The Effect of Dominant Airlines and Dominated Routes on the Timeliness and Reliability of Flights

Joshua Catalano
Department of Economics, University of Colorado at Boulder

Primary Thesis Advisor
Dr. Jeffrey Zax, Department of Economics

Committee Members
Dr. Jeffrey Zax, Department of Economics
Dr. Martin Boileau, Department of Economics
Dr. J. Anthony Cookson, Leeds School of Business--Finance

Defended April 3rd, 2014

Abstract

This paper investigates the effect of route-specific market share and route-day market concentration on quality-related variables pertaining to the reliability of airlines, such as cancellation status and diverted status, and the timeliness of airlines, such as flight time and arrival delay. When implementing a fixed effects model, the effects of route-specific market share and route-day market concentration on reliability are statistically insignificant. Route-day market concentration affects average arrival delay but not average flight time. Route-specific market share's effect on both measurements of timeliness, however, is significant and U-shaped. That is, in the absence of significant weather conditions, firms with low levels of market share experience decreases in average arrival delay and average flight time as their market share increases, but as market share passes a threshold, increases in an airline's market share begin to increase average arrival delay and average flight time. When weather conditions become problematic, this U-shaped curve inverts, and increases in market share harm the timeliness of small firms. After a relatively large market share is attained, these increases in market share become beneficial for timeliness in the presence of adverse weather.

Introduction

Capital-intensive industries tend to operate in an oligopolistic fashion. The need for large amounts of capital impedes the entry of new firms into the industry and bestows the few firms that operate in the market with substantial market shares. Airline providers, due to the high cost of business and the presence of natural efficiencies, enjoy considerable market share and operate within an oligopolistic market structure (Rubin, 2005). This paper investigates how the route-specific market share of an air carrier affects consumer welfare through the quality of airline service provided on that route.

This question is pertinent because a firm's profit-optimizing amount of quality might depend on their market share. Just as firms with market power can raise prices when competition is scarce, it is possible that firms with significant market share can sacrifice the quality that they provide to the customer in order to cut costs. This research proposes that air carriers with low market shares will provide higher levels of quality as their market share increases. Small firms that want to attract patrons will need to offer high levels of quality in order to divert business away from larger firms and will have more ability to do so as they experience the natural efficiencies of having larger market shares. Once a firm passes a certain threshold, however, market share might start to decrease the quality of air carrier service because competitive pressure to supply high quality service will diminish, and consumers will have fewer options to choose from.

When considering the timeliness and reliability of an airline, as this study does, many might ask how cost-cutting measures would result in the deterioration of these quality-related variables. The channel through which this paper expects cost cutting measures to deteriorate these measures of quality is a firm's decision to invest in capital and labor. For instance, when an airline decides how many fuel trucks they need at a given airport, how many laborers they need to hire for loading and unloading planes, or how to allocate those resources among simultaneous flights to different destinations, they must weigh the costs of an additional truck or an additional baggage handler against the benefits of having that additional unit of capital or labor. They must also consider the benefits and costs of prioritizing flights that take off at similar times.

One of the benefits of having more trucks or laborers would be the speed with which an airline could prepare its planes for flight. The timeliness and reliability of air travel is important to consumers and airlines alike. On-time planes contribute to the coherence of an airline's schedule, and consumers prefer to be on time so they can adhere to their own schedules. Pleasing the customers in this way helps ensure their continued business. In competitive markets, where consumers have a lot of choices, we would expect timeliness and reliability to have a large impact on customer retention because a disgruntled customer could choose to fly with another airline on their next business trip or family vacation. Markets that are dominated by a small number of firms or at least one large firm, however, provide fewer options to consumers, so a customer would be less likely to change their air carrier despite having a bad experience with their current one.

Therefore, firms with small market shares or firms in competitive markets might decide to make that extra investment in capital or labor while firms that dominate the market that they operate in might be less likely to make that investment. That is, we would expect airlines with high market shares or airlines that operate in concentrated markets to cut costs, with the consequence of a degradation of timeliness and reliability. Airlines with low market shares or airlines that operate in relatively dilute markets will be more likely to provide these investments because customer retention is a bigger worry for these airlines. It is likely that firms that dominate a market will have larger total investments in these production inputs, but it is possible that their investment per unit flight is smaller and consequently, their provided quality is inferior.

Literature Review

When competition is introduced into a market, prices for goods in that market tend to decrease. Although low-cost carrier competition has been shown to have a substantial effect on airfares, legacy carrier competition tends to have little influence on airfares (Brueckner et al, 2013a). Airlines are quick to respond to the price changes of competitors, and customers frequently end up making decisions about their air carrier by considering the amenities of the air carrier such as frequent flyer programs, food service, arrival delay, and other various metrics for quality (Jones and Sasser, 1995; Chen et al, 2013; Chang et al, 2002).

Airline studies find that the quality provided by an air carrier affects the consumption decisions, customer retention, and participation of consumers in the market (Jones and Sasser, 1995; Chen et al, 2013; Chang et al, 2002). Air carriers can benefit from adjusting the quality of service that they provide in order to optimize profits, and their profit-maximizing amount of quality might depend on their dominance of the market.

Airport-pair market share is found to be especially impactful on the price-based decisions that an airline makes (Jones and Sasser, 1995; Brueckner et al, 2013b). If a carrier's airport-pair market share can influence their ability to vary prices, there is reason to believe that an airline's ability to degrade quality without losing as many patrons is also affected by their market share. An "airport-pair" market is one that considers flights between airport A and airport B, regardless of direction, to be a single market. So if firm i controls 5 flights between airport A and airport B, and there are 10 total flights between airport A and airport B, firm i has a fifty percent airport-pair market share. In Brueckner et al (2013b), airport-pair market shares are considered on a quarterly basis.

Suzuki et al (1999) regress a firm's market share on their quality-based consumer welfare index. They find that losses in quality cause a statistically significant decrease in market share for that firm while quality gains are found to have no statistical effect on market share (Suzuki et al, 1999). Since these flight schedules are determined far in advance of any realized weather delays, reverse causation is not necessarily a problem for this study, but Suzuki et al (1999) may indicate that the quality of a firm's flights, or specifically a lack thereof, may have future implications for the market share of that firm.

Therefore, Suzuki et al indicates that route-dominant firms in particular might not want to degrade the quality of their service even if they have substantial market share. As mentioned above, degradation in quality could result in a loss of market share. If firms know these effects and take them into account, predicting their decision-making becomes difficult. Air carriers with greater market shares, due to the lack of competitive pressure, might have a lower profit-maximizing amount of quality. On the other hand, the effects that Suzuki et al (1999) discuss could be strong enough that airlines with already large market shares might make more profits by not reducing quality. Also the presence of some sort of natural efficiency, that benefits these measurements of quality, might be positively associated with route-specific market share. Theoretically, the effect of market share on quality is ambiguous.

Chen and Gayle (2013) investigate the effects of the Continental/United and Delta/Northwest airlines mergers on quality. Their particular measurement of quality, what they call routing quality, considers the time it takes to get a passenger from their origin airport to their final destination. The study uses the distance between airports as a proxy for flight time such that a non-stop flight would represent the shortest possible time it takes to get from the origin to the destination. Itineraries that include layovers are accounted for by considering the distance, relative to the non-stop distance, between the origin airport, all of the hub airports, and the final destination for a given flight. Using distance as a proxy for travel time is effective because longer distances will take longer times to traverse.

Chen and Gayle (2013) conclude that if the two firms were competing in the same market prior to the merge, their merge was associated with a quality decrease. If they were not competing in the same market prior to the merge, their merge was associated with a quality increase. These results highlight two competing effects outlined by Chen and Gayle (2013) in their theoretical model: the coordination and incentive effects. The coordination effects are the efficiencies that are experienced when merging firms share technologies, information, and coordinate production. The incentive effect eliminates the competitive pressure on firms to provided high-quality service. Consequently, these two effects work against each other.

Although this study investigates the effect of market share, not mergers, on quality, the results of Chen and Gayle (2013) indicate that a lack of competitive pressure, a luxury of firms with high market shares, could result in quality losses. While the coordination effect is not applicable to this study, it indicates some sort of natural efficiency that accompanies mergers. It is possible that those natural efficiencies might also be present when firms have large market shares.

Literature on the audit industry investigates the effect of market concentration on quality. Francis et al (2013) perform a cross-country comparison on the market structure of the audit industry and audit quality. They consider two measures of market concentration simultaneously in the same specification, and the two measures of market concentration have opposing effects on audit quality. Using a Herfindahl Index (HHI) to calculate market concentration based on the total sales of the four largest firms, they find that countries whose audit industries had higher Herfindahl Indices have generally inferior audit outcomes (Francis et al, 2013). The other measure calculates the proportion of companies that use one of the four largest firms in a given country. With this measurement, higher market concentrations were found to increase audit quality (Francis et al, 2013).

Since the HHI is negatively associated with quality and accounts for the distribution of the market among the top four firms, it is possible that countries with one or two dominant audit firms could suffer quality losses, but some sort of concentration of business among four firms might be beneficial for audit quality as a whole.

There may be reason to believe that route-day market concentration, and not just the route-specific market share of a firm, affects the quality of service provided by airlines in that market. Market concentration captures the environment that the firm operates in and not just that firm's standing in the market. For instance, an airline with 40% of the route-specific market share will make different decisions in markets where only one competitor controls the other 60% of the market than it would in markets where six other firms each control 10% of the market.

This research contributes to the literature by considering the causal effect of route-specific market share and route-day market concentration on the quality of air carrier service. Specifically, this paper will analyze the effects of these two variables on arrival delay, flight time, diverted status, and cancellation status.

Data

This study utilizes data on domestic flights from 2009 to 2013 provided by the Research and Innovative Technology Administration (RITA). The dataset includes nearly every domestic flight in the United States. RITA provides the following relevant variables for each flight: arrival delay, cancellation status, diverted status, flight time, delay due to weather, the origin airport of the flight, the destination airport of the flight, the airline that provided the flight, and the date of the flight.

Variables are measured in accordance with several guidelines. Cancelled flights are scheduled to fly but never take off, and flights are generally cancelled due to mechanical or weather-related problems. Flights are considered diverted if they land at an airport other than the originally scheduled destination airport. Diverted flights can be diverted prior to take off, but if there are weather, mechanical, or fuel-related problems after take off, they can be diverted mid-flight. Flight time is the time that passes between take-off from the origin airport and landing at the destination airport. Arrival delay is the discrepancy between the scheduled arrival time and the actual arrival time.

Although this paper's definition of a market is similar to the city-pair definition, it varies slightly. This paper utilizes the term "route-specific" because, when calculating market share, it considers the percentage of total flights from airport A to airport B that a firm offers in a day separate from the percentage of total flights from airport B to airport A that a firm offers in a day. The city-pair approach considers these two markets as one. This route-specific measurement may capture nuances between how firms operate differently when providing flights in different directions and is similar to the market definition implemented by Chen and Gayle (2013).

Additionally, the decision to consider markets on a daily basis instead of a quarterly basis is based off the idea that a firm's decision or ability to provide quality service may be dependent on the day. This consideration of the market share on a day may better reflect the decisions a firm has to make about the opportunity costs of allocating capital and labor between different flights in a day and the effect of exogenous factors such as weather delays. Also market concentrations in a given day may better capture the effect of congestion due to low market concentration.

For further reference, in this study, a "route-day" market refers to the market for a given route on a given day while "route-day" market concentration refers to the market concentration for a given route on a given day. A "route-day-firm" is an observation in this data set and denotes all of the flights for a given route that an individual firm provides on a day. The metrics utilized in this study are averaged by route-day-firms. Each of these route-day-firms corresponds to a route-specific market share, a route-day market concentration, and the various average metrics. "Small airlines" are airlines with relatively small route-specific market shares and "large airlines" are airlines with relatively large route-specific market shares.

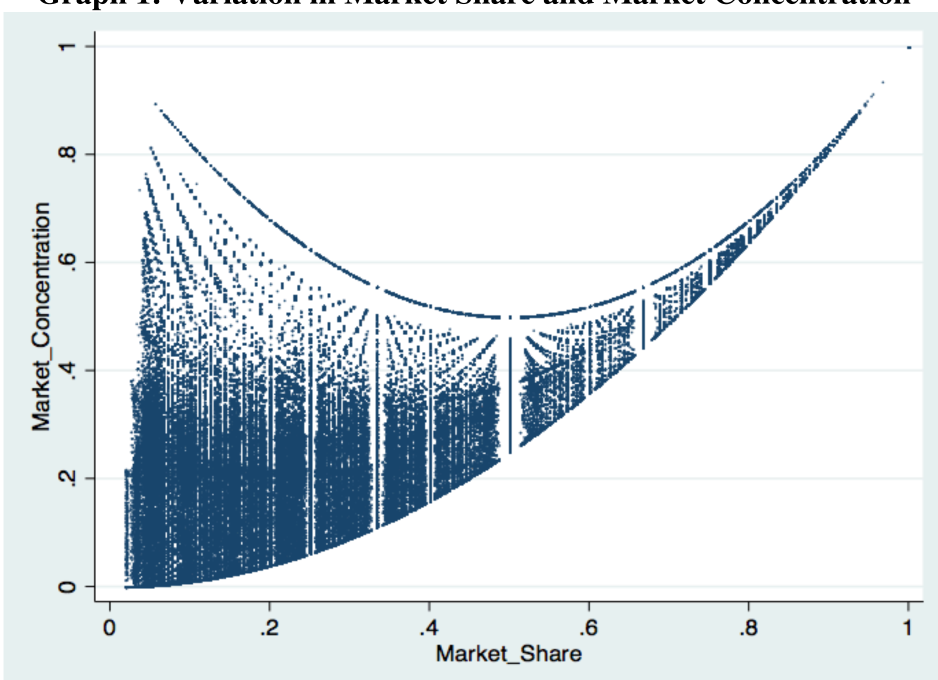
In order to attain some measure of route-specific market share and subsequently, route-specific market concentration, this study counts the number of flights that each airline provides for a given route on a given day, N_{irt}, and the total number of flights that are offered for that route in that day, N_{rt}. The Market Share of airline i for route r in day t, MS_{irt}, is the quotient (N_{irt}/N_{rt}). This study then calculates the Herfindahl Index, the measurement of route-day market concentration, by summing the market share squared for each route-day. That is, $HHI_{rt}=\sum_{i=1}(MS_{irt})^2$. Then, all of the various metrics are averaged by route-day-firm. This yields route-day–firm averages of arrival delay, weather delay, and flight time. Also, this averaging results in the proportion of flights that were cancelled or diverted for that route-day-firm.

The maximum route-day market concentration of a market given that a firm with a route-specific market share of θ, where $0\leq\theta\leq1$, operates in that market is $\theta^2+(1-\theta)^2$. That is, one competing firm controls the rest of the market. The minimum possible route-day market concentration, given that a firm with route-specific market share θ operates in that market, is $\theta^2+\boldsymbol{\varepsilon}$ where $\boldsymbol{\varepsilon}=\sum_{i=1}(1/N^2)$ from 1 to (N-

Nθ) and N is the number of flights on that route in that day. That is, the rest of the firms in the market each provide exactly one flight for that route-day market.

These maximums and minimums are visible in the following graph. Data points only exist for a countable number of route-specific market shares because route-specific market share is an inherently discrete variable. If there are N flights for a given route on a given day, all route-specific market shares will be in the form (1/N)*K where 0≤K≤N. When limiting our market to a day measurement, N will not be large enough to seem continuous.

Graph 1: Variation in Market Share and Market Concentration[1]



As indicated by the preceding graph, a variety of combinations of route-specific market share and route-day market concentration are represented in the

[1] Points that lie on the U-Shaped curve at the top of the plot represent all route-day-firms that compete with only one competitor in their route-day market. The points on the contour at the bottom of plot represent all of the route-day-firms that operate in route-day markets with many flights and face competitors that control about one flight each in a route-day market.

sample. These aforementioned maximum and minimum market concentrations, and many market concentrations in-between, are well represented in the data for many levels of market share. Table 1 illustrates the composition of route-specific market shares in these five years of data.

Table 1: Frequency of Route-Specific Market Shares

Route-Specific Market Share	Number of Observations	% of Observations	Observations cumulative %
0 < Market Share ≤ .1	184,253	0.0180	0.0180
.1 < Market Share ≤ .25	1,378,115	0.1349	0.1530
.25 < Market Share ≤.5	2,410,262	0.2360	0.3890
.5 < Market Share ≤ .75	1,095,518	0.1073	0.4962
.75 < Market Share < 1	270,522	0.0265	0.5227
Market Share=1	4,874,336	0.4773	1.0000

Roughly 48% of the firms for a given route-day-firm are the only airline serving a given market. That means that more than 48% of route-day markets are served by only a single airline. Although many firms have route-specific market shares of 1, only 2.65% of firms have route-specific market shares between .75 and 1. Approximately 24% of market shares in this data set are between .25 and .5. The least common range of market shares is between 0 and .1, but this is also the smallest interval in consideration, and it is still represented by almost 185,000 observations.   Although the distribution of market shares is weighted heavily towards 1, market shares of all sizes are relatively well represented in this dataset.

Another variable in this data that is important to understand is the average delay due to weather. In order to justify controlling for weather, this study should show that weather has a significant impact on arrival delays.

Table 2: Average Weather Delay Frequency			
Weather Delay	Number of Observations	% of Observations	Observations Cumulative %
Weather Delay=0	9,959,335	0.9754	0.9754
0<Weather Delay≤15	172,056	0.0169	0.9922
15<Weather Delay≤30	40,160	0.0039	0.9961
30< Weather Delay≤60	24,577	0.0024	0.9985
60<Weather Delay≤120	10,881	0.0011	0.9996
120<Weather Delay≤240	3,268	0.0003	0.9999
Weather Delay>240	678	0.0001	1.0000

Table 2 illustrates the frequency of weather delays measured in minutes. 253,671 route-day-firms suffer arrival delays due to weather conditions. 79,564 route-day-firms are affected by weather delays of an average of 15 or more minutes. While 97.54% of route-day-firms experience no average delay due to weather, some weather delays are incredibly extreme.

It is worth mentioning that unless the arrival delay of a given individual flight is greater than fifteen minutes, no explanation for why the delay happens is given in the data. So for individual flights, prior to averaging, arrival delays of less than 15 minutes are considered to have weather delay components of 0.

Methodology

The two measurements for reliability in this study are the proportion of flights serving a particular route that were diverted and the proportion that were cancelled by an individual firm in a given day. The two relevant metrics for timeliness are the average flight time and average arrival delay of flights for a route-firm-day. In order to provide a complete explanation for the dependent variables, this study implements a fixed effects model. The model includes fixed effects for the year, month, day of the week, airline, and route. Route-specific market share, route-specific market share squared, route-day market concentration, route-day market concentration squared, and the average delay due to weather for that route-firm-day are all controls and variables of interest.

The average delay due to weather is an important control because it is unquestionably correlated with the average total arrival delay and is likely correlated with the proportion of flights diverted and average flight time. Also, as the previous section indicated, some of these average weather delays, while infrequent, are substantially large. Weather delays factor directly into total delay measurements. For the diverted status and average flight time regressions, weather delays serve as a proxy for the weather conditions at the time of flight. Weather conditions presumably affect cancellations, but since cancelled flights do not ever arrive at their destination, they have no associated weather delay to use as a proxy for weather conditions.

These delays due to weather are, by definition, not a result of a firm's market share, so by controlling for them, this study is controlling for exogenous factors that could affect the reliability or timeliness of a firm's flights. Additionally, firms with higher route-specific market shares might be affected more by bad weather that occurs on that day in between the origin and destination airports, so the weather delay controls account for potential omitted variable bias as well.

This study implements the following specification in order to determine the effect of route-specific market share and route-day market concentration on the quality of service provided for that route by that firm on a given day. Subscripts i,r, and t represent firm-specific, route-specific, and day-specific variables respectively, so variables with subscript irt are route-day-firm level variables and variables with a subscript of rt are route-day level variables.

Specification:

$$Y_{irt} = \beta_1 MS_{irt} + \beta_2 (MS_{irt})^2 + \beta_3 HHI_{rt} + \beta_4 (HHI_{rt})^2 + \beta_5 WD_{irt} + \beta_6 WD_{irt} \times MS_{irt} + \beta_7 WD_{irt} \times (MS_{irt})^2 + \alpha_{D(t)} + \gamma_{M(t)} + \delta_{Y(t)} + \zeta_r + l_i$$

Y_{irt}, represents the four quality variables of interest: the average arrival delay of a route-day-firm, the average flight time of a route-day-firm, the proportion of flights that were diverted in a route-day-firm, and the proportion of flights that were cancelled in a route-day-firm. MS_{irt}, $HHI_{rt,}$ and WD_{irt} are the route-specific market share, the route-day market concentration, and the average weather delay of a route-day-firm respectively. For the regression on cancellation status, it is important to note that the weather delay term and the weather delay interaction terms are not present in the cancellation specification.

$\alpha_{D(t)}$ is a vector of fixed effects for the day of the week, $\gamma_{M(t)}$ is a vector of fixed effects for the month, $\delta_{Y(t)}$ is a vector of fixed effects for the year, ζ_r is a vector of fixed effects for the route, and l_i is a vector of fixed effects for the air carrier.

A quadratic term for market share is present in all of the specifications because an increase in market share may not have the same effect on quality at all levels of market share. As discussed earlier, we expect firms with large market shares to sacrifice quality in order to reduce costs. Firms with initially low levels of market shares, however, might be able to provide higher levels of quality as their market share increases because they want to attract more customers, and the benefits of having extra capital and labor might be greater when they are providing more flights.

Although the intuition for including a quadratic market concentration variable is less obvious in the context of the airline industry, the aforementioned study on the effect of market concentration on audit outcomes influence this paper to include the quadratic. There are discrepancies in the results of Francis et al (2013) when considering two different kinds of market concentrations. While they do consider HHI as one of those measurements, they do not consider HHI squared in their specification. The results between their two measurements might be more concurrent if they did. Furthermore, there may be a more complex effect that a quadratic route-day market concentration term might capture.

For the average arrival delay, average flight time, and diverted status regressions, delay due to weather interacts with market share and market share squared in order to see how an airline's ability to cope with weather is affected by their route-specific market share.[2]

Results

Table 3: Cancellation Status	
VARIABLES	Coefficients
Market Share	-0.00269 (-0.0024)
Market Share Squared	0.00124 (-0.00252)
Market Concentration	0.000635 (-0.00112)
Market Concentration Squared	-0.00137 (-0.00165)
Observations Number of Routes R-squared Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	1.02E+07 5762 0.006

[2] The following interaction terms were initially included in the study but were found to be highly insignificant in each specification: MS_{irt} * HHI_{rt}, $(MS_{irt})^2$ * HHI_{rt}, MS_{irt} * $(HHI_{irt})^2$ and $(MS_{irt})^2$* $(HHI_{irt})^2$

Table 4:Diverted Status	
VARIABLES	Coefficients
Market Share	-0.000745 (-0.0006)
Market Share Squared	0.000631 (-0.0007)
Market Concentration	-0.00019 (-0.0003)
Market Concentration Squared	0.000052 (-0.0004)
Weather Delay	-0.0000415*** (-0.000005)
Market Share * Weather Delay	0.000201*** (-0.00003)
Market Share Squared * Weather Delay	-0.000144*** (-0.00003)
Observations Number of Routes R-squared Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	1.02E+07 5762 0

Tables 3 and 4 contain the regression output for cancellation status and diverted status respectively. The route-specific market share of an air carrier and route-day market concentration do not have a statistically significant impact on whether or not an air carrier diverted a flight through another airport or cancelled the flight completely. For the diversion regression, it seems that weather delay and the interaction terms are statistically significant.

It is possible that diverting a flight or cancelling a flight is so detrimental to customer retention and the schedule of the airline itself that airlines of all sizes in all types of route-day markets avoid cancelling or diverting flights as much as possible. That is, when considering costs and customer retention, the profit maximizing number of cancellations and diversions is neither dependent on market share nor market concentration. It is likely that the main determinants of a flight being cancelled are exogenous factors like mechanical failures, bad weather, or general safety concerns. While average weather delay and the interaction models are statistically significant, the effects of a 10% increase in market share are still not economically substantial, especially when considering that weather delays, as indicated by the previous descriptive statistics, are relatively infrequent.[3]

Table 5: Average Flight Time	
VARIABLES	Coefficients
Market Share	-1.482*** (-0.509)
Market Share Squared	1.072** (-0.541)
Market Concentration	0.166 (-0.232)
Market Concentration Squared	-0.251 (-0.359)
Weather Delay	0.00637 (-0.0041)
Market Share * Weather Delay	0.0879*** (-0.0188)
Market Share Squared * Weather Delay	-0.0700*** (-0.0154)
Observations Number of Routes R-squared Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	1.01E+07 5662 0.025

Table 5 displays the results of the average flight time regression. Market concentration and market concentration squared do not have a statistically significant impact on average flight time. Market share squared is statistically significant at the five percent level and the linear market share term is statistically significant at the one percent level. The weather delay interaction models are statistically significant at the one percent level. The fact that market concentration has no statistical effect on average flight time is not particularly surprising. Once a

[3] See Appendix Grid 1

plane is up in the air, we would not expect the market concentration of the route to significantly affect its ability to fly at a normal pace. All planes flying into the destination airport may have an effect on a flight's ability to land quickly, but this phenomenon is not captured by the route-day market concentration variable.

Grid 1: The Effect of a 10% Point Increase in Market Share on Average Flight Time						
MS/WD	0	15	30	45	60	75
0.1	-0.127	-0.01591	0.095	0.206	0.317	0.427
0.25	-0.095	-0.01525	0.064	0.143	0.223	0.302
0.5	-0.041	-0.01415	0.013	0.040	0.066	0.093
0.75	0.0126	-0.01305	-0.039	-0.064	-0.090	-0.116

Grid 1 displays the effect of a ten percentage point increase in market share on average flight time. Since the effect of a change in market share on flight time is dependent on the current level of route-specific market share (MS) and average weather delay (WD). This table assumes various levels of market share, on the y-axis, and weather delay, on the x-axis. As indicated by the grid above and the coefficients on market share and market share squared in Table 5, in the absence of weather delays, a ten percentage point increase in market share decreases average flight times for smaller firms, but for firms with route-specific market shares larger than about 70%[4], a ten percentage point increase in market share results in longer average flight times.

This result agrees with the theory stated at the beginning of this paper. There may be some investment decision about labor that could cause this discrepancy. Smaller firms may make more investments in capital and labor per

[4] See Appendix Graph 1

flight as their route-specific market share increases because they feel more pressured to provide higher levels of quality and have a greater ability to do so due to some natural efficiency. As firms begin to dominate the route-day market, and the competitive pressure decreases, their investment in capital and labor per flight may decrease because customer retention becomes less of an issue and cutting costs will increase profits but also decrease quality. Additionally, the natural efficiencies gained with increasing route-specific market share might be smaller at these large levels of market share.

In the presence of average weather delays of fifteen minutes, a relatively benign average weather delay, all firms will fly faster as they gain more route-specific market share, but smaller firms will still benefit the most. It is possible that, in the presence of relatively mild weather, natural efficiencies outweigh any lack of competitive pressure throughout the range of market share or customer retention is a bigger issue when weather conditions are bad and the potential for weather delays is higher.

Grid 1 indicates that the U-shaped effect of route-specific market share inverts itself in the presence of weather delays greater than thirty minutes. When controlling for route-day market concentration, as small firms get larger, their average flight times go up. As firms attain a market share of about 60%[5] (depending on the weather delay in question), an increase in market share actually decreases a firm's average flight time again.

[5] See Appendix Graph 1

These results do not coincide with the theory of this paper, and a possible explanation for this first half of this inverse U-shaped curve is elusive when considering average weather delay as a proxy for weather conditions. Consider one firm that has a larger route-specific market share than another firm that operates in the same route-day market. Now consider adverse weather conditions on that day, and suppose that those conditions only last for a few hours that day. It is likely that the flights provided by the firm with a larger route-specific market share would be more adversely affected by this weather delay because they have more flights flying on that day, so their flights are more likely to coincide with that period of less than ideal weather. On the other hand, if the smaller firms' flights happen to coincide with this period of bad weather, their average weather delay is more adversely affected because they have fewer total flights during that day. Since an increase in market share is initially associated with an increase in flight time, it seems that the first explanation is more likely, that is the probability of having a larger average weather delay goes up with the number of flights that an airline provides on a route-day, and more flights could be associated with higher market shares.

It is possible that the second half of the inverse U-shaped curve can be explained by the natural efficiencies that come with high route-specific market shares. For instance, firms with higher route-specific market shares may have pilots that have flown the route in question more frequently than routes with smaller route-specific market shares. This could result in these pilots having a greater ability to fly and land in bad weather conditions because they are more experienced with the route and the runway they are landing on. Also, these firms with larger route-specific market shares may also have more seasoned landing-essential personnel or may possibly reallocate more personnel to routes that are experiencing weather problems.

Table 6: Average Arrival Delay	
Independent Variables	Coefficients
Market Share	-5.694*** (-1.239)
Market Share Squared	5.392*** (-1.35)
Market Concentration	1.404** (-0.579)
Market Concentration Squared	-2.389*** (-0.905)
Weather Delay	0.948*** (-0.0285)
Market Share * Weather Delay	1.773*** (-0.134)
Market Share Squared * Weather Delay	-1.367*** (-0.114)
Observations Number of Routes R-squared Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	1.01E+07 5662 0.086

As indicated by Table 6, the effects of route-specific market share and route-day market concentration on average arrival delay are more pronounced than the effects of route-specific market share or route-day market concentration on any other quality variable investigated in this study. All non-fixed effect variables are statistically significant at the one percent level except for the market concentration variable, which is significant at the five percent level.

Grid 2: The Effect of a 10% Point Increase in Market Share on Average Arrival Delay						
MS/WD	0	15	30	45	60	75
0.1	-0.462	1.788	4.037	6.287	8.536	10.785
0.25	-0.3	1.334	2.969	4.603	6.237	7.871
0.5	-0.03	0.579	1.188	1.797	2.406	3.015
0.75	0.239	-0.177	-0.593	-1.009	-1.426	-1.842

Grid 2 displays the effect of a ten percentage point increase in market share on average arrival delay. Since the effect of a ten percentage point change in market share on average arrival delay is dependent on the current level of route-specific market share and average weather delay, this table assumes various levels of route-specific market share (MS), on the y-axis, and average weather delay (WD), on the x-axis. As indicated by Grid 2 and the coefficients on market share and market share squared presented by Table 6, in the absence of any weather delay, a ten percentage point increase in route-specific market share decreases average arrival delay for smaller firms, but for firms with route-specific market shares of 52.80%[6] or more, a ten percentage point increase in market share results in longer average flight times.

Like the results for average flight time, these results for average arrival delay suggest a U-shaped curve consistent with the theory established by this paper. Both investments in capital and investments in labor could have an effect on arrival delay because the speed at which the plane is prepared prior to departure has an effect on arrival delay as does the speed at which the plane flies. For instance, smaller firms may feel more pressured to provide more fuel trucks, baggage handlers, and

[6] See Appendix Graph 2

landing/ take off essential personnel in order to retain customers where as larger firms will not be as pressured to do so because patrons in their route-day market will have fewer choices.

When weather delays of fifteen minutes or more are considered, however, the U-shaped curve inverts itself once again. In the presence of weather delays greater than 15 minutes, an increase in the route-specific market share of small airlines results in an increase in their average arrival delay. When firms have about 68%[7] (depending on the level of Weather Delay) of the route-specific market share, increases in market share begin to decrease their average arrival time again.

Intuition would suggest that firms that have the most flights operating on a given route might have the largest problems recuperating from bad weather because they would have more flights affected by the route, and the delay of earlier flights might affect flights throughout the rest of the day. This seems to be true up until a certain level of market share is attained.

After that threshold, however, it could be that those firms with larger route-specific market shares have more resources dedicated to those routes or are more willing to reallocate resources to those routes in the presence of larger weather delays. For instance, when there are weather-related delays, they may be able to divert another plane to serve that route and have more pilots on call to fly that extra plane. Also pilots who are employed by these dominant firms probably fly the route more often, and could possibly have more experience flying in bad weather conditions. Consequently they can outperform the pilots who fly for less route-

[7] See Appendix Graph 2

dominant airlines. It could be that these route-dominant airlines only take these extra steps when weather is an issue and not otherwise because the threat of losing customers is higher in these circumstances.

Table 7: The Effect of a 10% Increase in Market Concentration on Arrival Delay

HHI	Tipping Point	10% increase
0.1	0.588	0.11651
0.25		0.080675
0.5		0.02095
0.75		-0.038775

Table 7 displays the effect of a ten percentage point increase in market concentration for varying levels of initial market concentration. Route-day market concentration, when holding the market share of the firm in question constant, has a individually small impact on average arrival delay of that firm, but it seems that at low levels of market concentration, a ten percentage point increase in market concentration results in an increase in average arrival delay, but as market concentration reaches roughly 59%, increases in market concentration result in a decrease in average arrival delays. So high levels of market concentration are actually beneficial for average arrival delays. This may indicate that there are problems with congestion when many other firms are operating in the same route-day market because smaller route-day market concentrations tend to be associated with more flights because the market can be broken up into smaller portions, and more portions allows for the participation of firms in the market.

Conclusions

Route-specific market share and route-day market concentration seem to have no effect on the reliability of an airline as measured by the proportion of flights that were diverted and the proportion of flights that were cancelled for a route-day-firm. In the absence of weather delays, both measurements of timeliness decrease as firms with relatively low route-specific market shares experience an increase in route-specific market share, but once that route-specific market share reaches a certain threshold, subsequent increases in route-specific market share increase average flight time and average arrival delay. This could reflect a threshold where a lack of competitive pressure overcomes the natural efficiencies that accompany higher market shares, and larger firms stop making the decisions to provide as much capital or labor per flight that affects these measures of timeliness.

While the inverted U-shape results in the presence of weather delays are interesting, only 2.46% of route-day-firms from 2009 to 2013 experienced any weather delays at all, and 1.69% of those average weather delays were less than 15 minutes long. So while firms with market shares in the range of anywhere from 55%-70%[8] are the least timely in the face of bad weather conditions, they are the most timely in the absence of adverse weather conditions[9], and since weather delays are relatively infrequent, firms with market shares of these levels are probably more efficient overall.

While market concentration did not affect flight time, it does affect arrival delay, and that makes sense. Market congestion probably does not affect a plane in

---

[8] See Appendix Graphs 1 & 2
[9] See Appendix Graphs 1 & 2

flight, but it could very well affect the ability of a plane to take off on time, and this would affect arrival delay. Relatively high route-day market concentrations seem to be beneficial, but only when controlling for route-specific market share, so policy makers need to consider a balance of market concentration and market share when implementing policy.

Limitations and Further Studies

Like many studies in an economics, and academia in general, this study could be built upon, improved, or modified. The theory that firms with larger route-specific market shares can allocate more labor and capital in the face of bad weather conditions could be supported by studies that see if firms who have large route-specific market shares also tend to control more flights at the origin or destination airport. If this is true, then it is believable that these firms are able to exert their market share at an airport they dominate in order to reallocate more resources to flights that may be troubled by weather on their journey. This would also support the theory that their potentially larger amount of labor and capital would be spread thin relative to firms with smaller route-specific market shares.

While the weather delay term and the weather delay interaction terms are not the focus of this paper, due to the infrequent nature of weather-related arrival delays, it would be interesting to account for the number of flights that a route-day-firm provides. Controlling for this may affect the direction of the weather delay interaction terms. Also seeing how many flights are provided at each level of market share would be interesting. If firms with market shares of 1 tend to provide relatively fewer flights when compared with firms with market shares of .5 or .6, then the tapering of the inverted U-shaped curve at high levels of market share could be explained not by not only natural efficiencies, but also by the frequency of flights.

Also this study could utilize the airport-pair approach. A large amount of literature considers the flights that go between two airports, regardless of direction, as a definition for a market. With that being said, the airport-pair approach may not capture any effects on quality that are dependent on direction. An analysis comparing the market shares of firms in these two directions and the quality that they offer would inform which definition is more appropriate. When considering the different directions, if market shares and quality are relatively symmetric for a given airport-pair, then airport-pair approach may be more suitable. This route-specific method, however, would still capture the effects of these market shares on quality.

Another topic that could be explored, in the vein of Suzuki et al (1999), is the effect of these route-day-firm measurements of quality on an airline's future route-specific market share. Just as a firm's route-specific market share can influence the quality that an airline provides, the quality that a firm provides could influence a customer's decision to continue flying with that airline in the future.

Finally, many major cities in America have more than one airport. As Brueckner et al (2013b) discusses, markets can be described as city-pairs or airport-pairs. Accounting for regional airport competition would improve this study by accounting for spillover effects from one airport to another. Brueckner et al (2013b) identifies some metropolitan regions that could be reasonably treated as a single location. Alternatively, as in Brueckner et al (2013a), a variable could be utilized in order to control for regional competition while implementing the standard airport-pair approach. Both of these ideas could reasonably be utilized with the route-specific measurement as well.

Appendix

Appendix Grid 1: The Effect of a 10% Point Increase in Market Share on Flight Time[10]						
MS/WD	0	15	30	45	60	75
0.1	-0.000062	0.000196	0.000455	0.000713	0.000971	0.001230
0.25	-0.000043	0.000151	0.000344	0.000538	0.000731	0.000925
0.5	-0.000011	0.000074	0.000160	0.000245	0.000331	0.000416
0.75	0.000020	-0.000002	-0.000025	-0.000047	-0.000070	-0.000092

Appendix Graph 1: The Effect of a 10% Increase in Market Share on Flight Time			
Weather Delays	Market Share	10% increase	Threshold
0	0.1	-0.127	0.6912
0	0.25	-0.095	
0	0.5	-0.041	
0	0.75	0.013	
15	0.1	-0.016	3.7159
15	0.25	-0.015	
15	0.5	-0.014	
15	0.75	-0.013	
30	0.1	0.095	0.5618
30	0.25	0.064	
30	0.5	0.013	
30	0.75	-0.039	
45	0.1	0.206	0.5952
45	0.25	0.143	
45	0.5	0.040	
45	0.75	-0.064	
60	0.1	0.317	0.6061
60	0.25	0.223	
60	0.5	0.066	
60	0.75	-0.090	
75	0.1	0.427	0.6116
75	0.25	0.302	
75	0.5	0.093	
75	0.75	-0.116	

[10] The mean proportion of flights that were diverted in this data is .00258, so only in the presence of the most extreme weather delays is the effect of an increase in market share on the proportion of flights diverted substantial, but delays greater than 60 minutes are so rare that these effects are probably not economically significant.

Appendix Graph 2: The Effect of a 10% Increase in Market			
Weather Delays	Market Share	10% increase 2	Threshold
0	0.1	-0.462	0.5280
0	0.25	-0.300	
0	0.5	-0.030	
0	0.75	0.239	
15	0.1	1.788	0.6915
15	0.25	1.334	
15	0.5	0.579	
15	0.75	-0.177	
30	0.1	4.037	0.6667
30	0.25	2.969	
30	0.5	1.188	
30	0.75	-0.593	
45	0.1	6.287	0.6601
45	0.25	4.603	
45	0.5	1.797	
45	0.75	-1.009	
60	0.1	8.536	0.6570
60	0.25	6.237	
60	0.5	2.406	
60	0.75	-1.426	
75	0.1	10.785	0.6552
75	0.25	7.871	
75	0.5	3.015	
75	0.75	-1.842	

Sources

Brueckner, J. K., Lee, D., & Singer, E. S. (2013a). Airline competition and domestic US airfares: A comprehensive reappraisal. *Economics of Transportation*, *2*(1), 1–17. doi:10.1016/j.ecotra.2012.06.001

Brueckner, J., Lee, D., & Singer, E. S. (2013b). City-Pairs Versus Airport-Pairs: A Market-Definition Methodology for the Airline Industry. *Review of Industrial Organization*, 1–25. doi:10.1007/s11151-012-9371-7

Chang, Y.-H., & Yeh, C.-H. (2002). A survey analysis of service quality for domestic airlines. *European Journal of Operational Research*, *139*(1), 166–177. doi:10.1016/S0377-2217(01)00148-5

Chen, Yongmin & Gayle, Philip, (2013). Mergers and Product Quality: Evidence from the Airline Industry. MPRA Paper 51238, University Library of Munich, Germany.

Chen, P.-T., & Hu, H.-H. "Sunny." (2013). The mediating role of relational benefit between service quality and customer loyalty in airline industry. *Total Quality Management & Business Excellence*, *24*(9/10), 1084–1095.

Francis, J. R., Michas, P. N., & Seavey, S. E. (2013). Does Audit Market Concentration Harm the Quality of Audited Earnings? Evidence from Audit Markets in 42 Countries. *Contemporary Accounting Research/Recherche Comptable Contemporaine*, *30*(1), 325–355.

Jones, T. O., & Sasser, W. E. (1995). Why satisfied customers defect. *Harvard Business Review*, *73*(6), 88–99.

Rubin, R. M., & Joy, J. N. (2005). Where Are the Airlines Headed? Implications of Airline Industry Structure and Change for Consumers. *Journal of Consumer Affairs*, *39*(1), 215–228.

Suzuki, Y., Tyworth, J. E., & Novack, R. A. (2001). Airline market share and customer service quality: a reference-dependent model. *Transportation Research Part A: Policy and Practice*, *35*(9), 773–788. doi:10.1016/S0965-8564(00)00016-1