample. The scope of this project was to examine whether data supported statements regarding the effect of sequestration on air traffic, so the analysis was more descriptive than inferential in nature. Randomization is a condition upon which the probability of inference is based, so although it is important to note that a random sample was not used, the negative effect on the study results may not be as considerable as it would be if the researchers were attempting to produce some sort of generalizable inference for a population. The independence condition would appear to be verifiable when one considered delays from one month to the next.

Seven of the 123 months of data were significantly different than the grand mean model at the α=0.01 significance level: October 2003; November 2003; December 2003; July 2004; April 2004; December 2005, and April 2013. In particular the data from April 2013, which was the month that sequestration had the strongest direct impact on FAA and ATC resources, revealed a *t*-score of 2.400326, which was significantly greater than the mean, using a one tailed t-test, with a resultant *p*-value of 0.008946. Based on this *p*-value, the null hypothesis was rejected. There was sufficient evidence at the 0.008946 significance level to suggest that the number of delays in April 2013 was substantially higher than the expected number of delays.

Because of a concern for normality of the raw data, the researchers transformed the raw data to investigate the null hypothesis with a more normal distribution. Applying a naturallogarithmic transformation to the data produced the probability plot in figure 5.

Using these transformed data values for the raw data number of delays attributed to NAS – Other (with the same hypotheses used in the test of raw data values), the only month that produced a student-*t* score value more than two standard deviations above from the transformed grand mean since December 2005 was the month of April 2013. The student-*t* score was 2.027 yielded a *p*-value of 0.0224. As this *p*-value falls below the (acceptably used) significance level of $\alpha = 0.05$, the null hypothesis was rejected for the transformed data, as well. The month of April 2013 produced a significantly larger number of delays for the category NAS Other than any other month since 2005.

4. Discussion and Conclusions

Through a mixed-method design, incorporating an initial qualitative analysis and subsequent quantitative analysis, the researchers examined the assertion that the time period during which air traffic control employees were furloughed due to government sequester had significantly more flight delays. The chi-squared test of homogeneity supported assertions that there was a significant difference in the number of flight delays for reasons within the NAS – Other subcategory, during at least one year in the past ten years. Additional chi-squared testing indicated that the year from September 2012 through August 2013 included at least one month during which the number of flight delays for reasons within the NAS – Other subcategory that had a significantly different observed number of delays than the expected number. Further investigation through quantitative analysis, using both descriptive – graphing and inferential – student-*t* testing, indicated that in recent years (since 2005) the one month that had a significantly greater number of delays than the grand mean number of delays for a ten-year period was April 2013. This particular month was the month during which government sequestration resulted in furloughs of air traffic control personnel, further supporting the assertions found in articles and pamphlets written about the impact of sequestration on aviation safety. These articles provided a basis for the Reducing Flight Delays Act of 2013. In months after its enactment, there were no statistically significant differences shown for numbers of delays in the NAS-Other subcategory.

A *Journal of Transportation* (2013) article stated that furloughs caused flight delays to triple. The article did not indicate how this statistic was calculated. A comparison of the April 2013 number of delays to the grand mean number of delays did not yield a tripling of this expected value of 1494.033. However, when compared to the mean number of delays for the previous 12-month period (April 2012 through March 2013), the number of delays in April 2013 (x = 3673) is more than three times the average ($\bar{x}$ = 1051.583). An additional comparison of the number of delays in April 2013 to the mean number of delays for the month of April ($\bar{x}$ = 1540), using available data (2004 through 2012) did not show a tripling of the value but did show that it April 2013 had more than double the expected number of delays.

The results of this study indicate that it was highly likely that the furloughs caused by government sequestration led to a significant increase in the number of flight delays until Congressional action allowed the FAA to recall employees from furlough. Additional and more in-depth research might provide more evidence to support the assertion. However, the disaggregated data necessary for such study is not available for public use via the FAA website or the BTS at this time.

Figures

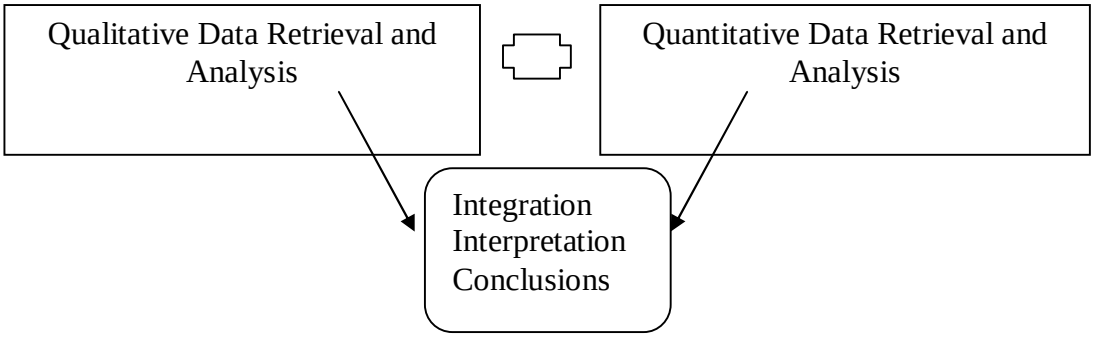

Figure 1: Flowchart of Mixed Methods Design Using Qualitative Data Analysis to Support Quantitative Data Findings

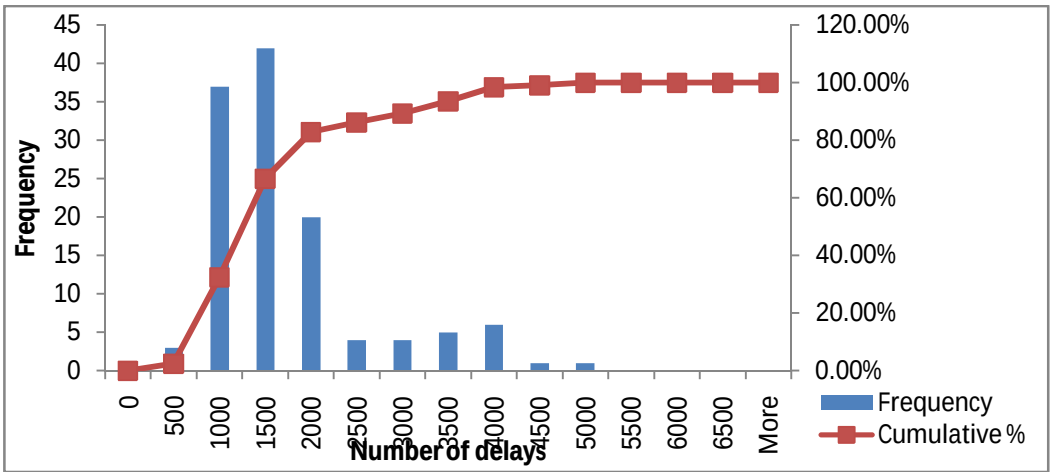

Figure 2: Bar Graph of the Number of NAS Other Delays June 2003 through August 2013

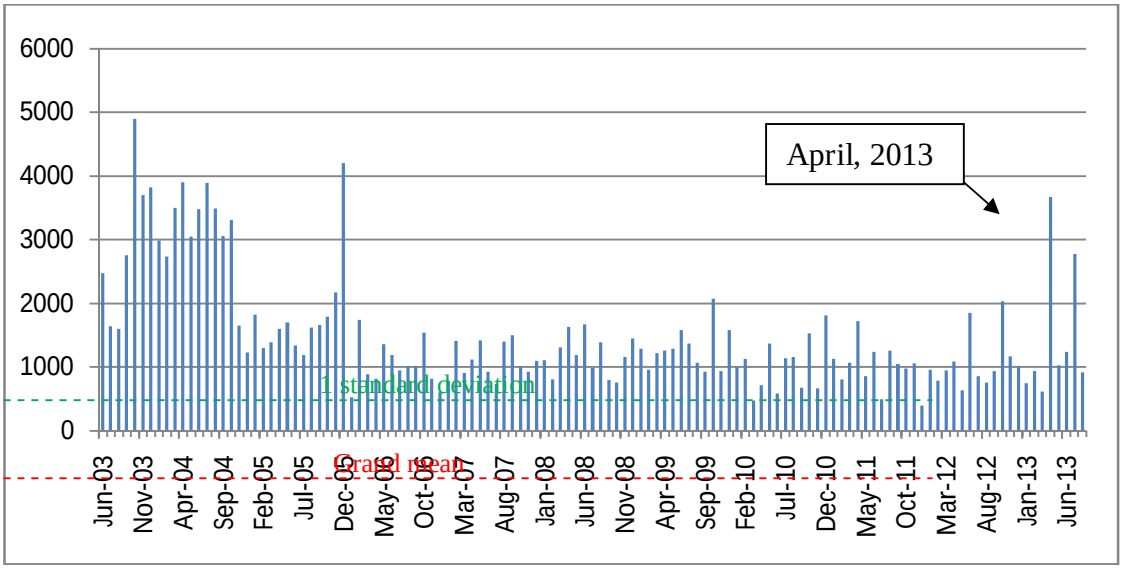

Figure 3: The Number of NAS Other delays from June 2003 through August 2013

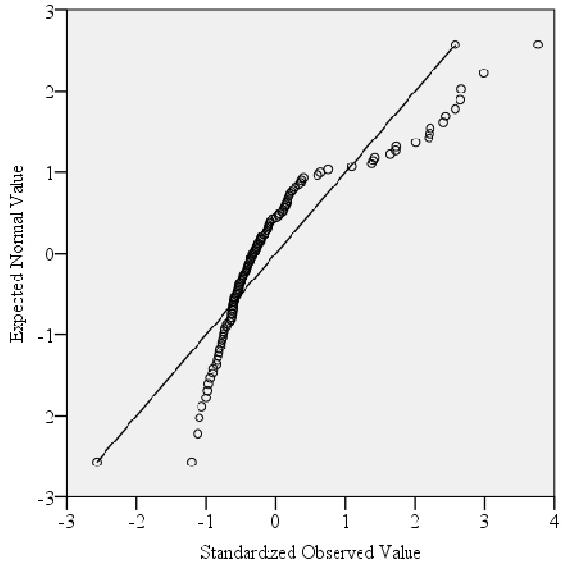

Figure 4: Normal Probability Plot of Frequencies of Delays by Month

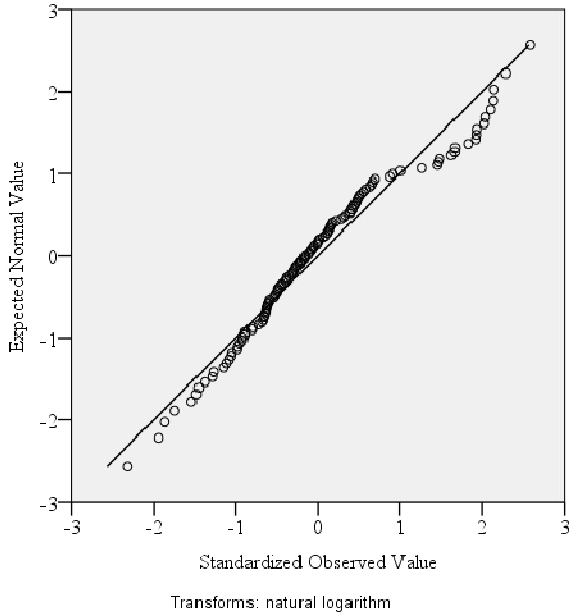

Figure 5: Normal Probability Plot of Transformed Values for Number of Delays By Month

References

(2013 May 18). Airlines for America commends House passage of the "Reducing Flight Delays Act," Journal of Transportation. Retrieved October 1, 2013 from http://search.proquest.com.ezproxy.libproxy.db.erau.edu/docview/1349136466?accountid=27203

Britto, R., Dresner, M., &Voltes, A. (2012). The impact of flight delays on passenger demand and societal welfare, Transportation Research, 48, 460-469.

Bureau of Transportation Statistics (2013, October). On-Time Arrival Performance National. Retrieved October 1, 2013, from http://www.transtats.bts.gov/OT_Delay/OT_DelayCause1.asp

Elias, B., Brass, C.T., & Kirk, R.S. (2013 May 7). Sequestration at the Federal Aviation Administration (FAA): Air traffic controller furloughs and Congressional response. CRS Report for Congress 7-5700, R43065.

Ferrer, J., Oliveira, P.R., &Parasuraman, A. (2012). The behavioral consequences of repeated flight delays, Journal of Air Transport Management, 20, 35-38.

Field, A. (2009). Discovering statistics using SPSS (3rd ed.). Thousand Oaks, CA: SAGE Publications Inc.

Jungai, T., &Hongjun, X. (2012). Optimizing arrival flight delay scheduling based on simulated annealing algorithm, 2012 International Conference on Medical Physics and Biomedical Engineering, 33, 348-353.

Laskey, K.B., Xu, N., & Chen, C-H. (2012 Jun 27). Propagation of delays in the National airspace system. Proceedings of the 22nd Conference on Uncertainty in Artificial Intelligence (UAI2006).

Lubbe, B. & Victor, C. (2012). Flight delays: Towards measuring the cost to corporations. Journal of Air Transport Management, 19, 9-12.

Martin, H., & Flores, A. (2013 Apr 23). Air travelers begin feeling the effects of sequestration, Los Angeles Times, Retrieved October 3, 2013 from https://owa.erau.edu/exchweb/bin/redir.asp?URL=http://articles.latimes.com/2013/apr/23/business/la-fi-airport-sequester-20130423

Peterson, E.B., Neels, K., Barczi, N., & Graham, T. (2013 Jan). The economic cost of airline flight delay, Journal of Transport Economics and Policy, 47(1), 107-121.

Pyrgiotis, N. (2011 Jul 18). Public policy model of delays in a large network of major airports, Transportation Research Record: Journal of the Transportation Research Board, 2206, 69-83.

Santos, G., & Robin, M. (2009 Oct). Determinants of delays at European airports, Economic Analysis of Airport Congestion, Transportation Research Part B, 44(3), 392-403.

Wong, J-T., & Tsai, S-C. (2012 Aug). A survival model for flight delay propagation, Journal of Air Transport Management, 23, 5-11.