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INFORMATION TECHNOLOGY SYSTEM FAILURE AND VALUE OF AIRLINES: A CASE STUDY OF AIRLINES IN 2016

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ABSTRACT

Technology is a critical component of a firm's operations. Technology failures can cause widespread problems in airlines. These failures cause disruptions in flight schedules, cause passengers to be stranded at airports and also increase airline operating costs. The objective of this study is to measure an effect of information technology failures on the firm value of passenger airline companies during the year 2016. In that year, there were cases involving delays and cancellations associated with JetBlue, Southwest, Delta, American, and Virgin America that received significant media coverage. Using the event study methodology, this study finds that the intensity of failures does not seem to affect the firm value as much as the time taken to address it and the presence of other compounding effects. The system failure case provides us with an insight into the effect on market value of airlines especially when they address their issues quickly and efficiently.

Keywords: Event Study, Airline Industry, Stock Returns

1. INTRODUCTION

It is not uncommon to witness airline passengers facing delays during their travel. Sometimes the factors causing these delays are exogenous such as weather or traffic-control issues etc. Under such situations, airlines' liability is smaller and the effect on the airline firm value is relatively less significant. This is especially true if the event is short lived. On the other hand, if the event is caused due to reasons that are endogenous, such as maintenance errors or technology and system failures, investors may not be so forgiving. Endogenous reasons can cause inconvenience to passengers, create trouble with regulators and can damage the safety record and reputation of the company. On the other hand, diligent follow-up during adverse events can effectively work toward rebounding and turning around the reputation of such a company to end up enhancing it (Gokhale et al., 2014a).

In the auto industry, fixes proposed by manufactures through recalls suggest a significant decline in sales, loss of reputation and firm value (as an illustration, see Davidson and Worrell, 1992; Kini, Shenoy and Subramaniam, 2013; Gokhale et al., 2014b and Gokhale and Raghavan, 2015). However, it may not be logical to compare a differentiated oligopoly such as the auto market with the more concentrated passenger airline sector, in which travelers may not have as many options to buy the product due to constraints on schedules, airports, corporate tie-ups and sunk costs from frequent flier relationships or credit card relationships.

Delays in airlines frequently arise when weather is a problem. Situations in which there is ice on the runway may lead to disruptions in take-off and landing and leads to a chain reaction of delays and/ or cancellations of flights. Gokhale and Raghavan (2015) study the effect of weather delays on airline firm value and find that the loss of revenue that results from such delays/ cancellations reflects on the firm value only if the delays are sustained over relatively longer periods of time. Another reason that could lead to a loss of airline firm's market value could be catastrophic events such as 9-11. However, as Guzhva (2008) and Carter and Simkins (2004) found, positive intervention by the Government can help

bring these firms back to profitability. The current study contributes to the existing literature by finding that in the case of information technology failure, rapid intervention by the airline itself can result in little or no loss of reputation.

Information Technology and Airlines

Information technology plays a key role in the smooth functioning of a firm. While any firm relies on its marketing skills to expand its business, its infrastructure consisting of fixed assets is equally important. A lack of support from infrastructure creates frictions in day-to-day operations and leads to several problems such as breakdown of schedules, delay in servicing of aircraft, negative externalities and customer dissatisfaction. The financial value of these disruptions can be measured by a reduction in future profits. Since the stock price of a company is equivalent to the expected discounted value of future cash flows, the stock price reflects this information assuming that the markets are efficient. However, any negative event is likely to adversely affect the expected future profits and causes a negative effect on the stock price.

More recently, passenger traffic in the US airline industry has growing rapidly due to increasing load factors and improving business cycle. An advancement of Information Technology (IT) is also helping sustain this acceleration. Airlines have used IT systems for a wide range of operations which include computerized airline reservation system, flight operations, telecommunications, website, maintenance systems including servers and check-in kiosks. Most of the airlines have their own mobile applications available for the customer, which can be used for various purposes.

Any failure in IT systems causes passengers to be stranded at airports for relatively longer periods of time. As airlines try and bring their operations back to normal, they have to compensate the affected passengers by giving vouchers for food and lodging. Historically, the airline industry has been a pioneer in introducing modern technology with computerized reservations in the 1960s. However, with the same computer systems built more than half a century ago, there is a need for constant updates (Mouawad, 2010). This can occasionally cause failure in transmitting data to other parts of the system or to the passengers. Moreover, consolidation in the US airline industry has led to further complications. A merger of two airlines leads to integration of different systems, a process that can be both complex and time consuming. As an instance when Delta Airlines merged with Northwest Airlines in 2010, it took nearly two years to merge its technology and reservation systems. The former CIO of American Mr. Monte E. Ford who led the airline to its automation in the mid-2000s made the following observation on modernizing technology at airlines,

“It’s like changing the engine of a plane in flight. But we firmly believe consumers will drive the technology, and we are trying to build an environment that will adapt to that.”

Today’s passenger airlines need strong support from their information technology infrastructure to appropriately serve customers, connect with suppliers, perform airport operations and aid operating staff. The year 2016 witnessed a number of cases where this support was lost due to various reasons. In this paper there is an illustration of cases where there was technology disruption in Delta, Southwest, JetBlue and Sabre (an information system support provider). These events are studied in order to assess the impact of internal vs external causes of failure, the impact due to the magnitude of the failure in terms of the number of days during which the services were disrupted and also the number of flights that were cancelled due to the technology breakdown.

Dehning et al. (2005) develop a “firm value framework” model to demonstrate the effect of adoption and updates of information technology on the economic value of a firm. In this research paper, the objective is to investigate the effect of failure in IT systems on the economic value of airlines. Using the Efficient Market Hypothesis (EMH), an empirical assessment is also made in order to determine whether there is

statistical significance in the financial impact felt by airlines. We consider four major events of IT failure that affected the major airlines in 2016 in the United States.

The first event is related to the data systems provided by Verizon to JetBlue. JetBlue relies completely on Verizon's Data Center to provide data and backup for its reservation and scheduling system. There was a power outage at a data center on the morning of January 14, 2016 (Mutzabaugh, 2016). Customers faced trouble to access the JetBlue website and mobile app (Chernicoff, 2016). Moreover, there were problems with check in and printing of boarding passes (Pramuk, 2016). While reservations and airport check-in services were restored within a few hours, complete restoration of all services was not achieved until that night. Consequently, travelers reported long lines at JetBlue hubs. More than 200 flights were delayed and 4 flights were cancelled by the afternoon (Sverdlik, 2016). This represents roughly 25% of the airline's daily traffic.

In the second event, there was a failure of the switchgear assembly at Southwest airlines that occurred on July 20, 2016 (Preimesberger, 2016). However, "the way the router failed", according to its CEO Mr. Gary Kelly, "the partial failure of the router meant that backup systems did not take over the broken-down processes in time" and this led to a cascade of multiple system failures (Shine, 2016b). Consequently, the airline had to cancel nearly 2,000 flights in five days. This is roughly equivalent to 11% of its peak total volume of flights (Shine, 2016a). In addition to the cancellations, more than 1,300 flights were delayed.

The third event of IT failure occurred when the switch that provides power supply to the servers at Delta Airlines crashed on August 8, 2016. Although Delta responded swiftly, the delays and cancellations could not be avoided for two days (Kurtz, 2016). About 2000 flights were cancelled, which represented roughly 20% its total flights per day and more than 1,932 flights were delayed. Mysteriously, the servers at Delta did not switch to the back up system at the time of outage, which is what led to the cascade effect of pressure on multiple systems (Isidore, 2016).

The final event under study is the outage that occurred on October 17 of 2016 at Sabre. This company hosts information on ticketing and reservations of airlines on its servers (Schlangenstein, 2016). This company also provides real-time data services to websites like Expedia and Travelocity. Additionally, it also hosts reservation information for several hotels. The outage at Sabre prevented customers from booking flights. Sabre is widely used by many airlines. As a result of the outage, American, Southwest Airlines, JetBlue Airways and Virgin America reported problems in their reservation system. American reported delays in 200 flights and 11 cancellations (Koenig, 2016), whereas Southwest reported an effect on the bookings of its domestic flights. JetBlue reported problems in booking with its mobile application and Virgin reported problems when passengers were attempting online check-in.

2. EVENT STUDY METHODOLOGY

The foundation of measuring the impact of the surprise created by a favorable/ adverse event is rooted in the measurement of financial information of a firm available from the stock markets. If R_{it} is the return from the stock of a company, then R_{it} can be measured using the stock price and dividends (if any) paid out by the company. This is correlated with the market returns by the following model

$$E(R_{it}/X) = \beta_0 + \beta_1 R_{mt} \quad \dots(1)$$

$$\text{Or} \quad R_{it} = \hat{\beta}_0 + \hat{\beta}_1 R_{mt} + \epsilon_{it} \quad \dots(2)$$

Where R_{it} is the return from the stock of company 'i' on day 't'
X is exogeneous information that determines the stock return R_{it}

As a special case, we can assume that if there are no other drivers that cause fluctuations to the stock price of company 'i', then the only factor causing a movement in the stock price is R_{mt} the return from the overall stock market.

$\hat{\beta}_0$ and $\hat{\beta}_1$ are respectively the intercept and the slope parameters of equation (1)

ϵ_{it} is random walk that is expected to follow a normal distribution. The normality assumption is asymptotically met because the number of observations in the data set are sufficiently large enough in this dataset.

Equation (1) is called the market model and is based on the assumption that markets are perfectly efficient, implying that any new information about a company is reflected from its stock price. This methodology was introduced by Ball and Brown (1968) and Fama, Fisher, Jensen and Roll (1969). It has been reviewed by MacKinlay (1997), Bhagat and Romano (2002a and 2002b) and by Corrado (2011). Keeping in mind the increased volatility of financial markets, Marshall et al. (2018) study the specification of event studies for intraday test statistics. Any shock due to new information about a company is transmitted instantaneously to its stock price (Brooks et al., 2003). The event study method has been extensively used to study the effect of favorable/ adverse shocks on the value of companies.

Equation (1) is estimated in the empirical literature through ordinary least squares (See Jarrell and Peltzman (1985), Hoffer, Pruitt and Reiley (1998), Wood and Gokhale (2018), Gokhale et al. (2014) and Gokhale and Raghavan (2015)) under the assumption that any new information pertaining to the value of an asset is immediately factored into its price. In other words, this model assumes that the financial markets are efficient. If there is a shock that changes the information about a company 'i', then the effect of this shock can be measured by error term. We call this abnormal return of the stock \widehat{AR}_{it} , which is given by

$$\widehat{AR}_{it} = R_{it} - \hat{R}_{it} \quad \dots(3)$$

And, \hat{R}_{it} is obtained from the predicted value of R_{it} from the model estimated through equation (2).

If the shock continues over a certain period of time say T , then we can define cumulative abnormal returns \widehat{CAR}_{iT} as

$$\widehat{CAR}_{iT} = \sum_{\tau=1}^T \widehat{AR}_{i\tau} \quad \dots(4)$$

Cumulative abnormal returns (CARs) measure the sum total of the effect of the abnormal returns arising out of a given event over a period of "T" days. One can test the significance of \widehat{AR}_{it} and \widehat{CAR}_{iT} . The null hypothesis for the test is that \widehat{AR}_{it} or \widehat{CAR}_{iT} are not significantly different from zero implying that the event had no effect on the stock returns of the company, i.e. investors do not perceive that the event caused any damage to either the profitability or the reputation of the firm.

When ARs and CARs are reported, it needs to be ascertained whether these are significant. On one hand, large abnormal return that is not significant does not mean anything for the firm value because it is not significantly different from zero. On the other hand, a small abnormal return that is significant also does not mean much. The only information that can be gleaned from such an abnormal return is that the event has a small but significant effect on the value of the firm. There are certain parametric and non-parametric tests available, which help evaluate the significance of ARs and CARs. The parametric test involves finding the variance of abnormal returns and cumulative abnormal returns and have been discussed in previous research. See Patell (1976), McWilliams and McWilliams (2000) & McWilliams and Siegel (1997). In addition to the parametric tests, there are non-parametric rank and sign tests to evaluate

the significance of ARs and CARs. See MacKinlay (1997), Corrado (1989, 2011), Corrado and Zivney (1992).

3. DATA AND ESTIMATION RESULTS

The dataset used for this study includes information on stock price of airlines Delta, Southwest, JetBlue, American and Virgin America and for information technology support companies Verizon and Sabre. Information on stock prices and returns was obtained from Yahoo! Finance. Returns are defined as the daily change in the stock price, including dividends if any. Table 1 below summarizes different event dates, estimation and event windows for each case of technology failure. Each estimation window covers a period of 1 year prior to the event. This includes 251 trading days for each event. The event window for each event covers a period of 11 trading days. Since all events occurred on the day stock markets were trading, stock price information for day zero could be affected by the event. Therefore, the event window for all four cases starts on day zero. However, it is significant to note that not all event windows start on day zero. Shocks such as earnings surprises that occur after the markets stop trading are typically covered with event windows that start on day 1.

Table 2 below discusses the summary statistics of the four events. Stock specific returns for estimation window vary between -9% (Southwest, in the estimation window for event 2) and 8.8% (JetBlue in the estimation window for event 1). Market returns for estimation window vary between -4.1% (events 1, 2 and 3) and 4% (events 2 and 3). In each event, neither returns from a stock nor the returns from overall markets were significantly different from zero at 10% significance during a means comparison test.

<i>Event</i>	<i>Event Date</i>	<i>Estimation Window dates</i>	<i>Event Window dates</i>	<i>Event Description</i>
<i>Event 1</i>	01/14/2016	1/15/15 to 1/13/16 (251 days)	1/14/16 to 1/29/16 (11 days)	There was a system failure at the Verizon data center which led to problems with online check-in and boarding of JetBlue flights.
<i>Event 2</i>	07/20/2016	7/22/15 to 7/19/16 (251 days)	7/20/16 to 8/3/16 (11 days)	There was a system failure at Southwest airline which led to cancellation of over 2000 flights and delay of another approximately 1300 flights.
<i>Event 3</i>	08/08/2016	8/10/15 to 8/5/16 (251 days)	8/8/16 to 8/22/2016 (11 days)	There was a system failure at Delta airlines, which led to a cancellation of 2300 flights and delay of approximately another 1900 flights.
<i>Event 4</i>	10/17/2016	10/19/15 to 10/14/16 (251 days)	10/17/16 to 10/31/2016 (11 days)	There was a system failure at Sabre, which led to delay of 200 flights and cancellation of 11 flights and a disruption in reservation system, online booking and online check-in.

Table 1: Description of estimation and event windows for four events of technology failure in airlines in 2016 at Verizon and JetBlue (Event 1), Southwest (Event 2), Delta (Event 3) and Sabre (Event 4)

Event	Variable	Description	N	Mean	Std. Dev.	Min.	Max.
Event 1: Tech. failure at JetBlue	R _{1t}	returns from JetBlue stock	251	0.002	0.023	-0.079	0.088
	R _{2t}	returns from Verizon stock	251	-0.000	0.010	-0.030	0.038
	R _{mt}	returns from S&P 500	251	-0.000	0.010	-0.041	0.038
Event 2: Tech. failure at Southwest	R _{1t}	returns from Southwest stock	251	0.001	0.019	-0.092	0.074
	R _{mt}	returns from S&P 500	251	0.000	0.011	-0.041	0.040
Event 3: Tech. failure at Delta	R _{1t}	returns from Southwest stock	251	-0.001	0.021	-0.082	0.056
	R _{mt}	returns from S&P 500	251	0.000	0.011	-0.041	0.040
Event 4: Tech. failure at Sabre	R _{1t}	returns from Southwest stock	251	0.000	0.020	-0.112	0.074
	R _{2t}	returns from JetBlue stock	251	-0.001	0.023	-0.091	0.080
	R _{3t}	returns from Virgin America	251	0.002	0.032	-0.065	0.417
	R _{4t}	returns from Sabre stock	251	-0.000	0.017	-0.083	0.075
	R _{mt}	returns from S&P 500	251	0.000	0.009	-0.036	0.025

Table 2: Summary statistics of the returns from each airline and market returns performed for each event which include the number of observations, the minimum, maximum, the standard deviation and the average of the returns for the period under study.

The regression results for each stock in events 1, 2 and 3 are displayed in table 3 (a), while those for each stock in event 4 are shown in table 3 (b) below. In each case there is a positive and significant relationship between the stock returns and the market returns. From event 1, the coefficient for Verizon (0.74) is much less volatile than that for JetBlue (1.12). From event 2, although the coefficient of market return is close to 1, the parameter estimate for r_{mt} in event 2 (Southwest) is not significantly different from 1. However, the parameter estimate is significantly different from that of JetBlue (1.197) at 10% level of confidence. Furthermore, for event 3 (Delta) the parameter estimate (1.179) is significantly different from that obtained for r_{mt} in both Events 1 and 2 at 5% level. This indicates that the relationship of the slope parameter for each airline with market returns is different from other airlines in different events. Overall, the returns of Verizon (0.74, event 1) and Virgin America (0.60, event 4) were the least sensitive to market returns and those of American (1.46, event 4) and JetBlue (1.31 in event 4) were the most sensitive to market returns. The parameter estimate for β_1 was significant at 0.1% level for all the regression models under study indicating a highly significant correlation of these stocks with overall markets.

	Event 1		Event 2	Event 3
Dependent Variable	Returns from Verizon Stock	Returns from JetBlue Stock	Returns from Southwest Stock	Returns from Delta Stock
Intercept	0.000	0.002	0.001	-0.001
(standard error)	(0.000)	(0.001)	(0.001)	(0.001)
coefficient of r_{mt}	0.739***	1.197***	0.983***	1.179***
(standard error)	(0.043)	(0.128)	(0.092)	(0.100)
N	251	251	251	251
R ²	0.540	0.259	0.320	0.357
Prob-F	0.000	0.000	0.000	0.000

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

Table 3a: Regression results for estimation period in events related to technology failure in airlines in 2016 for event 1 (Verizon and Jetblue), Event 2 (Southwest) and Event 3 (Delta)

Dependent Variable	Event 4				
	Returns from Sabre Stock	Returns from JetBlue Stock	Returns from Southwest stock	Returns from American stock	Returns from Virgin America stock
Intercept	-0.001	-0.001	0.000	-0.001	0.002
(standard error)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
coefficient of r_{mt}	1.031***	1.309***	1.235***	1.458***	0.603***
(standard error)	(0.098)	(0.137)	(0.118)	(0.135)	(0.221)
N	251	251	251	251	251
R ²	0.310	0.268	0.307	0.320	0.029
Prob-F	0.000	0.000	0.000	0.000	0.007

***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$

Table 3b: Regression results for estimation period in events related to technology failure in airlines in 2016 for event 4 (Sabre, JetBlue, American and Virgin America)

Abnormal returns and cumulative abnormal returns for each stock in each event are as shown in table 4 at the end of this paper. To check whether cumulative abnormal returns drop after each event, these are plotted against time for each event in figures 1 through 4 at the end. In the first event, when there was a system failure at Verizon that led to problems with check-in and boarding at JetBlue, the abnormal returns of JetBlue were negative only on day 2 but not statistically significant (at 10%). CARs for the company were not negative from days zero through 8 (table 4, panel 1). On January 28, 2016 (day 9), JetBlue reported its results for the fourth quarter of 2015. Although its revenues and profits exceeded investor expectations, volatility in fuel prices and slower outlook for tourism related revenues caused negative and significant abnormal returns on that day as seen in Figure 1 (Zacks equity research, 2016). Similarly, abnormal returns and cumulative abnormal returns from Verizon stock are not statistically significant on the event day, indicating no effect on the company's value as perceived by the investors (Figure 1) from technology failure. In fact, according to CNN Money, investors kept pouring into the Verizon stock and other high dividend stocks such as utilities due to weakness of overall stock markets and rotation into income stocks (La Monica, 2016). This explains why CAR for Verizon stock reached positive 10.9% by day 8 and was significant at 1%.

In the second event of system failure at Southwest airlines, the company saw its abnormal returns dip by 2.1% on day zero and by another 10.9% on day 1. The effects on day 1 were compounded by Southwest reporting its earnings for second quarter of 2016 (Figure 2). According to its press release, although the company booked record profits, they missed investor expectations. Even as the company claimed it had fixed the problem, delays and cancellations kept mounting and its cumulative abnormal returns went down to 18.1% by August 2, 2016 (day 9). According to the CEO Mr. Gary Kelly, this event was

expensive and the company was worried about the financial impact. However the top management was even more worried about its brand reputation and inconvenience caused to customers (Jansen, 2016). According to the company's press release when it reported its results for third quarter of 2016, it lost \$ 55 million of revenues approx. and \$ 24 million in additional expenses related to the failure. The Southwest case demonstrates that if technical issues do not get resolved quickly, investors tend to feel more nervous about the stock.

In the third event at Delta Airlines, abnormal returns were negative for the first three days. However, these were not significant at 10% (Table 4, panel 3). Even by day 4, cumulative abnormal returns (CARs) reached negative 3.2% (Figure 3). The company scrambled to address the issue and restore its operations within three days. Unlike southwest, there were no confounding effects for Delta. Also since Delta's operations are larger and the impact was slightly less on that airline as compared to Southwest. This explains why the airline stock did not witness as negative and significant cumulative abnormal returns as other airlines. However, CNN Money reported the loss due to this five-hour disruption to the airline was \$ 150 million (Isidore, 2016, Ostrower, 2016 and the press release reporting results for third quarter 2016 for the company).

In the fourth event, the systems operated by Sabre Corporation failed, resulting in delays to flights operated by almost all major airlines except United and Delta. Consequently, the shares of Sabre suffered negative abnormal returns for days 1, 2 and 3, with those on day 3 being significant at 10% (Figure 4(a)). However, none of the affected airlines showed abnormal returns and cumulative abnormal returns that were significant at levels as high as 10% (Table 4 panel 4 and figure 4(b)). On the other hand, Sabre did witness a dip in its CARs up to negative 3.1% on day 3. AR for that day was negative and significant at 10%.

This demonstrates that investors viewed technology failure as a significant event from the perspective of the provider of technology, i.e. Sabre Corp., but considered it as an exogeneous event from the airlines' perspective, similar to the JetBlue case in event 1. Therefore the affected airlines did not witness a financial market impact from this event, even though there was operational difficulty.

4. CONCLUDING REMARKS

Recently, all major airlines have faced problems due to failure in technology. The current study chooses the calendar year 2016 as a sample to evaluate and demonstrate the effects of technology failure on firm value of affected airlines and IT service providers. The main inference is that when technology failure causes delays or cancellations of flights, even when the technical issue is widespread across the airline's operations such as crew scheduling, flight scheduling, passenger back-up and reservation spillovers, if the problem is addressed swiftly, the drop in market value of the affected airline is neither sharp nor statistically significant as seen in the case of JetBlue (event 1), Delta (event 3), American (event 4), Southwest (event 4), JetBlue (event 4) and Virgin America (event 4). However, if the problem drags on and/ or gets compounded with other issues such as negative earnings surprise, perfect information transmission through the financial markets tends to demonstrate an evidence for more negative and statistically significant abnormal and cumulative abnormal returns.

Gokhale and Raghavan (2015) find a similar evidence in case of airlines affected by weather delays. The future scope of this work could be to find the threshold for such a drop in firms' market value. However, this can be limited by use of data from over different periods of time in which investor behavior may change significantly, thereby making such comparisons harder.

Day	Panel 1			
	Ar _{1t}	CAR _{1t}	AR _{2t}	CAR _{2t}
0	0.013 (0.657)	0.013 (0.513)	0.004 (0.613)	0.004 (0.479)
1	0.024 (1.195)	0.038* (1.389)	0.006 (0.888)	0.010 (1.126)
2	-0.024 (-1.190)	0.014 (0.399)	0.009* (1.312)	0.019** (1.666)
3	0.042** (2.053)	0.055* (1.487)	0.000 (-0.073)	0.019* (1.496)
4	-0.009 (-0.440)	0.047 (1.065)	0.029*** (4.173)	0.047*** (3.216)
5	0.007 (0.335)	0.053 (1.032)	0.010* (1.506)	0.058*** (3.312)
6	0.019 (0.940)	0.072* (1.357)	0.011* (1.605)	0.069*** (3.817)
7	-0.018 (-0.866)	0.055 (0.926)	0.016** (2.317)	0.085*** (4.236)
8	-0.004 (-0.197)	0.051 (0.829)	0.024*** (3.542)	0.109*** (5.261)
9	-0.071*** (-3.480)	-0.020 (-0.301)	-0.004 (-0.615)	0.105*** (4.738)
10	0.039** (1.894)	0.019 (0.267)	0.002 (0.232)	0.106*** (4.397)

(***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$)

Table 4 Abnormal returns (ARs) and Cumulative abnormal returns (CARs)
for company 'i' at time 't' for events 1, 2, 3 and 4 with significances, standard error in parenthesis
Panel 1: Event 1 – Companies JetBlue ('i' = 1) and Verizon ('i' = 2)

Day	Panel 2		Panel 3	
	AR _{1t}	CAR _{1t}	AR _{1t}	CAR _{1t}
0	-0.021* (-1.336)	-0.021 (-1.252)	-0.005 (-0.262)	-0.005 (-0.265)
1	-0.109*** (-6.925)	-0.130*** (-5.815)	-0.008 (-0.440)	-0.012 (-0.495)
2	0.008 (0.529)	-0.122*** (-4.332)	-0.014 (-0.828)	-0.026 (-0.892)
3	-0.011 (-0.674)	-0.133*** (-4.142)	0.001 (0.084)	-0.025 (-0.712)
4	0.023* (1.478)	-0.109*** (-3.048)	-0.008 (-0.443)	-0.032 (-0.834)
5	-0.021* (-1.314)	-0.130*** (-3.319)	0.013 (0.766)	-0.019 (-0.449)
6	-0.002 (-0.144)	-0.132*** (-3.114)	0.008 (0.437)	-0.012 (-0.257)
7	-0.015 (-0.934)	-0.147*** (-3.223)	0.014 (0.821)	0.002 (0.047)
8	0.001 (0.048)	-0.146*** (-3.024)	-0.013 (-0.784)	-0.011 (-0.212)
9	-0.035** (-2.222)	-0.181*** (-3.590)	-0.005 (-0.319)	-0.017 (-0.300)
10	0.006 (0.369)	-0.175*** (-3.291)	-0.003 (-0.198)	-0.020 (-0.344)

(***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$)

Table 4 Abnormal returns (ARs) and Cumulative abnormal returns (CARs) for company 'i' at time 't' for events 1, 2, 3 and 4 with significances, standard error in parenthesis
 Panel 2: Event 2 – Southwest Airlines ('i' = 1)
 Panel 3: Event 3 – Delta Airlines ('i' = 1)

Panel 4 – Part 1						
day	AR _{1t}	CAR _{1t}	AR _{2t}	CAR _{2t}	AR _{3t}	CAR _{3t}
0	0.004 (0.298)	0.004 (0.328)	0.002 (0.140)	0.002 (0.154)	0.002 (0.095)	0.002 (0.104)
1	-0.008 (-0.557)	-0.004 (-0.177)	0.003 (0.174)	0.005 (0.215)	-0.006 (-0.326)	-0.005 (-0.158)
2	-0.007 (-0.484)	-0.010 (-0.410)	0.010 (0.617)	0.016 (0.514)	0.024 (1.203)	0.019 (0.536)
3	-0.021* (-1.475)	-0.031 (-1.080)	0.003 (0.193)	0.019 (0.547)	0.023 (1.193)	0.042 (1.053)
4	0.015 (1.109)	-0.015 (-0.483)	0.003 (0.163)	0.022 (0.560)	-0.001 (-0.050)	0.042 (0.920)
5	-0.005 (-0.328)	-0.020 (-0.563)	-0.008 (-0.452)	0.014 (0.327)	0.005 (0.273)	0.047 (0.935)
6	0.006 (0.429)	-0.014 (-0.371)	-0.005 (-0.287)	0.009 (0.202)	-0.031* (-1.561)	0.016 (0.304)
7	-0.009 (-0.643)	-0.023 (-0.571)	-0.082*** (-4.879)	-0.073* (-1.497)	-0.025 (-1.269)	-0.009 (-0.153)
8	0.004 (0.267)	-0.019 (-0.454)	0.025* (1.495)	-0.048 (-0.930)	-0.006 (-0.311)	-0.015 (-0.247)
9	0.010 (0.682)	-0.010 (-0.220)	0.002 (0.126)	-0.046 (-0.847)	-0.001 (-0.033)	-0.015 (-0.246)
10	0.007 (0.485)	-0.003 (-0.065)	0.022* (1.316)	-0.023 (-0.414)	0.014 (0.709)	-0.002 (-0.023)

(***: $P < 0.01$, **: $p < 0.05$, *: $p < 0.1$)

Table 4 (continued) Abnormal returns (ARs) and Cumulative abnormal returns (CARs) for company 'i' at time 't' for events 1, 2, 3 and 4 with significances, standard error in parenthesis
Panel 4 : Event 4 – Part 1 - Companies Sabre ('i'=1), Southwest ('i'=2), Jetblue ('i'=3)

Panel 4 – part 2				
Day	AR _{4t}	CAR _{4t}	AR _{5t}	CAR _{5t}
0	0.004 (0.197)	0.004 (0.217)	0.034 (1.070)	0.034 (1.175)
1	0.011 (0.590)	0.015 (0.538)	-0.001 (-0.040)	0.033 (0.704)
2	0.029* (1.515)	0.044 (1.269)	-0.003 (-0.089)	0.030 (0.519)
3	0.002 (0.119)	0.047 (1.178)	0.003 (0.085)	0.033 (0.500)
4	-0.017 (-0.889)	0.030 (0.667)	0.010 (0.330)	0.043 (0.591)
5	-0.007 (-0.384)	0.022 (0.450)	-0.003 (-0.091)	0.040 (0.496)
6	0.002 (0.100)	0.024 (0.459)	0.005 (0.168)	0.045 (0.527)
7	-0.006 (-0.303)	0.018 (0.327)	-0.015 (-0.484)	0.030 (0.329)
8	0.019 (1.009)	0.038 (0.641)	-0.004 (-0.132)	0.026 (0.268)
9	0.009 (0.447)	0.046 (0.751)	0.001 (0.018)	0.027 (0.262)
10	0.014 (0.725)	0.060 (0.930)	-0.005 (-0.155)	0.022 (0.203)

(***: $P < 0.01$, **: $p < 0.05$, *: $p < 0.1$)

Table 4 (continued) Abnormal returns (ARs) and Cumulative Abnormal returns (CARs) for company 'i' at time 't' for events 1, 2, 3 and 4 with significances, standard error in parenthesis
Panel 4 : Event 4 – Part 2 - Companies American ('i'=4) and Virgin America ('i'=5)

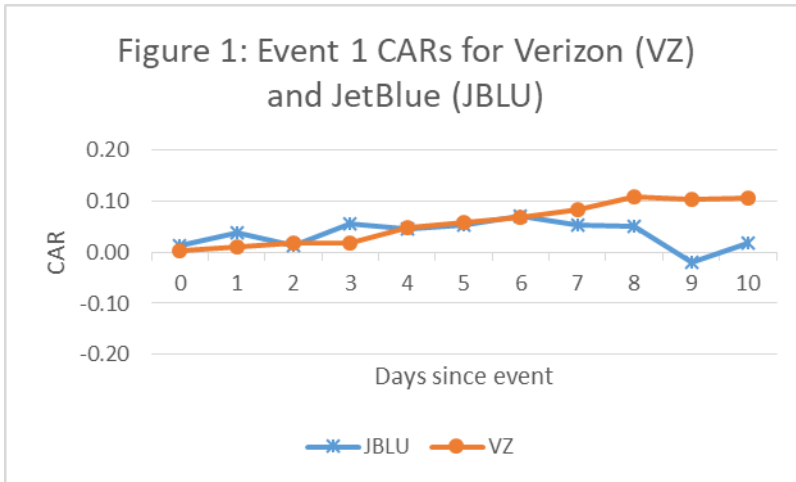


Figure 1: Cumulative abnormal returns (CARs) for Event 1

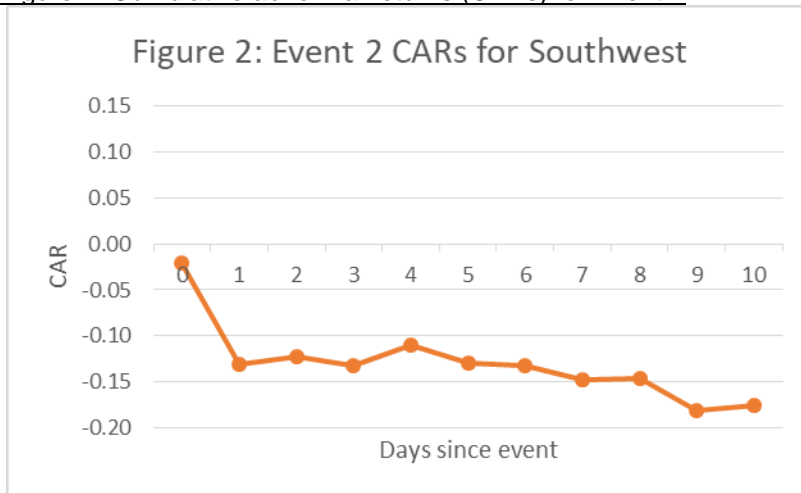


Figure 2: Cumulative abnormal returns (CARs) for Event 2

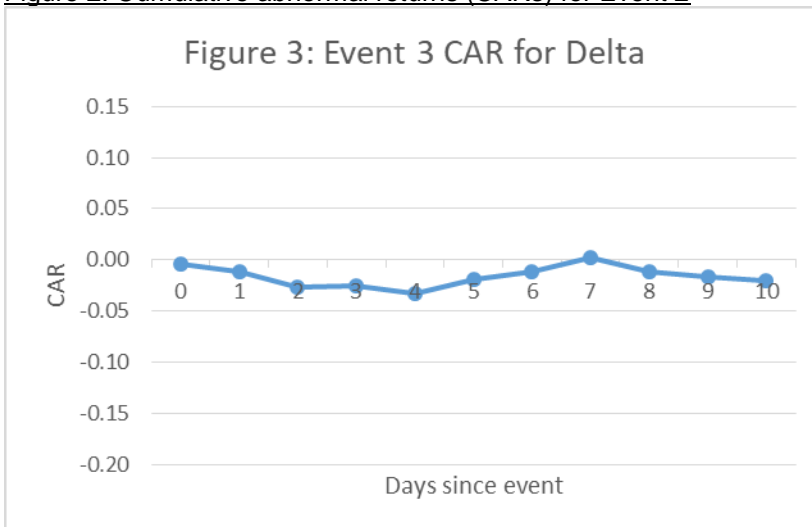


Figure 3: Cumulative abnormal returns (CARs) for Event 3

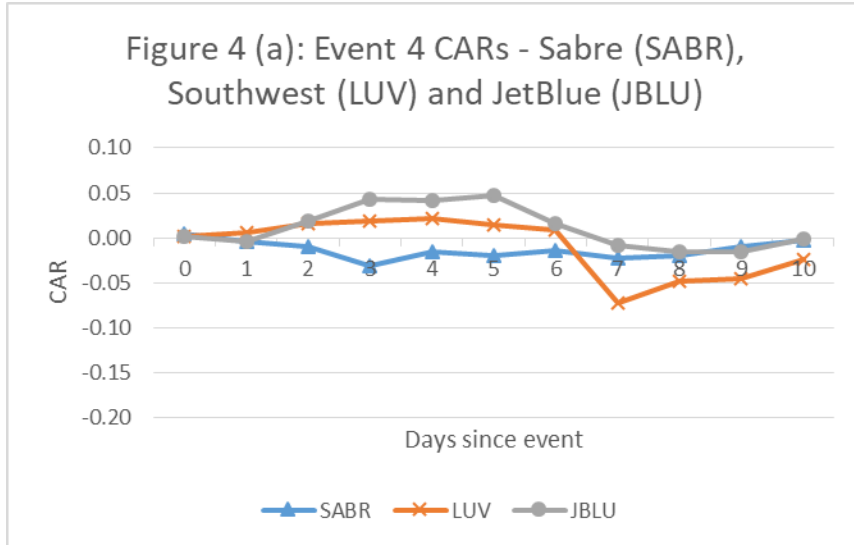


Figure 4 (a): Cumulative abnormal returns (CARs) for Event 4

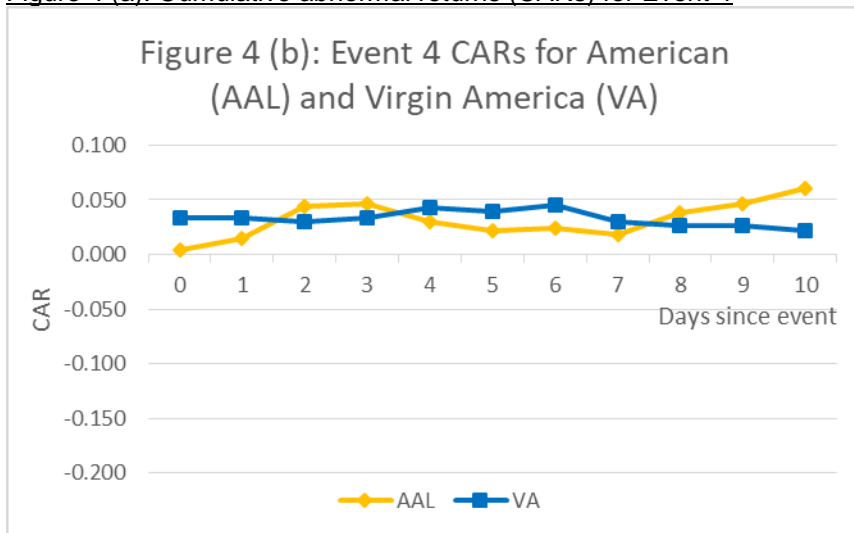


Figure 4 (b): Cumulative abnormal returns (CARs) for Event 4

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