The Heterogeneous Treatment Effect of a Merger on Airfares: Evidence from Alaska Airlines-Virgin America Merger

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Abstract

The field of industrial organization has rich literature on the impact of airline mergers and the impact of Low-Cost-Carriers (LCCs) etnry to markets, separately. This paper synthesizes these effects by studying the effect of the 2016 Alaska-Virgin merger on airfares and how the effect differs across markets with different degrees of competition from LCCs. Theoretically, we rationalize that the post-merger fare with an LCC competitor should be lower than the post-merger fare with a high-cost competitor. Empirically, we analyze the pooled cross-sectional microdata of airline tickets and show that, compared to non-LCC markets, markets with LCCs decrease the post-merger forces of Alaska and Virgin markets. This estimation not only endorses the validity of the Department of Justice's approval of the 2016 merger but also offers implications of how the DoJ should take LCC presence into account in its merger evaluation.[1]

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[1]All the codes for this project can be found here.

Contents

1 Introduction

1.1 Background

A set of exogenous shocks, the 9/11 attacks and the 2008 Global Financial Crisis, provoked the US airline industry to undergo two major shifts: the rise of the number of mergers as well as the number of Low-Cost-Carriers (LCCs).[2] The 9/11 crisis added security costs for mandatory screening and other operational changes at airports. Furthermore, oil price culminated in the global financial crisis of 2008 and resulted in a fuel cost spike to all-time highs in airlines' operating costs.[3] The combined effects of those shocks resulted in over 50 US airlines filing for bankruptcy and a series of M&A.

Eventually, the great recession and following price competition caused the airlines to consolidate into three legacy carriers: American Airlines, Delta Airlines, and United Airlines. Coupled with an LCC, Southwest, the Big Four airline[4] formed an oligopolistic US airline market that is of researchers' interest nowadays. In parallel to the merger wave, the industry experienced the growth of low-cost-carriers such as Southwest, Jetblue, and Frontier since they offered relatively inexpensive alternatives that attract many customers. This trend poses many untraditional questions. Among those inquiries, earlier research predominantly focuses on how LCCs' market entrance affects airfares after their penetration in the late 1990s. However, given over 20 years have passed since then, the time is ripe for a new type of research question: How does a merger differentially affect airfares of markets with LCCs and without LCCs?

This study aims to investigate the effect of a merger on airfares (also referred to as prices in this paper) and how the effect differs across different presence of LCCs in the case of the 2016 Alaska Airlines' merger with Virgin America. In every merger, a merged company needs to submit an application to the Department of Justice (DoJ), and the DoJ reviews the proposal to assess whether the merger confers market power on the newly merged company. The institution verifies if the newly merged company has the ability to lift prices above competitive levels or not.

Since Virgin America raised $307 million in its first public offering on the NASDAQ in November 2014, a number of airlines, especially JetBlue and Alaska Airlines were interested in pursuing the takeover. In April 2016, Alaska Airlines successfully announced the $2.6 billion takeover of Virgin America. The Department of Justice approved the takeover in December 2016. In the 2016 merger, the DoJ conditionally approved that Alaska Airlines acquired Virgin America by scaling back its route partnership with American Airlines.[5] This conditional approval is based on the ground that overlapping routes between American and Virgin will reduce the vigorous competition that Virgin showed against American. Traditionally, the DoJ makes an assessment based on the degree of overlap of routes between the merged companies and their competitors. But, if our result shows that competition against legacies rather than LCCs remarkably bestows on Alaska's market power, then the degree of overlap between the merged companies and competing LCCs should be calculated into the metrics of DoJ merger reviews. Therefore, examining the differential effect of the merger on airfares is unequivocally important for the DoJ.

As a result of the Alaska-Virgin merger, a combination of the two airlines created the fifth-largest U.S. airline by passenger traffic, following four major airlines. In January 2018, they were granted a single operating certificate from the Federal Aviation Administration and integrated their ticket reservation systems in April.[6] This timeline indicates that the Alaska/Virgin (this refers to "Alaska and Virgin" in this paper) merger is the most recently closed merger in the history of major US airlines, which the author believes that best reflects the current dynamics of the US airline industry.[7] Thus, this case study should provide an accurate estimate on how incumbent LCCs affect post-merger prices nowadays.

1.2 Summary

This paper attempts to answer the following questions: How does the 2016 merger affect airfares?; and How does the effect differ across markets with different degrees of competition from LCCs? We start from the hypothesis that a merged company will adjust its price levels, according to the competition it faces. Legacy carriers exert much less pressure on the market prices than LCCs. Such heterogeneity of airlines is worthy of further research in the context of assessing the airline merger because consumer benefit is contingent upon the consequence of the assessment.

To quantify the author's hypothesis that a merged company raises its airfares by less when facing LCCs, we employ a variant of widely-used oligopoly theory, the Cournot model with asymmetric costs. It predicts that the amount by which

[2] LCCs offer bargain prices usually in exchange for reduced service in contrast to legacy airlines.

[3] Aviation Industry Performance: A review of the Avian Industry, 2008-2011, United States of America Department of Transportation.

[4] As of 2018, shares of the Big Four airlines—Southwest Airlines, American Airlines, Delta Air Lines, and United Airlines—are 62% in terms of passengers for domestic flights, according to Department of Transportation.

[5] Wall Street Journal

[7] The second latest merger occurred between US Airways and American Airlines in 2013.

[7] Alaska Airlines press release

merging companies increase their price decreases with the marginal cost of their remaining competitors. To empirically estimate the effect of the merger on the merged company's airfares, this paper uses the DB1B database, a 10% sample of all domestic airline tickets collected from reporting carriers on a quarterly basis.

This paper employs two approaches to answer our research questions. First, we use fares of only Alaska/Virgin to run a first difference model and a fixed effects model. This model directly estimates how the 2016 merger affects the airfares of Alaska Airlines.[8] This model also measures the heterogeneous treatment effect of the merger on airfares across markets with different degrees of LCC competition. Second, we regress fares of all airlines using a fixed effects model. Similar to the first approach, this model investigates how the merger influences the market average fares of all airlines (instead of just Alaska/Virgin) and how the merger differentially affects the market fares across markets with different degrees of LCC competition. In other words, the second approach estimates the spillover effect of the merger on the Alaska/Virgin operating markets.

The first difference and fixed effects regressions of Alaska/Virgin's fares confirm that the merger is associated with higher post-merger airfares. Additionally, these models support our hypothesis that a merged company raises its airfares by less when facing LCCs. Next, analyzing fares of all airlines reveals that the presence of LCCs has a downward pressure on post-merger airfares of the Alaska/Virgin markets. However, the pressure is not limited to Alaska/Virgin serving markets. In fact, our model suggests that the non-Alaska/Virgin markets experience as much downward pressure from the presence of LCCs as the Alaska/Virgin markets. This finding implies that LCCs drive down post-merger prices for reasons other than the merger or that the merger is a treatment affecting all markets. Furthermore, our dataset allows us to regress two more dependent variables: the number of passengers and the amount of revenue. The fixed effects regression highlights that LCCs put more downward pressure on post-merger quantity and revenue on Alaska/Virgin markets than non-Alaska/Virgin markets, which is missing in our Cournot model.

In the next section of the paper, we discuss the economics literature on airline mergers and LCC entry. Synthesizing two existing literatures into our research question, Section 3 adopts the stylized Cournot model that offers a theoretical prediction for our estimation. To prepare for our investigation of our research questions, Section 4 introduces the data used for our econometrics models. Section 5 outlines this study's identification strategy to develop our models. Section 6 runs our models and presents the results. Finally, Section 7 concludes the findings with caution.

2 Literature Review

2.1 Merger Analysis

In the field of industrial organization, there exists a rich and substantial literature on airline mergers because the effect of airline competition on prices has been a long-standing topic since the deregulation of US airlines in 1978. Those studies mainly use two types of approaches for estimation of the merger effect on the market: a reduced-form and a structural estimation for merger simulation.

Luo (2014) is a good example of a reduced-form approach that studies the price effects of an airline merger. This is the first paper estimating the price effects of the merger between Delta/Northwest while controlling for other changes in an legacy carrier and an LCC competition. His regression model suggests that fares increase by 2.3% in connecting markets after the merger but price effects in nonstop markets are statistically insignificant. Yet, the model only accounted for LCCs by adding controls for the entry of LCC and legacy competitors, which resulted in no interacting effects between LCCs and non-legacy airlines.

Bontemps et al. (2021), on the other hand, employ a structural model of the US airline market to analyze the effect of the merger between American Airlines and US Airways. Their ex-post evaluation focuses on simulating the impact of mergers on prices and welfare after the merger. Their analysis meticulously decomposes the difference in price and consumer surplus between 2011 and 2016 into the effects of different factors such as changes in consumer preferences, the merger itself, and the entry/exit reactions of both the newly merged firm and the others. They find that consumers don't benefit from the merger itself; however, because slot divestiture at LaGuardia gave LCCs and Southwest Airlines slots, the merger still indirectly increases consumer surplus. Aside from Luo (2014) and Bontemps et al. (2021), notable contributions by S. T. Berry (1990), S. T. Berry (1992), S. A. Morrison et al. (1989), S. Morrison et al. (1995), and Brueckner et al. (2013a) also empirically confirm that fares respond to the level of competition in the markets.

[8]This paper refers to the post-merger firm as Alaska instead of Alaska/Virgin.

2.2 LCC Impact on Market Outcomes

Given that our paper focuses on the company's response to the threat of LCCs, the entry of LCCs is another relevant literature that needs to be discussed. The expansion of Southwest Airlines in the 1990s prompted a flurry of studies that measure LCC impact on domestic fare pricing.Earlier studies by Dresner et al. (1996) and S.A. Morrison (2001) indicate that the competitive effect of LCCs is significantly larger than that of legacies.

Dresner et al. (1996) gauge spillover effects that Southwest's service in one route has on the adjacent competitive routes including nearby airports. Building on Dreser's observation, S.A. Morrison (2001) aggregates the actual, adjacent, and potential competition from Southwest and finds that consumer saving was \$12.9 billion in total from Southwest's entry. Out of \$12.9 billion saved, Southwest's low fares directly represent \$3.4 billion, and the effect of actual, adjacent, and potential competition from Southwest is responsible for the remaining \$9.5 billion.

Beckenstein et al. (2017) revisit the "Southwest Effect", the impact of Southwest's low fare initiatives that led to a significant reduction in average market fares and the corresponding passenger boost from around 1990, to investigate if it still persists in the 2010s. The existing literature informs them that the market entry of Southwest lowers market fare in the 1990s when the legacy provides high-priced full-fledged service. They extend the argument that the introduction of nonstop service by Southwest after 2000 still reduces an additional market fare by 15% and increases the traffic by 28% to 30% on average. This analysis leads to their conclusion that one-way average market fares are \$45 and \$17 lower respectively when Southwest provides a nonstop and connecting service than when it does not. All of these results support the conventional view that the competitive effect of LCCs, especially Southwest, contributes to lowering market fares and boosting consumer savings.

2.3 Market Definition

When analyzing the panel data for airline tickets, it is important to use the appropriate market definition to obtain an accurate estimate, i.e. city-pairs, rather than airport-pairs. This is because measuring valid competitiveness of the market allows our model to represent actual business decisions by each airline. When it comes to competitors, a common idea is that competitors indicate other airlines on the same route connecting the same airport pair. However, recent studies show that competitors would also include other airlines connecting the same city pair which may comprise multiple airports in the origin and destination.

Dresner et al. (1996) measure competitive effects between all airports within 50 miles apart in Southwest's entry analysis. They identify that LCCs on a nearby route had a weaker effect on the prices of incumbent legacy carriers than an entry on the same route. Brueckner et al. (2013a) show that LCC competition in an airport-pair market has dramatic fare impacts whether it occurs in-market, in adjacent airports, or as potential competition. This result raises the point that failing to take into account competition from adjacent airports will lead to an incomplete definition of the market. To mitigate this concern, Brueckner et al. (2013b) suggest that the city-pairs rather than airport-pairs is an appropriate market definition for analyses of air transportation involving many large metropolitan areas. They even provide a list of airports that should be grouped together when creating a city-pair analysis. In the case of Washington D.C., for instance, the primary airport for the metro area, Washington Reagan National (DCA) should be grouped with the remaining core airports: Dulles International Airport (IAD) and Washington-Dulles and Baltimore-Washington (BWI). This grouping methodology is based on the magnitude of competitive spillovers across airports within a metropolitan area instead of airport proximity. Gayle et al. (2012) offer a more detailed definition of a market in a sense that they also consider a direction of a route. For instance, round-trip air travel from DCA to JFK is a distinct market from round-trip travel from JFK to DCA. The sequence of research demonstrates that a directional city-pair is an appropriate unit of the airline market. Therefore, a market used in this research may consist of multiple routes.

2.4 Contribution to the Literature

While previous studies cover the effect of airline mergers and LCC entrants on the market power of merging firms, we believe that our focus yields two unique contributions to this literature. Firstly, the differential effect of the merger on the prices of a merged company across markets with different LCC presences has not been thoroughly investigated. This paper aims to quantify the estimated effect of the merger on Alaska's post-merger prices by analyzing the DB1B dataset. Though the finding may not be applied beyond the case of the Alaska merger, the estimation will inform us whether the existence of incumbent LCC competitors in the market should affect the Department of Justice merger decision-making and the validity of its decision.

Second, this is the first study examining the recent merger. Since the merger occurred between 2016 and 2018 and post-merger analysis requires a few years of data following the merger, the Alaska merger has not been studied yet in the literature. Furthermore, past studies are centered around mergers that involve the Big Four airlines due to their market dominance. This paper sheds light on the recent merger of the second-tier player and its potential impacts on consumer welfare after the merger.

3 Theory

Most economists describe the US airline industry as an oligopoly. Following the deregulation act of 1978, market competition lowered fares for many airlines to the point where they only cover variable costs.[9] Since airlines have high fixed costs to buy and maintain aircraft, this means that many airlines were not able to cover the full cost of running the companies. This competitive market environment exposed firms to bankruptcy and prompted industry-wide mergers and acquisitions. Consequently, the industry decreased from nine major players to just four between 2000 and 2015. In 2015, the Big Four (Southwest, American, Delta, and United combined) controlled 80% of the US market, turning the US airline industry undoubtedly an oligopoly.[10]

Tabacco (2017) shows empirical support for this claim. His analysis of the 2006 DB1B dataset confirms that 88% of markets have a maximum of three firms (Table 1). He further finds that the (1) a large majority of airline markets are dominated by at most two firms and (2) for markets with at least two firms the largest firm is, on average, almost three times bigger than the second-largest (Table 2). These findings provide empirical evidence for this paper to assume that the airline market is an oligopoly.

Table 1: Number of airlines across city pairs

Relevant N	Number of Markets	Percent
1	340	51.44
2	159	24.05
3	82	12.41
4	37	5.6
5∽ 9	43	6.5
Total	661	100

This table is created by the author
based on Table 2.4 in Giovanni (2017).

Table 2: Market shares and concentration

Market shares	Markets	Mean
s_1	661	0.673
s_2	661	0.238
s_1+s_2	661	0.956
$s_1+s_2 \geqq 0.7$	635	0.971

s_1=first largest, s_2=second largest
This table is created by the author
based on Table 2.5 in Giovanni (2017).

The oligopolistic market structure suggests that we have two options to model the market: a Cournot model and a Bertrand model. In general, a Cournot model supposes that multiple firms compete on quantity, while the Bertrand model assumes that multiple firms compete on price. This paper uses a Cournot model because Brander et al. (1990) offer empirical evidence that a Cournot model best fits the duopoly of the US airline routes. They reject a Bertrand model because the model does not fit the industry. The Bertrand model best fits the situation where prices are close to marginal costs. However, in reality, the firms charge prices that are higher than their marginal costs. Therefore, this study prefers a Cournot model to a Bertrand model.

Drawing on a classic oligopoly model developed by Cournot et al. (1838), this section provides how facing competition against an LCC rather than a legacy reduces the likelihood of a price increase due to a merger. To represent predominantly oligopolistic markets of the airline industry, this paper employs the Cournot model with three firms, accounting for asymmetric costs (Tremblay et al. 2012). Suppose a market consists of 3 firms: firm 1, firm 2, and firm 3. Each firm

[9] Federal Reserve Bank of St. Louis
[10] Ibid.

decides its output to maximize its profit simultaneously, and the equilibrium prices clear the market. To determine the optimal values of the firm's output, price, and profit, we first assume a concise functional form of inverse demand, $P = a - bQ$ where demand curves are negatively sloped. Q is the industry output that is the sum of the output of firm 1 ($q1$), firm 2 ($q2$), and firm 3 ($q3$). In the inverse demand function, a is the price intercept of demand, and $-b$ is the slope of it. We consider that the marginal cost of firm 1, firm 2, and firm 3 are c, c, and c' respectively. Since we consider the scenario where two firms merge, we suppose that firm 1 and firm 2 are merged into firm 2_m that produces output q_m at the marginal cost of c: here, $Q = q1 + q2 + q3 = qm + q3$. In this scenario, firm 3 acts as a competitor to a merged firm and there is a possibility that this firm 3 is either an LCC or a legacy.

Consider a profit function of firm 1 that takes the difference between revenue and total variable cost:

$$\begin{aligned}
\Pi_1 &= (P - c)q_1 \\
&= (a - bQ - c)q_1 \\
&= (a - b(q_1 + q_2 + q_3) - c)q_1 \\
&= (a - c - b(q_2 + q_3))q_1 - bq_1^2
\end{aligned}$$

Taking the first-order condition of this payoff function with respect to q_1 provides the following calculation:

$$\begin{aligned}
\frac{\partial \pi_1}{\partial q_1} &= a - c - b(q_2 + q_3) - 2bq_1 \\
&= a - c - b(q_1 + q_2 + q_3) - bq_1 \\
&= a - c - bQ - bq_1
\end{aligned}$$

Setting this to be equal to zero to obtain the optimal output level, the equation above provides the following conditions for each firm.

$$\begin{cases}
a - c - bQ - bq_1 = 0 \\
a - c - bQ - bq_2 = 0 \\
a - c' - bQ - bq_3 = 0
\end{cases}$$

Aggregating the three equations provides:

$$3a - 3bQ - 2c - c' = bQ$$

$$Q = \frac{3a - 2c - c'}{4b}$$

By solving for the inverse demand, $P = a - bQ$, we can obtain:

$$\begin{aligned}
P &= a - b\,\frac{3a - 2c - c'}{4b} \\
&= \frac{a + 2c + c'}{4}
\end{aligned}$$

This price is the optimal price level for each firm prior to the merger. Now, we consider the post-merger prices in a similar fashion, which provides the following optimal quantity and price.

$$\begin{cases}
a - c_m - bQ - bq_m = 0 \\
a - c' - bQ - bq_3 = 0
\end{cases}$$

$$2a - 2bQ - c - c' = bQ$$

$$Q = \frac{2a - c - c'}{3b}$$

$$P = a - b\,\frac{2a - c - c'}{3b}$$
$$= \frac{a + c + c'}{3}$$

Subtracting the pre-merger price from the post-merger price yields:

$$\Delta P = \frac{a + c + c'}{3} - \frac{a + 2c + c'}{4}$$
$$= \frac{a - 2c + c'}{12}$$

ΔP is the theoretical prediction of the fare difference before and after the merger. In other words, if $\Delta P > 0$, a merged company has increased the price after the merger. This Cournot model predicts that lower c' makes ΔP smaller because ΔP is increasing in the marginal cost of a competitor. This is due to the fact that the merged company pricing would be skewed to the low marginal cost of firm 3, which ultimately leads to the conclusion that the post-merger price with an LCC competitor should be lower than the post-merger price with a legacy competitor. We cautiously note two underlying assumptions in this theoretical framework. First, the model assumes that firms compete in quantities, as empirically shown in Brander et al. (1990). Second, this model makes the assumption of homogeneous products though airline seats may differ across airlines. Despite these assumptions of our theory, the following empirical section independently examines the differential effect of the merger on the merged firm's prices.

4 Data

The primary data source for this project is the DB1B Passenger Origin-Destination Survey from the American Bureau of Transportation Statistics (BTS). The DB1B database consists of three data tables: the DB1B coupon, the DB1B market, and the DB1B ticket, all of which are traditionally used in economics research. Yet, access to the full information requires being a U.S. citizen, receiving authorization from the Department of Transportation, and paying a substantial amount of money, which limits public availability of the dataset.[11] Although the literature heavily relies on this dataset (Luo 2014, Brueckner et al. 2013a, Bontemps et al. 2021, etc.), this paper alternatively uses a DB1B public dataset, which aggregates key information from the three data tables.[12]

The DB1B public dataset is still a 10% sample of all domestic airline tickets collected from reporting carriers on a quarterly basis. Each sample contains information on the ticket price, the origin and destination of the flight, the operating carrier, the connecting stops, the number of passengers, and other characteristics of each flight segment on the itinerary at a given fare in each quarter. This paper aggregates the itinerary-level dataset by airport pairs in each quarter, and further aggregates it by city pairs, following Brueckner et al. (2013b) and our definition of the market (details in 4.1). Our dependent variable is the average airfares of each market in a given quarter. This variable is computed by taking the weighted average of each ticket. Major explanatory variables are the share of LCC seats in the markets, the ratio of restricted/business/first-class seats, and the indicator for a roundtrip and a transfer.

4.1 Data Description

Market Definition and Application

In this paper, a market is defined as directional round-trip air travel between an origin city and a destination city. When econometrically modeling businesses, we need to reflect actual business decisions made by consumers. From the viewpoint of airline passengers, the question is "How do we incorporate substitutability between airports in the same cities?" This paper, following the grouping method proposed by Brueckner et al. (2013b), employs a city-pair grouping method with directional consideration because the method meets the need for substitutability.

Then, the question turns to "Which airports should be grouped into a single destination?" In the eyes of passengers, geographically proximate airports appear to be one destination simply because they are intuitively close to each other. However, those airports may have different transportation availability, distance to the city center, and so on. As a criterion to group multiple airports into one destination, this paper instead utilizes competition spillovers across airports within a metropolitan area. Suppose we have two airports A and B in city 1 and travel to airport X in city 2. If A and B are

[11] National Bureau of Economic Research

[12] Those three data tables are available from here though downloading all variables is blocked. Alternatively, the DB1B public database is accessible from here.

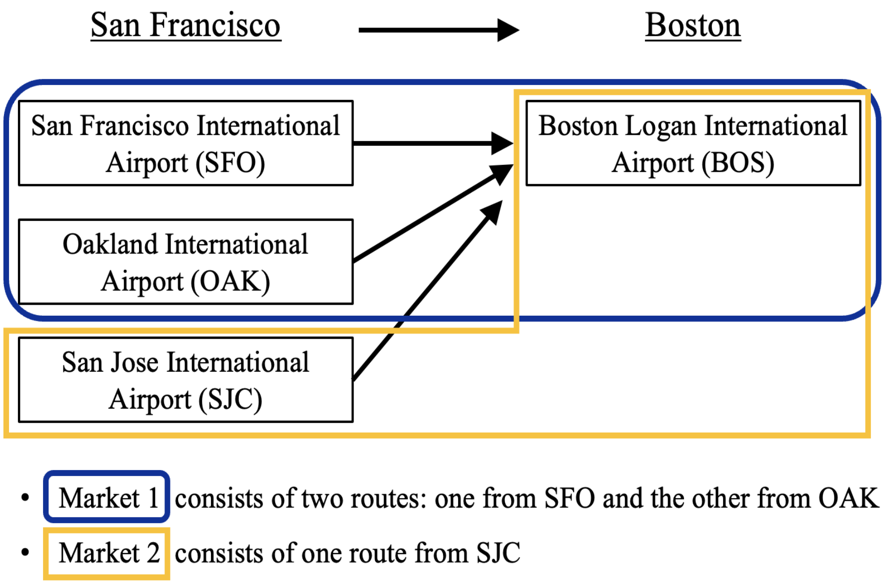

Figure 1: Difference between a route and a market

considered as a substitute, the level of competition on the A − X route affects the level of competition on route B − X as a spillover effect. This model provides more rigorous modeling than airport closeness because we don't misclassify airports that are not substitutes at all. For example, San Francisco is endowed with three airports San Francisco (SFO), Oakland (OAK), and San Jose (SJC). Although all of the three are within 30 miles away from one another, we observe spillovers only between OAK and SFO and not between SJC and SFO. As a result, we group only SFO and OAK as one origin/destination (Figure 1 visualizes how one market consists of multiple routes in San Franciso-Boston city pair.) In measuring the differential effect of a merger on Alaska airfares with different LCC presences, this notation is useful to incorporate spillover effects from its neighboring routes. Hence this grouping method gauging competition spillovers enables our model to consider LCC competitors that are both in the same route and in the neighboring routes.

In accordance with the directional city-pair grouping method, we construct our city-pair panel datasets from our raw itinerary-level dataset. In the process, we first aggregate the same type of tickets that connect the same airports at a given quarter as an airport-pair dataset. Then, we aggregate the airport-pair data to city-pair data based on airport groupings in Table 3. This paper assumes that customers in 10 urban cities interchangeably choose two or three airports. Going back to the case of San Francisco, consumers may choose between SFO and OAK and consider SJC as a separate option. As Alaska and Virgin have many routes around San Francisco (Figure 2 for their operating routes in 2016), this grouping method best reflects consumers' decision-making in real life.

Table 3: Airport grouping

City Name	Primary	Core	Ungrouped
Boston			BOS, MHT, PVD
Chicago	ORD	MDW	
Cincinnati	CVG	DAY	
Cleveland	CLE	CAK	
Dallas	DFW	DAL	
Detroit			DTW, FNT
Houston	IAH	HOU	
Log Angeles			LAX, BUR, LGB, SNA, ONT
Miami	MIA	FLL	PBI
New York	LGA	EWR, JFK	HPN, ISP
San Francisco	SFO	OAK	SJC
Tampa	TPA	PIE	SRQ
Washington, DC	DCA	IAD, BWI	

The author created this table based on Brueckner et al (2013b).
The IATA website displays a full name for the three digit airport code.

Figure 2: Operating Routes of Alaska Airlines and Virgin America[13]

B. *Variable Definitions*

Our raw dataset DB1B contains the following variables:

1. **Itinerary fare** is the price in the nominal US dollar that is paid for the ticket. The price covers not just a fare but also sales tax, service fee, fuel surcharge, and other associated costs. When aggregating to our airport/city-pair dataset, we calculate the mean of the airfares for Alaska/Virgin and all airlines in each route/market in a given quarter and take the log of it.

2. **Reporting / Operating / Ticketed carrier** variables indicate what reporting, operation, and ticketing carriers are respectively, and we choose to retain the operating carrier because they are primary service providers.

3. **Year / Quarter** is the time dimension of the data as carriers report their tickets to the BTS quarterly; the dataset does not allow us to obtain exact dates and times of flights.

4. **Coupons** indicate the number of separate flights in the itinerary. For a given flight ticket, one or more coupons are assigned, which specifies the number of flights incorporated in the ticket. When aggregated to airport-pairs and city-pairs, we compute the total number of coupons in the quarter.

5. **Passengers** show how many passengers bought a similar ticket in the same quarter in terms of itineraries, fares, carriers, etc. Having this variable taking any discrete values above 0 re-emphasizes that the unit of observation is not a passenger but an itinerary that shows the same routes, airfares, class of seats, and airfares in a given quarter (we call this itinerary-level in this paper).

6. **Origin / Destination airport, city, and state** are 3-digit identifiable codes for the airport of the origin, destination, and possibly (a) transit(s), which later allows us to group neighboring airports.

7. **Fare class** represents six different types of fare class that are split into restricted (i.e. non-refundable) and unrestricted, and first, business, and coach class coupons.

Based on the variables in the dataset, we construct two LCC indicators: the market shares of LCCs and the number of LCC carriers:

8. **Market shares of LCCs**: we start from our definition of LCCs—"LCCs are airlines that have smaller networks with a hybrid of a hub and spoke and point-to-point network attributes, simpler service levels and a lower overall

[13] Flying Better Together

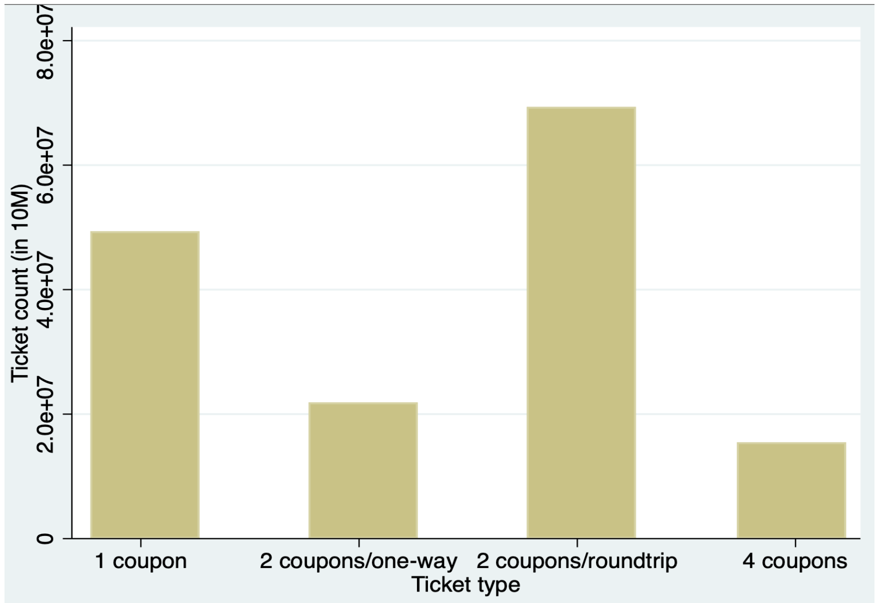

Figure 3: Distribution of ticket type

cost structure that allows them to offer significantly lower fares" (Tsoukalas et al. 2008). This definition classifies 7 US domestic airlines as Low-Cost-Carriers: Southwest, JetBlue, Spirit, Allegiant, Frontier, and Sun Country. We compute the total number of seats offered by LCCs in each market and compute the ratio to the total seats supplied.

9. **Number of LCCs**: we simply count the number of operating LCCs in each market.

Despite seemingly ideal panel data, the DB1B dataset is not complete in some aspects. It lacks information about when the flight occurred within the quarter range since the dataset is quarterly aggregated. Granular information about the time dimension would improve the accuracy of our estimate, but the heterogeneous treatment effect of the merger, if it exists, should be observable at a quarter level. Furthermore, this paper is conscious of a selection bias because the dataset only reports data from U.S. airlines and domestically-certified foreign airlines. A similar selection-bias concern also arises if we consider some small US regional airlines such as Central Airlines and Allegheny Airlines, which are not required to report their data. Yet, given our target data source is domestic flights that a few major US airlines hegemonize, data representability concerns are inconsequential (Cristea 2011).

4.2 Sample Selection

Since the DB1B dataset includes randomly selected samples of all airline tickets, we need to downsize our data based on several criteria.[14] Because we are analyzing the merger that begun in December 2016, we select data from 2015Q1 to 2019Q4. The pre-merger sample comes from samples until 2018Q1 because the Federal Aviation Administration granted a single operating certificate for Alaska Airlines and Virgin America in January 2018. The post-merger sample comes from after 2018Q2 because our dataset informs us that the number of tickets sold by Virgin America suddenly dropped to 0 in 2018Q2.

To maintain our dataset in a usable form, this paper focuses on tickets that are one-way or round-trip tickets with no more than one transfer. In order to select such samples, we exploit a data column, flight coupons, that is allocated one per flight; for instance, an indirect round-trip ticket from D.C. to Alaska with a transfer in San Francisco comes with four coupons. This suggests that we only keep tickets with less than five flight coupons. Among flight tickets that contain up to four tickets, this paper only analyzes the following four types of tickets: one-way nonstop tickets, one-way tickets with one transfer, round-trip nonstop tickets, and round-trip tickets with one transfer each. Figure 3 shows the distribution of four types of tickets. Apparently, round-trip tickets with and without a transfer are major options due to their cost advantage over one-way tickets.

Furthermore, we drop the markets that showcase fewer than 90 passengers in our samples during a quarter. In reality, this means that we remove markets that carry less than 900 passengers per quarter or 75 passengers per week

[14] According to a contact person in the Department of Transportation, "random sampling refers to that there is an entire population, and that the DOT is requesting a sampling of that population." This implies that its "randomness" may not be rigorous in the econometrics sense.

(since the DB1B data represents 10% of all tickets in the US). Having a small number of passengers implies that those markets are irregular flights in which we may not observe fare competition among carriers, which contradicts our model assumption of competitive markets in a pre-merger state. Additionally, extreme outliers of nonzero itinerary fares are removed from our main analyses based on its interquartile range within groups of fare classes. This paper defines extreme outliers as values that are greater than the 75th percentile plus 3 times the IQR or less than the 25th percentile minus 3 times the IQR. Even after our data cleaning process, our dataset still contains over 60 million itinerary-level samples or 140 thousand market-level samples, which is sufficient sample size for regression analyses.

4.3 Summary Statistics

We generate summary statistics to provide a rough sketch of the sample used for estimation. Among the four columns in Table 4, our estimation uses Column 4 for the first difference model, and Column 2 for the fixed effects regression. As previously described, we aggregate the itinerary-level dataset by airport pairs in each quarter, which is reported in Column 1. We further aggregate it by city pairs based on our grouping method, reported in Column 2. Since Column 2 is the summary of the dataset with all airlines operated on all markets, our fixed effects estimation analyzes this holistic dataset. A comparison of Column 1 and 2 highlights how city-pair grouping alters our airport-level data.

In addition, we also need to run the first difference model with only Alaska/Virgin airfares, and Column 2 contains more information than the model requires. Hence, we firstly create another aggregated dataset with only markets where either Alaska or Virgin operate, reported in Column 3. Then, we construct an aggregated dataset with only Alaska/Virgin tickets. Comparing Column 2 and 3 showcases the characteristics of markets that Alaska/Virgin operate. Comparing Column 2 and 4 in turn showcases how the characteristics of Alaska/Virgin routes deviate from the market average. Finally, comparing Column 3 and 4 sketches the idiosyncrasy of Alaska and Virgin tickets in their markets.

Interpreting the data in Column 2 and Column 4 provide us with a better sense of how our dataset behaves. Our key dependent variable is the mean of market airfare. The first row of Table 4 tells us that the average of Alaska/Virgin airfares is \$5 lower than the market average (\$330 $<$ \$335). On the other hand, the average of Alaska/Virgin tickets is \$8 higher than the average of the tickets in their operating routes (\$330 $>$ \$322). This implies that Alaska/Virgin overall charges lower fares than the market average, but if we limit our scope to their operating routes, they charge more than other competitors in the same market.

We will also use total passengers and total revenue as dependent variables to estimate the differential effect of the merger on quantity supplied and total sales in the markets with different LCC presences; hence those two variables are considered as auxiliary dependent variables. The second row reports the total number of passengers in a market in a given quarter, and the third row reports how much sales (calculated as airfares times the number of passengers) a market has in a given quarter. Comparing Column 3 and 4 informs us that Alaska/Virgin occupy roughly 38−39% of their markets in terms of passengers and revenue. Finally, our key independent variable is the ratio of LCC seats. The fourth row of Column 2 and 3 communicates that the average ratio of seats offered by the LCC is 28−32% and that the Alaska/Virgin market has a slightly higher LCC presence than the market average.

Furthermore, Figure 4 offers a casual observation of how our dependent variable for the first approach, average market airfares of Alaska/Virgin, distribute across markets with different degrees of competition with LCCs. Each boxplot represents how the fare distributions change before and after the merger closure in 2018Q1, depending on the ratio of LCCs in each market. “No LCC” represents that LCCs offer less than 10 percent of seats, “Low LCC” corresponds to 10−30 percent of LCC seats, “Medium LCC” responds to 30−60 percent of LCC seats, and “High LCC” does to over 60 percent of LCC seats. This figure visualizes that the greater presence of LCCs is associated with more downward pressure on Alaska/Virgin post-merger airfares.

Table 4: Summary Statistics

Market Definition Market Population Airfare Average	(1) Airport-Pair All All Airlines	(2) City-Pair All All Airlines	(3) City-Pair Alaska+Virgin Markets All Airlines	(4) City-Pair Alaska+Virgin Markets Alaska+Virgin
Market airfare (mean)	328.01 (111.2)	339.93 (117.8)	322.50 (114.3)	330.48 (100.5)
Total passengers	904.08 (1723.6)	1044.64 (2521.9)	2386.44 (4157.5)	897.85 (1366.5)
Total revenue	2.5e+05 (460619.5)	3.0e+05 (681678.9)	6.6e+05 (1124105.6)	2.6e+05 (358836.5)
Ratio of LCC seats	0.30 (0.292)	0.28 (0.261)	0.32 (0.238)	
Number of coupons (mean)	2.22 (0.609)	2.30 (0.620)	1.97 (0.521)	1.90 (0.624)
Roundtrip (mean of dummy)	0.51 (0.171)	0.52 (0.174)	0.44 (0.205)	0.43 (0.214)
Transfer (mean of dummy)	0.49 (0.421)	0.54 (0.418)	0.42 (0.394)	0.35 (0.458)
Ratio of restricted tickets	0.18 (0.188)	0.18 (0.169)	0.18 (0.141)	0.05 (0.0775)
Ratio of business-class	0.01 (0.0169)	0.01 (0.0179)	0.01 (0.0191)	0.02 (0.0268)
Ratio of first-class	0.04 (0.106)	0.04 (0.102)	0.04 (0.0813)	0.03 (0.0263)
Total carriers	12.03 (5.134)	12.41 (5.252)	14.23 (4.775)	
Total LCC carriers	1.74 (1.307)	1.87 (1.458)	2.91 (1.682)	
Alaska Route (mean of dummy)	0.33 (0.439)	0.33 (0.435)	1.00 (0.0417)	
Virgin Route (mean of dummy)	0.08 (0.250)	0.08 (0.242)	0.26 (0.396)	
Southwest Route (mean of dummy)	0.59 (0.491)	0.62 (0.484)	0.83 (0.371)	
N	153921	138435	39913	7812

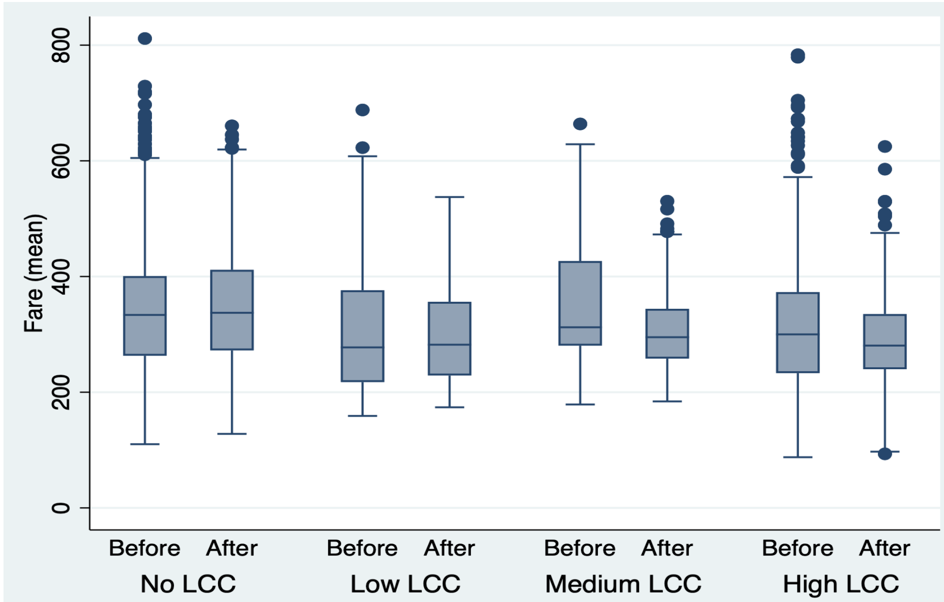

Figure 4: Comparison of Alaska/Virgin airfares before and after the merger across different LCC presences

5 Identification Strategy

We employ two separate approaches to answer our research questions. Firstly, we directly use the data on the merged company's airfares, which comes from Column 4 in Table 4, and employ a two-period first difference model and a fixed effects model. This model informs us of the direct effect of the merger on their fares and how the effect differs across markets with different degrees of competition from low-cost carriers. Secondly, we use the pooled OLS and the fixed effects model for the airfares of all airlines, which is presented in Column 2 of Table 4. These models measure the effect of the merger on the market fares that Alaska/Virgin serve and how the effect differs across markets with different magnitude of LCC presence. This allows us to estimate the spillover effect and to learn the effect of the 2016 merger on their competitors as well.

5.1 First Difference Model

To study the effect of the merger on the merged airline's airfares, I begin with a two-period first difference (FD) model to exploit the panel data between pre- and post-merger periods. The timing of the merger period from 2017Q1 to 2018Q1 creates two periods, one before and one after the merger: pre-merger from 2015Q1-2018Q1 and post-merger 2018Q2-2019Q4. This estimation utilizes the data on the merged company's airfares from Column 4 in Table 4. This dependent variable is denoted as Y_{mq}^{ASVX}, in which the superscript ASVX indicates that only Alaska/Virgin fares are included, and subscripts (m) and (q) denote market and quarter respectively.

An FD model is effective when we face unobservables that cause omitted variable bias. One of the identification challenges in this study is that there are unobservable confounders that can cause a serious omitted variable bias (e.g. time-invariant market-specific factors that individually affect each market). An FD model takes the difference of the same market across time, which allows us to eliminate unobserved variables throughout sample periods. Since this is a two-period FD model, the estimators are numerically equivalent to within estimators.

Suppose

$$\overline{Y}_{mq}^{ASVXbef} = Mean(Y_{m(2015q-2018q)}^{ASVX}) \text{ for } Y^{ASVXbef} = [Y_{2015q1}, Y_{2018q1}]$$

$$\overline{Y}_{mq}^{ASVXaft} = Mean(Y_{m(2018q-2019q)}^{ASVX}) \text{ for } Y^{ASVXaft} = [Y_{2018q2}, Y_{2019q4}]$$

$$\text{where } q \in \{q1, q2, q3, q4\}$$

Then we can start from the following fixed effects (FE) regression to construct the FD regression:

$$ln(\overline{Y}_{mq}^{ASVX}) = \alpha_m + \alpha_t + \alpha_p post + \beta(LCC_m^{bef} \times post) + \gamma \mathbf{X'_{mq}} + \epsilon_{mq} \tag{1}$$

$$\text{where } LCC_m^{bef} = \frac{Seats_{LCC_m^{bef}}}{Seats_{Total_m^{bef}}}$$

Taking the difference between pre- and the post-merger periods yield the following FD regression:

$$ln(\bar{Y}_{mq}^{ASVXaft}) - ln(\bar{Y}_{mq}^{ASVXbef}) = \alpha_p(1-0) + \beta LCC_m^{bef} + \gamma(\mathbf{X'^{aft}_{mq}} - \mathbf{X'^{bef}_{mq}}) + (\epsilon_{mq}^{aft} - \epsilon_{mq}^{bef})$$

$$\Delta ln(\bar{Y}_{mq}^{ASVX}) = \alpha_p + \beta LCC_m^{bef} + \gamma \mathbf{\Delta X'_{mq}} + \Delta\epsilon_{mq} \tag{2}$$

where

- $ln(Y_{mq}^{ASVX})$ represents a log market average fare of Alaska Airlines and Virgin America for a city-pair market (m) in a quarter (q). $\Delta ln(Y_{mq})$ is a log fare differential between pre-merger and post-merger, which is the outcome of our interest. We define q as a quarter to accommodate seasonality of ticket prices.
- LCC_m^{bef} is a ratio of the seats offered by LCCs in a given market (m) in the pre-merger period. This variable is computed by dividing the number of LCC seats by the number of all airlines' seats across all periods before the merger; hence this is denoted as LCC_m^{bef} instead of LCC_m. In this specification, ηLCC_m^{bef} is excluded from the model because it will be absorbed by the market fixed effects.
- $Post_t$ is an indicator of the time after the 2016 merger. Our primary model defines this to be equal to 1 if the period is 2018Q2 and onward.
- X'_{m1} is a vector of controls for a given market (m) in a quarter (q). This includes the number of coupons, a ratio of round-trip, a ratio of transfer, etc.
- α_m is market fixed effects.

Equation (2) calculates the difference between the two FE models in the pre- and post-merger periods. This approximates the percentage change of a time series Y_{mq}^{ASVX}. In this specification, we regress a log fare differential of Alaska Airlines on the ratio of LCC seats and other time-variant covariates with market fixed effects. Apart from it, we normally use clustered standard errors for panel regression since the errors are most likely correlated for the same market over time. In other words, concerning with serial correlation, we need to deal with an error term $\Delta\epsilon_{mt}$ that correlates with $\Delta\epsilon_{m(t-1)}$. However, our model does not require it because the sample periods are collapsed into two periods. In our example, we only have one $\Delta\epsilon_{mq}$ for each market due to the model construction; so, we don't need standard errors that are robust to serial correlation. Therefore, the FD model with simple heteroskedasticity-robust standard errors can extract a pure effect of the merger on the post-merger airfares of Alaska Airlines.

In addition to the FD model, we also use the FE model to validate the FD estimate. Equation (1) computes the numerically equivalent estimate as Equation (2). The FE model captures the heterogeneous treatment effect of the Alaska-Virgin merger on their airfares across markets with different degrees of LCC competition. Although α_p captures the direct effect of the merger, the coefficient cannot be observed since it is absorbed by the fixed effects. Combined with the FD model, the FE model computes the effect of the heterogeneous treatment effect.

It is important to note that the FD model that eliminates the time dimension may cause an endogeneity bias. The baseline assumption in Equation (2) is that pre-merger samples and post-merger samples are comparable after controlling for covariates $\Delta X'_{mq}$. This implies that we could include time-variant factors that systematically shift from the pre- to post-merger period as a part of the effect of the merger. Many unobservable factors such as consumers' willingness to pay for flight (S. Berry et al. 2010) and energy prices are potential sources of omitted variable bias. Furthermore, we may overestimate the effect of the merger on post-merger Alaska's fares. As Beckenstein et al. (2017) concludes, LCCs still lower average airfares of their operating markets. Our model may include this continuous effect, which causes us to overestimate the magnitude of the coefficient. This problem arises from the nature of the model that we don't have any control group to compare Alaska/Virgin with. These concerns motivate us to exploit samples of all airlines with a panel estimator, which would ideally yield a more unbiased estimator.

5.2 Pooled OLS Model and Fixed Effects Model

In the presence of omitted variables, we need a fixed effects (FE) model to obtain consistent estimators for the effect of the merger on post-merger airfares (Wooldridge 2001). Key distinctions from the FD model are that we can exploit panel structure to obtain a consistent estimator and that we can take advantage of all samples in the dataset. The FE model is designed to capture the intended effects by using all samples including ticket information of both Alaska/Virgin, and other airlines such as United, Southwest, American, and Delta. This change in the data samples allows us to estimate the effect of the merger on the Alaska/Virgin operating market and how the effect varies across markets with different degrees of LCC competition. Additionally, because adding the Big Four to our samples significantly increases the sample size, this estimation enables us to obtain a precise estimator of the treatment effect.

Before the FE model, we first introduce the Pooled OLS model with controls. Through the Pooled OLS, this paper explains how each interaction term measures the effects that this paper is keen on exploring. Even with numerous controls, this model computes an inconsistent and biased estimator because a necessary condition for OLS is not satisfied. This leads us to the FE model that mitigates the biasedness and consistency of our estimate due to its entity and time fixed effects.

To build up for our FE model, we first run the following Pooled OLS regression with controls:

$$ln(Y_{mt}) = \alpha + \beta_1(LCC_m \times Post_t) + \beta_2(ASVX_m \times Post_t) + \beta_3(ASVX_m \times LCC_m \times Post_t) + \gamma \mathbf{X'_{mt}} + \epsilon_{mt} \quad (3)$$

where

- $ln(Y_{mt})$ represents a log market average fare for a city-pair market (m) in a quarter (t). This market fare takes the log average of all airlines' fares operating in the market (m) in the quarter (t): $ln(Y_{mt}) = ln(Y_{mt}^{AllAirlines})$. Unlike the FD model, the FE model allows us to use a time dimension t instead of q.
- $ASVX_m$ is an indicator of the markets that either Alaska or Virgin operated prior to the 2016 merger.
- LCC_m is a ratio of the seats offered by LCCs in a given market (m). We divide the number of LCC seats by the number of all airlines' seats during the pre-merger periods; hence this is denoted as LCC_m instead of LCC_{mt}.

Note that LCC_m is not a dummy but a continuous variable that takes a value between 0 and 1. A unit of observation in our aggregated dataset is a city-pair market in a given quarter. This means that each market is made up of flights with one, two, and four coupons. In travels with two or four coupons, there are cases where only a fraction of the coupons are offered by LCCs and the rest are offered by legacy carriers.

This model intends to capture the effect of the merger on the average fares of Alaska/Virgin markets and how the treatment effect differs across markets. The first effect is measured via β_2. The second effect is measured via β_3. β_2 is also interpreted as the effect of the merger on the fares of Alaska/Virgin markets without LCCs, whereas β_3 is interpreted as the additional effect of the merger on the fares on the Alaska/Virgin markets with LCCs. β_1 is the effect of the merger on the fares of non-Alaska/Virgin markets with LCCs.

This model structure is akin to a popular difference-in-difference model with a continuous treatment variable because our data compares the difference between Alaska/Virgin and non-Alaska/Virgin markets before and after the merger, across different LCC ratios in the markets. However, even with time-variant market-level controls, this OLS model cannot yield an unbiased estimator because the model does not account for other time-variant or market-specific factors. For instance, it fails to control for macroeconomic factors ranging from inflation rate to fuel prices, consumers' propensity for airlines, etc. affecting airfares. In addition to those time-variant variables, heterogeneity of markets also influences the prices: for example, the presence of major players as direct competitors, the availability of connecting flights, etc. The combination of the two results in this model violating the orthogonality condition of the OLS, which leads to the violation of the necessary condition of strict exogeneity (Wooldridge 2001; Angrist et al. 2009). To eliminate the underlying endogeneity biases in the Pooled OLS model, this paper introduces the FE model.

The FE model allows us to observe the impact of the merger on the fares of the markets that Alaska/Virgin serve with and without LCCs. We employ a fixed effects model that includes both unit fixed effects and time fixed effects in OLS. By controlling for those effects, the model enables us to accurately estimate the differential effect of the merger on the Alaska/Virgin market airfares. The idiosyncratic (standard) errors are clustered by the market because our treatment, the LCC ratio, is defined at a market level. The clustered standard errors are robust to correlation within a market over time:

$$ln(Y_{mt}) = \alpha_m + \alpha_t + \beta_1(LCC_m \times Post_t) + \beta_2(ASVX_m \times Post_t) + \beta_3(ASVX_m \times LCC_m \times Post_t) + \gamma \mathbf{X'_{mt}} + \epsilon_{mt} \quad (4)$$

where

- α_m is market fixed effects. This term absorbs other market-specific terms: $ASVX_m$, LCC_m, and $ASVX_m \times LCC_m$
- α_t is time fixed effects. Similarly, this absorbs $Post_t$.

As previously mentioned, the market fixed effects control for heterogeneity of markets such as the presence of major players as direct competitors, the types of airports, seasonal travel demand, etc. In addition, time fixed effects control for time-variant factors such as inflation, fuel prices, aggregate demand for travel, etc. The FE model will capture the unobserved effects that are not fully absorbed by observable controls available in the dataset. As a result, this model is expected to mitigate the endogeneity bias concerns that we raised in the OLS model.

There are four caveats that need to be noted. First, the FE model does not allow us to measure the exact difference in Alaska's post-merger fares between a market with LCCs and a market without LCCs. Identifying this difference requires us to compute E[Y|ASVX=1, post=1, LCC=1] − E[Y|ASVX=1, post=1, LCC=0]. This assumption means that we need to add up the coefficients on four terms: LCC_m, $ASVX_m \times LCC_m$, $LCC_m \times Post_t$ and $ASVX_m \times LCC_m \times Post_t$. Out of the four, we can only observe the last two terms since our LCC ratio is defined as the average of the ratio during the pre-merger period and the first two terms are absorbed by the market fixed effects.

Secondly, this model cannot measure the causal effect of the merger on the Alaska post-merger airfares. A lack of instrumental variables and access to other identification strategies such as difference-in-difference lead us to make correlational statements on two variables, not necessarily their causal relationship. Third, this model makes sense only if the merger treatment does not affect the control group (i.e. the non-Alaska/Virgin markets without LCCs). This imposes an implicit assumption that the treatment has nothing to do with the control market. Fourth, we may have a weak simultaneity bias between the dependent variable and the pre-merger LCC ratio. Since our LCC ratios are defined as divisions of quantities, we may have a simultaneity issue. Yet, averaging them in each market would mitigate the issue. We will readdress the simultaneity issue when we discuss results in the subsequent section. Having said that, understanding these limitations helps us accurately interpret our results in the next section.

6 Results and Discussion

First, we run an analysis on data that includes only Alaska/Virgin airfares. The results demonstrate that the merger increases the Alaska/Virgin fares, conditional on many characteristics. Further, in accordance with our theory, LCCs mitigate the post-merger price increase of Alaska and Virgin markets compared to non-LCC markets. Second, our FE informs that LCCs decrease the post-merger prices of all airlines compared to non-LCC markets, regardless of whether Alaska and Virgin operate in the markets. This implies that LCCs drive down post-merger prices for reasons other than the merger itself or that the merger is a treatment influencing all markets. Additional analysis on quantity and revenue tells us that LCCs put downward pressure on post-merger quantity and revenue more on ASVX markets than non-ASVX markets, which our Cournot model does not capture.

6.1 Result 1: Effect of the merger on Alaska's airfares

We begin with FD and FE models, both of which use Alaska/Virgin airfares. The FE model should also provide a similar result as the FD model because an FD estimator is numerically equivalent to a within estimator. The results for the FE model (1) are reported in Table 5, and the results for the FD model (2) are reported in Table 6. In Table 5, Column 6 informs us of the result from the FE model with all controls. The coefficient on LCC ratio × Post is −0.23 and is statistically significant at the 1% level. This indicates that a market with a full presence of LCCs has on average 23% lower post-merger airfares of Alaska/Virgin than a market without LCCs. Column 4 in Table 6 gives a similar number for the coefficient on the LCC ratio. The magnitude is −0.23 and is also statistically significant at the 1% level. The first row of Table 6 shows that the merger has an upward force on Alaska/Virgin airfares, increasing it by 2.8% compared to the pre-merger level. This illustrates that the direct effect of the merger is positive on the Alaska/Virgin airfares.

6.2 Result 2: Spillover effect of the merger on Alaska/Virgin markets

We run the Pooled OLS and the FE model in Table 7. Our estimation in the Pooled OLS and the FE model includes all city-pair samples of all airlines' airfares including both Alaska/Virgin operating and Alaska/Virgin non-operating markets. The coefficient on the triple interactions, ASVX market × LCC ratio × Post, computes the additional effect of the merger on the fares of Alaska/Virgin markets with LCCs. Column 6 in the table reports that the post-merger prices of all airlines decrease in the markets with LCCs compared to non-LCC markets, independent of Alaska/Virgin operation in the markets. As the coefficient on the triple interaction is not statistically significant at the 10% level, we cannot observe a force that uniquely works in the Alaska/Virgin markets with LCCs. Instead, the coefficient on LCC ratio × Post explains what is happening here. These results indicate that the merger between Alaska and Virgin has a downward pressure on airfares in the markets where LCCs operate but are not limited to Alaska/Virgin serving markets. Additionally, ASVX market × Post captures the effect of the merger on the fares in the Alaska/Virgin market without LCCs. Akin to our Result 1, the merger increases the airfares by 2.4% compared to the pre-merger level.

This paper further investigates the fares of non-Alaska/Virgin markets in the similar specification:

$$ln(Y_{mt}^{nonASVX}) = \alpha_m + \alpha_t + \beta(LCC_m \times Post_t) + +\gamma \mathbf{X'_{mt}} + \epsilon_{mt} \tag{5}$$

The coefficient β of Equation (5) captures the effect of the merger on the airfares of non-Alaska/Virgin markets with LCCs. The result of this specification is reported in Table 8. The result shows that the presence of LCCs decreases the post-merger airfares of non-Alaska/Virgin markets by 3.4%, which confirms that the effect of the merger and LCCs are not limited to Alaska/Virgin markets.

Although this research focuses on airfares as the main outcome variable, there are other interesting dependent variables that are informative for grasping the effect on the merged company's outcomes. Table 9 regresses the number of passengers instead of airfares as an outcome variable. Noticeably, the coefficient of ASVX market × LCC ratio × Post is -0.082 and is now statistically significant at the 1% level with a higher t statistic than the previous (4.74 > 1.37). This illustrates that LCCs put downward pressure on post-merger quantity more in Alaska/Virgin markets than non-Alaska/Virgin markets.

Though the previous two tables report how the presence of LCCs affects airfares and the number of passengers, the overall impact on revenue is still mystifying. Hence, we generate Table 10 that runs the regression of revenue. In the third row, we obtain a negative coefficient of -0.067 on the triple interaction with statistical significance at the 1% level. This represents that LCCs put downward pressure on post-merger revenue more in Alaska/Virgin markets than non-Alaska/Virgin markets. Combined with the results from the previous two tables, this finding highlights that the negative effect of the merger on passengers exceeds the (marginally) positive effect of the merger on airfares; hence, the overall effect of the merger on revenue turns out to be negative. Furthermore, since the overall revenue goes down for Alaska, it means that an LCC ratio is associated with a decrease in its market shares. During the sample periods, the US domestic market experiences a monotone increase in its market size.[15] Thus, a drop in quantity supplied and revenue (in an absolute term) indicates a decrease in the market shares.

6.3 Discussion

Our results provide several implications for understanding the impact of the merger on Alaska Airlines. The first approach to the direct effect of the merger yields the result that the Cournot model anticipates. However, the second approach finds that LCCs decrease the post-merger prices of all airlines, regardless of Alaska/Virgin's operation in the markets. It raises a question of whether LCCs drive down post-merger prices for reasons other than the merger or if the merger is a "treatment" affecting all markets (not just Alaska/Virgin markets). Given the Southwest effect studies in Beckenstein et al. (2017), it is likely that LCCs drive down post-merger prices for reasons other than the merger (e.g. continuous downward pressure on market airfares).

The last set of regressions illustrates that LCCs put downward pressure on post-merger quantity and revenue more on Alaska/Virgin markets than non-Alaska/Virgin markets. Our Cournot model does not predict the change in the quantity and the revenue, but this result may indicate that Alaska Airlines move their seats from LCC to non-LCC markets. This scenario is plausible if airlines believe that the LCC-intensive markets are not lucrative for the merged company.

In addition, one natural question about the merger is how much the DoJ should have accounted for the presence of LCCs in their merger evaluation process. The first major implication of my study is that there is no evidence that LCCs affect only the fares of Alaska Airlines after the merger. More specifically, we find important evidence that the presence of LCCs is associated with lower Alaska's post-merger passengers as well as revenue. This supports the DoJ's conditional approval of the Alaska-Virgin merger on the ground that the merger does not harm the consumer benefits in terms of airfares.

At the same time, our evidence on revenue implies that the DoJ may have overestimated the bargaining power of the merged company. The DoJ usually evaluates not just how the airfares will change after the merger but also how the market share of the merged company will shift. Although this paper shows that LCCs do not affect airfares, we find that an LCC presence is associated with a lower market share of Alaska. Given the lack of literature on this topic, it is likely that the DoJ did not consider the presence of LCCs in their evaluation. With this assumption, this finding raises the concern that the DoJ could have overestimated the ex-ante market power of the merged airline.

When recognizing these implications, we should also acknowledge some limitations of our results. First, this paper does not claim that conclusions from this case study of the Alaska-Virgin merger are applicable to other mergers. Guar-

[15] The Bureau of Transportation Statistics

anteeing external validity requires multiple case studies or structural analysis, but this paper suffices for neither. Having said that, it would still be informative to apply the caveat from this ex-post study to other event studies. Second, the sample period of our dataset may also limit the external validity of this study. Though this paper follows traditional IO papers that use two or three years or post-merger samples, a longer period of observations would enable us to obtain a more accurate estimate. An integration process that occurs one or two years after a merger is called "Post Merger Integration" (PMI). The success of the PMI is contingent upon the quality of management and other internal factors. In general, taking a longer sample period allows us to estimate an unbiased estimator that is robust to those factors related to PMI. But, the COVID-19 pandemic, an exogenous shock to the US airline industry, prevents us from taking advantage of more recent data. Those limitations are inevitable in my research design, so we would like to caution readers when interpreting our results.

More importantly, our estimates of interest might be smaller than they are in reality because of a simultaneity bias. In other words, the simultaneity between the market airfares and the LCC ratios dwarfs our coefficients. When the market airfares are high, we expect LCC airlines to enter the markets because their markups from the markets would be high. As a result, we see the positive relationship between the market airfare and the LCC ratio, which leads to a positive simultaneity bias. Hence, the bias causes the estimates involving LCC ratio in the FE models to be higher than it should be. For example, in the first approach, the coefficient on LCC ratio $\times$ Post is -0.23, but this estimates may be skewed to 0. The same issue may arise the coefficients on LCC ratio $\times$ Post and ASVX market $\times$ LCC ratio $\times$ Post in the second approach. Thus, it is likely that the downward pressure of LCCs is even higher than what our estimation suggests.

For future research applications, another interesting question that is worthy of investigation is the spillover effects of the merger on adjacent Alaska/Virgin markets. Our research has examined the direct effect of the merger on the Alaska/Virgin markets where the merged companies operate. One can also look at the indirect effect that LCCs have on adjacent Alaska/Virgin markets. The following Figure 5 visualizes how three types of markets are defined. In this analysis, one can exclude the data for Alaska/Virgin markets (solid line in 5) and investigate if LCCs on Alaska/Virgin markets influence differentially between adjacent markets (dashed line) and non-Alaska/Virgin markets. The difference between adjacent markets and non-Alaska/Virgin adjacent markets will be easily compared. The reason we cannot run this analysis is due to the complexity of our markets. Our markets consist of multiple routes, and each route consists of tickets with different numbers of coupons. This complexity makes it infeasible to define the idea of adjacent markets because any market can be classified as adjacent to Alaska/Virgin markets. Although this paper cannot examine the spillover effect, analyzing the effect also allows the DoJ to make a more informed decision on the merger assessment.

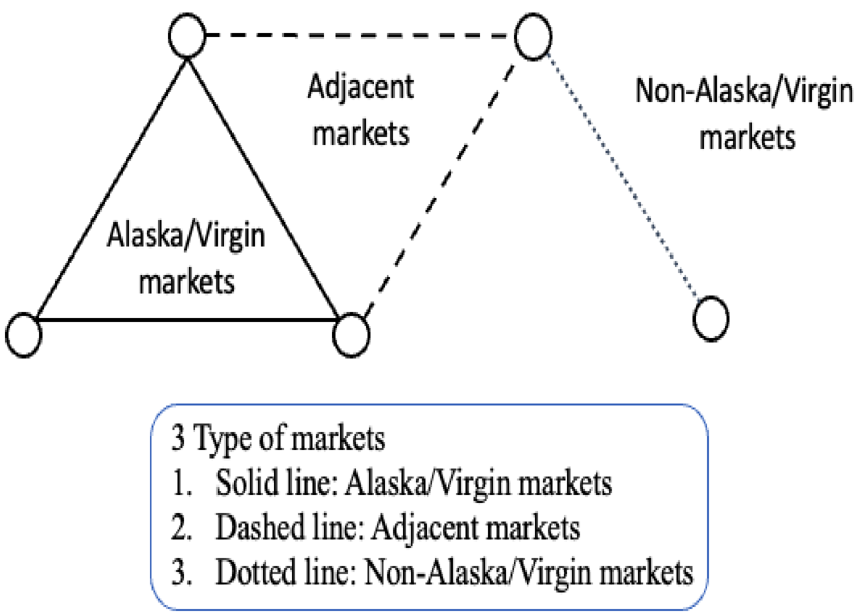

Figure 5: 3 types of markets

7 Conclusion

This paper contributes to a growing body of quantitative evidence that LCCs have multidimensional influences on the market outcomes of the US airline industry. This paper's analysis of specifically the Alaska-Virgin merger sheds light on the differential effect of the merger on post-merger airfares across markets with different LCC ratios. This paper draws insights from the DB1B public dataset, a rich and publicly available data source. First, the FD and FE models show that the merger increases the fares, but LCCs decrease the post-merger forces of Alaska/Virgin markets compared to non-LCC markets. Second, the FE model informs us that LCCs decrease the post-merger airfares of all airlines compared to non-LCC markets, regardless of whether Alaska/Virgin operate. Also, our results on the heterogeneous treatment effect demonstrate that LCCs put downward pressure on post-merger quantity and revenue more on Alaska/Virgin markets than non-Alaska/Virgin markets. The author believes that these results reflect the most up-to-date behavior of the US airline industry because the Alaska-Virgin merger is the latest merger among the major US airlines. To extend our findings beyond this period, considering the ramifications of the 2020 pandemic may provide researchers opportunities to extend my analyses in a more recent context.

Following our results, policymakers should be aware that they might have overestimated the ex-ante market power of Alaska Airlines in their assessment. It is important for them keep in mind that the presence of LCCs can limit the post-merger expansion of shares for the merged company. To evaluate the post-merger scenarios, we need to closely examine how market fares, as well as the number of passengers and revenue, will shift differentially across markets with different LCC ratios.

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8 Appendix

Table 5: Fixed Effects Regression
Regression of Alaska/Virgin airfares

	OLS			Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
	lfare	lfare	lfare	lfare	lfare	lfare
LCC ratio × Post	-0.17529***	-0.13931***	-0.24434***	-0.19055***	-0.17386***	-0.22725***
	(0.01406)	(0.01334)	(0.01689)	(0.01601)	(0.01488)	(0.01780)
Number of coupons		-0.11566**	-0.10371**		-0.12584**	-0.11725**
		(0.05123)	(0.04696)		(0.05176)	(0.04546)
Roundtrip (dummy)		0.66568***	0.72564***		0.67250***	0.76237***
		(0.08187)	(0.07579)		(0.08508)	(0.07533)
Transfer (dummy)		0.29508***	0.30653***		0.24716***	0.27655***
		(0.07808)	(0.07067)		(0.07818)	(0.06873)
Restricted seat ratio			0.90114***			0.99876***
			(0.06065)			(0.07344)
Business class ratio			-0.37394***			-0.60467***
			(0.11922)			(0.11168)
First class ratio			0.89618***			1.02701***
			(0.08956)			(0.09686)
Total of carriers × Post			0.00199			0.00005
			(0.00189)			(0.00169)
Total of LCC carriers × Post			0.00783**			0.01126***
			(0.00376)			(0.00349)
Southwest dummy × Post			-0.07205***			-0.07637***
			(0.01231)			(0.01278)
Number of aiports in origin × Post			0.01319			-0.00244
			(0.00804)			(0.00931)
Number of aiports in destination × Post			0.02119***			0.00349
			(0.00627)			(0.00753)
Market FE	No	No	No	Yes	Yes	Yes
Time FE	No	No	No	Yes	Yes	Yes
Itineary Controls	No	Yes	Yes	No	Yes	Yes
Other Controls	No	No	Yes	No	No	Yes
N	7648	7648	7648	7648	7648	7648
R^2				0.145	0.251	0.384

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: First Difference Regression
Regression of Alaska/Virgin airfares

	(1) Diff_lqfare	(2) Diff_lqfare	(3) Diff_lqfare	(4) Diff_lqfare
Post	0.00025	-0.02015***	-0.01017	0.02827***
	(0.00361)	(0.00764)	(0.00743)	(0.01005)
LCC ratio	-0.19205***	-0.19214***	-0.18009***	-0.23247***
	(0.01169)	(0.01155)	(0.01133)	(0.01334)
Number of coupons			-0.24155***	-0.10002
			(0.07693)	(0.07550)
Roundtrip (dummy)			0.67691***	0.50557***
			(0.11943)	(0.12086)
Transfer (dummy)			0.38933***	0.21556*
			(0.10896)	(0.11067)
Restricted seat ratio				0.79860***
				(0.12063)
Business class ratio				-0.31818**
				(0.15970)
First class ratio				1.05704***
				(0.19616)
Total of carriers × Post				-0.00194*
				(0.00102)
Total of LCC carriers × Post				0.01486***
				(0.00262)
Southwest dummy × Post				-0.08029***
				(0.01064)
Time FE	No	Yes	Yes	Yes
N	1500	1500	1500	1500
R^2	0.164	0.179	0.223	0.348

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Fixed Effects Regression
Regression of all airlines' airfares

	OLS			Fixed Effects		
	(1) lfare	(2) lfare	(3) lfare	(4) lfare	(5) lfare	(6) lfare
ASVX market × Post	-0.03970***	0.01498***	0.01265***	0.00963**	0.01358***	0.02374***
	(0.00346)	(0.00320)	(0.00387)	(0.00451)	(0.00397)	(0.00419)
LCC ratio × Post	-0.11762***	-0.07477***	-0.09005***	-0.01076	-0.05971***	-0.04351***
	(0.00506)	(0.00413)	(0.00571)	(0.00673)	(0.00580)	(0.00634)
ASVX market × LCC ratio × Post	0.10364***	0.02317**	0.04452***	0.01351	0.01905*	0.01477
	(0.01106)	(0.00980)	(0.01018)	(0.01200)	(0.01072)	(0.01079)
Number of coupons		-0.06883***	-0.05350**		-0.04603**	-0.02187
		(0.02198)	(0.02126)		(0.02293)	(0.02216)
Roundtrip (dummy)		0.79686***	0.79752***		0.72855***	0.69503***
		(0.03886)	(0.03772)		(0.04004)	(0.03888)
Transfer (dummy)		0.63441***	0.61153***		0.57569***	0.52830***
		(0.03487)	(0.03372)		(0.03608)	(0.03496)
Restricted seat ratio			0.16903***			0.16945***
			(0.00866)			(0.01079)
Business class ratio			0.86708***			1.10185***
			(0.04800)			(0.05692)
First class ratio			-0.04964***			-0.07254***
			(0.00913)			(0.00935)
Total of carriers × Post			-0.00219***			-0.00096***
			(0.00033)			(0.00037)
Total of LCC carriers × Post			-0.00329***			-0.00747***
			(0.00118)			(0.00122)
Southwest dummy × Post			0.00281			0.00349
			(0.00378)			(0.00382)
Number of aiports in origin × Post			0.01026***			0.01919***
			(0.00205)			(0.00233)
Number of aiports in destination × Post			0.01000***			0.02005***
			(0.00194)			(0.00228)
Market FE	No	No	No	Yes	Yes	Yes
Time FE	No	No	No	Yes	Yes	Yes
Itineary Controls	No	Yes	Yes	No	Yes	Yes
Other Controls	No	No	Yes	No	No	Yes
N	130154	130154	130150	130154	130154	130150
R^2				0.104	0.310	0.332

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Fixed Effects Regression
Regression of the market fares of Alaska+Virgin routes excluding Alaska+Virgin fares

	OLS			Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
	lfare	lfare	lfare	lfare	lfare	lfare
LCC ratio × Post	-0.11010***	-0.05375***	-0.07713***	0.00425	-0.04673***	-0.03433***
	(0.00390)	(0.00326)	(0.00515)	(0.00566)	(0.00497)	(0.00559)
Number of coupons		-0.03925*	-0.02871		-0.01669	-0.00058
		(0.02290)	(0.02232)		(0.02393)	(0.02337)
Roundtrip (dummy)		0.76423***	0.78014***		0.69884***	0.67746***
		(0.04021)	(0.03932)		(0.04133)	(0.04058)
Transfer (dummy)		0.57843***	0.56823***		0.52003***	0.48606***
		(0.03635)	(0.03547)		(0.03753)	(0.03681)
Restricted seat ratio			0.15811***			0.15354***
			(0.00892)			(0.01111)
Business class ratio			0.93942***			1.22027***
			(0.05101)			(0.06236)
First class ratio			-0.04970***			-0.07404***
			(0.00932)			(0.00972)
Total of carriers × Post			-0.00238***			-0.00117***
			(0.00034)			(0.00037)
Total of LCC carriers × Post			-0.00031			-0.00446***
			(0.00112)			(0.00114)
Southwest dummy × Post			0.00806**			0.00952**
			(0.00389)			(0.00393)
Number of aiports in origin × Post			0.00968***			0.02024***
			(0.00204)			(0.00235)
Number of aiports in destination × Post			0.00949***			0.02115***
			(0.00194)			(0.00229)
Market FE	No	No	No	Yes	Yes	Yes
Time FE	No	No	No	Yes	Yes	Yes
Itineary Controls	No	Yes	Yes	No	Yes	Yes
Other Controls	No	No	Yes	No	No	Yes
N	126693	126693	126689	126693	126693	126689
R^2				0.106	0.308	0.330

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Fixed Effects Regression
Regression of all airlines' passengers

	OLS			Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
	lpassenger	lpassenger	lpassenger	lpassenger	lpassenger	lpassenger
ASVX market × Post	0.20303***	0.13911***	0.06865***	0.03098***	0.04552***	0.04073***
	(0.00560)	(0.00486)	(0.00586)	(0.00710)	(0.00587)	(0.00620)
LCC ratio × Post	0.20403***	0.13977***	0.01704*	-0.11796***	-0.04330***	-0.05456***
	(0.00940)	(0.00741)	(0.00986)	(0.01161)	(0.00986)	(0.01076)
ASVX market × LCC ratio × Post	-0.28692***	-0.19175***	-0.13569***	-0.00397	-0.04697***	-0.08182***
	(0.01924)	(0.01562)	(0.01643)	(0.02035)	(0.01676)	(0.01723)
Number of coupons		-0.22120***	-0.24019***		-0.27018***	-0.30184***
		(0.04513)	(0.04462)		(0.04618)	(0.04617)
Roundtrip (dummy)		0.49206***	0.52778***		0.60302***	0.65546***
		(0.08005)	(0.07947)		(0.08177)	(0.08191)
Transfer (dummy)		-0.92794***	-0.88732***		-0.76827***	-0.70826***
		(0.07062)	(0.07015)		(0.07167)	(0.07202)
Restricted seat ratio			-0.08876***			-0.04682***
			(0.01429)			(0.01702)
Business class ratio			-0.74958***			-0.56846***
			(0.07767)			(0.08131)
First class ratio			-0.02631			-0.04373**
			(0.01936)			(0.02047)
Total of carriers × Post			0.00418***			0.00193***
			(0.00052)			(0.00058)
Total of LCC carriers × Post			0.01375***			0.01180***
			(0.00178)			(0.00184)
Southwest dummy × Post			0.00756			-0.00411
			(0.00610)			(0.00611)
Number of aiports in origin × Post			-0.00111			-0.01926***
			(0.00329)			(0.00366)
Number of aiports in destination × Post			0.00288			-0.01523***
			(0.00329)			(0.00376)
Market FE	No	No	No	Yes	Yes	Yes
Time FE	No	No	No	Yes	Yes	Yes
Itineary Controls	No	Yes	Yes	No	Yes	Yes
Other Controls	No	No	Yes	No	No	Yes
N	130154	130154	130150	130154	130154	130150
R^2				0.255	0.441	0.444

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Fixed Effects Regression
Regression of all airlines' revenue

	OLS			Fixed Effects		
	(1) lrevenue	(2) lrevenue	(3) lrevenue	(4) lrevenue	(5) lrevenue	(6) lrevenue
ASVX market × Post	0.16020***	0.15245***	0.08087***	0.04061***	0.05910***	0.06446***
	(0.00445)	(0.00380)	(0.00465)	(0.00541)	(0.00457)	(0.00483)
LCC ratio × Post	0.09380***	0.07099***	-0.06566***	-0.12872***	-0.10301***	-0.09806***
	(0.00810)	(0.00746)	(0.00941)	(0.01036)	(0.00957)	(0.00972)
ASVX market × LCC ratio × Post	-0.18181***	-0.17241***	-0.09370***	0.00953	-0.02792**	-0.06705***
	(0.01523)	(0.01302)	(0.01365)	(0.01645)	(0.01416)	(0.01404)
Number of coupons		-0.25717***	-0.26458***		-0.31621***	-0.32371***
		(0.04350)	(0.04353)		(0.04374)	(0.04427)
Roundtrip (dummy)		1.24025***	1.28061***		1.33157***	1.35049***
		(0.07986)	(0.07985)		(0.08027)	(0.08124)
Transfer (dummy)		-0.33938***	-0.31671***		-0.19258***	-0.17996***
		(0.06809)	(0.06838)		(0.06814)	(0.06923)
Restricted seat ratio			0.06713***			0.12263***
			(0.01189)			(0.01425)
Business class ratio			0.08986			0.53339***
			(0.06740)			(0.07357)
First class ratio			-0.08011***			-0.11627***
			(0.01871)			(0.01952)
Total of carriers × Post			0.00200***			0.00097**
			(0.00043)			(0.00047)
Total of LCC carriers × Post			0.00984***			0.00434***
			(0.00139)			(0.00146)
Southwest dummy × Post			0.01012**			-0.00062
			(0.00492)			(0.00488)
Number of aiports in origin × Post			0.00908***			-0.00007
			(0.00267)			(0.00292)
Number of aiports in destination × Post			0.01302***			0.00482
			(0.00271)			(0.00303)
Market FE	No	No	No	Yes	Yes	Yes
Time FE	No	No	No	Yes	Yes	Yes
Itineary Controls	No	Yes	Yes	No	Yes	Yes
Other Controls	No	No	Yes	No	No	Yes
N	130154	130154	130150	130154	130154	130150
R^2				0.275	0.404	0.407

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$