Empirical Essays in Industrial Organization

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A Dissertation submitted to

The Faculty of
The Columbian College of Arts and Sciences
of The George Washington University
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

May 15, 2022

Dissertation directed by

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Dedication

Dedicated to my parents, my brother, and my beloved Heenan Kim who continue to believe in me and helped me get this far.

Acknowledgments

I would like to express my special appreciation to my advisor, Prof. Wallace P. Mullin, who nurtured my research skills by challenging my intellect and whose invaluable advice, guidance, and constructive comments supported me from our first meeting to discuss research on the airline industry through the completion of my dissertation. I would also like to thank Prof. Sumi Joshi and Prof. Benjamin Williams for serving as my committee members. I appreciate all of them for making my defense an enjoyable moment and for their brilliant comments and suggestions.

Other members of the GW faculty helped me in various aspects of my doctoral study as well. In general, I would like to thank the Department of Economics at the GW. I was incredibly fortunate to have met and shared time with so many fellow students and friends who helped me with my academic work, my personal affairs, or, more often, both.

Last, I also want to thank my mom, my dad, my brother, and my beloved Heenan Kim. My hard-working parents have sacrificed their lives for my brother and me and have always provided us with unconditional love and care. I love them dearly, and I would not have made it this far without them.

Abstract of Dissertation

Empirical Essays in Industrial Organization

This dissertation contributes to the extant economics literature on industrial organization via three empirical essays that explore the strategic decisions of firms that compete in imperfectly competitive markets. By using data based on the United States' airline industry, I combine reduced-form analysis with structural form analysis to investigate the market- and industry-level behavior of oligopolistic firms.

Chapter 1 deliberates on the counterfactual merger simulations that have been carried out to establish the value of requiring slot divestiture at slot-controlled airports. I focus on two cases: the United Airlines–Continental Airlines merger and the American Airlines–US Airways merger. Slot divestment is done according to the requirements of antitrust enforcement agencies. The simulation results from three selected airports, Newark Liberty International Airport, Ronald Reagan Washington National Airport, and LaGuardia Airport, indicate that the average airfare reduced for all post-merger air travel products. As a result, the airlines attracted more passengers, creating consumer surplus at the airports. Nonetheless, the airlines are still struggling to alleviate anticompetitive risks resulting from overlapping non-stop routes. These problems occur when slot purchaser fail to enter the market for those routes. To address the structural limitations linked to slot divestiture, I tested other behavioral alternatives besides slot divestment: forcing the surrender of slots operating monopolistic routes, requiring code sharing between merged airlines and low-cost carriers, and opening frequent flyers programs to competitors and/or new entrants. Simulation results from these cases revealed that after merging the operations,

the alternative solutions would reduce the average airfare and the number of problematic routes. Therefore, the impact of price was dominant compared to only when slot divestment was needed. Also, requiring slot divestiture, combined with forcing slot purchasers to enter the market for overlapping nonstop routes and promoting code sharing, would have lowered the average airfare for all products and the overlapping non-stop routes. However, requiring slot divesture combined with the opening of the merged airlines' frequent flyer programs would not have addressed the problem of anti-competition on overlapping nonstop routes.

Chapter 2 is an investigation into the possibility that multimarket contacts result in collusion in the setting of capacity in the US domestic airline market. I first provide reduced-form evidence on the effect of multimarket contacts on the possibilities of firms colluding in setting capacity by demonstrating that levels of multimarket contract have significant negative correlations with the quantity of seats that airlines release. Specifically, the effect of multimarket contact is primarily led by the four largest airlines (Southwest, United, Delta, and American); this has a greater effect in smaller markets in comparison to medium-sized and larger ones. Lead by the evidence, I estimate structural model of demand and supply system with conduct parameter which capture the degree of collusion in setting capacity. The conduct parameter is specified as a function of multi market contact; it will be demonstrated that the conduct parameter shows that there is a significant and positive correlation between multimarket contact and collusion, suggesting that the greater the level of multimarket contact, the lower the quantity of seats that will be offered in comparison to non-collusive oligopoly equilibrium.

Chapter 3 empirically investigates how three recent major U.S. airline mergers affected their air travel product quality, focusing on passengers' convenience, connectivity, and flexibility arising from the merged airlines' network restructuring. Passenger convenience is measured via the difference between total travel time and average nonstop travel time between the origin and destination airports, termed extra travel time. Passenger connectivity is measured as the number of destinations offered at a given airport. Finally, passengers' travel flexibility is measured via the proxy of the merged airline's flight frequency on a given route. The regression results indicate that, in general, mergers significantly increase passengers' extra travel time in the short and long terms. Specifically, mergers lead to more extra travel time from/to de-hubbed airports. Furthermore, each merger was found to associate with increased extra travel time in markets in which the merging carriers had previously competed. In terms of passenger connectivity, while mergers result in an increased number of destinations, the number of destinations served by nonstop flights is not significantly affected. However, the number of nonstop destinations offered at de-hubbed airports reduces considerably following a merger. This study finds no evidence that the mergers' impact on the number of destinations differs in the case of pre-merger competition between the merging firms. Meanwhile, the results also indicate that mergers tend to lead to a decrease in flight frequency, meaning passengers experience less flexibility concerning flight options, with the effect appearing to be stronger for markets in which the merging carriers had previously competed.

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Chapter 1: Remedies in Airline Mergers: Analysis of the U.S. Domestic Airline Industry

1.1 Introduction

In assessing the potential impacts of a proposed merger, antitrust enforcement agencies typically attempt to predict how the union will alter the level and balance of market power. If the proposed merger may significantly weaken market competitiveness, then the agencies decide whether to block the merger or to negotiate regulatory remedies for the merging companies. Instead of outright blocking proposed mergers, developing regulatory remedies has expanded as the preferred method of resolving anti-competition related to mergers. In fact, from 2009 to 2019, 412 mergers were challenged by Federal Trade Commission (FTC) or Department of Justice (DOJ), 242 of which (59%) were resolved and settled via remedies.[1]

Traditionally, the two major categories of remedies have been structural and behavioral. Although structural remedies focusing on asset divestiture to competitors or new market entrants have continued to dominate, some structural remedies have broadened their scope to overlap with behavioral remedies. As a result, some divestiture strategies are combined with negotiations about the operation behavior of the merging companies. Such remedies typically yield mergers that receive approval, albeit at the expense of constraining merging firms with various prohibitive provisions and/or consent orders.

Since being deregulated in 1978, the U.S. airline industry has experienced more than 50 mergers or acquisitions. Nearly all have gone unchallenged, except the mergers of Northwest and Continental Airlines (2000) and of United Airlines and US Airways (2000). In two cases, antitrust enforcement agencies negotiated merger remedies

[1] Hart-Scott-Rodino Annual Report for fiscal years 2009-2019.
Available at https://www.ftc.gov/policy/reports/policy-reports/annual-competition-reports

as a means to proceed with the proposed mergers. The US Department of Justice (DOJ) announced on 27th August 2010 that it had ceased its investigation into the proposed United Airlines–Continental Airlines merger as both airlines had agreed to transfer their takeoff and landing slots at Newark Liberty Airport to Southwest Airlines. The decision to make this transfer was due to the DOJ's increasing concerns about the proposed merger's effects on competition. Specifically, due to the large overlap in the routes between both airlines' hub airports and Newark Liberty Airport, with Continental Airlines taking a large proportion of the available slots, it was difficult for other airlines to enter the market. Hence, there were antitrust concerns regarding the overlap routes where both airlines were offering nonstop services.

Despite Southwest Airlines holding 16.8% of the US domestic air travel market share in 2010, making it the leading US airline, Southwest was considered as the epitome of pro-competitive facilitator. This move highly favored competition as the airline had previously only serviced New York by way of 16 slots at LaGuardia Airport and some routes out of Long Island's Islip MacArthur Airport. Justifying the Newark Liberty Airport slot transfer to Southwest Airlines, the DOJ stated that Southwest Airlines would introduce low-fare competition against United Airlines, thereby balancing the latter's large Newark hub. Later, in 2013, the DOJ similarly challenged the proposed American Airlines–US Airways merger. In response, to boost competition in the US domestic airline industry, both airlines agreed to divest their slots and gates at key constrained airports across the country to low-cost carrier airlines. Specifically, the merging airlines were directed to divest 104 and 34 slots at Reagan National Airport and LaGuardia Airport, respectively. In this case, however, the recommendation from the DOJ to the Transportation Department was that a blind auction should be used to divest the slots, rather than selling them to a specific airline. As these cases show, in terms of airport divestiture, concerns with proposed US domestic airline mergers have frequently been mitigated with a focus on slots and

assets, i.e. gates and facilities.

The antitrust enforcement agencies' preference for such structural remedies stems primarily from the difficulties in monitoring behavioral remedies as well as the lessons learnt from a historical case. In 1974, an antitrust lawsuit was filed against AT&T by the DOJ following complaints by several long-distance service providers, including MCI. The lawsuit remained unresolved until 1982, when AT&T reached a landmark settlement with the government under conditions stipulated by Judge Harold H. Greene of the Federal District Court for the District of Columbia. AT&T was required to divest its local businesses, leaving it with only long-distance services and its telephone equipment manufacturing business. Having retained jurisdiction over the AT&T case for over a decade, Judge Greene essentially became the nation's telecommunications czar, giving him the power to grant approval, in conjunction with the FCC, of almost every major business decision in the industry. Several technological and business developments transpired following the AT&T case, some of which emerged due to instances of divestiture. However, while these developments generally improved the competitive environment in such fields as manufacturing and interexchange services, none changed the industry's fundamental dichotomy of a natural monopoly for local service provision and a competitive market for other segments of the industry. The consensus is that the federal district court focused too highly on AT&T's affairs and was hostile to the legitimate business interests of the company.

Due to the antitrust enforcement agencies' reluctance to use behavioral remedies, there is little evidence, if any, of their effectiveness in addressing the concerns raised by mergers. In response to this gap, this chapter conducts an explorative comparison of the effectiveness of behavioral and structural remedies in addressing the anticompetitive effects of proposed US airline mergers. Structural remedies usually encompass the slot divestiture requirements stipulated by antitrust enforcement agencies, yet there are often structural limitations. For example, divesting slots to low-cost carri-

ers does not mean that these will inevitably enter the market if it is likely to have antitrust risks as the transferred slots are not limited to specific routes. Responding to this, the current chapter aims to simulate the market outcomes if agencies force the slot purchaser to operate on problematic overlapping routes. Meanwhile, behavioral remedies include obligatory code-sharing and allowing rivals and new entrants to participate in frequent flyer programs.

The theoretical framework by Brueckner (2001) confirms that code sharing leads to a reduction in the average interline airfare in city-pair markets. Using another perspective that examined the effects of frequent flyer programs on air travel product demand, Lederman (2005) highlights their attractiveness to consumers due to the added value. Based on this, the current study employs a structural model based on U.S. domestic airline data to simulate the impact of remedies on post-merger prices. This model is deployed to test the slot divestitures negotiated at Newark Liberty International Airport (EWR) as part of the United Airlines–Continental Airlines merger and at LaGuardia Airport (LGA) and Ronald Reagan Washington National Airport (DCA) for the American Airlines–US Airways merger. These airports are among the five "high-density traffic airports" for which the Federal Aviation Administration (FAA) has imposed capacity constraints via restricted runway slots with the aim of limiting air traffic. As slots at these airports are limited for both takeoff and landing, new entrants struggle to enter the market and compete on existing routes. And while incumbents may lease or sell their slots if with FAA approval, this is not commonplace. Hence, proposed mergers between two airlines with numerous overlapping routes at these slot-controlled airports give rise to significant antitrust concerns. In response to this, the US Department of Justice has mandated the divestiture of slots and assets at such airports to address the antitrust concerns and benefit consumers on overlapping routes.

The structural model used to evaluate the effect of remedies in airline mergers fo-

cuses on counterfactual analysis by using merger simulation. To simulate the effect of divestiture and behavioral remedies on the post-merger equilibrium price, I developed a structural model of the U.S. domestic airline industry that describes the demand and supply for air travel. In the spirit of McFadden (1981) and Berry, Levinsohn and Pakes (1995), the demand model was a random-coefficient discrete-choice model of air travel demand—that is, a discrete-type version of the random coefficient model, which accommodates finite types of consumers to capture heterogeneous preferences for airfare and product characteristics for each type. Berry, Carnall and Spiller (2006) and Berry and Jia (2010) have modeled two types of consumers—business travelers and tourists—whose preferences differ in their valuations of various product characteristics, including airfare, availability of direct flights, and FFP. Following that literature, I also used business travelers and tourists as types of passengers in the demand model. By running the estimated demand parameters, the model could compute the marginal costs and markups by using the first-order conditions of the differentiated products firm's profit function. After estimating the demand parameters and marginal costs, I simulated the post-merger equilibrium price under the post-merger ownership structure, which reflects the completion of slot divestiture with reference to post-merger data.

At the same time, because behavioral remedies have never been deployed by U.S. antitrust enforcement agencies in response to proposed airline mergers, I constructed data for such remedies with reference to assumptions from various behavioral remedy scenarios in order to simulate the effect of the remedies on post-merger price. For instance, I assumed that the agencies would request behavioral remedies such as obligatory code-sharing or opening the FFP to competitors and/or new entrants. Moreover, my model simulates post-merger equilibrium prices under the assumption that the agencies would require a combination of divestiture and behavioral remedies for the mergers between United Airlines and Continental Airlines and between Amer-

ican Airlines and US Airways. The model was estimated and simulated using various publicly available datasets representing the Department of Transportation's (DOT) Airline Origin & Destination Survey (DB1B) and T-100 domestic segment data.

The counterfactual merger simulation suggest that slot divestiture and alternative behavioral remedies can indeed decrease the average post-merger airfare of all air travel products and thus increase the number of passengers and consumer surplus at EWR, DCA and LGA. The reduced airfares, however, would not be significant for overlapping nonstop routes if the DOJ required only slot divestiture from the merged party, and that result thus indicates that slot divestiture presents limitations to resolving risks of anticompetitive behavior on problematic routes. Although slot divestiture's ineffectiveness on some routes can be predicted, the combination of slot divestiture and alternative behavioral remedies would have a pro-competitive effect in those markets.

This chapter contributes to two streams of literature. On the one hand, it extends literature on mergers. Economists and antitrust practitioners have extensively studied the effect of horizontal mergers on price. In a review of eight studies on airline mergers in particular, Ashenfelter et al. (2014) found that most had examined how the mergers had impacted price and market share and, on that topic, revealed increases in price and market power that varied depending on the sample and econometric strategy. In a particular strand of studies (Borenstein, 1990; Kim & Singal, 1993; Morrison, 1996; Kwoka & Shumilkina, 2010; Luo, 2013), researchers have examined changes in price, quality, and consumer welfare by using comparative analysis or a reduced form model involving actual pre- and post-merger data.

In another strand (Richard, 2003; Peter, 2006), researchers have adopted a structural approach to simulating post-merger output. Meanwhile, among research on how price affects horizontal mergers, simulation based on economic models has become an increasingly important approach. However, studies on airline mergers have

also demonstrated significant limitations in their simulations of traditional mergers, usually by focusing solely on price changes while holding supply-side variables to be the same both pre- and post-merger. By contrast, Peters (2006) has examined the accuracy of simulations for five U.S. airline mergers completed between August 1986 and November 1987 by directly comparing the predicted and actual prices. Observing that standard methods of simulation did not generally provide accurate forecasts, Peters used counterfactual simulations, along with observed post-merger data, to measure the relative importance of other factors that also contributed to the price changes observed. The results indicated that the unexplained component of the price change was largely accounted for by supply-side effects, particularly cost-related factors. Peters (2006) also showed that a merged airline tends to reduce the frequency of flights in segments where the merging carriers once competed. By comparison, Bilotkach (2011), who investigated the implications of the America West–US Airways merger on multimarket contact (MMC), found that the merger affected the frequency of MMC. In the airline industry, frequency of flights is an important factor of the cost of airlines, and changes in frequency post-merger should prompt the merged airline to modify its operating costs.

In overlooking that aspect, however, the standard merger simulation, which ignores such changes in cost-related factors, creates significant bias between predicted and observed post-merger prices. On the demand side, each consumer derives utility from price, observed product characteristics, and unobserved variables. Consequently, because mergers affect product characteristics, new post-merger product characteristics are liable to alter consumers' choices and their market shares in the product. On the supply side, changes in marginal costs and fixed costs result in new, optimal product characteristics for the merged firm. In response to that limitation, studies on endogenous product choice have emerged within the field of merger simulations. For example, Fan (2013) has provided some brilliant guidance for overcoming the limita-

tion of the traditional merger simulation, namely by employing a structural model of newspaper markets to investigate the merger's effects. In the model, firms choose both price and quality, and the model can be estimated by using a new dataset of newspaper prices and characteristics. The simulated result of the effect in the Minneapolis newspaper market, for instance, that ignores adjustments in product characteristics will cause substantial differences in the estimated effects of mergers.

On the other hand, the chapter also contributes to the rather limited literature on merger remedies. In such work, to examine the effectiveness of merger remedies ordered by antitrust enforcement agencies, the Federal Trade Commission (FTC) examined 50 of its merger orders from 2006 through 2012 in case studies and found that more than 80% of its orders resolved antitrust concerns. In a similar study conducted in another jurisdiction, the European Commission (EC) examined its 96 cases involving remedies and concluded that 85 of the 96 remedies analyzed has been effective or at least partially effective. That study particularly revealed that 77% of the EC's divestiture orders maintained or decreased the market share of the divested businesses. Whereas those studies were descriptive and addressed the result of merger remedy orders, Park (2019) performed an ex ante analysis of how merger remedies can affect market competition and consumer welfare, with particularly reference to the merger of American Airlines and US Airways. That study focused on the DCA market, where the DOJ ordered the divestiture of slots and a slot-controlled airport, and the estimation suggested that such divestiture increased aggregate consumer surplus even though the surplus of the subset of DCA passengers decreased. Other literature addressing merger remedies has focused on the effectiveness of structural remedies, primarily asset divestiture. However, this chapter reports an ex ante analysis to examine the effectiveness of both structural and behavioral remedies in airline mergers.

The remainder of this chapter is structured as follows. Section 2 provides in-

stitutional details on the mergers between United Airlines and Continental Airlines and between American Airlines and US Airways. Section 3 presents the structural model of the U.S. domestic airline industry, the estimation approach, and the merger simulation strategy, and Section 4 discusses the data. Section 5 reports the results of demand estimation, whereas Section 6 explains the counterfactual analysis of the merger simulation. Last, Section 7 concludes the chapter by highlighting the implications of the findings and indicating directions for future research.

1.2 Institutional Details

This section presents the dilemmas with antitrust law posed by the merger and slot divestiture in two proposed mergers: United Airlines with Continental Airlines and American Airlines with US Airways.

1.2.1 The Merger of United Airlines and Continental Airlines

On May 3, 2010, when United Airlines and Continental Airlines publicly announced an agreement to merge, they proposed to create the world's largest airline, at least at the time. In evaluating the proposed merger, the DOJ considered the number of overlapping routes with flights operated by both airlines. According to data collected for this chapter, counting all connecting flights for 8,332 air travel products with at least 500 passengers per year, the merger would have been expected to cause 935 products to lose a competitor. Although the DOJ anticipated the presence of a low-cost carrier to somewhat dampen the anticompetitive effect on airfares for those routes, the effect was more significant because the routes offered what airline passengers greatly prefer: nonstop service. All told, United Airlines and Continental Airlines offered overlapping services in eight markets—that is, on 16 origin–destination directional routes with nonstop service. Table 1.1 details the total passengers on those nonstop directional routes and each airline's market share. While examining the merger, the

DOJ especially focused on overlapping routes with nonstop service offered only by United and Continental, most of which—for more than a 50% market share—flew from O'Hare International Airport, United's hub, or Newark Liberty International Airport (EWR), Continental's hub, to slot-controlled airports barring other airlines from entering. In particular, for the routes EWR–SFO, EWR–DEN, and EWR–IAD, only United and Continental offered services and would have created a monopoly had the proposed merger been approved. In response to that anticompetitive concern, the DOJ ordered slot divestiture, and after United and Continental agreed to permanently transfer 36 slots and other assets at EWR to low-cost carrier Southwest Airlines, the merger was approved.[2]

1.2.2 The Merger of American Airlines and US Airways

Six months after American Airlines and US Airways announced their intention to merge on February 13, 2013, the DOJ, expressing concerns with violations of antitrust law, filed a lawsuit to challenge the merger. In reviewing the proposed union, the DOJ stressed its likely implications, including a significant increase in market concentration and the elimination of competition. Indeed, American Airlines and US Airways overlapped in 12 nonstop markets, or on 24 origin–destination routes with nonstop service, whose pre-merger total passenger counts appear in Table 1.2, along with each airline's market share. The DOJ especially highlighted Ronald Reagan Washington National Airport (DCA), where the proposed merger would not only own 69% of all takeoff and landing slots but also create a monopoly on 63% of all nonstop routes. Another dilemma concerned LaGuardia Airport (LGA), where the merger of the two airlines, as the second- and third-most popular ones there, would possess 33% of slots and 29.7% of all capacity. In view of those situations, the DOJ predicted that passengers in the areas served would face significant increases in airfare

[2]Press Release, Department of Justice, United Airlines and Continental Transfer Assets to Southwest Airlines in Response to Department of Justice's Antitrust Concerns (Aug. 27, 2010)

were the merger approved. After litigation, the DOJ thus announced a proposed settlement that mandated the divesture of slots and gates at a "key airport" to low-cost carriers. Ultimately, American Airlines and US Airways agreed to divest slots at two congested, slot-controlled airports: 104 at DCA and 34 at LGA. [3]

1.2.3 Slot Divestitures

DCA and LGA are two of the three slot-controlled airports in the United States today, along with John F. Kennedy International Airport (JFK). Although Newark Liberty International Airport (EWR) was a slot-controlled airport when United Airlines–Continental Airlines merger was proposed, its slot restrictions have been eased since 2016.[4] To alleviate air traffic congestion and delays at those highly congested airports, the FAA began enforcing limits concerning the maximum number of flights per hour. EWR, for example, had an hourly limit of 81 flights during peak periods.[5] At LGA, airlines have been allowed to operate a maximum of 71 flights per hour, while DCA allows 60 flights per hour for specified airplane classes.

Because the FAA prohibits slot transactions between airlines, slots at slot-constrained airports are valuable assets, ones that airlines guard to block new entrants and reduce competition at those airports. As a consequence, concerns about anticompetitive conditions at slot-controlled airports have often been raised in evaluating airline mergers. As cases in point, the DOJ underscored that the United Airlines–Continental Airlines merger would eliminate competition at EWR, as would the American Airlines–US Airways merger at DCA and LGA. To allay those fears, the airlines agreed to divest their slots and assets at those slot-controlled airports

[3]Press Release, Department of Justice, Justice Department Requires US Airways and American Airlines to Divest Facilities at Seven Key Airports to Enhance System-wide Competition and Settle Merger Challenge(Nov. 12, 2013)

[4]Press Release, Federal Aviation Administration, Change of Newark Liberty International Airport (EWR) Designation (Apr. 6, 2016)

[5]Federal Aviation Administration, Slot Management and Transparency for LaGuardia Airport, John F. Kennedy International Airport, and Newark Liberty International Airport (Jan. 8, 2015)

to low-cost carriers. The new United Airlines completed its transfer of slots in June 2011, while the new American Airlines completed its transfer in February 2014.[6]

Orders for slot divestiture at slot-controlled airports significantly reduce barriers to entry faced by low-cost carriers and promote their expansion nationwide. Prior to their enforcement, legacy airlines had dominated those airports and made any effective competition from low-cost carriers notoriously difficult. Thus, if the mergers had been approved without structural remedies, they would have severely eroded competition. However, the DOJ anticipated that the low-cost carriers receiving the slots would reduce substantial market power of merging airlines in strategically important markets, including top business destinations such as New York City and Washington, DC. After all, increased access at slot-controlled airports allows low-cost carriers to offer more routes to more passengers at highly competitive rates, and the benefits for passengers as a result have been well documented.

Bennett and Craun (1993), for instance, found that the entry of Southwest Airlines at such airports not only lowered airfares but also increased passenger traffic. In their research for the U.S. Department of Transportation's Office of Aviation Analysis, they dubbed the phenomenon "the Southwest Effect," given the airline's impact on several point-to-point, intra-state routes in California upon entering the market. In their investigation, the authors identified the Southwest Effect's especially significant impact on the Oakland–Burbank intra-California route in 1990, when Southwest's entry caused airfares to drop by 55% and passenger traffic to skyrocket by sixfold. Later, Windle and Dresner (1995), analyzing data from 1991 to 1994, found that airfares fell by 48% and that passenger traffic ballooned by 200% after Southwest had begun operating in the studied routes. Vowles (2000) also found that low-cost carriers have had a remarkably diminishing effect on airfares. Figure 1.1, Figure 1.2 and Figure 1.3 depict changes in market shares pre- and post-merger at EWR, DCA,

[6]The Antitrust Division, United States, et al., v. US Airways Group, Inc., et al.; Public Comments and Response on Proposed Final Judgment (Mar. 13, 2014)

and LGA, respectively. After the mentioned mergers and orders for slot divestiture, the market share of low-cost carriers expanded significantly at all three airports while that of the newly merged airlines narrowed.

While the DOJ obligated airlines to divest slots at slot-controlled airports to foster competition, there were some structural limitations to the structural remedies they implemented. For example, low-cost carriers that have received divested slots may not necessarily enter a certain market if it is showing signs of antitrust risk because the routes for these slots are not specified. In addition, although low-cost carriers are increasingly serving primary US airports, they usually offer point-to-point services to secondary airports in major cities, which is not an efficient option for consumers who intend to use a connecting international flight from the hub of a major airline. Responding to the abovementioned limitations of structural remedies that do not incorporate mandatory changes to the operational patterns of slot-controlled airports, the current study proposes both behavioral and structural remedies to address the concerns raised by airline mergers.

1.3 The Model

In this section, I describe a model of supply and demand in the air travel market, particularly with reference to an oligopolistic framework in which airlines supply differentiated products. The model differentiates air travel products according to a set of characteristics including airfare, frequency of departure, number of connections, and presence of a frequent flyer program (FFP). Whereas airlines and passengers are assumed to consider all of those characteristics of air travel products, economists cannot observe certain characteristics that airlines and passengers can—for instance, ticket restrictions and flight-level details. In the model, those latter characteristics are accounted for with an error term in the demand system. Otherwise, because airlines have information about those characteristics and consider them when setting

airfares, ignoring the information can promote econometric endogeneity and substantially misleading results.

As part of that model, the demand for air travel is conceived in a discrete-choice model, hereafter called the "demand model," in which consumers select one of many options, ranging from choosing a product to not flying, as a way to maximize their utility. To capture the fact that each consumer's preference differs across various product characteristics, the demand model allows heterogeneity among consumers by estimating the distribution of that heterogeneity. It also captures endogeneity in pricing behavior and generates a realistic substitution pattern of the various air travel options on and outside the market.

On that topic, the model defines a market as a directional pair of airports—for example, DCA–EWR, which is distinct from the market EWR–DCA. That setup allows the characteristics of the origin airport to affect the consumer's demand. Beyond that, because airlines offer distinct sets of products in each market, I define a product as a possible combination of airline, airfare, and itinerary. For the DCA–EWR market, for instance, potential three products might be a nonstop flight on American Airlines for $199, a nonstop flight on American Airlines for $299, or a flight on American Airlines with a layover in Philadelphia for $179. In any group of products, the price difference is mostly due to ticket restrictions that econometricians cannot observe. Such characteristics are taken into account with an error term indicating a difference in fares for the same airline's products on the same itinerary.

1.3.1 Demand

In the spirit of McFadden (1981) and Berry, Levinsohn, and Pakes (BLP, 1995), the demand model is a random-coefficient discrete-choice framework with heterogeneous consumer preferences. Resembling the setups of Berry, Carnall, and Spiller (BCS, 2006) and Berry and Jia (2010), the model extends the nested logit model by adopting

heterogeneous preferences for both observable and unobservable characteristics of air travel products. Beyond that, because the preferences of business travelers and tourists differ significantly according to the characteristics of those products (e.g., number of connections and frequency of departure), the random coefficient model differentiates business travelers from tourists as types of consumers.

Following Berry and Jia (2010), the simple random coefficient discrete-choice model can be used to estimate the demand for air travel. Therein, based on personal preferences, the consumer chooses an air travel product on the market or the non-market option of not flying. For example, suppose r types of consumers and that each consumer i's utility for product j in market m can be identified by the utility:

$$u_{ijm} = x_{jm}\beta_r - \alpha_r p_{jm} + \xi_{jm} + \nu_{im}(\lambda) + \lambda\epsilon_{ijm}, \tag{1.1}$$

in which x_{jm} is a vector of observable product characteristics, p_{jm} is the price of the product, β_r is a vector of preferences for product characteristics, and α_r is the marginal disutility with an increase in price for type r consumers. Establishing random coefficients α_r and β_r for P_{jm} and x_{jm}, respectively, for each type of consumer captures heterogeneous preferences of business travelers versus tourists. Meanwhile, the unobserved characteristics of product j are captured by ξ_{jm}, whereas ν_{im}, the nested logit random preference constant across all air travel products, differentiates air travel from the non-market option of not flying. The use of a nested logit model is suitable when a consumer's set of alternatives can be divided into subsets, termed nests. The parameter λ, also called the dissimilarity parameter, measures the degree of independence in unobserved utility between the alternatives in a nest. Greater independence and reduced correlation are signified by a high λ, that is, the alternatives existing within the nest have reduced similarity for reasons that are cannot be observed. Complete independence in a nest is when $\lambda = 1$, whereby the correlation among the air travel products is 0, i.e. there is perfect differentiation. There is no

need for an option outside the air travel market, and thus the nested logit is reduced to the standard logit model. On the other hand, if λ reduces to 0, the alternatives within the nest increase in similarity for reasons that cannot be observed, indicating that the air travel products are increasingly substitutable. Whereas the first nest includes the non-market option of not flying, the second includes the on-the-market options of all air travel products.

Using the model, I examine the effect of structural and behavioral remedies in airline mergers. To capture how behavioral remedies influence consumers' demands, the observed product characteristic x_{jm} has to contain the dataset of code-sharing status and FFPs to effectively indicate the enforcement of those remedies. The utility of the non-market option of not flying is given by:

$$u_{i0m} = \epsilon_{i0m} \tag{1.2}$$

in which product $j = 0$ is the non-market product and ε_{i0m} is normalized to be 0 for all consumers. Thus, the mean utility of the on-the-market product j is:

$$\delta_j = x_{jm}\beta_r - \alpha_r p_{jm} + \xi_{jm}, \tag{1.3}$$

Supposing that they choose to fly, all consumers purchase air travel products that provide the highest utility. In that light, the model assumes that consumers' preferences vary with demographic and product-specific shocks as well as follows multivariate normal distribution. Meanwhile, the random coefficients on price and product characteristics vary with discrete types of consumers and thus follow discrete distribution. As a result, the market share function is derived by estimating the percentage of type r consumers in the population and the weighted sum of the market share for each type. Altogether, assuming that consumers purchase air travel products, the percentage of type r passengers in the population who choose product j in market m is given

by:

$$\frac{e^{(x_{jm}\beta_r - \alpha_r p_{jm} + \xi_{jm})/\lambda}}{\sum_{k=1}^{J} e^{(x_{km}\beta_r - \alpha_r p_{km} + \xi_{km})/\lambda}} \tag{1.4}$$

By extension, the share of type r consumers who choose to buy air travel products is:

$$s_m^r\left(x_m, p_m, \xi_m, \theta_d\right) \equiv \frac{\left[\sum e^{(x_{km}\beta_r - \alpha_r p_{km} + \xi_{km})/\lambda}\right]^{\lambda}}{1 + \left[\sum_{k=1}^{J} e^{(x_{km}\beta_r - \alpha_r p_{km} + \xi_{km})/\lambda}\right]^{\lambda}} \tag{1.5}$$

Let γ_r specify the percentage of type r consumers in the population, such that the overall market share of the jth product in market m is calculated by:

$$s_{jm}\left(x_m, p_m, \xi_m, \theta_d\right) = \sum_r \gamma_r \frac{e^{(x_{jm}\beta_r - \alpha_r p_{jm} + \xi_{jm})/\lambda}}{\sum_{k=1}^{J} e^{(x_{km}\beta_r - \alpha_r p_{km} + \xi_{km})/\lambda}} \cdot s_m^r\left(x_m, p_m, \xi_m, \theta_d\right) \tag{1.6}$$

in which θ_d is the vector of all demand-related parameters (i.e., β_r, α_r, λ, and γ_r) to be estimated. Thus defined by Equation (1.6), the internal and cross-price elasticity of air travel products for type r passenger yield:

$$\eta_{jkm}^r = \frac{\partial s_{jm} p_{km}}{\partial p_{km} s_{jm}} = \begin{cases} -\alpha_i p_{jt}(1 - s_{jt}^r) & \text{if } j = k \\ \alpha_i p_{kt} s_{kt}^r & \text{if} j \neq k \end{cases} \tag{1.7}$$

The demand model thus allows correlations between parameters of preference regarding price and product characteristics by adopting a random coefficient discrete-choice framework. For business travelers, airfare is not a primary factor when purchasing tickets, whereas they likely have different preferences for observed product characteristics such as frequency of departure and the option of a nonstop flight. For most potential passengers, however, airfare is the most important factor. Thus, preferences need to correlate across product characteristics and generate correlations between products that have similar product characteristics. Furthermore, because consumers

with the same preferences will have the similar substitution patterns, each type of consumer exhibits different price elasticity and substitution patterns. As a result, the aggregate per-consumer price elasticity and cross-price elasticity in terms of heterogeneity among consumers are given by:

$$\eta_{jkm} = \frac{\partial s_{jm} p_{km}}{\partial p_{km} s_{jm}} = -\frac{p_{jm}}{s_{jm}} \frac{\partial}{\partial p_{km}} \left(\int \int \frac{e^{(x_{jm}\beta_r - \alpha_r p_{jm} + \xi_{jm})/\lambda}}{1 + \sum_{k=1}^{J} e^{(x_{km}\beta_r - \alpha_r p_{km} + \xi_{km})/\lambda}} \right) dF(\xi, \delta) \tag{1.8}$$

$$\approx \begin{cases} -\dfrac{p_{jm}}{s_{jm}} \sum_r \alpha_r s_{jm}^r (1 - s_{jm}^r) & \text{if } j = k \\ \dfrac{p_{km}}{s_{jm}} \sum_r \alpha_r s_{jm}^r s_{km}^r & \text{if } j \neq k \end{cases} \tag{1.9}$$

1.3.2 Supply

The model draws on BLP's (1995) supply-side framework to estimate the competition in the US domestic airline industry, with each airline maximizing its expected profit by playing a static Bertrand–Nash price-setting game. Studies tend to assume a static game due to its mathematical tractability, which is particularly problematic when firms offer differentiated products or incur heterogeneous costs in oligopoly markets. Such heterogeneities often indicate that these models' dimensions increase exponentially with the numbers of products and firms, leading to increased computational costs in estimating and solving them. Following BLP (1995), equilibrium markups can be computed by using the first-order conditions of airlines. For instance, suppose there are F airlines and that each airline offers subset J_f of the J different air travel products on the market. The profit function of an airline f is given by

$$\pi_f = \sum_{j \in J_f} (p_j - mc_j)\, s_j\,(x, p, \xi, \theta)\, M - fc_f \tag{1.10}$$

in which M is the overall market size demonstrated by the geometric mean of the populations of the Metropolitan Statistical Areas (MSA) of the origin and destination cities. In turn, mc_j represents the marginal cost, while fc_f represents total fixed cost for airline f. The corresponding first-order conditions for each airline's product are thus determined by:

$$\frac{\partial \pi_f}{\partial p_j} = s_j\left(x, p, \xi, \theta\right) + \sum_{h \in J_f}\left(p_h - mc_h\right)\frac{\partial s_h\left(x, p, \xi, \theta\right)}{\partial p_j} = 0 \tag{1.11}$$

Assume that the term of $(p_h - mc_h)$ generates the $J_f \times J_f$ matrix, and define the $J_f \times J_f$ matrix Δ_{s_f, p_f} such that

$$\Delta_{s_f, p_f} = \begin{pmatrix} \frac{\partial s_1}{\partial p_1} & \cdots & \frac{\partial s_{J_f}}{\partial p_1} \\ \vdots & \ddots & \vdots \\ \frac{\partial s_1}{\partial p_{J_f}} & \cdots & \frac{\partial s_{J_f}}{\partial p_{J_f}} \end{pmatrix} \tag{1.12}$$

and such that the $J_f \times J_f$ matrix of the pre-merger ownership matrix, Ω_{uv}, is defined by

$$\Omega_{uv} = \begin{cases} 1 & \text{, if airline offers product } : \{u, v\} \subset J_f \\ 0 & \text{, otherwise} \end{cases} \tag{1.13}$$

Next, let Ω_{uv}^{Pre} be the product of Δ and Ω, such that

$$\Omega_{uv}^{Pre} = \begin{cases} \frac{\partial s_v}{\partial p_u} & \text{, if airline offers product } : \{u, v\} \subset J_f \\ 0 & \text{, otherwise} \end{cases} \tag{1.14}$$

By extension, the first-order condition of the airline's profit function can be rewritten as

$$0 = s + \Omega^{pre}\left(p - mc\right) \tag{1.15}$$

in which $s = \left[s_1, \cdots, s_{J_f}\right]'$, $p = \left[p_1, \cdots, p_{J_f}\right]'$, and $mc = \left[mc_1, \cdots, mc_{J_f}\right]'$. As a result, the marginal cost function of airline f yields

$$mc = p - \Omega^{pre^{-1}} s \tag{1.16}$$

in which the second term constitutes the markups of the airlines. Assuming the law of demand, the airlines face a downward-sloping demand curve, and those markups should be positive. I presume that the marginal cost function is a linear function of the set of cost-related characteristics and given by:

$$mc_{jm} = v_{jm}\varphi + \omega_{jm} \tag{1.17}$$

in which v_{jm} is a vector of observed cost characteristics (i.e., frequency, hub, distance for short-haul market, and distance for long-haul market). In particular, frequency indicates the quantity of air travel products and directly affects the marginal cost, whereas the hub is a dummy variable indicating whether the flight's origin, destination, or connection involves the airline's hub airport. Flight operations at hub airports cause two counter-effects to the airline's marginal cost. On the one hand, the hub-and-spoke system allows an airline to offer various connecting flights for consumers at its hub airport and results in a higher load factor, which consequently lowers the per-passenger cost. On the other, however, the hub-and-spoke system increases the airline's marginal costs due to airport congestion caused by hub operations. The function distinguishes the cost parameter for short-haul and long-haul routes in order to capture differences in fuel efficiency by type of aircraft. I control carrier-specific cost effects by adding carrier dummies; φ is a vector of cost parameters, while ω_{jm} indicates unobserved marginal cost shocks.

1.4 Data

This section discusses the data used in the empirical work and sample selection, which come from the Department of Transportation's (DOT) Airline Origin & Destination Survey (DB1B) and T-100 Domestic Segment. I combine those two publicly available datasets to estimate supply and demand in the airline industry and perform counterfactual analysis for merger remedies in airline mergers. The entire dataset is used in the process of estimating demand and marginal cost parameters, while data subsets of the EWR, DCA, and LGA markets are employed for counterfactual analysis using merger simulation.

1.4.1 Data Sources

Administered by the DOT, the DB1B is a quarterly 10% sample of airline tickets sold for domestic routes in the U.S. air travel market. The DB1B provides detailed information about air travel products including airfare, origin and destination airports, connecting airports, ticketing and operating carriers, distance traveled, and number of passengers. By using information in the DB1B, the market share of each air travel product and carrier can be computed.

Although the DB1B provides rich information about air travel products, it does not contain capacity-related data such as frequency of departure, load factor, and aircraft fleet. The T-100 dataset, however, provides domestic segment data reported by U.S. air carriers, including carrier, aircraft fleet, number of available seats, frequency of departure, and load factor. Therefore, I merge and match DB1B and T-100 data to be able to estimate demand in the airline industry.

1.4.2 Sample Selection

Following BCS (2006) and Berry and Jia (2010), I use only four segments of round-trip itineraries at most, because passengers who buy tickets with two or more connections

are rare. I eliminate itineraries with extremely low or high ticket prices (<\$25 or >\$1,250), which may be due to coding errors. Similar to Evans and Kessides (1994), I also exclude observations of air travel products that carry less than 1% of passengers on a route, because those products are not regular flights but chartered ones.

I define a market as a directional airport–pair and a product as a possible combination of airline, airfare, and itinerary. As in Borenstein (1990), market size is determined by the geometric mean of the populations of the metropolitan statistical areas (MSA) of the origin and destination cities.

In this chapter, I consider only medium-to-large markets, defined as having passenger traffic at both the origin and destination airports of at least 1,000,000 passengers per quarter and located in a medium or large MSA with at least 850,000 residents in 2010. I exclude small markets for three reasons. First, according to Berry and Jia (2010), the substantial difference in patterns of demand and operating costs between small markets and medium-to-large ones complicates capturing those effects in a stylized model. Second, the DB1B dataset imposes the limitation that distorted data can occur in small markets, because it contains a random 10% sample of flight tickets issued for passenger air travel, adjusted by multiplying the dataset by a factor of 10 to estimate the entire market. Third and last, in order to overcome the computational burden, I restrict market size.

Following Peters (2006), I collect four quarters of data prior to the merger's announcement (i.e., pre-merger period) and four quarters of data following the merger's completion (i.e., post-merger period) to estimate demand in the airline industry and evaluate the effect of merger remedies in airline mergers. Because United Airlines and Continental Airlines publicly announced their agreement to merge in May 2010, I set the pre-merger period as 2009:Q2 through 2010:Q1. All flights operated by the merged airline began flying under the carrier code "UA" in November 2011, such that the post-merger period runs from 2012:Q1 through 2012:Q4. By contrast, the Amer-

ican Airlines–US Airways merger was announced in February 2013 and completed in October 2015. Therefore, its pre-merger period is defined as 2012:Q1 through 2012:Q4 and its post-merger period as 2016:Q1 through 2016:Q4.

1.4.3 Data Summary

For the United Airlines–Continental Airlines merger, the dataset contains 198,217 unique itinerary–airline–airfare products in 4,127 unique origin–destination directional markets. Table 1.3 summarizes the pre-merger statistics for in means with standard deviations. As noted, I use the entire pre-merger dataset to estimate the demand-related and marginal cost parameters and a subset of the dataset associated with EWR for the counterfactual analysis of the merger. The average airfare for all products in the dataset was $288, and each had an average of 2,012 passengers. Although 61.2% of passengers traveled on direct flights, only 17.2% of the air travel products offered nonstop service. Each product had 1.45 connections on average; 19% of flights departed from the carrier's hub, whereas 79% departed, arrived, or connected there. On average, 24% of flights passed through at least one slot-controlled airport during the operation. Among other statistics, 19% of passengers experienced a code-sharing flight, and 31% were rewarded the advantage of FFP. The bottom panel of Table 1.3 summarizes statistics for the market averages. The column "EWR Products" summarizes statistics for the subsample of EWR products in particular. Despite no significant differences in most variables between all products and EWR products, EWR products tended to award more FFP advantages than the average product in the domestic market.

For the American Airlines–US Airways merger, the dataset contains 211,002 unique itinerary– airline–airfare products in 4,309 unique origin–destination directional markets. Table 1.4 summarizes the pre-merger statistics in means and standard deviations. As with the other merger, the entire pre-merger dataset is used to esti-

mate the model's parameters, while datasets of the refined LGA and DCA products are employed to simulate the effect of the merger remedies. The average airfare for all products was $303, and, on average, 2,091 passengers purchased the same air travel product. While 20.2% of all air travel products consisted of a direct flight, 70.4% of passengers took direct flights. Each product had 1.39 connections on average; 22% flew from the carrier's hub airport, whereas 80.2% departed, arrived, or connected there. On average, 29% of flights passed through at least on slot-controlled airport. Nearly a quarter (24%) of flights were code-shared with partner airlines, and 35% of tickets sold gave passengers FFP rewards. Despite no significant difference in most variables between all products and both LGA and DCA products, the average price and number of departures related to DCA tended to be higher.

I thus use a dataset for the United Airlines–Continental Airlines merger from 2009:Q2 to 2010:Q1 and another for the American Airlines–US Airways merger from 2012:Q1 to 2012:Q4 merger. Relative to those two pre-merger periods, the average number of passengers traveling on direct flight increased by 8.2% from 2009 to 2012, and the number of connecting flights tended to decrease throughout the period sampled. Berry and Jia (2010) have asserted that the increase in direct flights but decrease in connecting flights relate to the trend of de-hubbing among major airlines as a result of network restructuring after mergers.

1.5 Estimation

This section details of the chapter's empirical strategy. I begin with estimating demand parameters for airline industry and compute the marginal costs of the airlines. I also describe the econometric problem of endogenous problem and introduce instrument to resolve that issue. The merger simulation method to simulate the post-merger equilibrium prices by using estimated demand parameter and marginal cost will be explained and finally how consumer surplus changes following mergers is discussed.

1.5.1 Demand

To estimate the demand-related parameters for the airline industry, I use the structural error—that is, unobserved product characteristics in the demand model—as a function of those parameters and data. I estimate the parameters by forming moments representing expectations of how the unobserved product characteristics interact with exogenous instruments. Following BLP (1995), the estimation techniques depend on an assumption that the unobserved product characteristics, ξ are independent of vector of the exogenous instruments, z_t:

$$E\left(\xi\left(p_m, x_m, s_m, \theta_d\right) \mid z_t\right) = 0, \tag{1.18}$$

which yields the vector of demand parameters, θ_d, that makes the covariance of the unobserved product characteristics and the instrument as close to 0 as possible.
The method of moments requires solving for the unobservable product characteristics as a function of the data. Those characteristics as a function of the price, the observed product characteristics, and the observed market shares can be derived by inverting the market share in Equation (1.6):

$$\xi_m = s^{-1}\left(p_m, x_m, s_m, \theta_d\right). \tag{1.19}$$

As in Berry and Jia (2010), I estimate the demand-related parameters by using a slight modification of a contraction-mapping method adopted by BLP (1995) to solve for ξ_{jm} which equate the estimated market share to observed market share.

$$\xi_{jm}^{H} = \xi_{jm}^{H-1} + \lambda\left[\ln s_{jm} - \ln s_{jm}\left(x_m, p_m, \xi_m, \theta_d\right)\right], \tag{1.20}$$

in which H is the Hth iteration, $s_{jm}$is the observed market share, and $s_{jm}\left(x_m, p_m, \xi_m, \theta_d\right)$ is the estimated market share defined by Equation (1.5).

The demand model is affected by airfare, the number of connections, frequency of departure, presence of an FFP, code sharing, flight distance, distance squared, a dummy for carrier hub, a dummy for slot-controlled airport, carrier dummies, and a tour dummy for airports in Las Vegas, Orlando, or Miami. I treat prices and frequency as endogenous and instrumented.

The demand model allows two passenger types—business travelers and tourists—in order to capture heterogeneity in consumers' preferences. Given the well-documented negative relationship between price sensitivity and a preference for convenience in relation to products, I allow two random coefficient parameters: the coefficient of airfare and the number of connections. I also allow random coefficient parameters for FFPs to capture differences in the preference for them between business traveler and tourist.

1.5.2 Supply

From the supply model presented in Section 3.2, the marginal cost can be estimated as the difference between prices and markups. Whereas the marginal cost function is a function of observed cost characteristics, markup is a function of demand-related parameters. The unobserved marginal cost can thus be derived as a function of the observed cost characteristics and demand-related parameters:

$$\omega_{jm} = p_{jm} - \Omega^{pre^{-1}} s_{jm}\left(x_m, p_m, \xi_m, \theta_d\right) - v_{jm}\varphi \tag{1.21}$$

As with demand, cost-related parameters can be estimated by forming moments, which represent expectations of the unobserved cost shock, in interaction with cost-side exogenous instruments. The supply model assumes that those two factors are independent:

$$E\left(\omega\left(p_m, x_m, s_m, \theta_d, \varphi\right) \mid z_t\right) = 0, \tag{1.22}$$

in which z_t is a vector for variables of exogenous instruments.

The marginal cost equation is regressed on the following shifters of cost: frequency, a dummy for carrier hub, a dummy for slot-controlled airport, distance, number of connections, and carrier dummies. Following Berry and Jia (2010), I also include long- and short-haul markets, separated by a threshold of 1,500 miles, to capture the fuel efficiency of differently sized aircraft.

1.5.3 Instruments

As airlines are usually aware of product characteristics that econometricians cannot observe, they can reflect their value in their pricing; thus, airfares are probably endogenous. Therefore, exogenous instrumental variables are essential for the estimation. As long as the model has been correctly specified, an instrument will produce consistent parameter estimates if two conditions are met: (1) it has a correlation with the endogenous variable, and (2) it is independent of the model's error term. Hence, instruments that correlate with airfares – but not with structural errors, such as unobserved product characteristics (ξ_m) and marginal cost shock (ω_m) – must be sought.

In general, the characteristics of competing airlines as well as the degree of market competition are used when instrumenting for price. According to the BLP (1995) model, this intuition emerges from a natural characteristic of pricing in an oligopoly, namely if products have good substitutes, they are likely to have low markups; as other products then tend to have high markups, they will have high prices compared to costs. Meanwhile, as there is a difference in the response to own and competitors' products among Nash markups, optimal instruments separate the characteristics of a multi-product firm's product from those of competitors' products. Thus, markets with closer substitutes will have lower average airfares, meaning that a market's competitiveness is signified by its number of air travel products. Continuing on the market

level, the Herfindahl-Hirschman Index (HHI),– a market concentration measure – is included, as is the total number of competing carriers in the market. Furthermore, the market's number of non-participating potential entrants is incorporated, defined as how many carriers use an origin and/or destination airport but do not actually serve the market itself.

Input cost variables can be drawn on as a second price instrumenting strategy as they correlate with price but are likely to not correlate with the product characteristics valued by consumers, whether observed or unobserved. Following BCS (2006), for instruments I employ the airline's hub status at connecting and destination airports, which affect the marginal cost of flight operations. Briefly put, because flights that connect to or terminate at hubs tend to carry large volumes of passengers by using larger, more fuel-efficient aircraft, they create economies of density. However, hub status at origin airports likely affects the demand of air travel, because the benefit of FFPs and the airline's network size at the origin airport are important factors for certain types of passengers when they purchase airline tickets. In a similar vein, both the route-level distance and its square are included; these relate directly to a flight's marginal operating cost. It is likely that distance's impact on demand is limited to how many connections a flight has and how far these are "out of the way" compared to a non-stop flight between that city-pair; both characteristics are incorporated here as exogenous product attributes.

1.5.4 Merger Simulation

This chapter's chief purpose is to simulate the effect of merger remedies on post-merger equilibrium prices. After estimating parameters of demand and marginal cost based on the pre-merger data, including the pre-merger ownership matrix, using structural model I can simulate a post-merger equilibrium output by modifying the ownership matrix and determining the post-merger equilibrium prices by using

numerical methods. Assuming no merger remedies, the post-merger prices yield:

$$p^{post} = mc - \Omega^{post^{-1}} s(x, p, \hat{\xi}, \hat{\theta}_d) \tag{1.23}$$

in which p^{post} denotes the post-merger prices and Ω^{post} is the post merger ownership matrix reflecting new ownership matrix, Ω', and $\Delta(p')$.

The benefit of merger simulation method is to allow various counterfactual analysis assessing the effect of slot divestiture imposed by antitrust enforcement agencies and ex ante analysis of assumed behavioral remedies scenarios. I execute counterfactual merger simulation with different merger remedy scenarios. The details of the counterfactual analysis are discussed in the Section 7.

1.5.5 Consumer Welfare

After estimating demand parameters and post-merger prices, I can estimate expected changes in consumer welfare following the airline mergers. To measure changes in consumer welfare, I employ compensating variations, V_{rm}^{pre} and V_{rm}^{post}, defined by demand system of airline market using estimated parameters for demand and pre- and post-merger prices:

$$V_{rm}^{pre} = \ln \left[1 + \left(\sum_{j \in J} \exp \left(\left(x_{jm}\beta_r - \alpha_r p_{jm}^{pre} + \xi_{jm} \right) / \lambda \right) \right)^{\lambda} \right] \text{ and} \tag{1.24}$$

$$V_{rm}^{post} = \ln \left[1 + \left(\sum_{j \in J} \exp \left(\left(x_{jm}\beta_r - \alpha_r p_{jm}^{post} + \xi_{jm} \right) / \lambda \right) \right)^{\lambda} \right]. \tag{1.25}$$

Following McFadden (1981) and Small and Rosen (1985), the compensating variation of the equation for type r consumer in market m is:

$$CV_{rm} = \frac{V_{rm}^{pre} - V_{rm}^{post}}{\alpha_r} \tag{1.26}$$

in which α_r indicates the consumer's marginal disutility relative to the increase in airfare. Integrating CV_{rm} over the type of consumers and multiplying it by the market size yields the change in the total surplus of consumers due to airline merger.

1.6 Estimation Results

In this section, I report the estimated parameters of the supply and demand models, including marginal costs and markups.

1.6.1 Demand Parameters

Table 1.5 presents the estimated parameters of the demand model, in which all estimated coefficients were statistically significant, and the sign of the coefficient of each product characteristic was consistent with expectations. As mentioned in Section 5, several product characteristics influenced demand among consumers: airfare, number of connections, presence of an FFP, code sharing, flight distance, flight distance squared, a dummy for carrier hub, the dummy for slot-controlled airport, carrier dummies, and the tourist destination dummy for airports in Las Vegas, Orlando, or Miami.

The first column in Table 1.5 reports the estimated parameters of demand for United Airlines and Continental Airlines during the pre-merger period, whereas the second column reports corresponding parameters for American Airlines and US Airways. First, for the coefficient of airfare, representing consumers' sensitivity to changes in price, I included the random coefficient across two groups of consumers: business travelers and tourists. For the United Airlines–Continental Airlines pre-merger period, the airfare coefficients of business travelers and tourists were -0.099 and -1.003, respectively. For the American Airlines–US Airways pre-merger period, by comparison, the respective price coefficients were -0.112 and -1.058. Although both types of consumers sensed disutility in the increased prices, tourists were nearly

10 times more sensitive to price than business travelers. That result validates the heterogeneity of consumers' preferences in response to price increases and aligns with the estimated demand calculated by BCS (2006) and Berry and Jia (2010).

During the pre-merger periods in both cases, both business travelers and tourists experienced significant disutility by taking flights with connections. No significant difference emerged in the coefficients of the number of connections between the types of passengers, which indicates that both types preferred nonstop flights and, in turn, explains why most passengers traveled on direct flights: 61.2% in 2009 and 70.4% in 2013.

With FFPs, the airlines in the cases award consumers points for each flight purchased. Thus, FFPs create an incentive for both types of passengers to choose flights that award points, although business travelers are generally more willing to do so, arguably for the sake of status. Briefly explained, the FFPs of U.S. legacy airlines are structured with tiers based on accumulated points, and, each year, members need to accumulate a minimum number of points to achieve a certain tier status. In turn, airlines provide different levels of service and convenience according to the member's status. Although business travelers are generally less sensitive to price—their travel costs are covered by their companies—they do place positive weight on achieving status. Indeed, the estimated results for the pre-merger periods in both cases imply that business travelers' willingness to pay for FFP points is nearly 12 times higher than that of tourists.

Because passengers have more options to select a desired departure time if carriers offer multiple times, they value flight schedules with more frequent departures. For the pre-merger periods in both cases, the results for the coefficient of frequency validate that phenomenon. However, passengers derived less utility from code-sharing products; its estimated coefficients during the pre-merger period were -0.089 for United Airlines and Continental Airlines and -0.075 for American Airlines and US Airways.

Because ticketing carriers and operating carriers differ on code-shared flights, the coordination involved with such flights may not be as convenient as purchasing from and flying on single airlines. In addition, code-shared flight tickets can entail restrictions to baggage services and access at the boarding gate.

Estimating flight distance and flight distance squared as parameters of demand captured the U-shaped demand for air travel in terms of distance—that is, air travel on short-haul flights rose bit eventually dropped as distance increased. Ivaldi and Vibes (2008) have posited that in the case of short-haul flights, substitution between air travel and outside-the-market options (e.g., driving, buses, and trains) is higher. As distance increases, however, air travel becomes a more effective way to travel, and the substitution of air travel with alternative options wanes. At the same time, traveling in general becomes less pleasant as distance increases, and the utility of flights thus also starts to wane.[7]. The coefficients of distance and distance squared thus confirm well-known characteristics of demand for air travel in the literature.

Meanwhile, the coefficients of hub airport dummy for the pre-merger periods in both cases—0.701 for United Airlines and Continental Airlines and 0.912 for American Airlines and US Airways—imply that passengers preferred to travel to or from a carrier's hub airport. Because carriers offer a wider range of destinations and flight schedules to or from their hub airports, passengers are more likely to find convenient flight options there. The FFPs provided by the carriers with significant market share attract consumers to carriers' hubs as well. The positive parameter detected in analysis corroborates Borenstein's (1989) finding of so-called "airport dominance" by legacy airlines. The corresponding coefficients of the slot-controlled airport dummy were -0.188 and -0.355, which suggests that traveling via slot-controlled airports, as notoriously crowded, congested facilities, creates disutility for passengers. The airports in Las Vegas, Orlando, and Miami, all treated as offering access to tourist

[7]See Berry and Jia (2010)

destinations, attracted more passengers than their slot-controlled counterparts. Thus, the tour dummy's coefficient was consistent with expectations.

The nested logit parameter λ, measuring all of the airline products' ability to be substituted, was 0.697 for United Airlines and Continental Airlines and 0.699 for American Airlines and US Airways during their pre-merger periods. Because all air travel products became perfect substitutes as λ approached 0, the coefficients 0.697 and 0.699 imply only slight substitutability among the air travel products. Last, the coefficient γ_{Business} represents the percentage of business travelers in the population. Along those lines, the coefficients for γ_{Business} in both cases, 0.054 and 0.059, indicate that an average 5.7% of potential travelers were business travelers. Despite the small percentage of business travelers in the population, business travelers have been shown to account for 43.1% of actual travelers based on a computation method suggested by BCS (2006).

1.6.2 Marginal Cost

Using the estimated parameters of demand, I computed the marginal cost by regressing the difference between observed prices and estimated markups on the characteristics of marginal cost, as shown in Equations (1.16) and (1.17). Table 1.6 details the parameters of marginal cost, all of which were statistically significant. As mentioned in Section 5, the following characteristics of marginal cost affected the marginal cost of carriers: number of connections, flight distance, the dummy for carrier hub, the dummy for slot-controlled airport, carrier dummies, and frequency. I included two sets of marginal cost parameters for distance and the number of connections, long- and short-haul markets, separated by a threshold of 1,500 miles.

The coefficient of frequency had a negative relationship with marginal cost in the pre-merger periods in both cases. In general, more frequent flights accelerate aircraft turnaround at gates and thus increase aircraft utilization, the latter of which

distributes fixed costs over an increased number of flights, thereby decreasing costs per passenger and per flight. In their pre-merger periods, the coefficients of the hub dummy—that is, -0.087 for United Airlines and Continental Airlines and -0.137 for American Airlines and US Airways—imply that flights via a carrier's hub airport reduced the marginal cost. Two offsetting factors affecting that cost, as explained in Section 3.2, were flying to or from a carrier hub and using a slot-controlled airport. On the one hand, the hub coefficient reflected the net effect of those two countervailing factors, and the negative coefficient of the carrier hub dummy indicates that the reduced cost from higher load factors exceeded the increased cost due to airport congestion. On the other, the positive coefficient of the slot-controlled airport dummy implies that the marginal cost was higher for flights operating via slot-controlled airports. Most likely, congested traffic at slot-controlled airports had caused frequent flight delays and thus increased the operating costs of flights.

Although the marginal cost increased with distance in markets for both short- and long-haul flights, the coefficient of distance in the short-haul market exceeded that of the long-haul market. As to why, because aircraft consume massive amounts of fuel during takeoff and landing, and because large aircraft enjoy fuel efficiency due to economies of scale, carriers tend to use large aircraft on long-haul routes. The marginal cost also increased with connecting flights, albeit under the influence of two countervailing factors. For one, by transferring passengers from different origins to different destinations by using connecting flights, carriers can achieve higher load factors, spread the fixed cost, and reduce per-flight and per-passenger costs. As for the other, because aircraft consume massive amounts of fuel during takeoff and landing, an additional landing and additional takeoff substantially increase the fuel component of the marginal cost. The negative coefficient of connecting flight thus implies that increased cost due to an extra landing and takeoff outweighs the cost reduction achieved with economies of scale.

1.6.3 Model Fit

An extension of the logit model, the BLP (1995) model enables unobserved product characteristics to be captured, while also, crucially, accounting for heterogeneity in consumers' tastes for certain characteristics. Let us assume the availability of airline data that facilitates the estimation of two different price coefficients – with all other coefficients remaining equal for all types of consumers. Now, take two identical city-pair markets that have products that are identical in all ways except pricing: The first market with two products ($200 and $100) and the second with three products ($200, $100 and $100). If the logit model has no random coefficients, then if the first market's two market shares are equal, the three market shares will similarly be equal in the second market. This general problem occurs in any discrete choice model with an error structure that is additive i.i.d across products. However, in the real world, the second market's two low-priced products will probably compete for the same pool of consumers, meaning the $200 product's market share will exceed the $100 products' individual shares. In light of this, the current study's model estimates two coefficients on price to accommodate this type of data.

Due to the solid micro foundation of the BLP model, it is adaptable and can be utilized for different data types, allowing a good fit. The BLP model makes a crucial contribution in that it demonstrates how to perform inversion in random-coefficient logit models to highlight errors, enabling any endogeneity problems to be mitigated. In addition, it also makes a valuable contribution by showing that the model's machinery can give plausible results. The BLP model performs its estimation by identifying which model parameters enable the best fit for the given data. During its estimation procedure, the BLP model takes its predicted expected market shares and matches them to the observed market shares. As the model is here fitted to match the aggregate observed market shares, the estimation results can be considered reliable and show a good fit for the data. For instance, estimating the percentage of

business travelers among the general population as well as among actual air travel passengers, we find that 5.7% of potential travelers are business travelers and that they account for 43.1% of actual air travel passengers. Meanwhile, as per the 2001–2002 National Household Travel Survey, approximately 39-47% (the range is due to whether personal business trips are counted as business trips) of air travel passengers are business travelers. Thus, the predictions made by our model match very well with actual business passenger data from the survey.

1.7 Counterfactual Merger Simulation

The purpose of merger remedies is to mitigate anticompetitive risks. To resolve those risks, antitrust enforcement agencies strive to tailor appropriate merger remedies while preserving the benefit of mergers. Although the agencies continue to prefer requesting structural remedies, those remedies are undesirable under certain market circumstances and have thus come to overlap with behavioral remedies as well.

In this section, I report upon various counterfactual merger simulations as a means to identify the implications of policies imposing remedies for airline mergers. I simulated the post-merger equilibrium prices such that antitrust enforcement agencies were assumed to have imposed both structural and behavioral remedies. Using standard merger simulation, I derived the post-merger equilibrium outcomes by using estimated parameters of demand and marginal cost along with a post-merger ownership matrix. To perform the simulations, I modified observations of several product characteristics in the pre-merger dataset and, in turn, computed the post-merger outcomes by using standard merger simulation. Because the DOJ requested slot divestiture at EWR for the United Airlines–Continental Airlines merger and at LGA and DCA for the American Airlines–US Airways merger, the counterfactual merger simulation used a subset of the dataset including products and markets representing EWR, DCA, and LGA.

1.7.1 Structural Remedies

In addressing airline mergers, antitrust enforcement agencies tend to employ structural remedies, including the divestiture of slots and airport facilities, to mitigate anticompetitive concerns. As mentioned in Section 1.2, the United Airlines–Continental Airlines and the American Airlines–US Airways mergers are two cases in which the DOJ mandated slot divestiture and approved the mergers only after the airlines agreed to permanently transfer slots to low-cost carriers.

The United Airlines–Continental Airlines Merger

In the case of the United Airlines–Continental Airlines merger, 36 daily takeoff and landing slots at EWR were divested to Southwest Airlines by June 2011. With 1,296 total slots available at EWR, those divested slots represented approximately 3.6% of the average daily flight at the airport. Following the divestiture, the new United Airlines discontinued nonstop services to five destinations—Columbus (CMH), Kansas City (MCI), Myrtle Beach (MYR), Ontario, California (ONT), and Sacramento (SMF)—from EWR. Once Southwest Airlines entered the EWR market, it inaugurated nonstop service to six new destinations—Baltimore (BWI), Chicago (MDW), Dallas (DAL), Denver (DEN), Houston (IAH), and St. Louis (STL)—as well as approximately 60 additional connecting services via those destinations. However, because Southwest Airlines entered the markets for only two of four problematic nonstop routes—EWR–DEN, EWR–IAD, EWR–ORD, and EWR–SFO—the DOJ voiced anticompetitive concerns. After all, in offering the other services, United Airlines–Continental Airlines would create a monopoly market if their merger were approved. That situation would have raised the structural limitations of structural remedies by exemplifying how slot divestiture to low-cost carriers cannot guarantee that low-cost carriers will enter problematic markets and thus mitigate anticompetitive concerns.

The American Airlines–US Airways Merger

When American Airlines and US Airways proposed merging, the DOJ mandated the divesture of 104 daily takeoff and landing slots at DCA and 34 daily at LGA, representing 7.2% and 2.9% of available daily slots at DCA and LGA, to low-cost carriers. Among them, Southwest Airlines permanently acquired 56 of the slots at DCA, JetBlue acquired 40, and Virgin America acquired eight. In response to divestiture, American Airlines ceased operating nonstop service to 17 destinations from DCA; the full list of American Airlines' network changes due to slot divestiture appears in the first column of Table 1.7. By contrast, Southwest Airlines added daily nonstop flights between DCA and 14 new destinations, JetBlue launched five new nonstop flights from DCA, and Virgin America added four flights to its one daily nonstop route to San Francisco. The summary of DCA-related market entries by low-cost carrier airlines resulting from divestiture due to the American Airlines–US Airways merger appears in the second and third column of Table 1.7.

In LGA's market, once 34 takeoff and landing slots were transferred to low-cost carriers, American Airlines ceased operating nonstop flights to Atlanta (ATL), Cleveland (CLE), and Minneapolis (MSP). Southwest Airlines and Virgin America each acquired 22 and 12 of the slots. Because Southwest already operated in six destinations: Akron–Canton (CAK), Chicago (MDW), Houston (HOU), and Nashville (BNA)—it used the divested slots to add round-trip flights between those destinations and LGA. With its 12 divested slots, by contrast, California-based airline Virgin America launched nonstop flights from LGA to Dallas (DAL) to provide connections to Los Angeles and San Francisco.

The proposed remedy for the American Airlines–US Airways merger mandated the divestiture of nearly four times as many slots as required for the United Airlines–Continental Airlines merger. The DOJ expected that low-cost carriers were in a position to be effective competitors and thus to benefit consumers. Although litera-

ture addressing the effect of slot divestiture in airline mergers has remained sparse, most literature reports retrospective studies based on the post-merger period. By extension, conducting counterfactual merger simulations to systematically examine the effect of slot divestiture ex ante stands to aid antitrust enforcement agencies in tailoring appropriate merger remedies.

Counterfactuals

To measure the effect of slot divestiture in airline mergers, I simulated post-merger equilibrium outcomes in cases in which slot divestiture occurred at EWR, DCA, and LGA during the merger procedure. I also executed a merger simulation assuming that no divestiture had occurred. Comparing the outcomes of those two merger simulations allowed measuring slot divestiture's effectiveness in airline mergers.

Available post-merger data informed the results for actual slot divestiture, while estimated parameters of demand and marginal cost allowed the simulation of counterfactuals. From the results of the simulations, the marginal effect of slot divestiture on post-merger equilibrium prices could be probed by comparing the counterfactual simulation's outcomes involving divestiture with those from the case not involving divestiture. Three simulated merger scenarios were examined. The first (i.e., baseline) entailed post-merger prices in the case that the DOJ did not order slot divestiture. The second (i.e., slot divestiture) reflected the DOJ's actual slot divestiture at EWR for United Airlines–Continental Airlines and at DCA and LGA for American Airlines–US Airways. For the third scenario, I simulated post-merger prices under the assumption that slot divestiture influenced consumer demand in the model.

The baseline scenario held observed and unobserved product characteristics as well as estimated marginal costs fixed at pre-merger levels. The ownership matrix of first-order conditions for profit maximization was changed to reflect post-merger changes in ownership. Simulated equilibrium outcomes under those conditions predicted post-

merger outcomes changes due to the loss of competition following the merger. Next, to measure slot divestiture's impact on post-merger outcomes, I derived equilibrium outcomes from the ownership matrix that reflected the actual slot divestiture required for the merger to be approved. Similarly, to measure how changes in product characteristics affected demand among consumers following the merger, for the last scenario I employed a post-merger ownership matrix reflecting slot divestiture and post-merger observations of both observed and unobserved product characteristics in order to simulate post-merger equilibrium. Because slot divesture changed the values of product characteristics, including frequency, number of connections, presence of an FFP, code sharing, and airport's status as a carrier hub, estimating the parameters of demand and marginal cost by using pre-merger levels of product characteristics generated inaccurate post-merger predictions of slot divestiture's effect on air travel prices.

Table 1.8 presents the results of the simulated merger outcomes of the three scenarios. Using all air travel products to or from EWR, DCA, and LGA to derive post-merger outcomes, the simulations projected an increase in average airfare and a reduction in the number of passengers at all three airports had the DOJ not stipulated slot divestiture to low-cost carrier airlines prior to the mergers. The simulations also projected that mergers without slot divestiture would have disadvantaged consumers who travel via EWR, DCA, and LGA, because higher airfares generally deplete the surplus of consumers. However, the second scenario, assuming that the DOJ had mandated slot divestiture, indicated significantly different post-merger outcomes. Although the average airfares at EWR were projected to increase by approximately 1% following the United Airlines–Continental Airlines merger, the magnitude of the price increase was less than in the baseline scenario. Reductions in the number of passengers and consumer surplus would have also weakened had the merger proceeded with slot divestiture. Predicted post-merger airfare changes at DCA and LGA amid

slot divestiture were both negative in the case of American Airlines and US Airways. However, slot divestiture's effect on post-merger prices would have been more substantial at DCA (-1.13%) than at LGA (-0.03%). The simulations thus predicted an increased number of passengers and consumer surplus at both airports, albeit to a greater degree at DCA than LGA. After all, the DOJ ordered the divesture of nearly three times as many slots at DCA, and, according to the results, the pro-competitive effect generally increased with the number of divested slots. As a case in point, the new American Airlines transferred 104 takeoff and landing slots at DCA but only 34 at LGA. The results accordingly suggest evidence of a positive relationship between the number of divested slots and slot divestiture's effect on the airline mergers.

Despite slot divestiture's pro-competitive effects after the mergers, they did not necessarily resolve risks of anti-competition in such a problematic market, at least as far as the DOJ was concerned. As mentioned, because antitrust enforcement agencies do not generally require slot purchasers to enter specific markets, slot divestiture to low-cost carriers cannot guarantee that low-cost carriers will enter markets with risks of anticompetitive tendencies. As a case in point, even though the overlapping nonstop routes to or from slot-controlled airports operated by the merged airlines were the DOJ's chief concerns, Southwest Airlines began serving only two of four of those routes also operated by new United Airlines at EWR, and no slot-purchasing airline entered the market for the corresponding routes served by the new American Airlines at DCA and LGW.

Table 1.9 reports the outcomes of simulated mergers for overlapping nonstop routes to or from EWR, DCA, and LGA. Among the results, the airline mergers without slot divesture would have substantially increased the airfare of overlapping nonstop routes relative to all other products at three airports. As a consequence, the mergers would have greatly reduced the number of passengers on those routes and their welfare as consumers. The simulated post-merger prices in the case of

slot divestiture, by contrast, indicated that mergers increased airfare by 7.17% at EWR—that is, nearly 10% less than in the baseline scenario. That result implies that the entrance of Southwest Airlines into two overlapping nonstop routes partly eased anticompetitive effects. Beyond that, although the simulations in the case of slot divestiture predicted a drop in prices at DCA and LGA after the mergers, the magnitude of such drops was insignificant and not enough to counter the anti-competitive risks. Mergers entailing slot divestiture decreased airfare by 6.0% and 3.5% at DCA and LGA, respectively, relative to simulated ones without divestiture. Thus, although the mergers nevertheless significantly increased prices and harmed the welfare of consumers traveling on overlapping nonstop routes, following slot divestiture the emergence of low-cost carriers at those airports spawned various connecting flights with competitive prices, which partly served to decrease airfares on those same routes. However, slot divestiture did not prevent increases in the average airfare for those routes due to consumers' strong preferences for nonstop flights. Altogether, the results of the counterfactual merger simulations for overlapping nonstop routes revealed the structural limitations of imposing slot divestitures to low-cost carriers without forcing their entry into markets for overlapping nonstop routes.

1.7.2 Behavioral Remedies

The potential limitations of slot divestiture to low-cost carriers without forcing their entry into markets for nonstop overlapping routes urge alternative merger remedies. To that end, I developed three behavioral remedies ancillary to slot divestiture: (1) requiring the surrender of slots to operate flights for overlapping nonstop routes, (2) requiring code-sharing agreements between slot sellers and purchasers, and (3) opening FFPs to competitors and/or new entrants. To assess the effect of those behavioral remedies, I simulated the post-merger equilibrium outcomes under the assumption that antitrust enforcement agencies would mandate a combination of slot

divestiture and each behavioral remedy before approving the proposed airline mergers.

Requiring the Surrender of Slots to Operate Flights for Overlapping Nonstop Routes

Mandating slot divestiture without forcing slot purchasers to enter the market for specific routes does not necessarily resolve risks of anticompetitive practices. The DOJ required slot divestiture to low-cost carriers airlines specifically, given their record as effective competitors against legacy carriers with significant market power. Therefore, the counterfactual merger simulation in the case of slot divestiture combined with the requirement to surrender slots to operate flights for overlapping nonstop routes assumed that low-cost carriers have purchased divested slots and have to enter the market for those routes. For the sake of simply constructing data under those assumptions, I assumed that Southwest Airlines began offering services on all of the merged airlines' overlapping nonstop routes to or from EWR, DCA, and LGA. That assumption was reasonable because Southwest acquired nearly 70% of all divested slots in the two merger cases.

Requiring Code-Sharing Agreements

Code-sharing agreements are contracts among airlines in which an operating carrier, acting as a ticketing carrier, is allowed to sell seats on its partner's flight for segments of an itinerary operated by its partner. In Section 6, the estimated parameters of demand suggest that consumers generally experience significant disutility by traveling on code-shared flights due to their inconvenience compared with flights whose ticketing and operating carriers are one and the same. However, studies have suggested that code sharing lowers airfares and has a pro-competitive effect in the market. According to Chen and Gayle (2007), code sharing can also prevent double marginalization, such as when two non-allied airlines set airfares for different segments of inter-line

trips independently. That marginalization effect, which results in higher airfares, occurs when each airline determines its airfare with the goal of maximizing its profit on the segment that it operates in the absence of an alliance. If two airlines form a code-sharing agreement, however, they negotiate a pricing contract that can eliminate the marginalization effect by setting the airfare to maximize their joint profit. Code sharing also enables airlines to offer customers a broader range of networks and thus ensure better connection options.

In the counterfactual merger simulation, I assumed that code sharing allowed low-cost carriers to place their codes on the flights of overlapping nonstop routes operated by the merged airlines to or from EWR, DCA, and LGA. That assumption ensured that low-cost carrier airlines had access to connecting flights and that merged airlines could achieve higher load factors with connecting passengers, consequently increase their profitability on overlapping nonstop routes, and, in effect, reduce airfares. Using the DB1B, which contains information about ticketing and operating carriers, I constructed a dataset reflecting the assumption that antitrust enforcement agencies request obligatory code-sharing agreements between merged airlines and low-cost carrier airlines on overlapping nonstop routes to or from EWR, DCA, and LGA.

Opening the FFPs to Competitors and/or New Entrants

In assessing competition in cases of airline mergers, not only origins and destinations but also network effects need to be considered to determine the boundaries of the market. Network effects may be significant for corporate consumers and others who are members of FFPs, whose choice of airline can depend upon its network. The estimated parameters of demand in Section 6 suggest that business travelers receive greater utility from FFPs than tourists when purchasing air travel products, which exemplifies a phenomenon of network effects. Network effects arise for certain types of consumers because FFPs act as an entry barrier to new entrants in markets

where merged airlines enjoy a significant market share. At EWR, DCA, and LGA, the merged airlines had an overwhelming market share. Although slot divestiture reduced the market power of the merged airlines at those airports, the existence of network effects due to FFPs nevertheless continued to interrupt the entry of effective competitors into the market. Therefore, the behavioral remedy of allowing the consumers of new entrants to receive FFP points for the merged airlines was expected to enhance the appeal of other airlines among loyal customers of the merged ones.

To simulate the effect of opening FFPs to competitors and/or new entrants, I assumed that United Airlines opened its FFP to the new routes served by Southwest Airlines to or from EWR and that American Airlines allowed rewarding FFP points to consumers traveling on the new routes of Southwest Airlines, JetBlue, and Virgin America to or from DCA and LGA following its merger with US Airways. I first estimated the average own and cross-price elasticities of demand by using demand parameters for all air travel products at each of the three airports (i.e., EWR, DCA, and LGA). Table 1.10 presents those average elasticities for United Airlines and Southwest Airlines concerning all air travel products to or from EWR. The first two columns list the results regarding slot divestiture, whereas the last two columns list the average estimated own and cross-price elasticities under the assumed mandatory opening of the FFPs to competitors and/or new entrants. The results suggest that own price elasticity concerning demand for United Airlines rose by 0.1% and for Southwest Airlines dropped by 0.1%. Although those changes in were not significant, the results imply that the consumers of United Airlines were more sensitive to United's airfares after the airline opened its FFP to Southwest. The estimated cross-price elasticity of demand suggests that an increase of 1.0% in United's airfare would increase Southwest's demand by 0.54% without the FFP's opening and of 0.78% otherwise.

The own and cross-price elasticities of demand on all air travel products to or

from DCA and LGA appear in Table 1.11 and Table 1.12, respectively. Although the magnitude of changes in the cross-price elasticities of demand differed, slot purchasers' cross-price elasticities tended to increase at all three airports under the assumption that the merged airlines' FFPs were opened to slot purchasers. Thus, though the FFPs of dominant airlines with hub-and-spoke systems are designed to deter the entry of effective competitors, slot divestiture with the mandatory opening of the FFPs to competitors and/or new entrants incentivized consumers to switch to those airlines.

Although the estimated own and cross-price elasticities under the assumed merger remedy offer valuable information about consumers' preferences and competition between the merged airlines, simple averages cannot support definitive interpretation. Therefore, I simulated the precise effect on competition of opening FFPs to competitors and/or new entrants by using counterfactual merger simulation.

Counterfactuals

To simulate the post-merger outcomes under the assumption that the DOJ would require slot purchasers to enter the market for overlapping nonstop routes operated by the merged airlines, I held observed and unobserved product characteristics as well as estimated marginal costs fixed at pre-merger levels. The ownership matrix of the first-order conditions for an airline's profit maximization was changed based on the actual change in ownership following the respective merger. In the second scenario, Southwest Airlines entered four markets for overlapping nonstop routes (i.e., EWR–SFO, EWR–DEN, EWR–ORD, and EWR–IAD) operated by United Airlines and, at DCA, commenced service for DCA–RDU and DCA–BNA. Last, Southwest was assumed to enter LGA–CLT and LGA–MIA. The post-merger ownership matrix needed to be modified to reflect those behavioral remedies ancillary to slot divestiture, after which the post-merger outcomes could be derived using the parameters of

demand and marginal cost along with the modified post-merger ownership matrix.

Table 1.13 presents the results of the counterfactual simulation in the case that entering overlapping nonstop routes was required along with surrendering slots for all products at EWR, DCA, and LGA. Although the United Airlines–Continental Airlines merger increased airfares for all products to or from EWR by 0.05% under the assumption that slot purchasers would be required to enter the merged airlines' overlapping nonstop routes, the magnitude of the anticompetitive effect was less than in the merger case imposing slot divestiture only. That ancillary behavioral remedy to slot divestiture was also predicted as a more effective policy for reducing risks of anticompetitive practices at DCA and LGA following the American Airlines–US Airways merger. The effect of requiring entry into overlapping nonstop routes and surrendering slots was more significant when those routes were considered in relation to simulated post-merger outcomes. As shown, both merger cases substantially increased the airfare of such routes operated by the merged airlines, even with slot divestiture. However, the counterfactual merger simulation under that assumption predicted that the airfare of the overlapping nonstop flights via EWR operated by the new United Airlines would decrease by 0.71%, whereas the merger mandating slot divestiture only would cause an increase of 7.17% in those flights. The results in Table 1.14 suggest that requiring mandatory operation on overlapping nonstop routes to or from DCA and LGA more significantly decreased the average airfare on those routes. Because no slot purchaser entered the market for those routes at DCA and LGA according to actual post-merger data, the additional behavioral remedy's effect was far more significant when the DOJ was assumed to require Southwest Airlines to enter four overlapping nonstop routes operated by the new American Airlines via DCA and LGA. Figure 1.4, Figure 1.5, and Figure 1.6 plot the simulated post-merger equilibrium airfare density for the baseline scenario, with slot divestiture, and with slot divestiture combined with forcing slot purchasers to enter the markets for the

overlapping nonstop routes at EWR, DCA, and LGA, respectively.

The next alternative merger strategy assessed in counterfactual merger simulation was obligatory code-sharing agreements between merged airlines and low-cost carrier airlines on overlapping nonstop routes to or from EWR, DCA, and LGA. In that scenario, I assumed that the new United Airlines and Southwest Airlines were engaged in code-sharing agreements for EWR–SFO and EWR–IAD. In the American Airline–US Airways merger, the new American Airlines was assumed to agree to code sharing with Southwest Airlines, JetBlue, and Virgin America on DCA–RDU, DCA–BNA, LGA–CLT, and LGA–MIA. To simulate post-merger outcomes under that assumption, I modified the pre-merger data regarding the status of code sharing to reflect changes due to the additional behavioral remedy, and thus, parameters of demand and marginal cost were re-estimated.

Table 1.15 presents the results of the counterfactual simulations with obligatory code sharing for all products at EWR, DCA, and LGA. Although the magnitude of the effect of obligatory code sharing was insignificant compared with that of requiring slot purchasers to enter the overlapping nonstop routes, slot divestiture combined with obligatory code sharing decreased the airfares of all products at all three airports. As a result, the number of passengers and consumer surplus would have increased following the merger. The predicted changes in price after the merger combining slot divestiture and obligatory code sharing for overlapping nonstop routes are listed in Table 1.16. The results suggest that slot divestiture combined with obligatory code sharing substantially lowered the airfares for those routes compared with airfares when only slot divestiture was imposed. However, the post-merger prices of overlapping nonstop routes were nevertheless predicted to respectively increase and decrease the number of passengers and consumer surplus. Whereas obligatory code sharing on such routes decreased airfares by jointly maximizing profit among code-sharing partners based on true marginal costs, the pro-competitive effect was less than that

of the alternative behavioral remedy that directly required slot purchasers to enter the markets for problematic routes. Figure 1.7, Figure 1.8, and Figure 1.9 plot the simulated post-merger equilibrium airfare density for the baseline scenario, with slot divestiture, and with slot divestiture combined with obligatory code-sharing agreements between merged airlines and low-cost carriers on overlapping nonstop routes at EWR, DCA, and LGA, respectively.

To examine how the combination of slot divestiture and requiring the merged airlines to open their FFPs to competitors and/or new entrants affected post-merger outcomes, I assume that United Airlines allowed awarding its FFP's points to Southwest's customers who travel to new destinations from Newark—that is, EWR–BWI, EWR–MDW, EWR–DAL, EWR–DEN, EWR–IAD, and EWR–STL. For the American Airlines–US Airways merger, I assumed that the new American Airlines would open its FFP to customers on Southwest's 17 new routes, JetBlue's five new routes, and Virgin's one new route to or from DCA, as well as Southwest's six new routes and Virgin's one new route to or from LGA. Those customers were assumed to be entitled FFP benefits identical to those enjoyed by customers who fly with the merged airlines' alliance partners.

The results in Table 1.17 suggest that slot divestiture combined with opening the FFPs of merged airlines would decrease the average airfare of all products by 0.03%, 1.39%, and 0.03% at EWR, DCA, and LGA, respectively, and thus boost the number of passengers and consumer surplus. However, the simulated post-merger outcomes under that scenario suggest that requiring opening the FFPs would not effectively resolve the risks of anticompetitive practices on the overlapping nonstop routes. Table 1.18 shows results suggesting that the average airfares of overlapping nonstop routes would increase by 6.8% at EWR, by 23.1% at DCA, and by 12.9% at LGA and thus substantially decrease the number of passengers and consumer surplus. Although the results suggest of simulations indicate that the average airfares of those routes

would increase substantially, the predicted increase in airfares was less than when the DOJ mandate slot divestiture only. Figure 1.10, Figure 1.11, and Figure 1.12 depict the simulated post-merger equilibrium airfare density for the baseline scenario, with slot divestiture, and with the combination of slot divestiture and the opening of the merged airlines' FFPs to consumers of low-cost carriers' new destinations to or from EWR, DCA, and LGA, respectively.

The results of the counterfactual merger simulation with three alternative behavioral remedies suggest that, on average, slot divestiture combined with enforcing slot purchasers to enter the markets for overlapping routes would be the most effect remedy to reduce risks of anticompetitive practices at slot-constrained airports. All three behavioral remedies were predicted to have pro-competitive effects when considering all products following the merger. However, the results also show that slot divestiture combined with opening FFPs to competitors and/or new entrants would not significantly decrease the average airfares for overlapping nonstop routes operated by the merged airlines.

1.8 Conclusion

In brief, the objective of the study was to identify the structural limitations of merger remedies imposed in airline mergers and suggest alternative ones. To address those limitations and alternative merger remedies, I developed a random-coefficient discrete-choice model based on the characteristics of air travel products. The model accounts for the fact that airline consumers may have heterogeneous preferences concerning characteristics of air travel products. Focusing on the United Airlines–Continental Airlines merger and the American Airlines–US Airways merger, in which the airlines were required to divest daily takeoff and landing slots at EWR, DCA, and LGA, I assessed the effectiveness of slot divestitures and various alternative behavioral remedies, namely involving an obligation to surrender slots operating monopolistic routes,

mandatory code-sharing, and the required opening of FFPs to competitors and/or new entrants by using counterfactual merger simulation. EWR, DCA, and LGA are slot-controlled airports with strict entry barriers to effective competitors and thus provide ideal circumstances to study the effect of slot divestitures and alternative behavioral remedies in airline mergers. The analysis focused on the price effect of the slot divestitures and three alternative behavioral remedies, as well as the effects on demand among consumers and their welfare.

The results reported herein suggest that slot divestiture and alternative behavioral remedies can indeed decrease the average post-merger airfare of all air travel products and thus increase the number of passengers and consumer surplus. The reduced airfares, however, would not be significant for overlapping nonstop routes if the DOJ required only slot divestiture from the merged party, and that result thus indicates that slot divestiture presents limitations to resolving risks of anticompetitive behavior on problematic routes. Although slot divestiture's ineffectiveness on some routes can be predicted, the combination of slot divestiture and alternative behavioral remedies would have a pro-competitive effect in those markets. The counterfactual merger simulations in the case of slot divestiture combined with an obligation to surrender slots operating monopolistic routes predicted that reductions in average airfare would be greater in the model stipulating only slot divestiture than in the baseline model for all air travel products and overlapping nonstop routes. Obligatory code-sharing ancillary to slot divestiture also would decrease average airfares, even as the price effect would be less than that of forcing slot purchasers to enter markets for those routes. Last, opening merged airlines' FFPs would decrease the airfares of air travel products overall. The price effect, however, would be insignificant on overlapping nonstop routes. The counterfactual simulations additionally suggest that slot divestiture at slot-controlled airports would benefit consumers by lowering airfares and adding flight options. However, slot divestiture cannot guarantee benefits

for every consumer. Therefore, the simulated outcomes of alternative merger policies examined in the study could aid policymakers in antitrust enforcement agencies.

Some limitations of the study indicate room for improvement in both modeling and estimations in future research. One remedy would be to improve the merger simulation model by adding flexibility in the supply system. Peters (2006) has suggested that standard merger simulations tend to overly predict the price effect of mergers due to ignoring supply-side effects, particularly the cost efficiency of the merged airlines. Second, my model does not incorporate the analysis on the changes in producer surplus caused by the merger remedies. Because the alternative behavioral remedies may create substantial costs for the merged airlines, the analysis on the profitability of the merged airlines was necessary to not intervene in effective competition. Last, I simulated post-merger outcomes by using only a subset of data associated with slot-controlled airports. Although the pro-competitive effects of slot divestiture combined with alternative behavioral remedies are apparent, those merger remedy schemes are unavailable at most airports whose capacity is not constrained.

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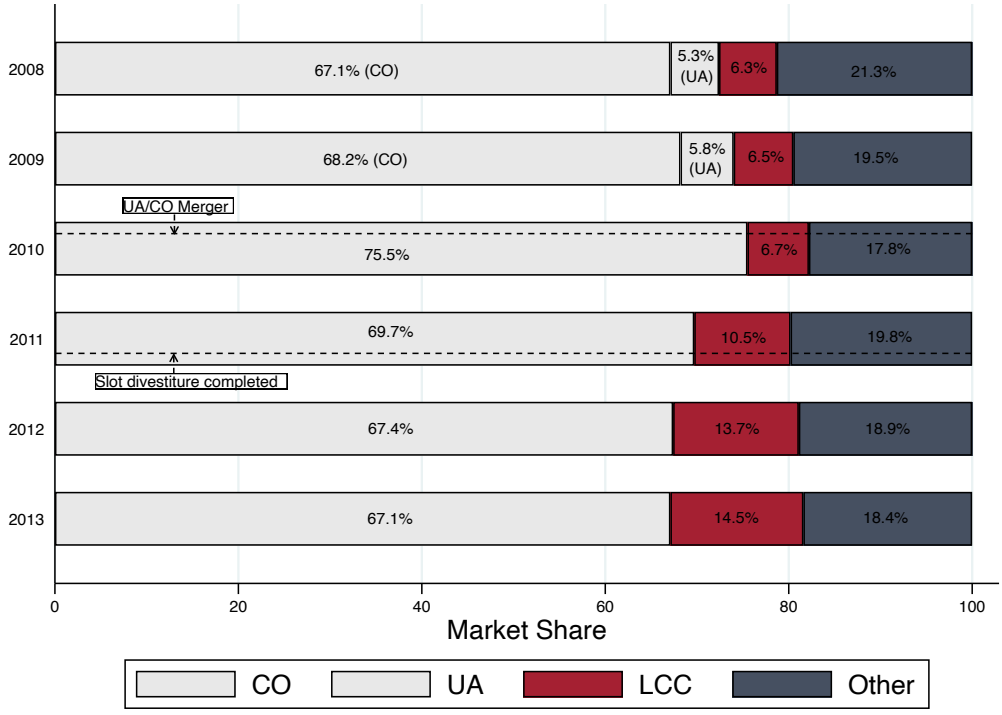
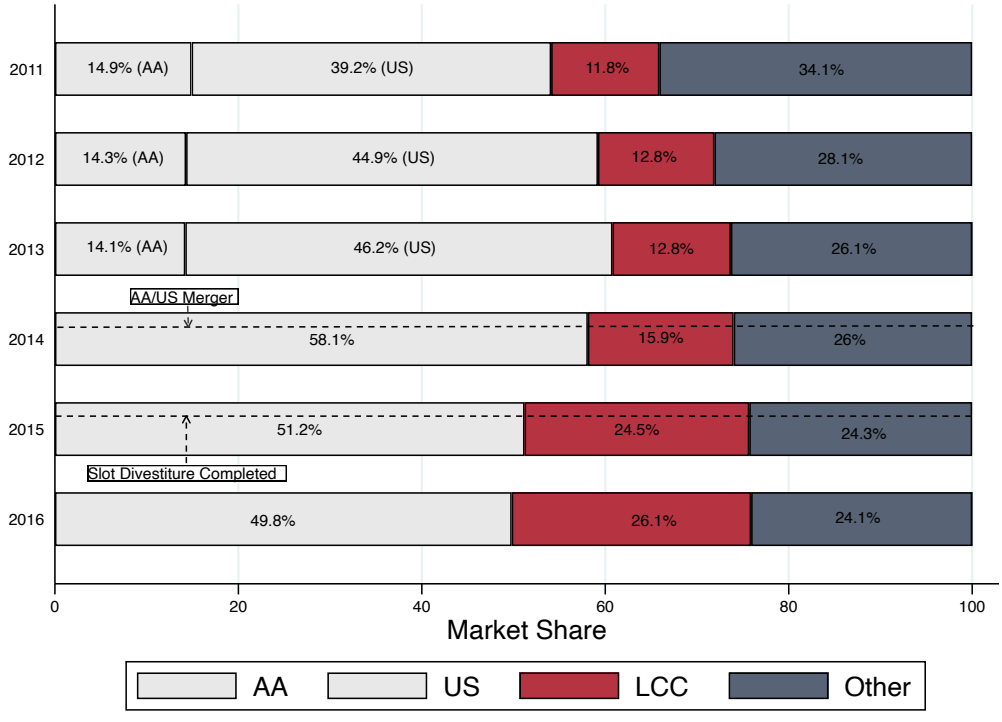
Figure 1.1: Market Share Trends at Newark Liberty International Airport (EWR)



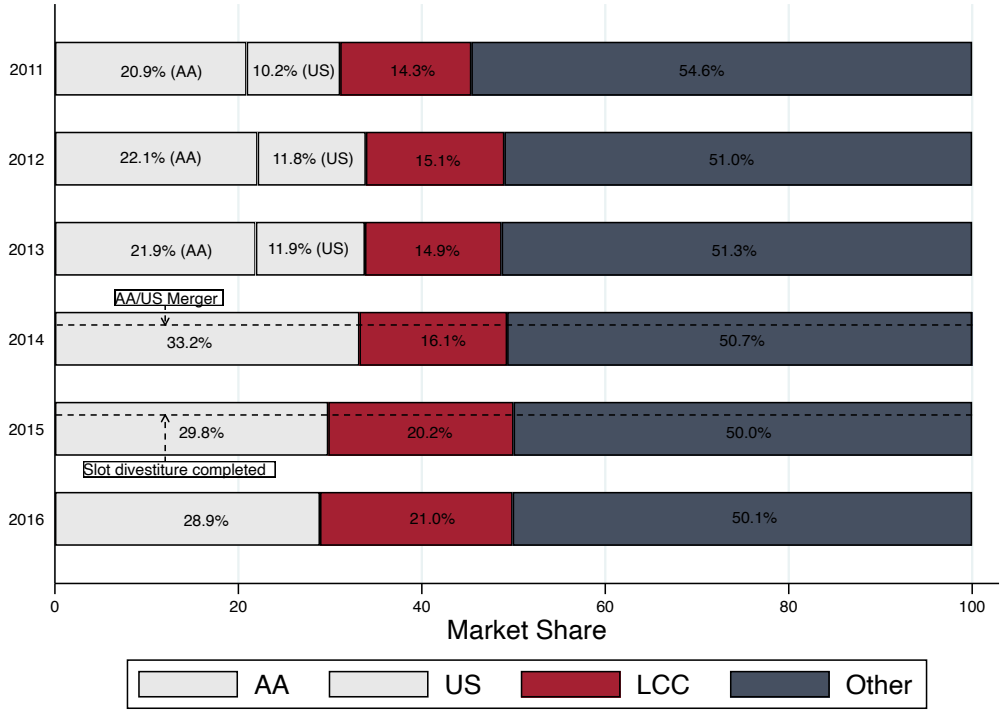
Source: DOT T-100 Domestic Segment

Figure 1.2: Market Share Trends at Ronald Reagan Washington National Airport (DCA)



Source: DOT T-100 Domestic Segment

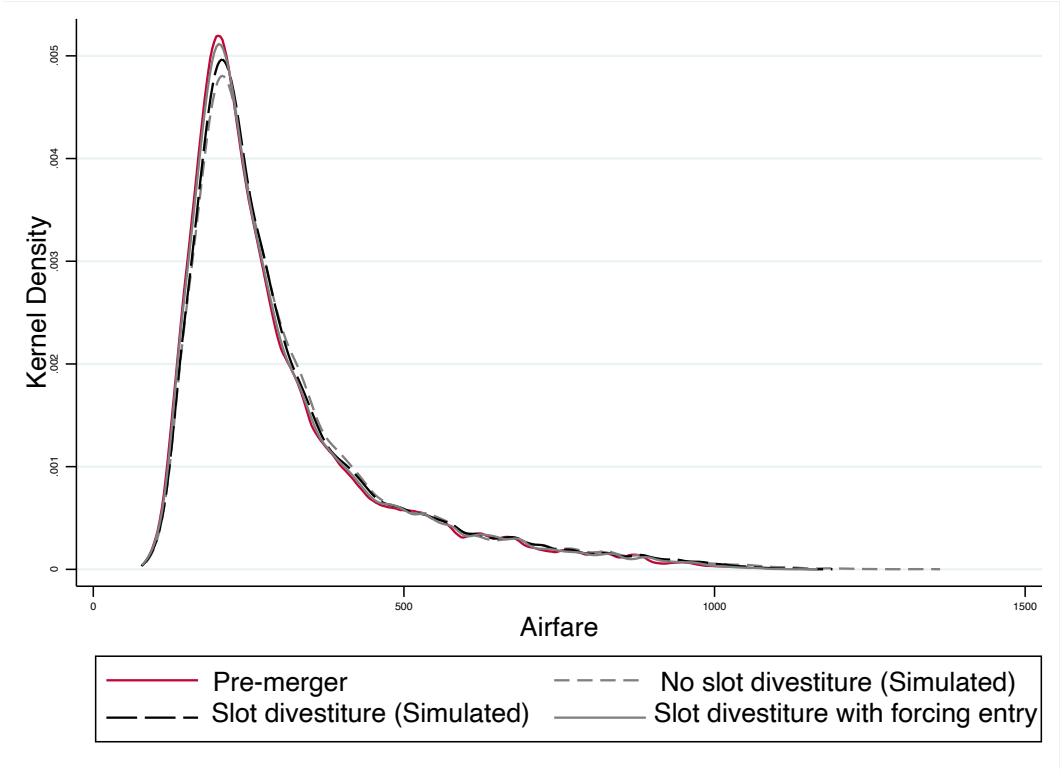
Figure 1.3: Market Share Trends at LaGuardia Airport (LGA)



Source: DOT T-100 Domestic Segment

Figure 1.4: Distribution of Airfare for United Airlines−Continental Airlines Merger (EWR): Pre-Merger vs. No Slot Divestiture vs. Slot Divestiture vs. Slot Divestiture with Forcing Entry

(a) All EWR Products



(b) Overlapped Nonstop Products

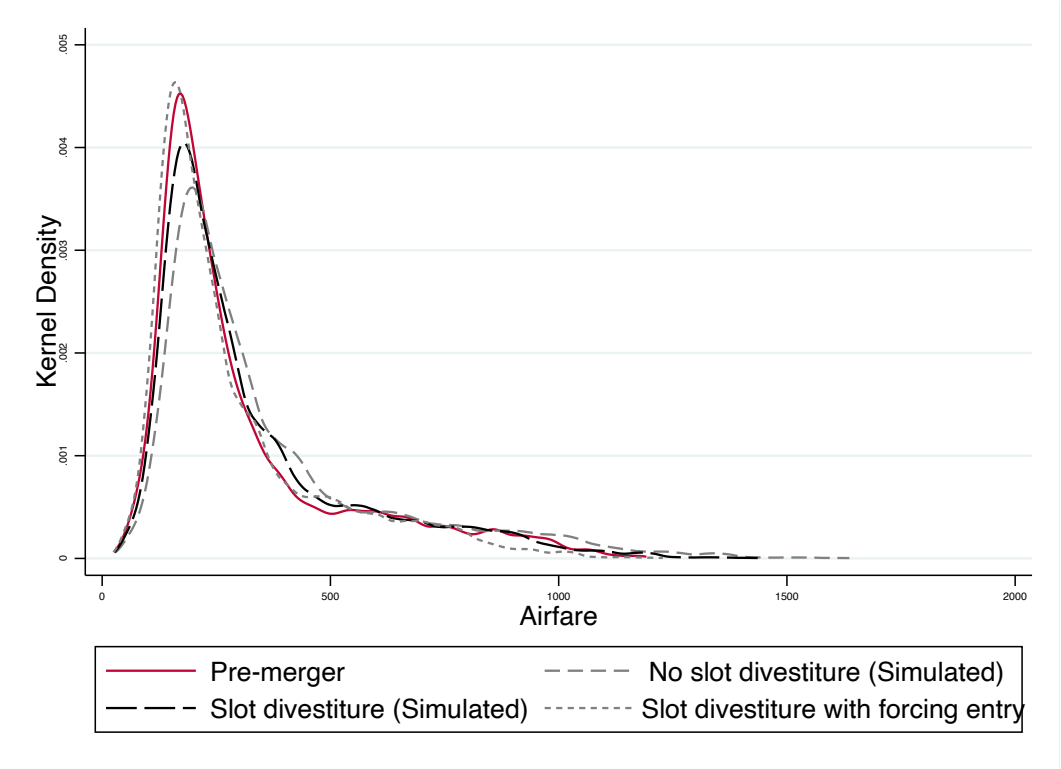
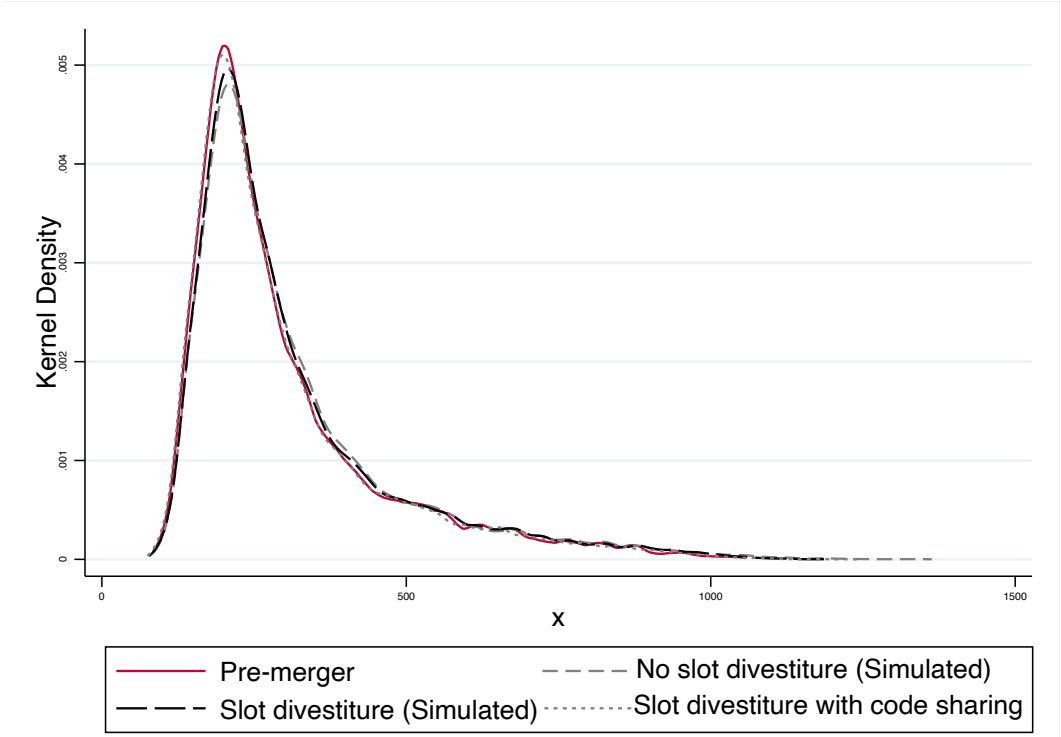


Figure 1.5: Distribution of Airfare for United Airlines−Continental Airlines Merger (EWR): Pre-Merger vs. No Slot Divestiture vs. Slot Divestiture vs. Slot Divestiture with Code Sharing

(a) All EWR Products



(b) Overlapped Nonstop Products

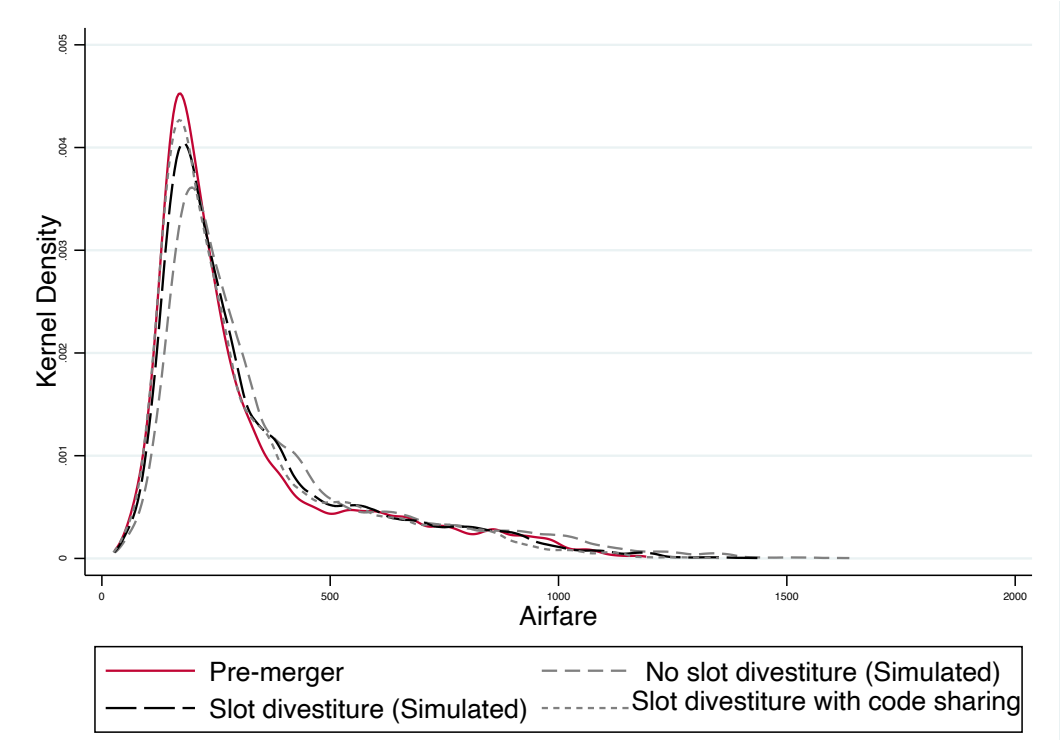
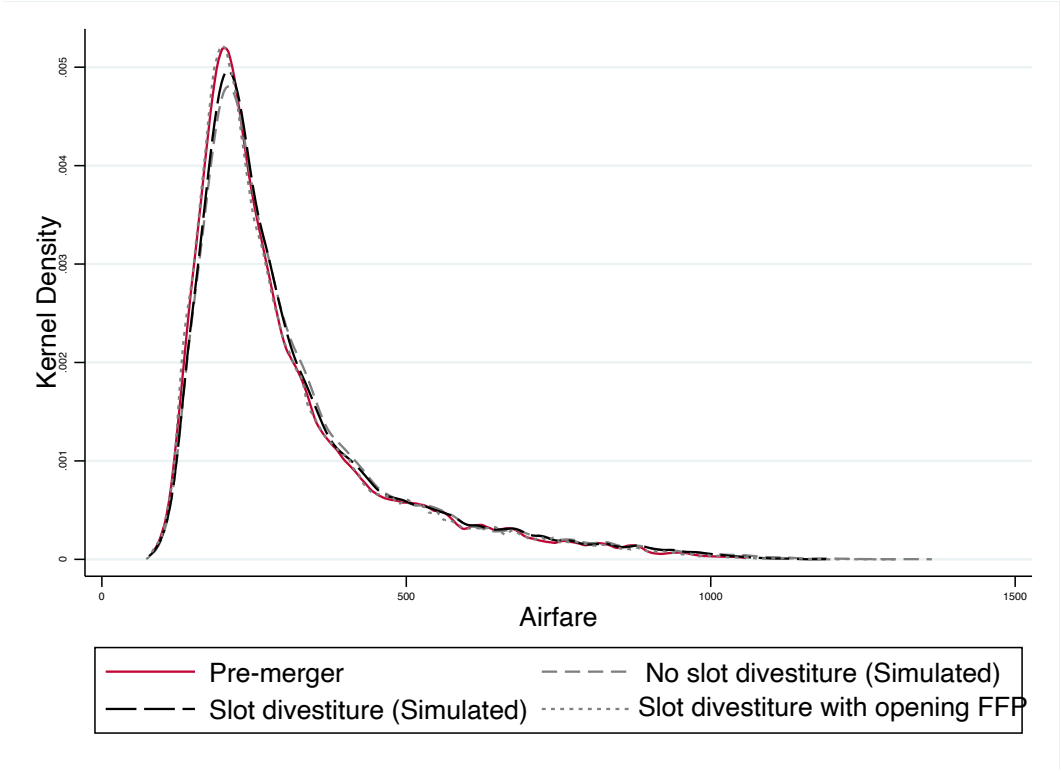


Figure 1.6: Distribution of Airfare for United Airlines−Continental Airlines Merger (EWR): Pre-Merger vs. No Slot Divestiture vs. Slot Divestiture vs. Slot Divestiture with Opening FFP

(a) All EWR Products



(b) Overlapped Nonstop Products

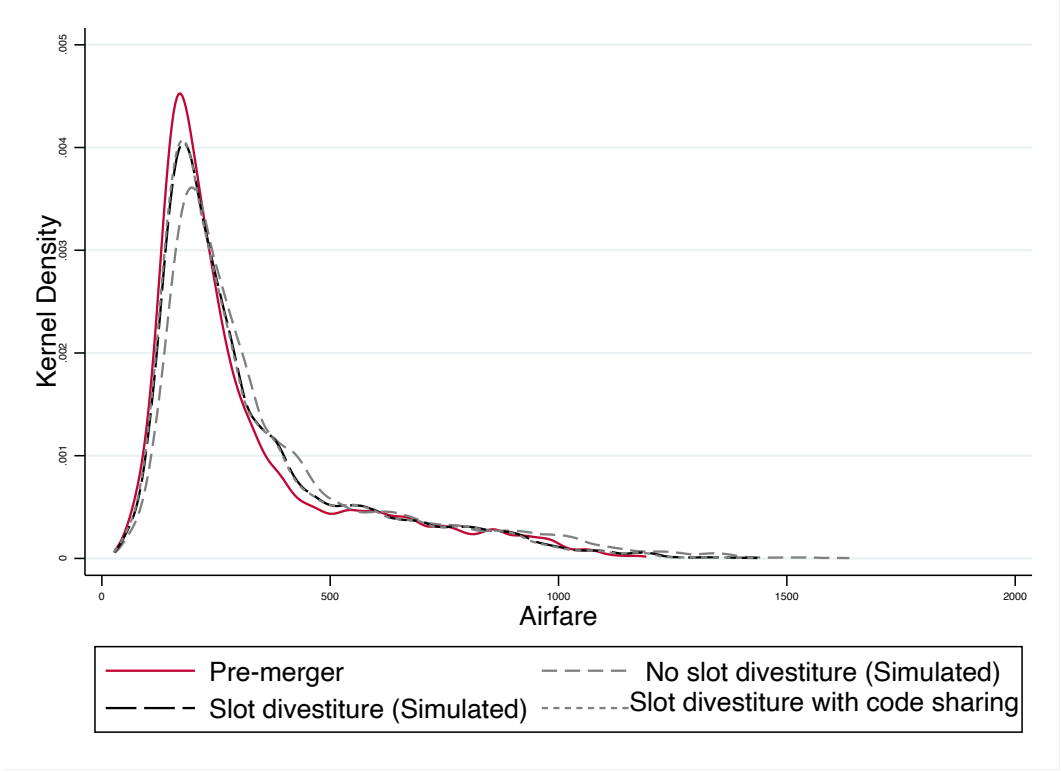
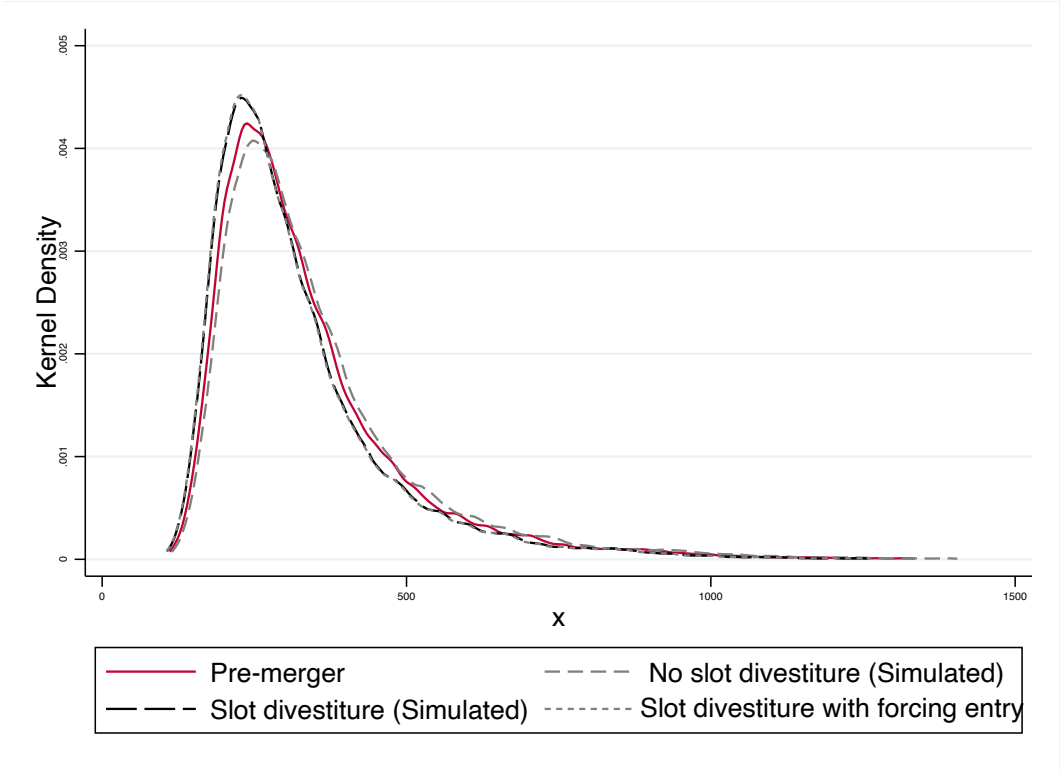


Figure 1.7: Distribution of Airfare for American Airlines−US Airways Merger (DCA): Pre-Merger vs. No Slot Divestiture vs. Slot Divestiture vs. Slot Divestiture with Enforcing Entrance

(a) All DCA Products



(b) Overlapped Nonstop Products

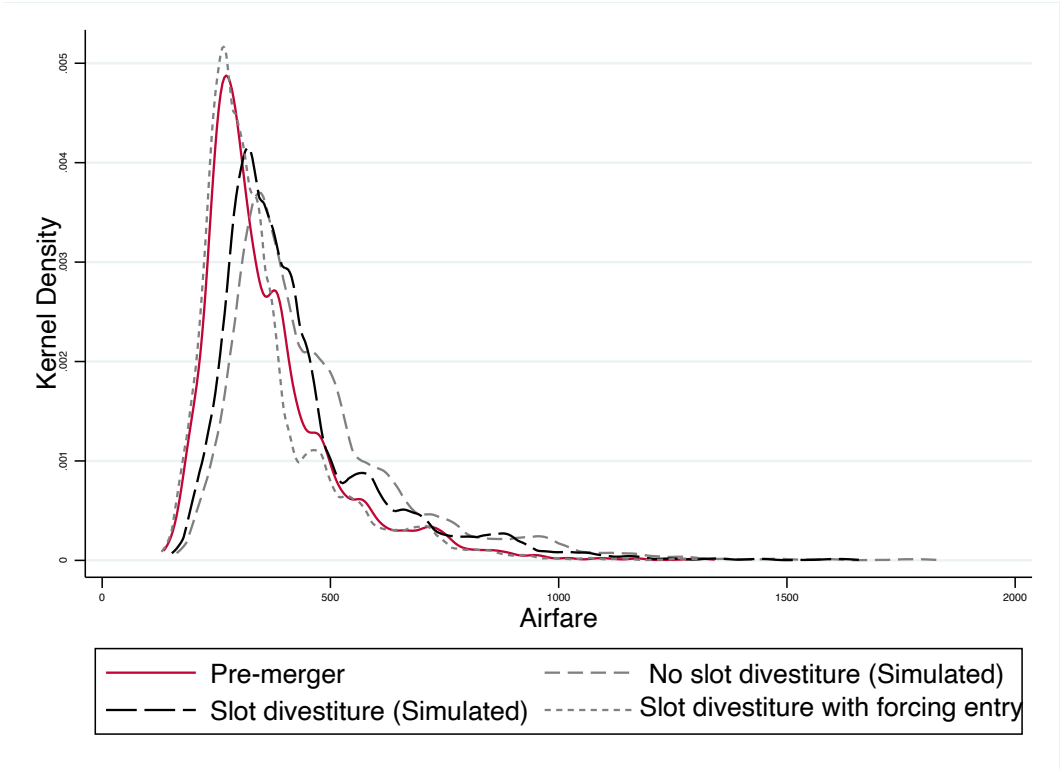
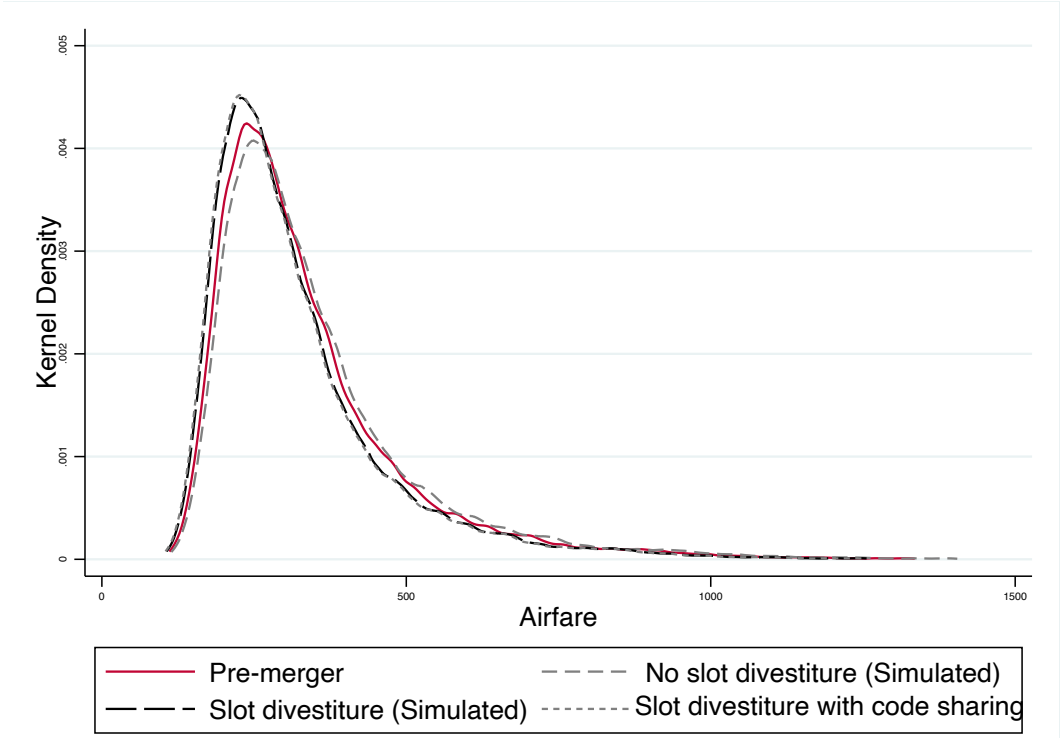


Figure 1.8: Distribution of Airfare for American Airlines−US Airways Merger (DCA): Pre-Merger vs. No Slot Divestiture vs. Slot Divestiture vs. Slot Divestiture with Code Sharing

(a) All DCA Products



(b) Overlapped Nonstop Products

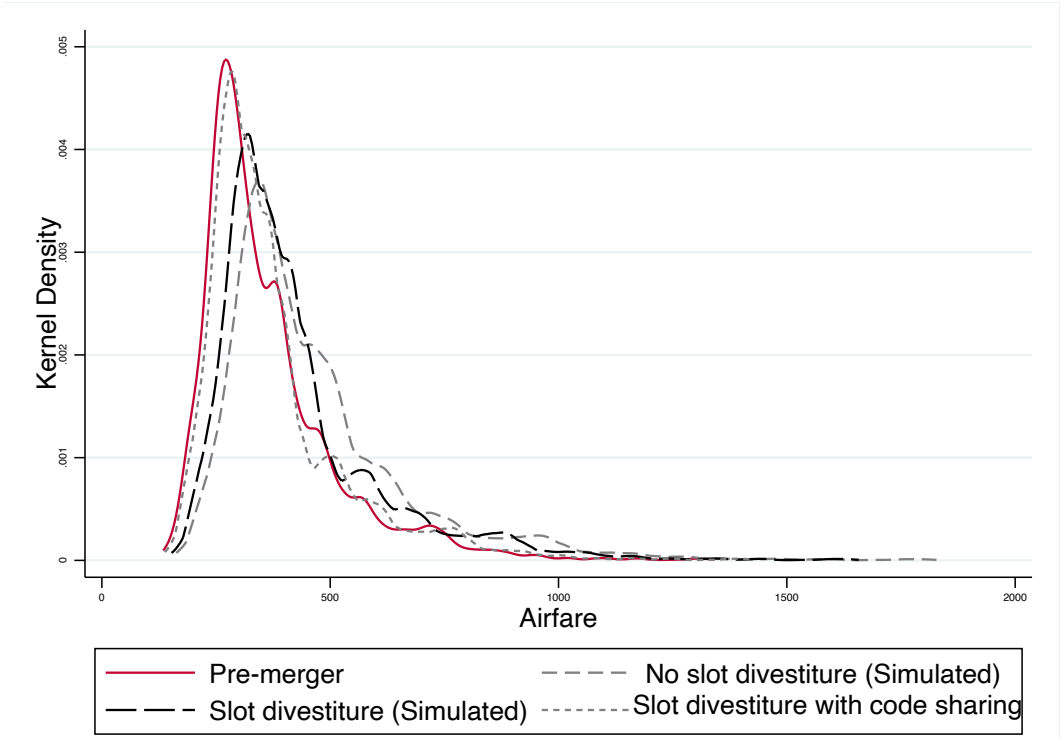
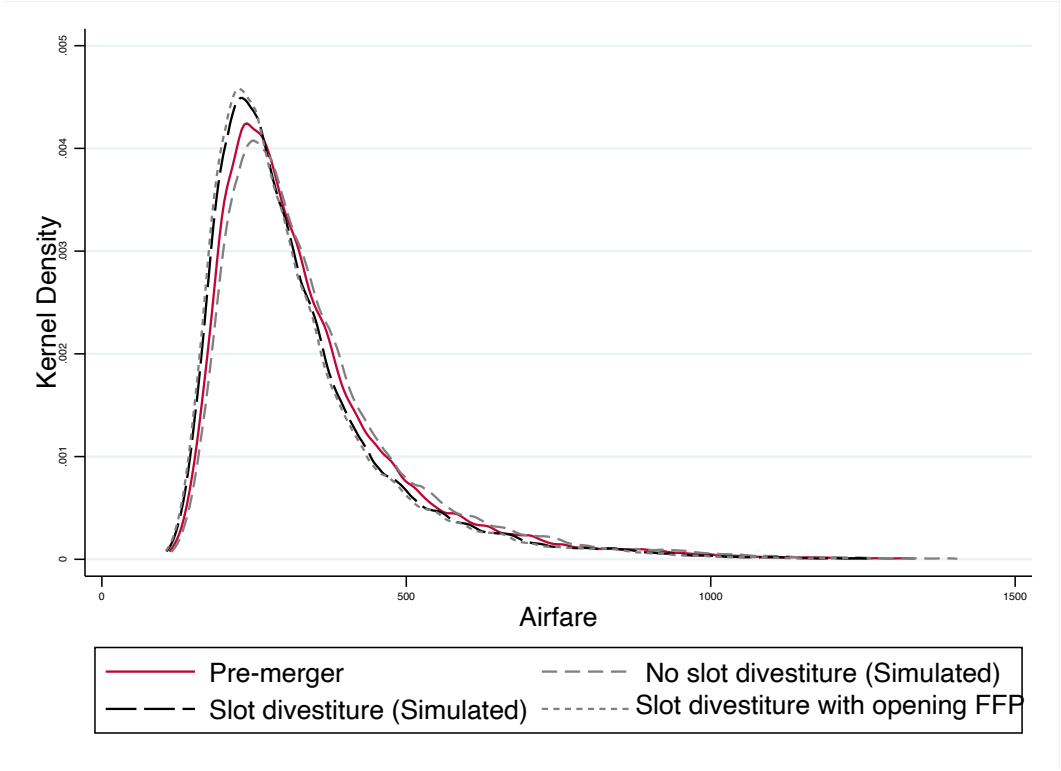


Figure 1.9: Distribution of Airfare for American Airlines−US Airways Merger (DCA): Pre-Merger vs. No Slot Divestiture vs. Slot Divestiture vs. Slot Divestiture with Opening FFP

(a) All DCA Products



(b) Overlapped Nonstop Products

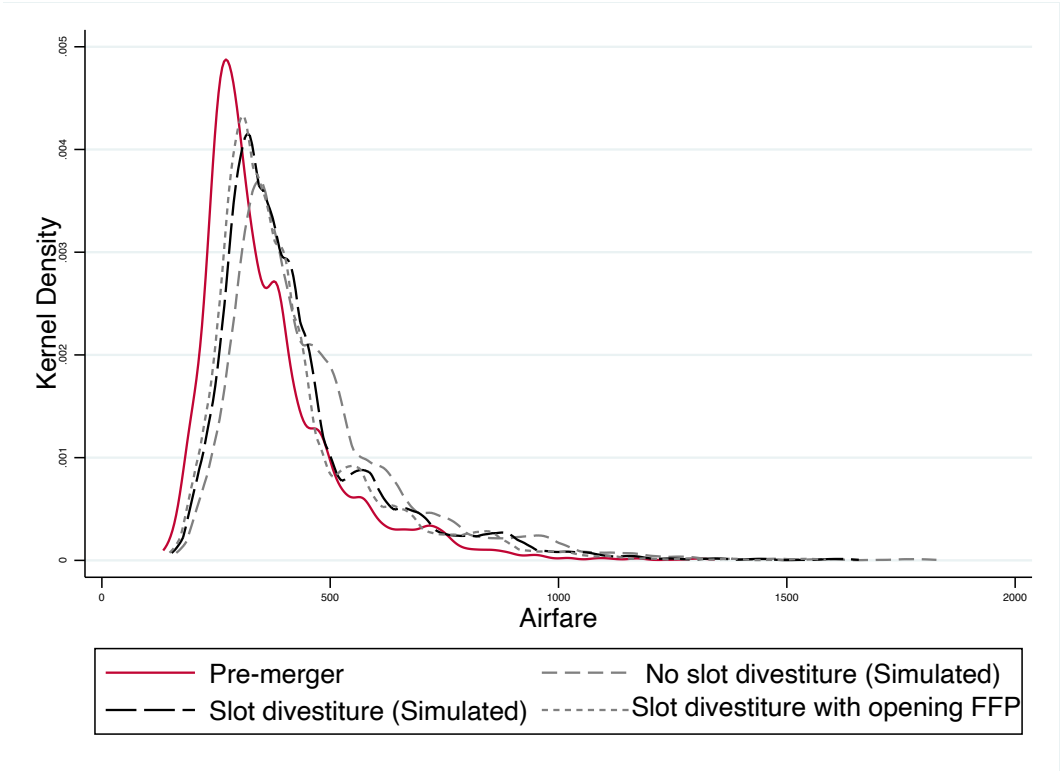
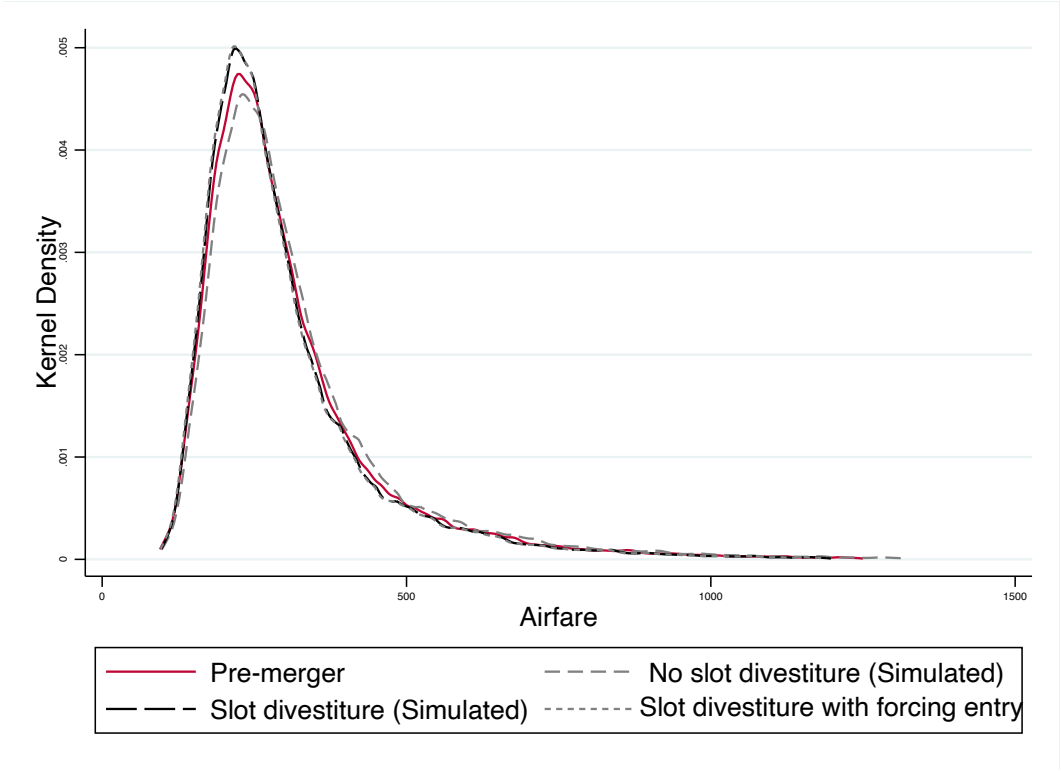


Figure 1.10: Distribution of Airfare for American Airlines−US Airways Merger (LGA): Pre-Merger vs. No Slot Divestiture vs. Slot Divestiture vs. Slot Divestiture with Enforcing Entrance

(a) All LGA Products



(b) Overlapped Nonstop Products

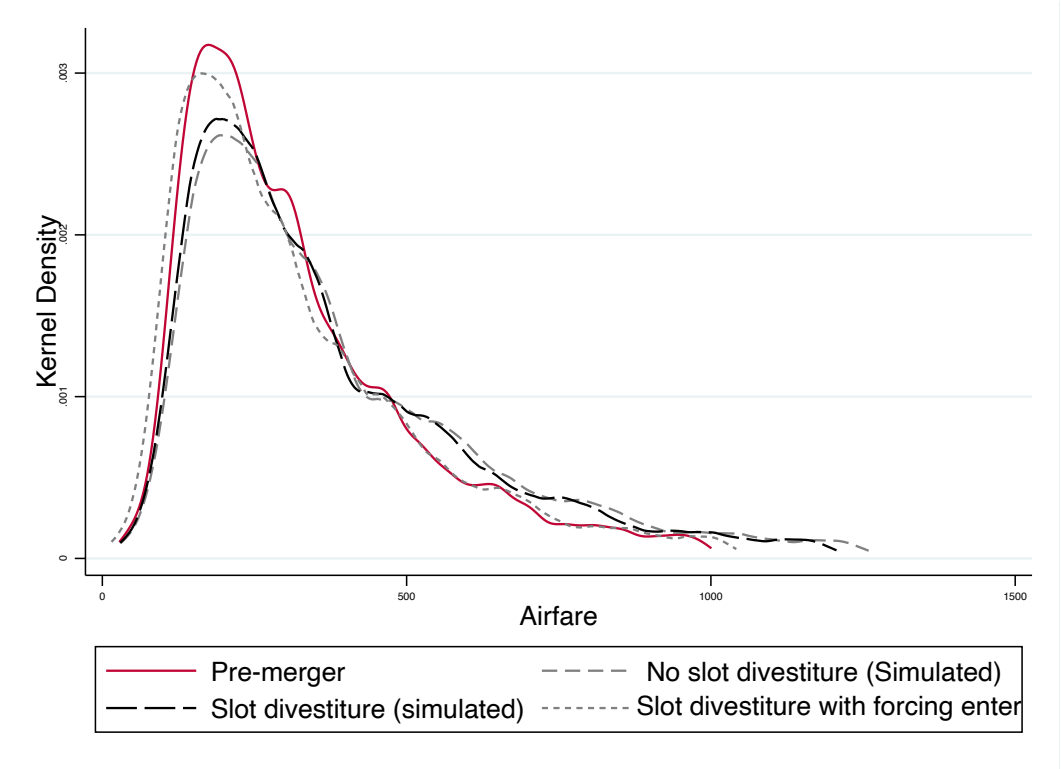
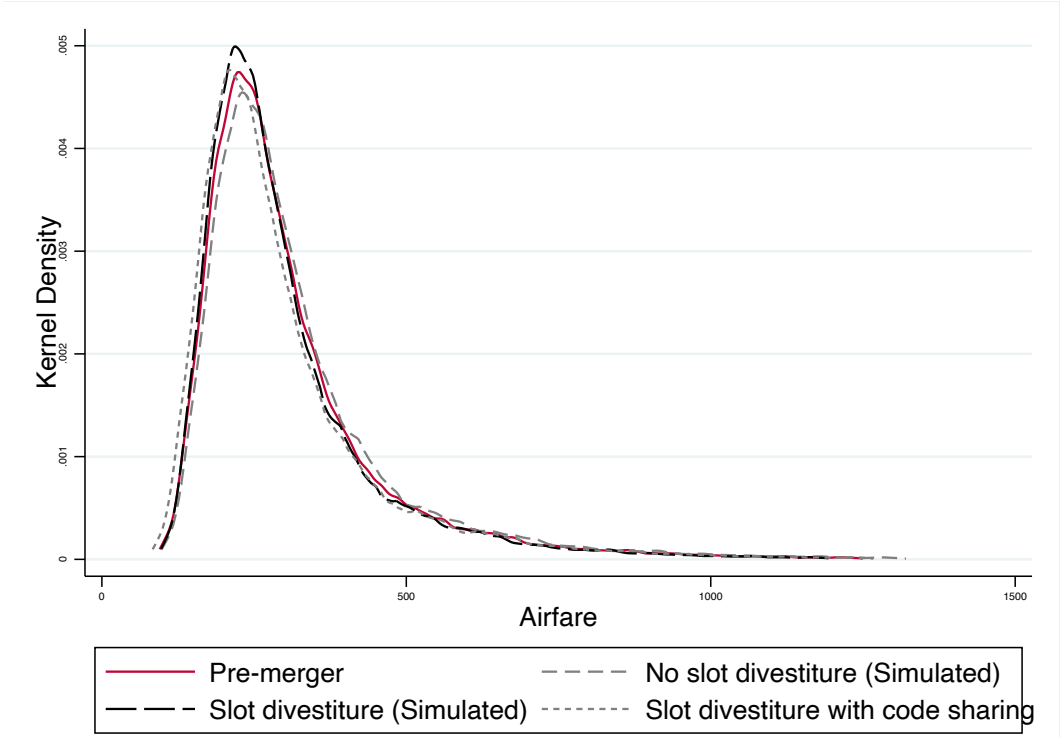


Figure 1.11: Distribution of Airfare for American Airlines−US Airways Merger (LGA): Pre-Merger vs. No Slot Divestiture vs. Slot Divestiture vs. Slot Divestiture with Code Sharing

(a) All LGA Products



(b) Overlapped Nonstop Products

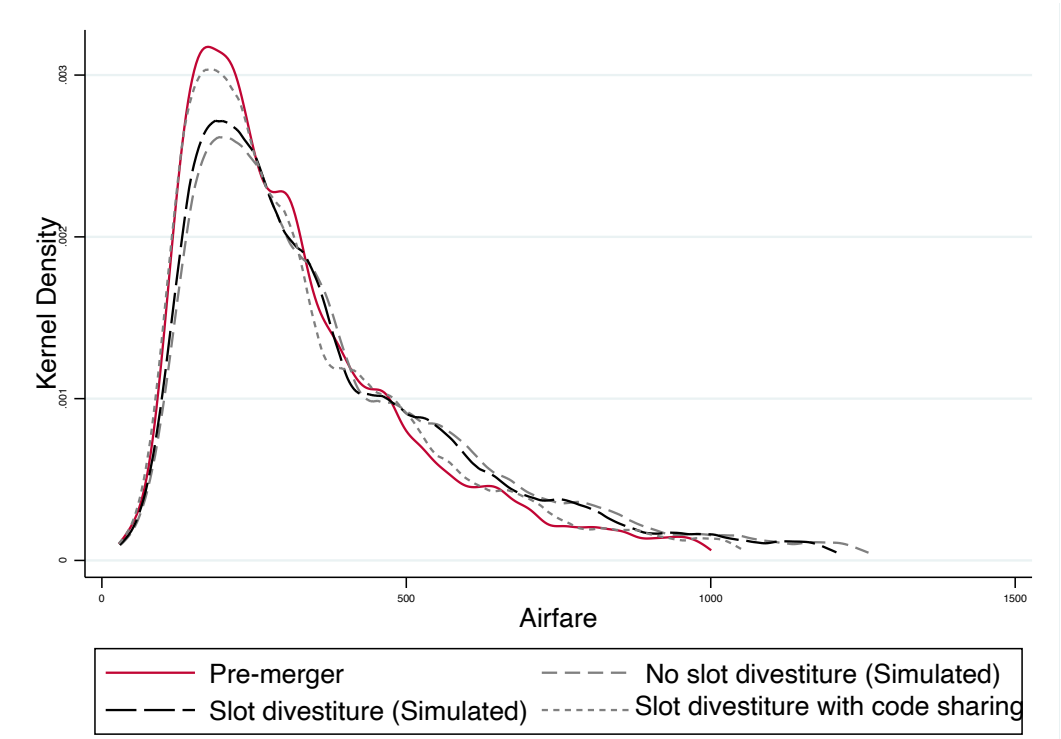
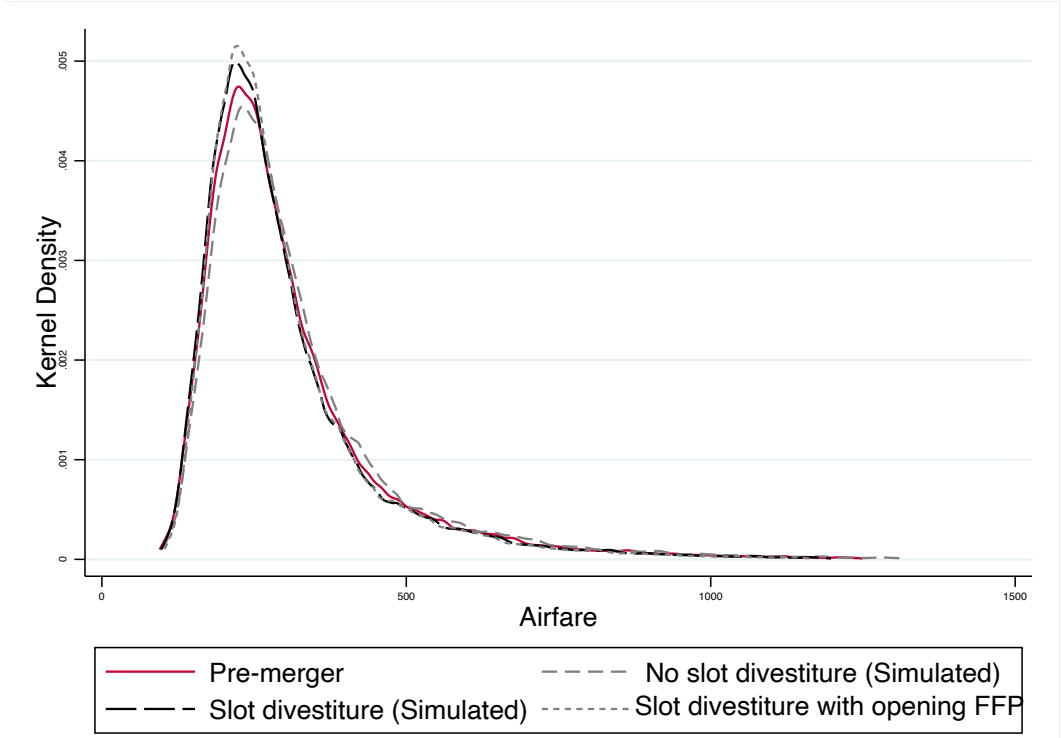


Figure 1.12: Distribution of Airfare for American Airlines−US Airways Merger (LGA): Pre-Merger vs. No Slot Divestiture vs. Slot Divestiture vs. Slot Divestiture with Opening FFP

(a) All LGA Products



(b) Overlapped Nonstop Products

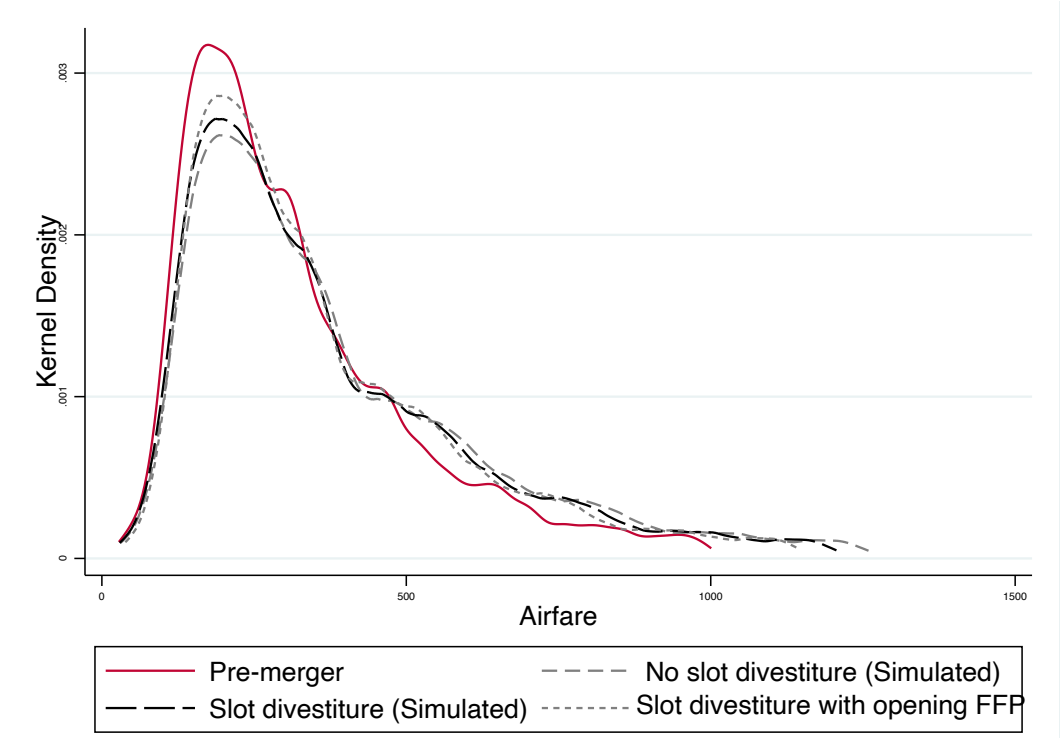


Table 1.1: Passengers on Nonstop Overlapping Routes between United Airlines and Continental Airlines (Q1 2010)

Routes	Passengers			Market Share		
	United	Continental	Others	United	Continental	Others
HNL−LAX	39,312	7,006	68,132	0.34	0.06	0.60
DEN−IAH	28,255	49,862	14,708	0.30	0.54	0.16
EWR−ORD	32,184	26,538	20,607	0.41	0.33	0.26
IAH−SFO	5,921	52,129	0	0.11	0.89	0
EWR−SFO	6,012	41,298	0	0.13	0.87	0
CLE−ORD	22,243	10,927	14,682	0.46	0.23	0.31
DEN−EWR	17,951	21,657	0	0.45	0.55	0
EWR−IAD	9,726	6,384	0	0.60	0.40	0
IAD−IAH	8,587	6,230	0	0.58	0.42	0
CLE−DEN	6,574	7,055	0	0.48	0.52	0
CLE−IAD	7,022	1,387	0	0.84	0.16	0
IAH−ORD	18,377	49,028	9,822	0.24	0.63	0.13

Source: DOT T-100 Domestic Segment

Table 1.2: Passengers on Nonstop Overlapping Routes between American Airlines and US Airways (Q4 2012)

Routes	Passengers			Market Share		
	American	US	Others	American	US	Others
BNA−DCA	4,315	3,943	0	0.52	0.48	0
CLT−DFW	16,557	38,299	0	0.30	0.70	0
CLT−LGA	4,795	49,208	0	0.09	0.91	0
CLT−MIA	5,816	20,408	0	0.22	0.78	0
CLT−ORD	5,681	38,256	9,184	0.11	0.72	0.17
DCA−RDU	4,851	7,247	0	0.40	0.60	0
DFW−PHL	19,470	18,404	0	0.51	0.49	0
LAX−PHX	29,039	21,175	0	0.58	0.42	0
MIA−PHL	11,503	6,922	0	0.62	0.38	0
ORD−PHL	11,230	30,122	18,038	0.19	0.51	0.30
ORD−PHX	17,191	28,176	12,081	0.30	0.49	0.21

Source: DOT T-100 Domestic Segment

Table 1.3: Summary Statistics for United Airlines and Continental Airlines Pre-Merger Period

Product average				
Variable	All Products		EWR Products	
	Mean	SD	Mean	SD
Airfare ($100)	2.88	1.28	2.99	1.61
Passengers (1,000)	2.01	4.16	1.95	3.21
Nonstop	0.17	0.28	0.19	0.11
No. connection	1.52	0.63	1.28	0.54
No. daily departure	4.21	2.04	4.05	1.45
Hub	0.19	0.22	0.61	0.42
Code shared	0.21	0.49	0.19	0.75
Frequent-flyer program	0.38	0.12	0.72	0.39
Slot-control	0.32	0.84	1.00	1.00
Distance	2.74	1.32	2.56	0.58
Tourist place	0.24	0.42	0.11	0.58
American	0.15	0.32	0.11	0.71
Continental	0.09	0.28	0.35	0.29
Delta	0.20	0.41	0.08	0.51
United	0.14	0.28	0.24	0.40
US Airways	0.15	0.30	0.03	0.02
JetBlue	0.02	0.11	0	0
Southwest	0.08	0.28	0.02	0.54
Virgin Atlantic	0.01	0.18	0	0
Market average				
Variable	All Markets		EWR Markets	
	Mean	SD	Mean	SD
No. products	48.21	23.58	40.75	31.22
No. carriers	3.24	1.99	2.98	1.53
No.passengers (1,000)	28.06	22.35	25.20	23.49

Notes: The sample contains 198,217 unique itinerary–airline–airfare products in 4,127 unique origin–destination directional markets. Sample period is from 2009:Q2 to 2010:Q1

Table 1.4: Summary Statistics for American Airlines and US Airways Pre-Merger Period

Product average						
Variable	All Products		DCA Products		LGA Products	
	Mean	SD	Mean	SD	Mean	SD
Airfare ($100)	3.03	1.51	3.30	1.94	3.08	1.88
Passengers (1,000)	2.09	3.02	2.55	1.81	2.15	1.91
Nonstop	0.20	0.18	0.22	0.41	0.19	0.24
No. connection	1.39	0.88	1.30	0.43	1.41	0.97
No. daily departure	4.54	1.94	4.85	2.05	4.29	3.21
Hub	0.22	0.20	0.45	0.72	0.38	0.87
Code shared	0.24	0.89	0.19	0.31	0.28	0.39
Frequent-flyer program	0.35	0.12	0.67	0.41	0.48	0.87
Slot-control	0.29	0.74	1.00	1.00	1.00	1.00
Distance	2.66	1.69	1.10	0.67	1.25	0.60
Tourist place	0.22	0.51	0.18	0.29	0.25	0.39
American	0.17	0.50	0.29	0.45	0.19	0.42
Delta	0.22	0.81	0.10	0.31	0.32	0.49
United	0.24	0.48	0.11	0.58	0.12	0.58
US Airways	0.11	0.47	0.39	0.57	0.15	0.44
JetBlue	0.06	0.31	0.02	0.05	0	0
Southwest	0.11	0.44	0.05	0.80	0.03	0.42
Virgin Atlantic	0.01	0.20	0	0	0.01	0.09
Market average						
Variable	All Markets		DCA Markets		LGA Markets	
	Mean	SD	Mean	SD	Mean	SD
No. products	45.11	19.44	38.99	24.93	39.08	23.46
No. carriers	3.20	2.04	2.81	1.62	2.98	1.25
No.passengers (1,000)	29.55	20.39	30.90	18.77	30.02	20.79

Notes: The sample contains 211,002 unique itinerary– airline–airfare products in 4,309 unique origin–destination directional markets. Pre-merger period is defined as 2012:Q1 through 2012:Q4

Table 1.5: Estimation Results on Demand Parameters

Demand variables	UA/CO Pre-Merger Periods	AA/US Pre-Merger Periods
$\text{Airfare}_{\text{Business}}$	-0.099** (0.003)	-0.112** (0.003)
$\text{Airfare}_{\text{Tourist}}$	-1.003** (0.014)	-1.058** (0.029)
$\text{Connection}_{\text{Business}}$	-0.562** (0.022)	-0.581** (0.021)
$\text{Connection}_{\text{Tourist}}$	-0.559** (0.028)	-0.580** (0.024)
$\text{FFP}_{\text{Business}}$	0.911** (0.018)	0.980** (0.021)
$\text{FFP}_{\text{Tourist}}$	0.072* (0.013)	0.088** (0.019)
Frequency	0.053** (0.009)	0.062* (0.010)
Code share	-0.089** (0.004)	-0.075** (0.006)
Distance	0.125** (0.003)	0.241** (0.007)
Distance^2	-0.097**(0.001)	-0.052** (0.001)
Hub	0.701** (0.043)	0.912** (0.053)
Slot-control	-0.188** (0.011)	-0.355**(0.019)
Tour	0.408** (0.024)	0.420** (0.035)
λ	0. 697** (0.002)	0.699** (0.003)
γ_{Business}	0.054** (0.003)	0.059** (0.004)
Carrier dummy		
Alaska	0.121** (0.020)	0.108** (0.012)
Continental	-0.125** (0.025)	
Delta	0.002** (0.016)	-0.008** (0.009)
United	0.133** (0.027)	0.102** (0.022)
US Airways	-0.001 (0.001)	0.009** (0.001)
Frontier	-0.757** (0.016))	-0.991**(0.018)
JetBlue	0.457** (0.043)	0.510**(0.026)
Southwest	-0.032	0.103** (0.049)
Observations	237,878	248,013

Notes: Standard errors are in parentheses.

**Significant at the 5% level. *Significant at the 10% level.

Table 1.6: Estimate Results on Marginal Cost

Demand variables	UA/CO Pre-Merger Periods	AA/US Pre-Merger Periods
Frequency	-0.039** (0.003)	-0.012** (0.001)
Hub	-0.087** (0.007)	-0.137** (0.011)
Slot-control	0.098** (0.007)	0.043** (0.002)
$\text{Distance}_{\text{short}}$	0.281** (0.018)	0.250** (0.006)
$\text{Distance}_{\text{long}}$	0.153** (0.011)	0.178** (0.003)
$\text{Connection}_{\text{short}}$	0.072* (0.005)	0.082** (0.004)
$\text{Connection}_{\text{long}}$	0.053**(0.004)	0.071** (0.006)
Carrier dummy		
Alaska	-0.187** (0.015)	-0.205** (0.012)
Continental	-0.003** (0.025)	
Delta	-0.158** (0.015)	-0.199** (0.018)
United	-0.061 (0.009)	-0.089** (0.012)
US Airways	-0.092** (0.001)	0.118** (0.003)
Frontier	-0.357** (0.021)	-0.342**(0.018)
JetBlue	-0.357** (0.039)	-0.359**(0.028)
Southwest	–0.214** (0.018)	-0.292** (0.024)
Observations	237,878	248,013

Notes: Standard errors are in parentheses.
**Significant at the 5% level. *Significant at the 10% level.

Table 1.7: Network Changes Due to Slot Divestiture

American	**Southwest**	**JetBlue**
Discontinue	Enter	Enter
Augusta	Chicago Midway	Charleston
Detroit	Nashville	Jacksonville
Fayetteville	New Orleans	Fort Myers
Fort Walton Beach	Tampa Bay	New York (JFK)
Islip	Akron-Canton	Windsor Locks
Jacksonville	Dallas Love Field	
Little Rock	Indianapolis	
Minneapolis	Houston	
Montreal	St. Louis	
Myrtle Beach	Kansas City	
Nassau	Orlando	
Omaha	Columbus	
Pensacola	Fort Lauderdale	
San Diego	Pensacola	
Savannah		
Tallahassee		
Wilmington		

Source: DOT T-100 Domestic Segment

Table 1.8: Simulated Post-Merger Outcomes (All Products)

	Pre-merger	Post-merger		
		Baseline	Slot Divestiture	Slot divestiture Changes Demand-Side
United/Continental				
EWR all products				
Price	\$299.12	+3.27%	+1.09%	+1.02%
Passengers	3,876,243	-1.47%	-0.02%	-0.04%
Consumer Surplus		-2.12%	-0.97%	-0.62%
American/USAir				
DCA all products				
Price	\$330.21	+4.98%	-1.13%	-1.48%
Passengers	2,711,781	-2.87%	+0.81%	+0.97%
Consumer Surplus		-5.52%	+1.53%	+1.89%
LGA all products				
Price	\$308.12	+3.94%	-0.03%	-0.03%
Passengers	3,014,332	-1.95%	+0.57%	+0.61%
Consumer Surplus		-4.22%	+0.54%	+0.69%
No. all EWR products	4,310	4,310		
No. all DCA products	4,009	4,009		
No. all LGA products	3,967	3,967		

Notes: The units in simulated post-merger outcomes are all relative to observed pre-merger values.

Table 1.9: Simulated Post-Merger Outcomes (Overlapping Nonstop Routes)

	Pre-merger	Post-merger		
		Baseline	Slot Divestiture	Slot divestiture Changes Demand-Side
United/Continental Airlines				
EWR nonstop overlapped routes				
Price	\$231.26	+17.29%	+7.17%	+6.02%
Passengers	321,760	-15.41%	-6.81%	-6.01%
Consumer Surplus		-16.53%	-6.13%	-5.96%
American/US Airways				
DCA nonstop overlapped routes				
Price	\$340.35	+32.21%	+26.17%	+25.12%
Passengers	62,976	-21.14%	-19.02%	-18.14%
Consumer Surplus		-25.12%	-20.18%	-19.14.%
LGA nonstop overlapped routes				
Price	\$319.77	+20.66%	+17.27%	+13.91%
Passengers	55,321	-18.20%	-16.68%	-11.97%
Consumer Surplus		-19.14%	-16.12%	-12.15%
No. EWR nonstop Overlapped routes	4	4		
No. DCA nonstop Overlapped routes	2	2		
No. LGA nonstop Overlapped routes	2	2		

Notes: The units in simulated post-merger outcomes are all relative to observed pre-merger values. Overlapped routes from/to EWR are EWR−ORD, EWR−SFO, EWR−DEN and EWR−IAD. Overlapped routes from/to DCA are DCA−RDU and DCA−BNA. Overlapped routes from/to LAG include LGA−CLT and LGA−MIA.

Table 1.10: Average Estimated Own- and Cross-Price Elasticities (All EWR Products)

	Not Opening the FFP to Southwest			Opening the FFP to Southwest	
	UA	WN		UA	WN
UA	-1.185	0.541	UA	-1.289	0.781
WN	0.418	-2.703	WN	0.420	-2.611

Table 1.11: Average Estimated Own- and Cross-Price Elasticities (All DCA Products)

	Not Opening the FFP to New Entrants					Opening the FFP to New Entrants			
	AA	WN	B6	VX		AA	WN	B6	VX
AA	-1.007	0.202	0.099	0.052	AA	-1.351	0.402	0.157	0.054
WN	0.123	-1.886	0.011	0.008	WN	0.102	-1.951	0.010	0.011
B6	0.021	0.005	-1.201	0.007	B6	0.017	0.006	-1.102	0.005
VX	0.012	0.014	0.009	-1.001	VX	0.008	0.016	0.011	-1.127

Table 1.12: Average Estimated Own- and Cross-Price Elasticities (All LGA Products)

	Not Opening the FFP to New Entrants				Opening the FFP to New Entrants		
	AA	WN	VX		AA	WN	VX
AA	-1.512	0.419	0.010	AA	-1.894	0.621	0.013
WN	0.210	-2.802	0.009	WN	0.179	-2.706	0.008
VX	0.315	0.021	-2.981	VX	0.302	0.030	-2.811

Table 1.13: Simulated Post-Merger Outcomes (All products)

	Pre-merger	Post-merger		
		Baseline	Slot Divestiture	Slot Divestiture with Forced Entrance
United/Continental Airlines				
EWR nonstop overlapped routes				
Price	\$299.12	+3.27%	+1.09%	+0.05%
Passengers	3,876,243	-1.47%	-0.02%	+0.01%
Consumer Surplus		-2.12%	-0.97%	-0.02%
American/US Airways				
DCA nonstop overlapped routes				
Price	\$330.21	+4.98%	-1.13%	-1.48%
Passengers	2,711,781	-2.87%	+0.81%	+0.97%
Consumer Surplus		-5.52%	+1.53%	+1.89%
LGA nonstop overlapped routes				
Price	\$308.12	+3.94%	-0.03%	-0.05%
Passengers	3,014,332	-1.95%	+0.57%	+0.61%
Consumer Surplus		-4.22%	+0.54%	+0.69%
No. all EWR products	4,310	4,310		
No. all DCA products	4,009	4,009		
No. all LGA products	3,967	3,967		

Notes: The units in simulated post-merger outcomes are all relative to observed pre-merger values. The counterfactual merger simulation assume that Southwest Airlines began offering services on all of the merged airlines' overlapping nonstop routes to or from EWR, DCA, and LGA.

Table 1.14: Simulated Post-Merger Outcomes (Overlapping Nonstop Routes)

	Pre-merger	Post-merger		
		Baseline	Slot Divestiture	Slot divestiture with Forced Entrance
United/Continental Airlines				
EWR nonstop overlapped routes				
Price	\$313.06	+17.29%	+7.17%	-0.71%
Passengers	321,760	-15.41%	-6.81%	+1.29%
Consumer Surplus		-16.53%	-6.13%	+1.78%
American/US Airways				
DCA nonstop overlapped routes				
Price	\$340.35	+32.21%	+26.17%	-3.27%
Passengers	62,976	-21.14%	-19.02%	+2.75%
Consumer Surplus		-25.12%	-20.18%	+1.07%
LGA nonstop overlapped routes				
Price	\$319.77	+20.66%	+17.27%	-0.78%
Passengers	55,321	-18.20%	-16.68%	+0.07%
Consumer Surplus		-19.14%	-16.12%	+0.41%
No. EWR nonstop overlapped routes	4	4		
No. DCA nonstop overlapped routes	2	2		
No. LGA nonstop overlapped routes	2	2		

Notes: The units in simulated post-merger outcomes are all relative to observed pre-merger values. Overlapped routes from/to EWR are EWR−ORD, EWR−SFO, EWR−DEN and EWR−IAD. Overlapped routes from/to DCA are DCA−RDU and DCA−BNA. Overlapped routes from/to LAG include LGA−CLT and LGA−MIA. The simulation assumed that Southwest Airlines began offering services on all of the merged airlines' overlapping nonstop routes to or from EWR, DCA, and LGA.

Table 1.15: Simulated Post-Merger Outcomes (All Products)

	Pre-merger	Post-merger		
		Baseline	Slot Divestiture	Slot divestiture Obligatory Code-sharing Agreement
United/Continental Airlines				
EWR all products				
Price	$299.12	+3.27%	+1.09%	-0.08%
Passengers	3,876,243	-1.47%	-0.02%	+0.18%
Consumer Surplus		-2.12%	-0.97%	+0.24%
American/US Airways				
DCA all products				
Price	$330.21	+4.98%	-1.13%	-1.26%
Passengers	2,711,781	-2.87%	+0.81%	+1.39%
Consumer Surplus		-5.52%	+1.53%	+1.61%
LGA all products				
Price	$308.12	+3.94%	-0.03%	-0.05%
Passengers	3,014,332	-1.95%	+0.57%	+0.59%
Consumer Surplus		-4.22%	+0.54%	+0.68%
No. all EWR products	4,310	4,310		
No. all DCA products	4,009	4,009		
No. all LGA products	3,967	3,967		

Notes: The units in simulated post-merger outcomes are all relative to observed pre-merger values. The simulation assumed that code sharing allowed low-cost carriers to place their codes on the flights of overlapping nonstop routes operated by the merged airlines to or from EWR, DCA, and LGA.

Table 1.16: Simulated Post-Merger Outcomes (Overlapping Nonstop Routes)

	Pre-merger	Post-merger		
		Baseline	Slot Divestiture	Slot divestiture Obligatory Code-sharing Agreement
United/Continental Airlines				
EWR nonstop overlapped routes				
Price	$313.06	+17.29%	+7.17%	+0.27%
Passengers	321,760	-15.41%	-6.81%	-0.19%
Consumer Surplus		-16.53%	-6.13%	-0.36%
American/US Airways				
DCA nonstop overlapped routes				
Price	$340.35	+32.21%	+26.17%	+4.28%
Passengers	62,976	-21.14%	-19.02%	–2.89%
Consumer Surplus		-25.12%	-20.18%	-2.72%
LGA nonstop overlapped routes				
Price	$319.77	+20.66%	+17.27%	+2.91%
Passengers	55,321	-18.20%	-16.68%	-2.10%
Consumer Surplus		-19.14%	-16.12%	-3.27%
No. EWR nonstop overlapped routes	4	4		
No. DCA nonstop overlapped routes	2	2		
No. LGA nonstop overlapped routes	2	2		

Notes: The units in simulated post-merger outcomes are all relative to observed pre-merger values. Overlapped routes from/to EWR are EWR−ORD, EWR−SFO, EWR−DEN and EWR−IAD. Overlapped routes from/to DCA are DCA−RDU and DCA−BNA. Overlapped routes from/to LAG include LGA−CLT and LGA−MIA. The counterfactual merger simulation assumed that code sharing allowed low-cost carriers to place their codes on the flights of overlapping nonstop routes operated by the merged airlines to or from EWR, DCA, and LGA.

Table 1.17: Simulated Post-Merger Outcomes (All Products)

	Pre-merger	Post-merger		
		Baseline	Slot Divestiture	Slot divestiture with opening the FFP
United/Continental Airlines				
EWR nonstop overlapped routes				
Price	\$299.12	+3.27%	+1.09%	-0.03%
Passengers	3,876,243	-1.47%	-0.02%	+0.05%
Consumer Surplus		-2.12%	-0.97%	+0.01%
American/US Airways				
DCA nonstop overlapped routes				
Price	\$330.21	+4.98%	-1.13%	-1.39%
Passengers	2,711,781	-2.87%	+0.81%	+1.57%
Consumer Surplus		-5.52%	+1.53%	+1.68%
LGA nonstop overlapped routes				
Price	\$308.12	+3.94%	-0.03%	-0.03%
Passengers	3,014,332	-1.95%	+0.57%	+0.11%
Consumer Surplus		-4.22%	+0.54%	+0.29%
No. all EWR products	4,310	4,310		
No. all DCA products	4,009	4,009		
No. all LGA products	3,967	3,967		

Notes: The units in simulated post-merger outcomes are all relative to observed pre-merger values. The simulation assumed that United Airlines opened its FFP to the new routes served by Southwest Airlines to or from EWR and that American Airlines allowed rewarding FFP points to consumers traveling on the new routes of Southwest Airlines, JetBlue, and Virgin America to or from DCA and LGA following its merger with US Airways.

Table 1.18: Simulated Post-Merger Outcomes (Overlapping Nonstop Routes)

	Pre-merger	Post-merger		
		Baseline	Slot Divestiture	Slot divestiture with opening the FFP
United/Continental Airlines				
EWR nonstop overlapped routes				
Price	$313.06	+17.29%	+7.17%	+6.81%
Passengers	321,760	-15.41%	-6.81%	-6.02%
Consumer Surplus		-16.53%	-6.13%	-6.99%
American/US Airways				
DCA nonstop overlapped routes				
Price	$340.35	+32.21%	+26.17%	+23.11%
Passengers	62,976	-21.14%	-19.02%	–22.79%
Consumer Surplus		-25.12%	-20.18%	-24.16%
LGA nonstop overlapped routes				
Price	$319.77	+20.66%	+17.27%	+12.98%
Passengers	55,321	-18.20%	-16.68%	-11.08%
Consumer Surplus		-19.14%	-16.12%	-13.20%
No. EWR nonstop overlapped routes	4	4		
No. DCA nonstop overlapped routes	2	2		
No. LGA nonstop overlapped routes	2	2		

Notes: The units in simulated post-merger outcomes are all relative to observed pre-merger values. Overlapped routes from/to EWR are EWR−ORD, EWR−SFO, EWR−DEN and EWR−IAD. Overlapped routes from/to DCA are DCA−RDU and DCA−BNA. Overlapped routes from/to LAG include LGA−CLT and LGA−MIA. The simulation assumed that United Airlines opened its FFP to the new routes served by Southwest Airlines to or from EWR and that American Airlines allowed rewarding FFP points to consumers traveling on the new routes of Southwest Airlines, JetBlue, and Virgin America to or from DCA and LGA following its merger with US Airways.

Chapter 2: Collusive Capacity Reduction Patterns in the US Airline Industry

2.1 Introduction

In 2015, the U.S. Department of Justice undertook an investigation into 'possible unlawful coordination' by four U.S. airlines (American, Delta, United, and Southwest; hereafter 'the major airlines'), which had been accused of collusion to limit both routes and number of affordable seats ('capacity discipline') available in order to boost prices.[8] Although the inquiry has found no evidence of collusion on either pricing or capacity, it remains ongoing.[9] Findings of previous empirical economic studies across diverse industries indicate that collusive behavior among oligopolistic firms leads to monopolistic output which causes a drop in efficiency across output level and price and is not in the interest of consumers. Detecting collusion has been a mainstream task in the field of industrial organization for so long that a wide range of economists and practitioners have dedicated themselves to identifying the factors indicating and underlying collusive behaviors. Among such factors, market structure stands out and has been the focus of multiple studies in this area. Early studies tended to investigate firms within a single market; however, more recent work has taken account of the fact that as most companies produce more than one product, they also compete across multiple markets.

Previous study in this field has often made reference to Edwards' (1955) 'mutual forbearance hypothesis,' which posits the generation of anti-competitive output when firms compete across several markets. This hypothesis holds that when there is competition in more than one market, competition becomes more aggressive and

[8]https://www.washingtonpost.com/business/economy/doj-investigating-potential-airline-collusion/2015/07/01/42d99102-201c-11e5-aeb9-a411a84c9d55_story.html.

[9]https://www.wsj.com/articles/obama-antitrust-enforcers-wont-bring-action-in-airline-probe-1484130781.

hence more costly; if, on the other hand, firms choose to collude in such markets, the costs are reduced. Bernheim and Whinston's (1990) seminal theoretical study on the association between collusive behaviors and multimarket contact created several formal models, applied Edwards' hypothesis, and found that the incentive constraints which serve to restrict collusion are less strong in a condition of multimarket contact. Economists have empirically extended their work by applying the hypothesis to collusive pricing patterns across a wide range of industrial settings.

Evans and Kessides (1994) investigated the link between multimarket contact and pricing within the U.S. domestic airline industry, finding significantly higher fares where multiple airlines served a single city with higher level of multimarket contact. Several researchers have since investigated the relationship between multimarket contact and collusion in the same sector. The earlier research studies (Singal, 1996; Bilotkach, 2011; Ciliberto and Williams, 2014; Ciliberto et al., 2019) looked exclusively at links between collusive pricing and degree of multimarket contact while the later ones (Mazzeo, 2003; Rupp et al., 2003; Prince and Simon, 2017; Chen and Gayle, 2018) also investigated the impact of market structure on product quality, using the metric of on-time performance.

These studies indicate that a range of market factors can negatively impact product quality in the airline industry, including mergers, monopolies, and dehubbing; however, little work has investigated whether multimarket contact is among these factors. The literature includes only one example of in-depth investigation of collusive behavior: Subsequent to the Department of Justice inquiry in 2015 mentioned above, Aryan et al. (2017) examined the possibility that earnings announcements by U.S. airlines served as a signal to undertake a coordinated campaign of 'capacity discipline', that is, for all players to reduce capacity. Their investigation found that each time the more important players discussed this concept, such capacity was reduced by between 1.14% and 1.48%. To date, while the majority of studies in this area have

only investigated the impact of multimarket contact on collusive pricing behavior by using reduced-form analysis, Ciliberto and Williams' (2014) study provides structural analysis of relationship between multimarket contact and collusive pricing behavior.

The empirical examination described in this chapter aims to determine whether multimarket contact results rise to collusive capacity setting among U.S. domestic airlines, with a focus on capacity setting competition. Relevant data were gathered from two Department of Transportation (DOT) sources: first, the Airline Origin & Destination Survey (DB1B); and second, the T-100 domestic segment covering both monthly and non-stop routes during the period 2008-2019. Degree of multimarket contact is measured in terms of the number of overlapping markets in which a given carrier competes with at least one other. The robustness of this analysis was verified by the use of two alternative multimarket contact measures (size of airline, and market share on routes operated concomitantly), which allow for any asymmetry in degrees of coordination.

First, a reduced-form analysis is used to reveal whether the two principal variables of airlines in a given market, namely market-level capacity and multimarket contact, correlate. The primary concern in terms of identification is the potential endogeneity of average multimarket contact. While Evans and Kessides (1994) and Bernheim and Whinston (1990), among others, consider multimarket contact an external factor, there is likely to be unobservable heterogeneity that informs decision-making on price, entry and exit, thereby influencing average multimarket contact. Therefore, to resolve these multimarket contact endogeneity concerns, in building the instrumental variables for average multimarket contact, this study uses data on each airline's number of gates at US airports. Although the number of gates controlled by an airline at an airport naturally correlates with that airline's decision to serve a given market, due to the long-term nature of airport-airline leasing agreements, this number cannot be easily adjusted. As a result, these variables represent valid instruments

to measure multimarket contact. As the economic and market circumstances influence airlines' capacity decision-making, I incorporate multiple covariates to control for market-specific factors that vary over time. Subsequently, I investigate whether multimarket contact's effect on collusion in terms of capacity-setting strategy varies with the size of the market. As a rule, larger markets imply more competitors and higher demand volatility than small markets, increasing airlines' difficulty in coordinating their capacity-setting measures. Nevertheless, airlines with a higher share of business travelers may be incentivized to coordinate capacity reduction as these passengers are more immune to price changes and are more present in large markets; in such a circumstance, there is more likely to be collusion.

Thereafter, investigation was made of whether the effect of multimarket contact on capacity reduction varies according to carrier type. The four major airlines investigated by the Department of Justice in 2015 were responsible for about 80% of U.S. domestic air travel. Given the allegation that they had colluded to limit routes and the number of affordable seats to boost ticket prices, an investigation is necessary to determine whether these four companies were principally responsible for the effect of multimarket contact on capacity reduction. Therefore, in the current analysis, effect of multimarket contact on capacity reduction is permitted to vary according to first, carrier type and second, whether only the major airlines serve the market or there is a mixture of major airlines and low-cost carriers (LCC). The results of reduced-form analysis suggest that for each one unit increase in average multimarket contact, there is a consequent 2.91% reduction in the number of offered seats. Specifically, the effect of multimarket contact is primarily led by the four largest airlines (Southwest, United, Delta, and American); this has a greater effect in smaller markets in comparison to medium-sized and larger ones.

The next step consists of structural analysis: the formulation of a structural model to estimate inter-airline competition in terms of capacity and price. The demand

framework formulated for this analysis built on the work of Berry, Levinsohn, and Pakes (1995), being a random-coefficient discrete-choice model with heterogeneous consumer preferences. In the two-stage supply framework used, airlines first decide capacity per product and then price. Hence, it is possible to determine whether the introduction of first-stage capacity-related decisions taken in light of the degree of multimarket contact has a significant effect on how many seats airlines make available and therefore whether prices change. Conduct parameters built into the model detect whether multimarket contact impacts collusive capacity setting by measuring how far outcomes deviate from a non-collusive oligopoly setup. Following Cililberto and Williams (2014), the conduct parameters in the model are modeled as a function of multimarket contact. An estimation of conduct parameters enables the relationship between multimarket contact and collusive behavior in capacity setting to be determined. I find that carriers with more multimarket contact, such as the major four airlines, collude when setting capacity, while those with an insignificant multimarket contact do not.

The study makes three major contributions to the literature. First, it expands on the currently meager body of empirical research investigating what facilitates collusion, particularly among airlines. Second, it contributes to the multimarket contact literature, which has focused exclusively on the effect of multimarket contact on collusive pricing behavior rather than on capacity setting. To the best of my knowledge, the latter has not yet been examined. This was achieved in the current research by carrying out a reduced-form analysis using instrumental variable regression. Third, the chapter puts forward a structural model linking degree of multimarket contact and degree of collusive behavior in capacity setting. The reduced-form analysis demonstrated only how multimarket relates to market outcomes, but shed less light on how changes to the degree of multimarket contact affects degree of coordination among airlines. The findings of this empirical research are of use to policy makers as they

indicate that antitrust enforcement agencies should monitor airlines' capacity-setting behaviors on routes characterized by a high degree of multimarket contact.

The remainder of this chapter is structured as follows. Section 2 presents institutional details relating to the antitrust case against the four major airlines, while section 3 explores the data collected, including market definition and MMC measures. Section 4 sets out the reduced-form analysis and results, and section 5 describes the structural analysis and results. Finally, section 6 concludes by presenting the implications of the findings and outlining future research avenues.

2.2 Background

In July 2015, the U.S. Department of Justice began an investigation into allegations that four major domestic carriers, American, Delta, United and Southwest Airlines, had engaged in collusive behavior. It was reported in the Washington Post and other media outlets that, according to sources close to the inquiry, the Department of Justice was looking into a possible attempt to boost ticket prices through a coordinated reduction of capacity, by limiting seats available on some routes and eliminating other routes altogether.

Although no hard evidence has been submitted to prove this allegation, both consumer advocacy organizations and lawmakers, including Sen. Richard Blumenthal, D-Connecticut, have raised the possibility that the consolidation of market power in the hands of these four airlines may be a breach of antitrust legislation. Their suspicions were further raised by the unprecedentedly high profits all four had recently posted, along with the fact that ticket prices had risen, despite the rapid drop in jet fuel prices in the 12-month period before the inquiry which should have led to price reductions.[10]

Hence, the DOJ asked the airlines to submit their documented communications

[10]https://www.ctpost.com/news/article/After-Blumenthal-s-call-DOJ-investigates-6361614.php

with each other concerning flight capacity intentions. In particular, they were asked to produce all documents which might show the necessity or desirability of reducing capacity or limiting their own growth of that of any other airline. Moreover, the airlines were requested to submit regional reports as proof of their monthly capacities as far back as 2010.

Despite sitting for a considerable period, the DoJ inquiry was ultimately unable to find sufficient proof of collusion in regard to capacity and pricing and therefore no antitrust action was brought against the four carriers involved. Nonetheless, the investigation remains officially ongoing.

After reports of the DoJ inquiry first appeared in the Washington Post, lawyers representing consumers filed dozen of lawsuits against the four carriers under investigation. Consolidated into a single lawsuit, their case is currently being heard in the U.S. District Court for the District of Columbia. One of the defendants, Southwest Airlines, paid out a $15 million settlement in 2018 and agreed to assist the other side's attorneys[11]; another, American Airlines, refused to admit to any wrongdoing but paid a $45 million settlement nonetheless, on the grounds that doing so would be less damaging than engaging in long and costly legal proceedings.[12] The other two carriers, United Airlines and Delta Air Lines, on the other hand, have refused to either admit wrongdoing or come to a financial settlement: Delta insists it has done nothing illegal, and both Delta and United have announced their intention to carry on fighting the allegations in court.[13] This case offers just one example of how difficult it is for government to bring an antitrust action against U.S. airlines. Hence, academic research remains ongoing and important in the area of facilitation and collusive behavior.

[11] https://www.nytimes.com/2018/01/06/business/southwest-airlines-lawsuit-prices.html

[12] https://www.bloomberg.com/news/articles/2018-06-15/american-agrees-to-pay-45-million-to-settle-fare-collusion-suit

[13] https://www.ajc.com/business/settlements-air-fare-collusion-suit-puts-pressure-delta-united/J6bgHDJ4ymc995g1EDAxHI/

2.3 Data

Four primary sources were used to collect the data for the empirical analysis. The first was the T-100 Domestic Segment, providing the non-stop domestic flight information reported by US carriers, e.g., carrier, seating capacity, load factor, origin, and destination. The second was the Airline Origin and Destination Survey (DB1B) from the US Department of Transportation; this comprises a random 10% sampling of airline tickets as reported by carriers, providing such details as ticketing and operating carriers, airfare, distance, passenger numbers, and airports (origin, destination, and connecting). [14] The third source was the Bureau of Economic Analysis, from which the populations of the Metropolitan Statistical Areas (MSA) of both origin and destination airports were derived. The data were obtained for the period between January 2005 and December 2015. This period was selected as it saw multiple airlines merging, leading to four major carriers dominating 80% of air traffic and creating a substantial shift in the multimarket contacts among US domestic airlines. The collected data used for the reduced-form and structural analyses are summarized in Table 2.1.

While general airline data, including pricing and market data, are publicly available, airport gate data remain elusive. To capture gate data, this study constructed a gate leasing dataset derived from information taken from airport competition plans submitted to the Federal Aviation Administration (FAA), combined with information obtained directly from the respective airports. Following the Wendell H. Ford Aviation Investment and Reform Act for the Twenty-First Century (AIR 21), the U.S. Department of Transportation required all major airports to submit such plans to the FAA in return for federal grants. The airports targeted by AIR 21 are commercial airports that account for at least 0.25 percent of the annual total passenger boardings in the United States and have no more than two carriers controlling over 50 percent

[14] The DB1B database contains a sample of 10% of airline tickets supplied by those carriers who report; it is issued every quarter. The DB1B contains a trio of sub components, these being the ticket dataset, coupons, and market. In this research, the ticket dataset and coupon are combined.

of passenger boardings. This study used these plans to glean information on airport gate availability, gate and airport facility leasing and subleasing arrangements, and airport-airline agreements. Table 2.2 reports the observed airports and airlines.

The gathered dataset bears a limitation. As the competition plans are only submitted if there is a change in the conditions, they tend to be only erratically available and each airport only offers a single observation. To overcome this limitation, this study restricted the sample to the 2008-2018 period, which is suitable as airlines sign long-term gate use contracts with airports. According to the Government Accounting Office (GAO, 1990), at the 66 large and medium-sized airports, almost 88 percent of the 3,129 gates were leased to airlines, and 85 percent of these were for the leasing airline's exclusive use. Furthermore, 87 percent of leased gates at these airports had long-term leases lasting 20 years, and two-thirds of the gates at the large airports had at least 10 years remaining on the lease.

2.3.1 Market Definition

This study defines a market as any non-directional round trip from the origin airport to the destination airport irrespective of the number of connections, as previously defined by Borenstein (1989) and Evans and Kessides (1994).[15] This study considers only those itineraries that either begin or end within an MSA boundary.[16] Only markets with no less than 250 passengers are included, while those that did not transport 100 passengers during at least one month during the sample period were excluded to factor out charter flights and seasonal travel. Similarly, airlines serving less than 1 percent of a market's passengers were also excluded. As certain regional carriers, e.g., SkyWest, Endeavor and Piedmont Airlines, whether the subsidiaries of network airlines or independent airlines, function as agents for major airlines, these

[15]In line with other research into airline industry, passengers who have very expensive (over $1250) or very cheap (under $25) fares are removed as outliers.

[16]Defined by the Office of Management and Budget in bulletin 18-03 issued on April 10, 2018.

are merged with their network carriers.

2.3.2 Market Types

The markets were differentiated in two ways, based on their size or on which carrier type operated them, to assess to what extent the market type affects how multimarket contact impacts on capacity decisions. Specifically, as markets vary in terms of competition, carriers' decision-making in terms of seating capacity may differ between markets, making market size and operating carrier type key factors in evaluating how multimarket contact affects collusive behavior. Following Berry, Carnall, and Spiller (1996), I compute population of the market by using the geometric means of the end-point cities' populations. In addition, Aryal et al. (2018) have defined the concept as being based on the market's population distribution. I ranked market size based on the geometric mean of the population sizes in the end-point cities and defined three variables of market size (i.e., large, medium, and small) based on the population distribution of the market. [17]

This study differentiates between major, mixed, and legacy markets in its empirical analysis. Major markets are those fully serviced by major carriers, referring to the four largest US carriers, i.e. American Airlines, United Airlines, Delta Airlines, and Southwest Airlines. Mixed markets refers to those in which major and LCC carriers operate concurrently, while legacy markets comprise those serviced by American Airlines, United Airlines, and Delta Airlines.

2.3.3 Multimarket Contact

An empirical examination of the impact of multimarket contact on capacity decision-making first needs multimarket contact to be quantified. While a variety of such measures exist, that of Evans and Kessides (1994) measures in how many overlapping

[17] Since the average population is used across the sampling timeframe for the classification of small, medium, and large marketplaces, a fixed classification for market size is used over this timeframe.

markets an airline faces competition with another, thereby showing the absolute extent of multimarket contact. This study considers it a multimarket contact if airlines i and j both offer non-stop services within the same market; the total number of these markets is the multimarket contact measure for this airline pair. Assuming n airlines with m routes, this number can be calculated by:

$$mmc1_{ij} = \sum_{k=1}^{m} D_{im} D_{jm} \tag{2.1}$$

where D_{im} is a dummy variable showing 1 if airline i serves market m, and 0 otherwise. $MMC1$ is an $n \times n$ symmetric matrix with the generic element $mmc1_{ij}$ expressing in how many markets airlines i and j compete; $mmc1_{ii}$, on the matrix's diagonal, is the number of markets in which airline i operates. The multimarket contact measures for the 11 airlines found in the study sample for the 2015 fourth quarter are presented in Table 2.3. Meanwhile, matrix $MMC1$ provides the average multimarket contact measure,$AvgMMC1$, defined as how many markets on average overlap within any given market:

$$AvgMMC1_m = \frac{1}{[N_m (N_m - 1)]} \sum_{i=1}^{N_m} \sum_{j=1, j \neq i}^{N_m} mmc1_{ij} D_{im} D_{jm}, \tag{2.2}$$

where N_m is the number of carriers serving market m.

However, as this multimarket contact measure solely captures the number of overlaps while weighing all carriers and markets the same, any variation in carrier size of market dominance is not taken into account. Hence, to assess the robustness of the results, two alternative multimarket contact measures are used. This first is a second multimarket contact measure, $mmc2_{ij}$, which is determined by dividing the previous measure $mmc1_{ij}$ by the number of markets that airline i serves:

$$mmc2_{ij} = \frac{mmc1_{ij}}{mmc1_{ii}} \tag{2.3}$$

$MMC2$, presented in Table 2.4, is an $n \times n$ asymmetric matrix with the generic element $mmc2_{ij}$ expressing that each airline in a pair serves a different number of routes. This allows MMC_2 to capture different airlines sizes, in contrast to MMC_1, which equally weights all multimarket contact pairs. If one airline serves fewer markets than its competitor in any pair, its multimarket contact measure will be larger as the $mmc2_{ij}$ will be asymmetric. This indicates that smaller airlines face a greater cost of deviation from collusive agreements. The following airline size weighted multimarket contact measure for market m is derived from this matrix. From this matrix I create the following airline size weighted measure of average multimarket contact for market m:

$$AvgMMC2_m = \frac{1}{[N_m\,(N_m - 1)]} \sum_{i=1}^{N_m} \sum_{j=1, j\neq i}^{N_m} mmc2_{ij} D_{im} D_{jm}, \tag{2.4}$$

The other alternative multimarket contact measure, $MMC3$, also considers the market shares of the carriers. Specifically, the MMC_3 matrix has a generic element calculated as $mmc2_{ij}$ multiplied by airline i's US market share:

$$mmc3_{ij} = mmc2_{ij} \cdot \text{market share of airline } i \tag{2.5}$$

The market share weighted average multimarket contact measure for market m can thus be derived from this matrix:

$$AvgMMC3_m = \frac{1}{[N_m\,(N_m - 1)]} \sum_{i=1}^{N_m} \sum_{j=1, j\neq i}^{N_m} mmc3_{ij} D_{im} D_{jm}, \tag{2.6}$$

The time series of the relative extent of the multimarket contact measures emerging during the sample period is depicted in Figure 1.1, Figure 1.2, Figure 1.3 and Figure 1.4. Figure 1.1 illustrate a fluctuation in $mmc2_{ij}$ measure of multimarket contact between American Airlines and other airlines and the $mmc2_{ij}$ measure of

multimarket contact between Delta and other airlines, United and other airlines, and Southwest and other airlines are illustrated in Figure 1.2, Figure 1.3 and Figure 1.4, respectively. The time-series variation for the pairs of four major airlines highlights the many source of variation present in the data: expansion of networks, de-hubbing and mergers.

2.3.4 Endogeneity of the Multimarket Contact Variable

As the market-specific measures of average multimarket contact are endogenous, there is a potential for bias in both the reduced form and structural analysis results. As noted by Ciliberto, Murry, and Tamer (2021), market-specific multimarket contact may be endogenous because of unobservables that correlate with the decisions that airlines make on pricing, entry and exit. Specifically, firms choose to enter those markets that offer the best fit for their observable and unobservable characteristics, meaning that they base their market entry decision-making on the profits that they may gain from this entry. Meanwhile, each market contains idiosyncratic time-varying unobservables. For example, additional airlines will enter the market if it is experiencing a positive demand shock. Any change in the airlines operating in a market will lead to a time-dependent variation in that market's average multimarket contact. As the market structure variation is directly linked to the market-specific measure of average multimarket contact, and is furthermore likely to correlate with price-affecting unobservables, cross-sectional variation cannot be used to determine a causal relationship between multimarket contact and airlines' capacity decision-making. In repeated observations, fixed-effect identification strategies are primarily used to control unobserved and unchanging characteristics related to both the causing variables and their outcomes. As per Griliches and Mairesse (1995), when endogeneity is driven by time-varying unobservables that are market-specific, fixed-effects models are ineffective. Meanwhile, Ciliberto and Williams (2014) propose the use of instrumental variables

to mitigate concerns of endogeneity in AverageContact.

Following Ciliberto and Williams (2014), this study constructs the instrumental variables for both the reduced-form and structural analysis based on a dataset comprising individual carriers' access to boarding gates at the respective airports. These data encompass the percentage of gates an airline uses at the origin and destination airports, respectively, as well as the percentage of gates at the respective origin and destination airports used by Southwest Airlines and other low-cost carriers. The long-term nature of airline-airport leasing agreements implies that the number of gates used by a carrier is likely to remain reasonably resistant to shocks. The abovementioned competition plans offer information on the number of gates available, the number of gates in common use, and the number of gates leased to airlines, whether exclusively or preferentially, as reported by the airlines. Thus, I construct $OwnGatesOrigin$ and $OwnGatesDest$, measuring the percentage of gates leased exclusively or preferentially to airline j at the origin and destination endpoints of market r, respectively. Further, I build $LCCGatesOrigin$ and $LCCGatesDes$t for the same information on the low-cost carriers' leases and use $WNGatesOrigin$ and $WNGatesDest$ based on the leases of Southwest Airlines. As airlines have control of their gates while they are using them, exclusive and preferential leases are treated the same. Unlike Ciliberto and Williams (2014), who used the sum of the average fraction of gates leased at a market's endpoints, this study distinguishes between origin gates and destination gates for this measure in order to capture any differences in the effects.

Ciliberto and Williams (2014) provide the following reasoning for why gate information is a valid instrument for multimarket contact. First, airlines have difficulty in adjusting their airport facility access in response to unpredictable demand and cost changes. As noted by GAO (1990), carriers are unable to unilaterally terminate gate leases and subleasing them incurs costs. Second, as individual markets rarely represent a large proportion of an airline's revenue from any given airport, carriers

are likely to shy away from changing the number of gates they lease based on market-specific demands. Finally, leasing decision-making is based at the level of airports, and thus fluctuations in a specific market are often offset by those in other markets, meaning that the overall airport demand, i.e. the need for gates, is mostly unaffected.

2.4 Reduced-form analysis

Using reduced-form analysis, this study examines the extent to which airlines take the degree of multimarket contact into account during capacity decision-making for certain routes. Ceteris paribus, based on multimarket contact and the antitrust risks inherent to airlines' capacity decision-making, it is expected that a higher degree of multimarket contact will correlate with fewer seats on offer. Hence, in the following I explore whether reduced seating capacity stems from a higher degree of multimarket contact using regressions of the instrumental variable and market-specific random effects.

This analysis uses a two-pronged approach. First, a baseline model is specified that will analyze the relationship between the degree of multimarket contact and the natural logarithm of the number of seats. This will enable the extent of the effect of multimarket contact on airlines' capacity decision-making to be determined. Next, as this effect may vary across markets with different sizes, with some characterized by competition between LCCs and legacy carriers and others being served solely by the latter, the second approach considers market size and competing carrier types in estimating the effect of multimarket contact.

2.4.1 Econometric Models

Base Model

The following evaluates how the degree of multimarket contact relates to the number of seats offered by carriers for the 2005-2015 period. Airline data were used to derive

the following model, which describes airline i in market m for time t:

$$\ln(seats_{imt}) = \beta_1 AvgMMC1_{mt} + \beta_2 Controls_{imt} + \mu_i + \mu_t + \varepsilon_{imt} \tag{2.7}$$

where the dependent variable is the natural logarithm of the number of seats offered by airline i in market m at time t. The primary variable of interest is $AvgMMC1$, and its coefficient β is expected to be negative. Multimarket contact's negative coefficient suggests that carriers might restrict seating capacity even if there is sufficient demand, and this behavior may differ across time and markets. The controls employed for the analysis were taken from the work of Evans and Kessides (1994) and Ciliberto and Williams (2014) and encompass the following: service type, i.e. connecting or nonstop; a hub airport indicator that equals one if either the origin or the destination airport of market m is a hub airport for airline i; market size, i.e. the geometric mean population sizes of the endpoint cities; and finally, to capture the different market structure of non-monopoly markets, whether a market is served solely by a monopoly carrier is indicated by a dummy variable. Beyond these control variables, the specifications all incorporate airline and year-quarter fixed effects, which are respectively represented by μ_i and μ_t.

The Effect of Market Types

The influence of multimarket contact on airlines' capacity decision-making is also analyzed according to the type of carrier. Four major airlines carried 80% of US domestic passengers in 2018. There is a need to identify whether multimarket contact's effect on capacity reduction was driven by the major airlines, particularly in light of the 2015 investigation by the U.S. Department of Justice into potential collusion between them in restricting the number of affordable seats and routes to drive up fares. Therefore, the base model is expanded to examine the variation in the effect of multimarket contact on capacity reduction based on the type of carrier and on

whether the market is a mix of major airlines and LCCs or is only served by the major airlines. Hence, the model is as follows:

$$\ln(seats_{imt}) = \gamma_1^{major} AvgMMC1_{mt} \cdot major_{mt} + \gamma_2^{lcc} AvgMMC1 \cdot lcc + \gamma_3 Controls_{imt} + \mu_i + \mu_t + \varepsilon_{imt} \quad (2.8)$$

where $Major$ and lcc respectively indicated whether the operating airline is a major airline or an low-cost carriers. Markets served only by major carriers, also known as major markets, are set at $\gamma_2^{lcc} = 0$.

Based on Stigler (1964), some markets facilitate collusion better than others. For example, all else being equal, larger markets with significant volatility in demand are less able to sustain coordination than smaller markets. Meanwhile, the definition of market size from Berry, Carnall, and Spiller's (1996), i.e. the geometric mean of the origin and destination cities' populations, is drawn upon here to account for the variation in multimarket contact's capacity reduction effect in markets of different sizes. Furthermore, and as mentioned above, three market size variables, namely large, medium and small, are derived from the respective market's population distribution, ranking market size according to the geometric mean of the destination cities' population. In other words, the population of a large market exceeds the 75th percentile of the population distribution, between the 25th and 75th percentiles is classed as a medium market, and beneath the 25th percentile is a small market. Large markets are less likely to offer airlines opportunities to collude on capacity restrictions as they face more volatile demand. Meanwhile, the market size variable also informs on how many airlines serve a large market. As there is more competition in large markets, with the very largest facing fierce competition from LCCs, carriers are more likely to find it difficult to limit the number of seats they offer. Nevertheless, those airlines

with a higher share in the business traveler market may be more motivated to coordinate to reduce capacity as such passengers are more frequent in large markets and have less price elasticity. In such a scenario, there is a greater likelihood of coordination to reduce capacity. The following model, incorporating the variation in the multimarket contact effect on market size, is developed to examine the influence of market size on the degree of collusion to reduce capacity:

$$\begin{aligned}\ln(seats_{imt}) = {} & \delta_1^{small} AvgMMC1_{mt} \cdot small_{mt} + \delta_2^{medium} AvgMMC1 \cdot medium_{mt} \\ & + \delta_3^{large} AvgMMC1 \cdot large_{mt} + \delta_4 Controls_{imt} \\ & + \mu_i + \mu_t + \varepsilon_{imt}\end{aligned} \tag{2.9}$$

where $Small$, $Medium$, and $Large$ are dummy variables that respectively take the value of 1 for small, medium, and large markets.

2.4.2 Results

Table 2.5, Column (1) shows the estimation results for the baseline model. According to the model, competition between carriers with a higher degree of multimarket contact in a given market leads to a subsequent reduction in the number of seats they offer. Average multimarket contact has a coefficient of -0.291, suggesting that 0.1 increase in average multimarket contact results in a 2.91% reduction in how many seats are offered. This effect is averaged for all markets, time periods, and carrier types. Robust standard errors are reported, whereby the decrease is significant at the 5% level.

Table 2.5, Column (2) gives the estimation results for the model incorporating both carrier type variations and variations regarding major market versus mixed market. The main variables of interest are the product of the market indicator dummies and the average multimarket contact measure. Based on this model, 0.1 increase

in multimarket contact correlates with 3.18% less seating capacity offered in major markets, referring to those solely served by major airlines. This indicates that the average multimarket contact effect that was identified in the baseline model is being driven by collusion among the major airlines. The estimated coefficient for major airlines and LCCs in mixed markets presents an additional insight, with major airlines' multimarket contact resulting in them offering 1.85% less seating capacity, whereas the LCCs show no such changes.

Table 2.5, Column (3) presents the results of the model that assesses how market size influences airlines' collusion in the number of seats they offer. The model shows that, in small markets, an increase in multimarket contact leads to a 3.07% reduction in the number of seats. In medium and large markets, this is 1.17% and 0.65%, respectively, indicating that carriers made the most substantial seat number reductions in small markets. This finding implies that carriers in markets with more business travelers, who have less price sensitivity, are less incentivized to collude than when demand is uncertain or LCCs have entered the market.

Overall, I show that multimarket contact causes a reduction in the number of available seats, which in turn leads to an increase in the average fares. Meanwhile, the reduced-form analysis suggests that multimarket contact's anti-competitive effect on fares established here may be exacerbated by limitations in supply as these correlate directly with the overall travel costs for passengers.

Besides the abovementioned results, I use the Wu-Hausman test to measure the endogeneity of the variable of multimarket contact. In none of the cases does this cause us to reject the null hypothesis concerning the consistency of the instrumental variable regression estimator. This indicates that average multimarket contact is in fact endogenous, corroborating the use of this specification.

2.4.3 Robustness Check

To check the results' robustness, I perform the analysis again with different multimarket contact measures, namely $AvgMMC2$ and $AvgMMC3$. Table 2.6 presents the results of the instrumented regression. The previous analysis is replicated for the two new multimarket contact measures utilizing the instrumental variable regression based on the same gate dataset, producing results that are qualitatively the same. The average multimarket contact presented in Column (2) is hereby estimated via $mmc2$, which is asymmetric if the respective carrier pair members each serve a non-identical number of markets. Column (3), meanwhile, uses $mmc3$, which is the multimarket contact measure, weighted by market share. The findings are statistically significant and in line with those of the baseline model based on the multimarket contact measure $mmc1$; nevertheless, the coefficients' magnitude is dissimilar as $mmc1$ represents the absolute number of contacts whereas $mmc2$ and $mmc3$ are given in percentages. Hence, the definition of multimarket contact is likely robust and offers similar implications.

2.5 Structural Analysis

This section presents the structural analysis, thereby drawing on Ciliberto and Williams (2014), who used structural analysis to examine the relationship between multimarket contact and collusive pricing behavior among the airlines. This facilitates a more in-depth examination of the findings from the reduced-form analysis, showing to what extent multimarket contact affects airlines' degree of collusion in setting capacity.

2.5.1 Demand Model

The demand model follows Berry, Carnall, and Spiller (BCS, 2006) and Berry and Jia (2010) by extending the nested logit model through heterogeneous preferences

for observable and unobservable characteristics of air travel products. There are two types of consumer, $r = \{1, 2\}$. The indirect utility of consumer x having type r and purchasing product j in market m is given by:

$$u_{xjm} = x_{jm}\beta_r - \alpha_r p_{jm} + \xi_{jm} + \nu_{xm}(\lambda) + \lambda\epsilon_{xjm}, \tag{2.10}$$

where x_{jm} is the vector of product j's observable characteristics; p_{jm} is the price of the product, β_r is a vector of preferences for product characteristics, and α_r is the marginal disutility, which has an increased price for consumers of type r. ξ_{jm} captures product j's unobserved characteristics. v_{im}, which is the nested logit random preference and is constant for all air travel products, distinguishes air travel from the not-flying option. The substitution patterns between the nests of the airline travel and not-flying options are governed by λ, ranging from 0 to 1. ε_{ijm} is a stochastic error term with a mean of 0. Altogether, the error structure $\nu_{im}(\lambda)+\lambda\varepsilon_{ijt}$, is the error structure required to generate nested logit choice probabilities for each consumer type.

The share of type r consumers who purchase air travel products is:

$$s_m^r\left(x_m, p_m, \xi_m, \theta_d\right) = \frac{\left[\sum e^{(x_{jm}\beta_r - \alpha_r p_{jm} + \xi_{jm})/\lambda}\right]^{\lambda}}{1 + \left[\sum_{j=1}^{K} e^{(x_{jm}\beta_r - \alpha_r p_{jm} + \xi_{jm})/\lambda}\right]^{\lambda}} \tag{2.11}$$

Consumers purchase those air travel products on the market that maximize their indirect utility. This is an optimization problem that results in the following probability of a type r consumer purchasing product j, conditional on the consumer choosing an air travel product:

$$\frac{e^{(x_{jm}\beta_r - \alpha_r p_{jm} + \xi_{jm})/\lambda}}{\sum_{k=1}^{J} e^{(x_{jm}\beta_r - \alpha_r p_{jm} + \xi_{jm})/\lambda}} \tag{2.12}$$

Thus, market share of product j can be considered as the average purchase probability for all consumers in a given market:

$$s_{jm}\left(x_m, p_m, \xi_m, \theta_d\right) = \sum_r \gamma_r \frac{e^{(x_{jm}\beta_r - \alpha_r p_{km} + \xi_{jm})/\lambda}}{\sum_{j=1}^{K} e^{(x_{jm}\beta_r - \alpha_r p_{jm} + \xi_{jm})/\lambda}} \cdot s_m^r\left(x_m, p_m, \xi_m, \theta_d\right) \quad (2.13)$$

where γ_r is the percentage in the population of consumers with type r in market m.

2.5.2 Supply Model

To develop the supply model, airlines' collusion in setting capacity is estimated using Ciliberto and Williams' (2014) framework, which states that the conduct parameter capturing collusive behavior can be modeled as a function of multimarket contact. The extent of deviation from a non-collusive oligopoly outcome is hereby used to measure aggressive or cooperative behavior. As the equally and positively weighting of all competing firms' profits results in full cooperation, firms positively weighting the profits of their competitors will cause the equilibrium outcome to be more cooperative compared to the non-collusive oligopoly equilibrium. Airlines are assumed to compete on prices while offering differentiated products on the market. First, a simple two-stage game is defined: carriers decide on capacity in the first stage, followed by a product-differentiated market game on prices in the second stage[18]. In the first stage, firm f makes the capacity decision q^f to maximize profit, thereby considering both the profits for it and its competitor f'. The profit function can be formally specified as:

[18]An assumption is made that the structures of airline networks, e.g., airports used, airport location, routes, and market places, are exogenous. Such an assumption is justifiable because the majority of airlines have extended usage and lease agreements with airports allowing them to use the airport facilities. In addition, because the offer of an airline is a combination of the carrier and route, we may regard it is similar to other environments in which there is an exogenous offer of product quantity.

$$\Pi_f^I = \sum_{j \in J_f} \left(p_j - MC_j(q_j)\right) s_j M + f\left(MMC_{ff'}\right) \sum_{j' \in J_{f'}} \left(p_{j'} - MC_{j'}(q_{j'})\right) s_{j'} M - fc(q_j, \mu_j; \tau) \tag{2.14}$$

where J_f is the set of all the products offered on the market by firm f;[19]. $MMC_{ff'}$ is the level of multimarket contact between firm f and f'; mc_j is the marginal cost of product j, M is a market size, i.e. the geometric mean of the two end-point cities' MSA populations; and fc_j represents the fixed cost function. The level of capacity setting coordination between carriers f and $f\prime$ is given by the conduct parameter function $f\left(MMC_{ff'}\right)$.

Following Berry and Jia (2010), the marginal cost function is assumed to be a linear function of the set of cost-related characteristics and given by:

$$mc_{jm} = v_{jm}\varphi + \omega_{jm} \tag{2.15}$$

where v_{jm} is the vector of the observed marginal cost characteristics, namely frequency, hub, distance of short-haul markets, and distance of long-haul markets; φ is the vector of cost parameters and ω_{jm} indicates unobserved marginal cost shocks.

Following Fan (2013), a quadratic function is used to estimate the fixed cost function, whereby the fixed cost slope $fc_j(q_j, \mu_j; \tau)$ regarding carrier capacity choice q_j is assumed to be: [20]

$$\frac{\partial fc_j(q_j, \mu_j; \tau)}{\partial q_j} = \tau_0 + \tau_1 q_j + \nu_j \tag{2.16}$$

[19]Following Berry and Jia (2010), I make the assumption of market independence. This means that every profit equation that describes the supply model can be used with all markets without losing generality.

[20]The fixed cost slope may be dependent on the capacity behaviors of competitors should market competition be imperfect. Nevertheless, an assumption is made in this study that input price is fixed, and so the slope of fixed costs does not depend on decisions made by competitors regarding capacity.

where τ is the vector of parameters and ν_j represent unobservable fixed-cost shock. The capacity choice of a carrier refers to the average number of seats it offers on a route per month. Although airlines can easily adjust prices, capacity is less flexible as changes in seat numbers require changes in aircraft sizes and crew numbers. In addition, agreements with airport authorities are also affected due to the reallocation of gates or landing fee adjustments. Hence, the fixed cost is affected by changes in capacity. ν_j captures other fixed cost shocks, e.g. maintenance. Finally, the conduct parameter $f(mmc)$ is modeled as a linear function of multimarket contact:

$$f\left(MMC_{ff'}\right) = \psi_1 + \psi_2 mmc1_{ff'} \tag{2.17}$$

The constant term, ψ_1, represents capacity setting behavior that is unrelated to the multimarket contact effect. ψ_2 describes the effect of multimarket contact on collusive capacity setting behavior; a positive conduct parameter indicates that firm f is taking the profit its competitor f' into account in its capacity decision making (cooperative behavior), while a negative parameter implies it aims to minimize the profit of its competitor (aggressive behavior). Following Ciliberto et al. (2019), I divide $mmc1_{ff'}$ by 1000 to keep the measure of multimarket contact similar in scale. A simple linear function is used here to model the conduct parameter, unlike Ciliberto and Williams (2014), who restricted $f(mmc_{ff'})$ between zero and one.[21]

Assuming that q^f decided in the first stage, firm f sets the price, p_j, to maximize its profit in the second stage, whereby the profit function is:

$$\Pi_f^{II} = \sum_{j \in J_f} (p_j - mc_j) \cdot M \cdot s_j. \tag{2.18}$$

[21]The conduct parameter restricted model is tested in line with the practice of Ciliberto and Williams (2014). There is no statistical significance in conduct parameter estimates. The objective function value derived from the restricted conduct parameter model was in excess of the final results from the linear model, which implies that the restricted model is not a good fit with the assumptions this study makes related to airlines' behaviors.

The following derives the conditions of optimality for both capacity and prices. Using backward induction, firm f sets the price to maximize its second-stage profit function. Using the derivative of the second-stage profit function Π_f^{II} with respect to price p_j, the following first-order condition is produced:

$$\frac{\partial \Pi_f^{II}}{\partial p_j} = s_j + \sum_{j \in J_f} (p_j - mc_j) \cdot \frac{\partial s_j}{\partial p_j} = 0 \tag{2.19}$$

Define Ω_{jm}^* is an $N \times N$ matrix such that $\Omega_{jm}' = 1$ if $j \in J_f$, and 0 other wise. Let S_{jm} is an $N \times N$ matrix such that $S_{jm} = \dfrac{\partial s_{jm}}{\partial p_{jm}}$ if $j \in J_f$, and 0 other wise. I define Ω_{jm} as a product of Ω_{jm}^* and S_{jm}, such that $\Omega_{jm} = \dfrac{\partial s_{jm}}{\partial p_{jm}}$ if $j \in J_f$, and 0 other wise. Subsequently, the first-order condition of firm f's profit function in the second stage can be reformulated as:

$$0 = s_{jm} + \Omega_{jm} (p_{jm} - mc_{jm})$$

Then the optimal price function of firm f yields

$$p_{jm} = mc_{jm} - \Omega_{jm}^{-1} s_{jm}$$

Following the determination of the optimal price function, the first stage is addressed. For convenience, the profit function in the first stage can be rewritten as:

$$\Pi_f^I = \Pi_f^{II} + f\left(MMC_{ff'}\right) \Pi_{f'}^{II} - fc(q_j, \mu_j; \tau) \tag{2.20}$$

The first-stage profit function Π_f^I is differentiated with respect to capacity q_j yielding the first-order condition:

$$\sum_{j \in J_f} \frac{\partial \Pi_f^{II}}{\partial q_j} + \sum_{j \in J_f} \sum_{j' \in J} \frac{\partial \Pi_f^{II}}{\partial p_{j'}} \frac{\partial p_{j'}}{\partial q_j} + f(MMC_{ff'}) \sum_{j \in J_f} \sum_{j' \in J} \frac{\partial \Pi_{f'}^{II}}{\partial p_{j'}} \frac{\partial p_{j'}}{\partial q_j} - \frac{\partial fc}{\partial q_j} = 0 \tag{2.21}$$

A cooperative effect is implied by the third term in the first-stage first-order condition. The additional cooperative term indicates to what extent multimarket contact affects a carrier's collusive capacity setting behavior via firm f's capacity decision-making impact on its competitor's profit.

2.5.3 Estimation

The model parameters are measured by recovering the structural errors in the demand and supply models as a function of the model's parameters and data. Structural errors refers to the unobserved product characteristics (ξ_j), unobserved marginal cost shock (ω_{jm}), and unobserved fixed cost shock (ν_j). The market share function is presented in Equation (2.13), and can be inverted to derive ξ_j:

$$\xi_{jm} = s_{jm}^{-1}\left(x_m, p_m, \xi_m, \theta_d\right) \tag{2.22}$$

Following Berry, Levinsohn and Pakes (1995) and Berry and Jia (2010), the equation is solved for ξ_j, equating the estimated market share with the observed market share using contraction mapping with the demand parameters θ_d and data x_m,

$$\xi_{jm}^{H} = \xi_{jm}^{H-1} + \lambda\left[\ln s_{jm} - \ln s_{jm}\left(x_m, p_m, \xi_m, \theta_d\right)\right], \tag{2.23}$$

where H is the Hth iteration, $s_{jm}$is the observed market share, and $s_{jm}\left(x_m, p_m, \xi_m, \theta_d\right)$ is the estimated market share, as given in Equation (2.13). This process is reiterated until the difference between ξ_{jm}^{H} and ξ_{jm}^{H-1} is as close as possible to zero.

The first-order condition of firm f's second-stage profit function is used to recover the unobserved marginal cost shock. ω_{jm} is derived as a function of the marginal cost characteristics v_{jm} and parameters φ,

$$\omega_{jm} = p_{jm} - v_{jm}\varphi + \Omega_{jm}^{-1} s_{jm}\left(x_m, p_m, \xi_m, \theta_d\right) \tag{2.24}$$

Last, the first-order condition of firm f's first-stage profit function can be used to derive the unobserved fixed-cost shock in setting capacity:

$$\nu_j = \sum_{j \in J_f} \frac{\partial \Pi_f^{II}}{\partial q_j} + \sum_{j \in J_f} \sum_{j' \in J} \frac{\partial \Pi_f^{II}}{\partial p_{j'}} \frac{\partial p_{j'}}{\partial q_j} + f(MMC_{ff'}) \sum_{j \in J_f} \sum_{j' \in J} \frac{\partial \Pi_{f'}^{II}}{\partial p_{j'}} \frac{\partial p_{j'}}{\partial q_j} - \tau_0 + \tau_1 q_j \quad (2.25)$$

To estimate the model parameters, the respective moments representing the expectations for each structural error's interaction with the exogenous instruments are formed. For the demand parameters, this is:

$$E\left(\xi\left(p_m, x_m, s_m, \theta_d\right) \mid Z_{jm}^d\right) = 0 \quad (2.26)$$

For marginal cost parameters:

$$E\left(\omega\left(p_m, x_m, s_m, \theta_d, \varphi\right) \mid Z_{jm}^{mc}\right) = 0, \quad (2.27)$$

Finally, for the fixed cost and conduct parameters:

$$E\left(\nu_j(p_m, x_m, s_m, \theta_d, \varphi, \psi, \tau) \mid Z_{jm}^{fc}\right) = 0 \quad (2.28)$$

where Z_{jm}^d, Z_{jm}^{mc} and Z_{jm}^{fc} , respectively, the vectors of the instruments for the endogenous variables in the demand, marginal cost, and fixed cost specifications [22]. The generalized method of moments method is used to estimate the nonlinear parameters. $\Phi = [\theta_d \ \delta \ \psi \ \tau]$ is estimated by minimizing

[22]Berry et al (1995) note that there is validity to any instrument that does not involve factors with correlation with ξ_j, ω_j and ν_j. In this study, price, frequency and capacity decisions are and a genius. The exogenous price instrument incorporates how many routes exist in a market and how many competitive rates there are in order to encapsulate the market environment's competitively. The status of the hub shifts costs but does not influence demand, so is employed as a price instrument. Hub status also impacts frequency and airline capacity decisions. The interaction terms have been carefully selected to avoid collinearity.

$$Q(\Phi) = G(\Phi)' W^{-1} G(\Phi) \tag{2.29}$$

where $G(\Phi)$ represents the stacked set of moments conditions and $W$is an optimal weighing matrix.

2.5.4 Results

Table 2.7 presents the structural estimations for the demand and supply models. The column (1) presents the estimates for the demand, marginal costs, and fixed costs for the case where there is no capacity setting collusion between two firms in the first stage. In implementing the non-collusion model, the conduct parameter is assumed to be zero. The resulting demand parameters are generally in line with the airline merger study presented in the previous chapter. The estimated coefficients are all statistically significant, with the expected coefficient signs for the product characteristics. Specifically, the negative sign for the airfare coefficient implies that consumers dislike price increases. Moreover, the airfare coefficients for both groups indicate that there are different types of consumers who derive different disutilities from increases in price. Meanwhile, direct flights from primarily non-congested airports without slot control are preferred, as are routes that include the hub airport of the carrier. The U-curve in air travel demand in terms of distance is captured by estimating the parameters of demand, namely flight distance and squared flight distance; in other words, demand for short-haul flights first increases and then declines with increasing distance. Those airports with proximity to tourist destinations, including Miami, Las Vegas, and Orlando, also experience higher passenger numbers. Moreover, consumers tend to switch carriers in the event of an airfare increase instead of selecting the no-fly option, as evidenced by the nested logit parameter λ, which gives the substitutability of all the airline products as 0.631. Similarly, the marginal cost coefficients are as expected. As indicated by the negative sign on the coefficient of seating capacity, for

each seat added to a given route, the cost of serving the extra passenger declines. An airline routing flights through its hub airport is likely to have a cost advantage, as demonstrated by the estimated parameter for hub status. While the marginal cost rises with distance for both the short- and long-haul markets, the coefficient of distance is greater for the former. [23] Finally, the fixed cost parameters are estimated by a regression of the slope of the fixed costs against the number of seats chosen by the carrier; in other words, the constant term is used to measure the marginal effect of additional seating capacity. This shows that carriers substantially increase their fixed cost when they add seats – an intuitive finding as more or bigger aircraft, with the corresponding increases in ground and flight crews, are needed to increase the capacity on a route.

Table 2.7, Column (2) presents the model results under the assumption that airlines are colluding in setting capacity. A single conduct parameter delineates the total degree of collusion in this specification and no facilitators are considered. Meanwhile, rather than the function of multimarket contact, $f(mmc)$, the sole conduct parameter ψ_1 is used; a statistically significant positive sign suggests that there is capacity setting collusion. Table 2.7, Columns (1) and (2) present differences in the marginal cost, estimated demand and fixed cost coefficients, which agrees with the finding by Bresnahan (1987), who demonstrated that models grounded in dissimilar behavioral assumptions create different estimation results.[24]

Next, the column (3) in Table 2.7 provides the model estimates assuming that the degree of collusion in capacity setting relates to the degree of multimarket contact

[23]Two groups of marginal cost parameters have been incorporated, long and short haul markets, related to connection numbers and distance. I create dummy variable $D_{\text{Short}} = 1$ if distance between origin and destination is below 1,500 miles and $D_{\text{Long}} = 1$ if market distance exceeds 1500. Then the distance variables are computed as $Distance_{\text{Short}} = Distance \cdot D_{\text{Short}}$ and $Distance_{\text{Long}} = Distance \cdot D_{\text{Long}}$.

[24]Bresnahan (1987) undertook empirical research into a price war between manufacturers of automobiles in 1955. This was one of the first empirical study that provided a structural model of consumer demand in an industry in which products were differentiated that ran tests on supply-side competitive hypotheses.

between carriers in a given market. In this case, carriers vary their behavior according to their competitors. The estimates for demand, marginal cost and fixed cost are consistent with those of the previous model, while ψ_1, i.e. the constant conduct parameter describing the effect of other factors leading to carriers' capacity collusion behavior, is 0.008 and shows no statistical significance. This indicates that there are no additional factors shaping collusive behavior among carriers in regards to capacity. Meanwhile, ψ_2 is revealed to be statistically significant with a positive sign, implying that increased multimarket contact leads to a greater degree of collusion among carriers, i.e. they set lower capacity levels.

Finally, Table 2.8 gives $f(mmc_{ff'})$, utilizing the estimated conduct parameters to assess each degree of multimarket contact level presented in Table 2.3, which numerically presents the airline size weighted measure of multimarket contact for the 11 carriers in the sample that operated during the fourth quarter of 2015. Based on the results, it can be concluded that the four major carriers, i.e. American Airlines, Delta, United Airlines, and Southwest Airlines, show collusive behavior when setting capacity; however, no significant collusion is observed between low-cost carriers and the major airlines. This is in line with the results of the reduced-form analysis demonstrating that the multimarket contact effect is being driven by collusive behavior among the major carriers.

2.6 Conclusion

This chapter explores to what extent multimarket contact affects US airline's capacity setting behavior. According to the reduced-form analysis, a higher degree of multimarket contact leads to fewer seats being made available, driven in particular by the collusion among major carriers with a substantial degree of multimarket contact. Furthermore, this effect is stronger in small markets than in medium or large markets. To conduct the structural-form analysis, Ciliberto and Williams's (2014) framework

is adapted to nest the conduct parameters in a two-stage oligopoly model. The degree of collusive behavior in setting capacity is hereby estimated based on the variation in the degree of multimarket contact across air travel markets. The results indicate that carriers with more multimarket contact, such as the major four airlines, collude when setting capacity, while those with an insignificant multimarket contact do not.

This study contributes to current understanding in three main ways. First, it adds to the lack of empirical analysis of the factors that facilitate collusion between airlines. Second, it provides further meaningful insights into the multimarket contact literature, which, until now, has primarily focused on the impact that multimarket contact has on collusive pricing behavior as opposed to capacity setting. The current study employed a reduced-form analysis based on instrumental variable regression to generate evidence to prove the mutual forbearance hypothesis regarding capacity supply. Third, this study outlines a structural model to correlate the degree of multimarket contact with the extent of collusive behavior within capacity setting.

The findings of this research have practical implications for policymakers. Specifically, they indicate that mutual forbearance and tacit collusion between airlines may contribute to a reduction in capacity within airline industry. As there is typically a correlation between capacity limitations and increased fares, the mutual forbearance can lead to an increase in the price of tickets charged to air travelers. As such, mutual forbearance represents a factor regulators should consider when evaluating the benefits and disadvantages of airline mergers. Meanwhile, the study's methodology is applicable to not only the air travel sector but also any industry in which there are distinct markets featuring competition between firms.

This study has some limitations that point to promising avenues for future research. First, for simplicity, the linear functional form assumed for the multimarket contact conduct parameters is applied to all carrier pairs, even though these contain the potential for heterogeneity. Thus, future research could use more flexible func-

tional forms to model the conduct parameters, thereby extending the findings of this chapter. Second, while the test in this study indicates where collusive behavior may be occurring, there is no definitive proof of collusion between airlines; hence, extending the test beyond multimarket conduct, e.g. by linking capacity setting behavior to alternative potential facilitators of collusion such as code sharing, would provide further insight.

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Figure 2.1: *mmc*2 Measure of Multimarket Contact between American Airlines and other Airlines (2005-2015)

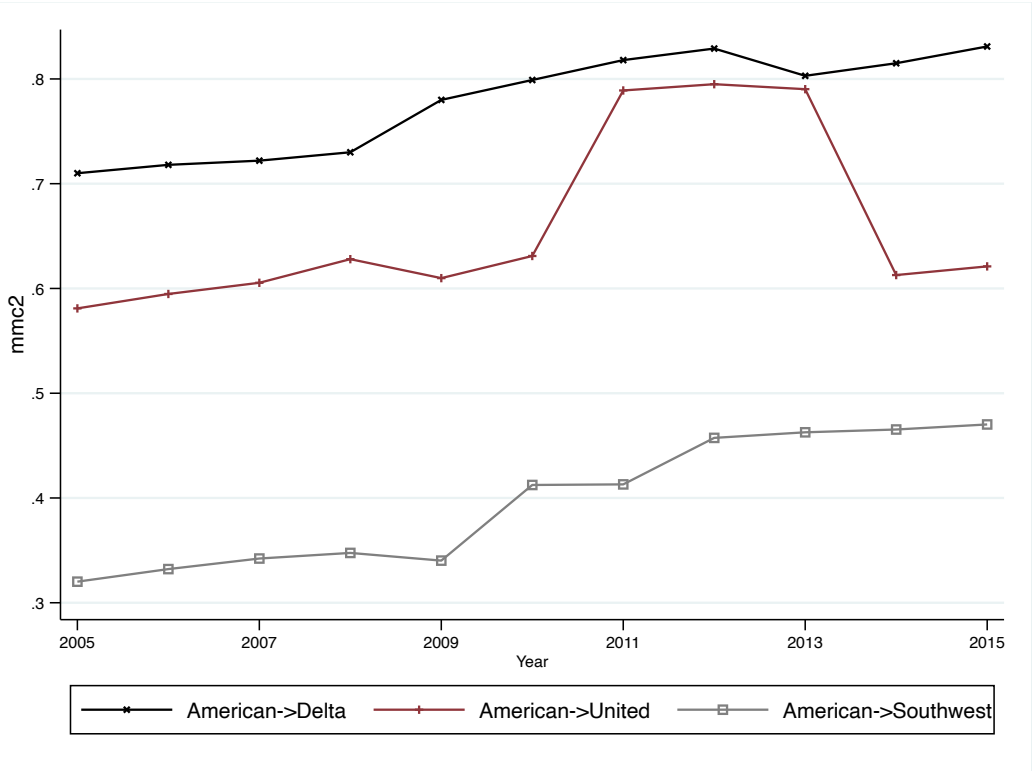

Figure 2.2: *mmc*2 Measure of Multimarket Contact between Delta Airlines and other Airlines (2005-2015)

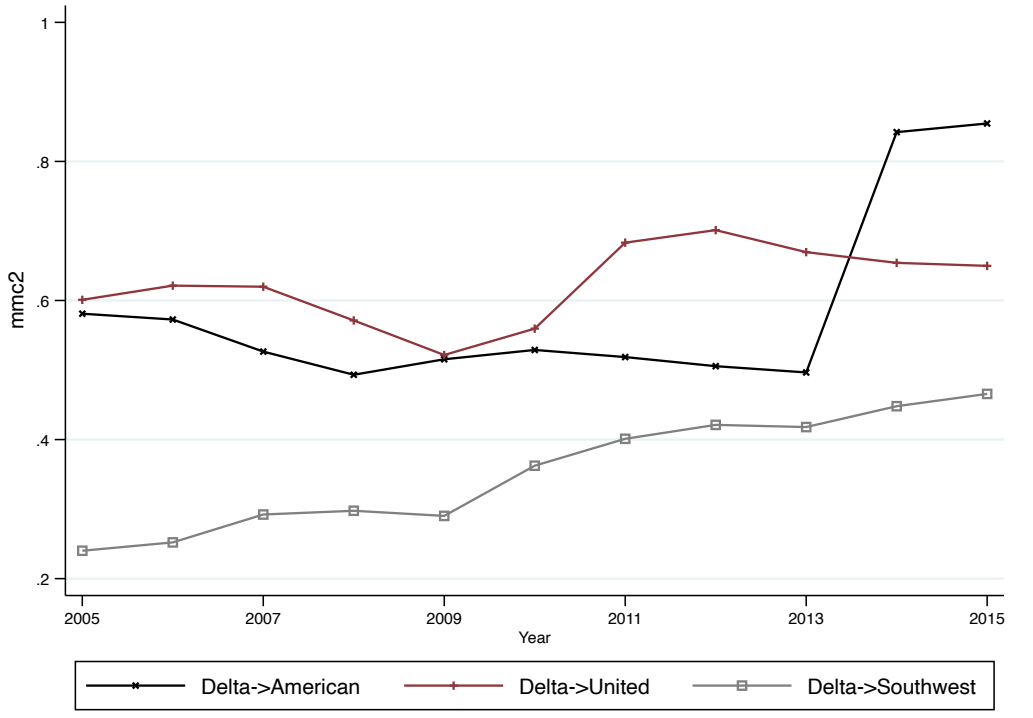

Figure 2.3: *mmc*2 Measure of Multimarket Contact between United Airlines and other Airlines (2005-2015)

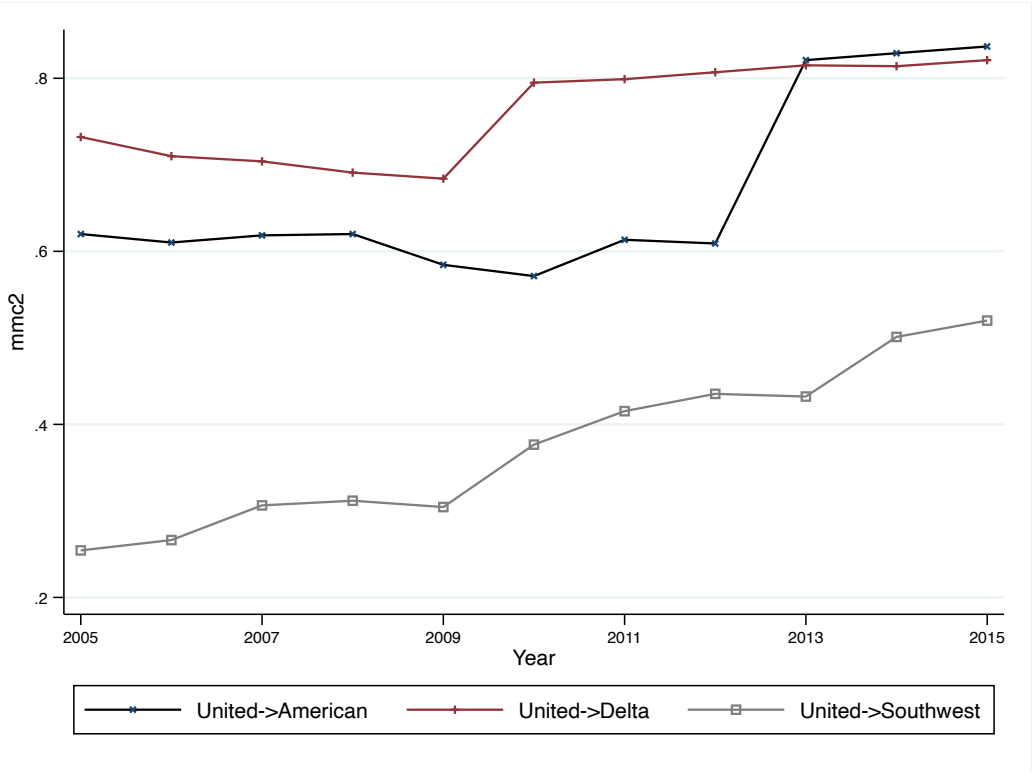

Figure 2.4: *mmc*2 Measure of Multimarket Contact between Southwest Airlines and other Airlines (2005-2015)

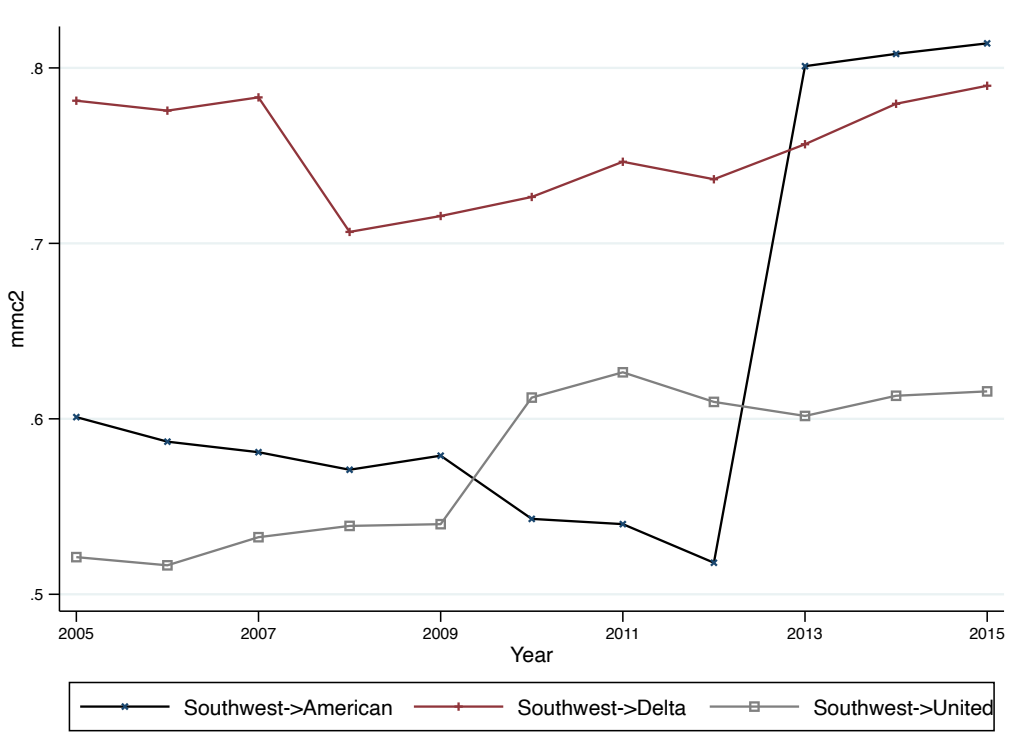

Table 2.1: Summary Statistics

	Mean	Std. Dev.	Min	Max
Carrier-Market-Specific Variables				
Airfare	272.99	82.35	25	1,197
Passengers (1,000)	3,391.27	4094.95	572	224,108
Nonstop	0.21	0.27	0	1
No. connection	0.77	1.32	0	3
No. daily departure	2.73	5.91	1	22
Hub	0.21	0.31	0	1
Code shared	0.29	0.10	0	1
Slot-control	0.73	0.53	0	1
Distance	1,279	969	210	5,084
Tourist place	0.07	0.17	0	1
American	0.21	0.20	0	1
Continental	0.11	0.18	0	1
Delta	0.18	0.18	0	1
United	0.13	0.21	0	1
US Airways	0.09	0.26	0	1
JetBlue	0.06	0.12	0	1
Southwest	0.15	0.17	0	1
Virgin Atlantic	0.03	0.14	0	1
Market-Specific Variables				
$mmc1$	625	601.29	9	855
$mmc2$	0.47	0.61	0.001	1
$mmc3$	0.45	0.66	0.001	0.91
Number of Observations	173,791			

Notes: The data were extracted for the period between January 2005 and December 2015.

Table 2.2: Observed Airports

Airports	
Albuquerque International	(ABQ)
Ted Stevens Anchorage International	(ANC)
Ronald Reagan Washington National	(DCA)
Atlanta International	(ATL)
Austin-Bergstrom International	(AUS)
Baltimore/Washington International	(BWI)
Boston Logan International	(BOS)
Bob Hope Burbank	(BUR)
Charleston International	(CHS)
Charlotte/Douglas International	(CLT)
Chicago Midway International	(MDW)
Chicago O'Hare International	(ORD)
Cleveland-Hopkins International	(CLE)
John Glenn Columbus International	(CMH)
Cincinnati/Northern Kentucky International	(CVG)
Dallas Love Field	(DAL)
Dallas-Fort Worth International	(DFW)
Denver International	(DEN)
Detroit Metropolitan Wayne County	(DTW)
Washington Dulles International	(IAD)
Honolulu International	(HNL)
George Bush Intercontinental	(IAH)
William P Hobby	(HOU)
Kahului	(OGG)
Kansas City International	(MCI)
Miami International	(MIA)
General Mitchell Milwaukee International	(MKE)
Minneapolis-St Paul International	(MSP)
Nashville International	(BNA)
Louis Armstrong New Orleans International	(MSY)
Newark Liberty International	(EWR)

Airports	
Metropolitan Oakland International	(OAK)
Ontario International	(ONT)
Philadelphia International	(PHL)
Phoenix Sky Harbor International	(PHX)
Sacramento International	(SMF)
Salt Lake City International	(SLC)
San Antonio International	(SAT)
Norman Y Mineta San Jose International	(SJC)
John Wayne Airport-Orange County	(SNA)
Seattle-Tacoma International	(SEA)
St Louis Lambert International	(STL)
Palm Beach International	(PBI)

Table 2.3: Pair-wise Number of Multimarket Contacts (2015:Q4)

	AA	UA	DL	AS	B6	F9	G4	HA	NK	SY	WN
AA	912										
UA	721	833									
DL	855	778	901								
AS	69	70	92	319							
B6	85	36	138	3	197						
F9	101	91	118	4	1	161					
G4	7	0	0	0	0	0	61				
HA	17	29	11	5	0	0	0	103			
NK	61	91	92	5	21	10	0	0	252		
SY	34	10	19	7	0	0	0	0	13	102	
WN	591	531	621	119	122	125	6	6	37	23	771

Notes: The diagonal's number represents the totality of markets a carrier serves. The numbers off the diagonal represent how many markets the carrier serves concomitantly (row) and the carrier (column).

Table 2.4: Relative Measure of Multimarket Contacts

	AA	UA	DL	AS	B6	F9	G4	HA	NK	SY	WN
AA	1	.790	.937	.075	.093	.110	.007	.018	.066	.037	.648
UA	.866	1	.933	.084	.004	.109	0	.034	.109	.012	.637
DL	.949	.863	1	.102	.153	.130	0	.023	.102	.021	.689
AS	.216	.219	.288	1	.009	.012	0	.015	.016	.022	.373
B6	.431	.182	.700	.015	1	.005	0	0	.106	0	.619
F9	.627	.565	.732	.024	.006	1	0	0	.062	0	.776
G4	.114	0	0	0	0	0	1	0	0	0	.098
HA	.165	.281	.106	.048	0	0	0	1	0	0	.058
NK	.242	.361	.365	.019	.083	.039	0	0	1	.051	.146
SY	.333	.098	.186	.068	0	0	0	0	.127	1	.225
WN	.766	.689	.805	.154	.158	.162	.007	.007	.048	.029	1

Notes: This table illustrates the market fraction a carrier serves, with the numerator being the off-diagonal number in Table 2.3 and the denominator being the number on the diagonal in the same table.

Table 2.5: The Effect of Multimarket Contacts on Number of Seats

	(1)	(2)	(3)
Dependent variable	log($seats$)	log($seats$)	log($seats$)
Average MMC	-0.291***		
	(0.012)		
Major market · Avg MMC		-0.318***	
		(0.009)	
Mixed market· Avg MMC (Major)		-0.185***	
		(0.009)	
Mixed market· Avg MMC (LCC)		-0.0071	
		(0.006)	
Small market· Avg MMC			-0.307***
			(0.011)
Medium market· Avg MMC			-0.117***
			(0.008)
Large market· Avg MMC			-0.065
			(0.012)
Log Population	0.117***		
	(0.009)		
Nonstop	0.006	0.0043	0.0039
	(0.002)	(0.006)	(0.002)
Monopoly	-0.020***	-0.0193***	-0.0199***
	(0.003)	(0.004)	(0.004)
Wu-Hausman	1,090***	1,121***	1,097***
Number of observations	173,791	173,791	173,791

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10.
All regressions include carrier and year-quarter fixed effects.

Table 2.6: The Effect of Multimarket Contacts on Number of Seats, Robustness Check

	(1)		(2)		(3)	
	$mmc1$		$mmc2$		$mmc3$	
Dependent variable	log($seats$)		log($seats$)		log($seats$)	
Average MMC	-0.291***	(0.012)	-0.612***	(0.021)	-0.791***	(0.019)
Log Population	0.117***	(0.009)	0.175***	(0.008)	0.139***	(0.005)
Nonstop	0.006	(0.002)	0.002	(0.001)	0.001	(0.002)
Monopoly	-0.020***	(0.003)	-0.029***	(0.004)	-0.037***	(0.008)
No. Observations	173,791		173,791		173,791	

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10.
All regressions include carrier and year-quarter fixed effects.

Table 2.7: Model Estimation Results

	(1) No Collusion		(2) Collusion Allowed		(3) Full Model	
	Estimates	Standard Error	Estimates	Standard Error	Estimates	Standard Error
Demand						
$\text{Airfare}_{\text{Business}}$	-0.112**	(0.004)	-0.124**	(0.003)	-0.127**	(0.007)
$\text{Airfare}_{\text{Tourist}}$	-1.003**	(0.009)	-1.027**	(0.011)	-0.981**	(0.017)
$\text{Connection}_{\text{Business}}$	-0.627**	(0.018)	-0.858**	(0.020)	-0.857**	(0.034)
$\text{Connection}_{\text{Tourist}}$	-0.601**	(0.010)	-0.631**	(0.020)	-0.692**	(0.030)
$\text{Constant}_{\text{Business}}$	-5.009**	(0.233)	-5.923**	(0.151)	-5.724**	(0.199)
$\text{Constant}_{\text{Tourist}}$	-8.157**	(0.302)	-8.751**	(0.231)	-8.199**	(0.334)
Code share	-0.080**	(0.001)	-0.082**	(0.005)	-0.101**	(0.005)
Distance	0.310**	(0.008)	0.286**	(0.008)	0.291**	(0.008)
Distance^2	-0.073**	(0.001)	-0.055**	(0.002)	-0.064**	(0.002)
Hub	0.891**	(0.019)	0.830**	(0.020)	0.801**	(0.010)
Slot-control	-0.107**	(0.004)	-0.228**	(0.016)	-0.241**	(0.002)
Tour	0.275**	(0.010)	0.319**	(0.029)	0.216**	(0.005)
λ	0.631**	(0.003)	0.617**	(0.002)	0.595**	(0.003)
Marginal Cost						
Constant	1.021**	(0.013)	0.929**	(0.020)	1.204**	(0.014)
No. seats	-0.022**	(0.004)	-0.019**	(0.003)	-0.025**	(0.003)
Hub	-0.203**	(0.009)	-0.183**	(0.021)	-0.180**	(0.001)
$\text{Distance}_{\text{Short}}$	0.255**	(0.004)	0.231**	(0.012)	0.210**	(0.008)
$\text{Distance}_{\text{Long}}$	0.129**	(0.002)	0.153**	(0.003)	0.095**	(0.005)
Fixed Cost						
Constant	5.221**	(0.031)	5.62**	(0.022)	5.002**	(0.020)
No. seats	0.038**	(0.002)	0.036**	(0.003)	0.032**	(0.001)
Conduct Parameters						
ψ_1			0.797***	(0.365)	0.008	(0.087)
ψ_2					0.887***	(1.129)
Model Fit						
GMM function	112.018		105.939		105.207	
Observations	173,791		173,791		173,791	

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10.
All three GMM estimations include Year-Quarter dummies and Carrier dummies.

Table 2.8: Estimated Degree of Coordination in Setting Capacity

	AA	UA	DL	AS	B6	F9	G4	HA	NK	SY	WN
AA	•										
UA	.776	•									
DL	.849	.773	•								
AS	.199	.202	.263	•							
B6	.390	.170	.629	.021	•						
F9	.564	.509	.658	.030	.013	•					
G4	.109	.008	.008	.008	.008	.008	•				
HA	.154	.257	.102	.051	.008	.008	.008	•			
NK	.222	.328	.331	.025	.081	.043	.008	.008	•		
SY	.303	.094	.173	.068	.008	.008	.008	.008	.121	•	
WN	.687	.619	.722	.144	.148	.151	.015	.015	.051	.034	•

Chapter 3: Mergers and Product Quality

3.1 Introduction

While the literature on mergers has long examined the impacts of horizontal mergers, it initially focused on their effects on price. However, it soon emerged that the price changes instigated by mergers can also affect the quality of the products offered by the merged firm. While this effect has received some recent research attention, its exact implications for product quality are still largely unanswered.

Airlines rely on a system of networks to conduct their operations. However, this implies scarcity of resources, such as airport services, take-off and landing slots, and gate space. By merging with other carriers, airlines can more readily access these resources and expand their network capabilities. The significance that this network structure is growing as the number of carriers still operating has decreased recently through mergers, underlining the need for prospective merger analysis as part of the evaluation of network evolution. Changes to the network structure after a merger can also mean that an airport is "de-hubbed", which inevitably leads to a reduction in product quality for passengers, e.g. a lack of direct flights, inconvenient connecting options, and a reduction in the departure frequency and destinations on offer. In light of this, the current chapter empirically investigates how changes in the network structure due to three recent airline mergers, namely Delta Airlines–Northwest Airlines, Continental Airlines–United Airlines, and American Airlines–US Airways, have affected product quality.

Mergers and acquisitions in the US airline industry increased sharply during the first decade following deregulation in 1978 and continue to do so, albeit at a lesser rate. Most of empirical research on airline mergers (Borenstein, 1990; Kim and Singal, 1993; Kwoka and Shumilkina, 2010; Richard, 2003; and Peter, 2006) mainly examined the effects on price, although some recent studies (Prince and Simon, 2017; Chen and

Gayle, 2018) explored how horizontal mergers in the US domestic airline industry affect product quality. Specifically, Prince and Simon (2017), measuring product quality using on-time performance (OTP), discovered that in the short term, mergers lead to lower OTP, yet this increases over time due to efficiency gains. Meanwhile, Chen and Gayle (2018) proposed routing quality as an alternative product quality indicator, referring to the percentage ratio of the nonstop flight distance between the origin and destination airports to the itinerary flight distance of the product. As connecting flights imply a greater total distance than nonstop flights, routing quality is always a number between 0 and 100. Passengers tend to select nonstop over connecting flights, and thus a higher routing quality relates to higher product quality. In line with this, those authors revealed a decrease in product quality if a merger occurred in a market in which the merging airlines had previously been competitors, and a product quality increase occurred in markets that had no such prior competition.

For passengers, changes to the network structure following a merger can impact convenience, network connectivity, and flexibility of departure. To examine how a merger impacts consumers' convenience as a proxy for product quality, the study reported here involved measuring the quality of air travel products using the difference ($ExtraTravelTime$) between total travel time from the origin to the destination airport and the average nonstop travel time. For passengers, because selecting a connecting flight significantly increases positive extra travel time, which consequently lengthens overall travel time, connecting flights increase inconvenience. Hence, in place of nonstop flights, shorter detours to destinations using transit flights represent preferable travel itineraries for most passengers. Nonetheless, this measure is unable to capture the value of changes to network connectivity following a merger. Carriers tend to claim that mergers allow them to increase their network connectivity and offer passengers more destinations. Therefore, to evaluate the changes to the network

connectivity quality experienced by passengers following a merger, this chapter utilizes the changes to the number of destinations a merged carrier is offering. Finally, an additional significant dimension of air travel product quality is flight frequency. The preference of passengers, especially business travelers, for flexibility is reflected in their favoring airports that offer multiple departure and arrival times. In line with this, passengers have similarly demonstrated a preference for larger airports because these offer more flight options should problems occur; for example, if a passenger misses a flight, they are more likely to be able to catch a flight to the same destination later that day. Hence, the analysis of the changes to flight frequency that follow a merger describes airline mergers' quality effect on consumer flexibility.

This study performs a reduced-form analysis to assess the effects on product quality of three airline mergers. The base model compares the pre- and post-merger periods in terms of product quality changes for the merged carriers, in light of the product quality changes related to non-merged carriers. First, the effect of a merger on passenger convenience is examined via a difference-in-difference model that defines those air travel products operated by the merged airlines as the treatment group, with the other products of non-merged carriers representing the control group. This model aims to conduct a preliminary check on the overall effect of merger on the product quality. Following Prince and Simon (2017), a distinction is made between the short-term and long-term effects of a merger by dividing the post-merger period into two sub-periods, i.e. the first year post-merger is the short term, and the subsequent two to three years post-merger constitute the long term. [25]

Furthermore, both the mergers' average effect on air travel product quality in all markets and their varying quality effects across markets are examined. To increase efficiency gains, airline mergers generally lead to a restructuring of route networks,

[25]For a given merger, the non-merging carriers in the control group are carriers that were not involved in that particular merger; i.e., they either never merged or were involved in a different merger at a different time.

meaning that fewer airports function as airline hubs. Hence, the mergers' effect on product quality varies according to the extent to which this restructuring affects the products. In the context of nonstop flights, Rupp and Tan (2018) used OTP and flight cancelation measures to examine product quality. They revealed that de-hubbing an airline—whether due to a merger or any other reason—affects the quality of its products. On the other hand, mergers that improve efficiency (leading to de-hubbing) can also increase product quality, although this tends to be due to the reduced airport congestion stemming from fewer flights operating out of a de-hubbed airport. While the authors demonstrated that de-hubbing can increase air travel product quality for de-hubbed airports, the reduction in the nonstop destinations and flights operating from these, which adversely affects convenience and connectivity for consumers, were not considered. Hence, to address these studies' limitations, the current study employs a different product quality measure and draws on different data for nonstop and connecting flights to show how de-hubbing due to mergers differently affects the product quality.

Chen and Gayle (2019) theorize that a merger between carriers without prior competition enhances the product quality, while a merger between those that did previously compete is likely to lead to reduced quality. However, each merger implies multiple types of market. In some markets, the carriers will not have had any pre-merger competition, while in others they will have been in direct competition to varying degrees of intensity. Thus, it is important to investigate not only how a merger affects the average product quality, but also the differences in the quality effects across markets with various pre-merger competition structures.

Using a difference-in-difference model, the merger-driven changes in the number of destinations offered by merging firms at an airport are compared with the number offered by non-merging firms at the same airport to examine how mergers affect network connectivity for consumers. In addition, the flight frequency offered by merged

airlines is used as a dependent variable for regression to investigate the impact of mergers on the flexibility of flight options for consumers. Assuming that the treatment group (merging firms) and control group (non-merging firms) are subject to the same trends in a market allows a merger's causal effect to be captured. After assessing the average effect on network connectivity and flexibility for consumers, the study explores how different market types, such as de-hubbed airports and pre-merger competition structures, influence the strength of this effect.

Using data from the US airline industry spanning the period 2008–2018, I found that all Delta–Northwest, United–Continental, and American–US Airways mergers led to an increase in extra travel time. Merged airlines' de-hubbing in the process of network restructuring following a merger significantly increase overall travel time, and this effect is stronger at airports that the merged carriers de-hubbed by curtailing nonstop services. In addition, each merger is associated with a decrease in extra travel time in markets in which the merging carriers were not competitors before they merged but an increase in the extra travel time in markets where they did compete. Considering the impact of a merger on the number of destinations available at the airports served by the merging airlines, the results indicate a significant increase in the number of overall destinations, yet there is no such effect on the number of nonstop destinations. Based on this, any improvement to product quality due to increased passenger connectivity is likely to have been driven by the addition of connecting services following the merger. However, passengers traveling via post-merger de-hubbed airports experience a decline in air travel connectivity service as the merged carriers significantly limit their nonstop flights to and from these airports. Finally, the study finds no evidence that pre-merger competition is correlated with the number of destinations offered at airports. An investigation of flight frequency suggests that, on average, mergers decrease flight frequency and, therefore, passengers experience less flexibility in regard to flight options. This effect seems to be stronger for the

markets in which the merging carriers de-hubbed. Consumers using these markets for their travel needs experience significant reductions in flight option flexibility due to significant decreases in flight frequency. The impact of mergers on flight frequency is stronger in the market in which merging carriers were formerly competitors compare to they did not have pre-merger competition.

This study contributes to the empirical research on mergers and their effect on product quality. It hereby not only offers a well-founded explanation of firms' behavior under various competitive conditions but also introduces passengers' convenience, network connectivity, and flexibility of departure as additional product quality measures. While economists have thus far primarily examined how mergers influence prices, the quality of products offered by merged firms can also be affected. Yet, unlike prices, the somewhat opaque effects of efficiency and market power might affect product quality through a variety of potential mechanisms and with ambiguous relationship directions. As it employs a quality metric that considers changes to the network structure and incorporates differing time effects, the analysis of this study should be considered a complement to the existing body of literature on mergers and their effect on product quality.

The remainder of the chapter is structured as follows. Section 2 details the network structure changes after each merger. In section 3, the data is discussed in terms of data source, market definition, sample selection, and the measures for product quality. Section 4 introduces the econometric model, while Section 5 presents the empirical results. Section 6 draws the conclusions.

3.2 Network Structure Changes after Mergers

The recent spate of airline mergers has led carriers to seek efficiency gains by re-evaluating their route network structures. Airline mergers frequently lead to a reduction in hub airports, a process also known as "de-hubbing" as carriers, aiming

to maximize their profits, rationalize their route structures, thereby often limiting passengers' flight options. In light of this, the following section describes how three airline mergers caused substantial shifts in route structure and hub usage.

3.2.1 De-Hubbing

After the U.S. airline industry experienced deregulation in 1978, legacy airlines primarily employed the hub-and-spoke system to operate their route network. However, carriers sometimes make the decision to stop running hub operations from certain airports, effectively de-hubbing them. This has happened to 10 airports since 1998, namely Nashville International Airport (BNA), Raleigh–Durham International Airport (RDU), St. Louis Lambert International Airport (STL), Cincinnati/Northern Kentucky International Airport (CVG), Dallas/Fort Worth International Airport (DFW), Newark Liberty International Airport (EWR), Denver International Airport (DEN), McCarran International Airport (LAS), Memphis International Airport (MEM), and Cleveland Hopkins International Airport (CLE). This chapter considers only the three airports that were de-hubbed during carriers' post-merger route network restructuring efforts. Table 3.1 provides a chronological list of the de-hubbed airports investigated here as well as the mergers that lead to their de-hubbing.

When Delta and Northwest Airlines merged, Delta acquired Detroit Metropolitan Airport (DTW) and Memphis Airport (MEM) as hub locations. It subsequently made the decision to de-hub Cincinnati Airport (CVG) and MEM by rerouting its flights through DTW and Minneapolis–Saint Paul International Airport (MSP).[26] Similarly, when merging with Continental Airlines, United Airlines acquired the hub locations of Bush International Airport (IAH) in Houston and Newark Liberty International Airport (EWR). The airline then reduced its flights to its previous hubs of

[26]Before the Delta–Northwest Airlines merger, Cincinnati was Delta's only Midwest hub and also its second-largest hub regarding the number of flights per year. Nevertheless, due to its proximity to Minneapolis, Detroit and Memphis, Delta downsized its Cincinnati operations after the merger.

Washington Dulles International Airport (IAD), Denver International Airport (DEN), and Chicago O'Hare International Airport (ORD) while increasing its connections to IAH and EWR by 3.02% and 1.32%, respectively. Ultimately, Unites Airlines fully de-hubbed its previous hub of Cleveland Hopkins International Airport (CLE).

Due to the consistent trend of airport de-hubbing following mergers, lawsuits were filed by the state attorney generals of Arizona, Florida, Michigan, Tennessee, Pennsylvania, and Virginia to oppose the proposed merger between American Airlines and US Airways. The fear was that the states' airports would be de-hubbed, leading to considerable job losses. As a result, in the settlement agreement with the state attorney generals and the Department of Justice, the parties in the American Airlines-US Airways merger agreed to maintain existing operations at the pre-merger hubs of Charlotte Douglas International Airport (CLT), Miami International Airport (MIA), Philadelphia International Airport (PHL), and Phoenix Sky Harbor Airport (PHX). However, as this condition is only in effect for three years, they may still face de-hubbing in the future.

Carriers substantially reduce the number of nonstop flights they offer from de-hubbed airports. [27] To illustrate this, Table 3.2 presents the nonstop flights operated each day by the respective airlines from the three de-hubbed airports examined here, offering a comparison of the pre- and post-de-hubbing numbers. It shows a significant decline in the number of daily nonstop flights serving merger-related de-hubbed airports, which has led to a considerable reduction in passenger convenience and network connectivity. Based on this clear reduction in passengers' travel flexibility, it is crucial to examine the varying effect that these mergers have had on the quality of air travel products offered at de-hubbed airports compared to mergers' overall effects.

[27] A potential reason for eliminating nonstop flights following a merger is that the connecting flights may enable airlines to better achieve the economies of passenger-traffic densities.

3.2.2 Network Structure Changes

Following a merger, the two merged airlines begin rationalizing their route structure, seeking to maximize their profits. Within any given market, a particular airline can offer various nonstop and/or connecting flight options, namely (1) nonstop and connecting, (2) nonstop only, (3) connecting only, or (4) no service. A carrier's flight option combination can be maintained or adjusted as necessary following a merger.

Table 3.3 outlines the changes to the flight options made following the Delta-Northwest Airlines merger in 2008; the number of entries in this merger surpassed the number of exits by 118. However, the 2008 recession caused by the global financial crisis is likely to have had a substantial effect on some of the route structure changes that followed the merger. The greatest change in the post-merger flight options was a net 271 decrease in markets with both nonstop and connecting flight options. Following the restructuring, an additional 43 markets offered only connecting flights. Table 3.4 presents the changes in the flight options that followed the 2010 merger between United Airlines and Continental Airlines merger. This merger saw a substantial increase in the number of markets, with 617 more entering than exiting. Ultimately, 511 more markets offered only a connecting service, 18 more markets only had nonstop flights, and 88 more markets offered both nonstop and connecting flight options. Finally, Table 3.5 lists the changes to the flight options after the American Airlines-US Airways merger in 2013. It shows that post-merger, American Airlines entered 1,776 markets and exited 1,037, i.e. there was a net increase of 739 markets. However, following the restructuring, 701 additional markets offered only connecting flights, 6 more had only nonstop flights, and 26 more provided both connecting and nonstop flight options. The evaluation of these three mergers highlights the drastic changes to the available flight options that occurred post-merger.

3.3 Data

The following section first outlines the data sources used in this study and then defines the employed measures of product quality.

3.3.1 Data Source

As its primary data source, this study selects the Airline Origin and Destination Survey (DB1B), conducted by the U.S. Department of Transportation (DOT). This is a sample comprising data on 10% randomly selected carrier-reported airline tickets, covering airfare and ticketing, type of service, such as connecting or nonstop flight, nonstop flight distance, and total travel distance for each market. The T-100 Domestic Segment for U.S. airlines is also used as a data source. This encompasses monthly census information on domestic nonstop flights in the U.S., e.g. airline, origin and destination airports, passenger numbers, seats per flight segment, frequency of flights, and type of aircraft. Crucially, this dataset distinguishes between regional and network carriers despite these being affiliated with each other on the route level through contracts. Hence, in this study, pairs of regional and network carriers at the segment level are matched using the DB1B operating-ticketing carrier pairs; subsequently, for a given flight segment, the regional carriers are substituted by their affiliated network carriers. Table 3.6 provides a summary of the data employed in the empirical analysis.

3.3.2 Market Definition and Sample Selection

Following Chen and Gayle (2018), a market is a directional pair of airports: the Airport A-Airport B market is separate from the Airport B-Airport A market. The study dataset, i.e. between the first quarter of 2008 and the last quarter of 2018, includes the mergers of three major airlines. Only markets with the origin and destination airports located with an Metropolitan Statistical Areas (MSA) boundary, as per the U.S. Office of Management and Budget's bulletin 18-03 published 10 April 2018, are considered.

Moreover, to ensure no seasonal or charter flights are included, only those markets that served a minimum of 250 passengers in at least one month during the sample period are considered. To enable pre- and post-merger route comparisons, carriers that merged into one airline at any point during the sample period are combined, in line with Prince and Simon (2015). Finally, similar to Gayle (2013), 2009:Q1–2013:Q4 is considered the post-merger period for the Delta Airlines–Northwest Airlines merger, 2011:Q1–2014:Q4 for United Airlines–Continental Airlines, and 2016:Q1–2018:Q4 for American Airlines–US Airways.[28]

3.3.3 Measuring Product Quality

Evaluating the association between mergers and product quality requires a suitable measure of the latter. Research in the context of the airline sector often assesses air travel product quality based on the dimension of service timeliness. This dimension can be measured using a carrier's schedule delay and on-time performance, which can be extracted directly from an existing dataset. However, the current study considers a slightly different aspect of air travel product quality, namely passenger convenience, measured via the time taken to travel from the origin airport to the destination airport. This study uses the difference between the total travel time and average nonstop travel time from the origin to the destination airport, termed $ExtraTrabelTime$. In this measure, a nonstop flight represents the shortest itinerary travel time between the origin and destination airports, while a connecting flight indicates additional travel time, implying extra travel time for the passenger. The extra travel time required by a connecting air travel product compared with the corresponding nonstop air travel product negatively correlates with quality of those products.

Meanwhile, to measure network connectivity for passengers, the number of desti-

[28]Following Prince and Simon (2014), airlines that merge at any point are combined into a single airline for the entire sample; their observations for the same origin-destination pair in the same month are thus summed. This resolve the issue of carriers disappearing from the dataset after a merger.

nations offered by the merged airline at a given airport is used as a proxy. As evidenced by Berry and Jia (2010), consumers tend to favor airlines that offer a greater number of destinations, which also increases connectivity for passengers, regardless of whether these are connecting or nonstop flights.

Finally, passengers' travel flexibility is measured via the proxy of the merged airline's flight frequency on a given route. Passengers prefer flight schedules with more departure times as they can choose the one most convenient for them (Richard, 2003). The empirical studies by Morrison and Winston (1995) and Berry and Jia (2010) revealed that passengers' choice of airline is strongly influenced by flight frequency, making this a crucial dimension of air travel product quality.

Although the literature on air travel product quality generally employs carriers' on-time performance as a measure, the current study considers extra travel time, network connectivity, and flight frequency as similarly critical measures of air travel product quality. Primarily, this is because these factors have a greater impact on the consumer purchase decision-making process. Therefore, this study aims to explore how carriers' restructuring of a market following mergers for the purpose of optimization influences passengers' convenience, network connectivity, and flexibility of departure.

3.4 Econometric Model

Developing a suitable counterfactual is crucial to evaluating how mergers impact product quality. This chapter examines this impact utilizing difference-in-differences identification strategies, i.e., by performing a comparison of the pre- and post-merger periods regarding changes in the air travel product quality offered by merged airlines relative to the changes in non-merging airlines' product quality during the same period and in the same market. In other words, the changes in the air travel product quality of airlines that did not merge is the counterfactual to the changes of the

merged airlines. Hence, this study utilizes the non-merged carriers as the control group, unlike previous airline merger research (e.g., Kwoka and Shumilkina (2010) and Luo (2013)), which compared pre- and post-merger periods for markets that did or did not experience mergers in terms of their changes in outcomes at the market level. The current approach is advantageous in that it controls for the different changing conditions experienced by markets with and without mergers. For instance, if the route network of a merged carrier contained more high-growth markets, this would lead to an overestimation of product quality improvement as the merged airline would consequently increase its flight frequency and number of nonstop destinations in response to the increased passenger demand.

The following reduced-form specification of the equation for product quality is used as the baseline:

$$\begin{aligned} Product\ Quality_{ijt} =& \beta_1 PostMerger01_{it} + \beta_2 PostMerger13_{it} \\ &+ \beta_3 Controls_{ijt} + \mu_{ij} + \tau_t + \varepsilon_{ijt} \end{aligned} \tag{3.1}$$

where $Product\ Quality_{ijt}$ is a measure of product quality, $ExtraFlightDistance_{ijt}$ for carrier i on route j during time period t, number of destinations offered by carrier i at airport j at time $t$or the flight frequency of carrier i on route j. To interpret the regression coefficient as a percentage term, both product quality measures are log-transformed. The post-merger impact is measured through two merger event dummy variables, namely $PostMerger01_{it}$ and $PostMerger13_{it}$. $PostMerge01_{it}$ is equal to one if carrier i is one of two merged firms and t is the first year following the merger, and zero otherwise. $PostMerger13_{it}$ similarly defined, with the difference that t is the first two to three years post merger. β_1 and β_2 measure the extent to which the change in average product quality offered by merged carriers differs from that of non-merged carriers, whereby β_2 is a better indicator of the relatively long-run merger effect.

The numbers of both nonstop and connecting flights offered by an airline's market competitors are included to control for the level of market competition a given product faces that is specific to its service type. The effect of distance between the origin and destination airports as well as the status of hub airport are also controlled for. Fixed effects controlling for unobserved differences between carriers within a given market are similarly included, and time-fixed effects are used to account for unobserved time trends.

Airlines' de-hubbing decisions are partially influenced by their desire to optimize the number of hubs in a hub-and-spoke network. Bilotkach et al.'s (2013) study on post-merger network reorganization among hub-and-spoke networks indicated that, in the case of a highly congested primary hub, an airline may move its flights to its secondary hubs. Nonetheless, a model that does not incorporate congestion assumes that an airline is likely to continue focusing on its primary hub. For instance, after merging, Delta Airlines likely continued prioritizing its Atlanta hub rather than shifting to Northwest Airlines' pre-merger hub of Memphis.[29] As a merger implies substantial overlap, and thus redundancies, in the network, a merged carrier is likely to seek to exploit synergies and maximize cost efficiency by restructuring its flight network. Hence, hubs lacking in size or demand are likely to be de-hubbed. However, an airline's hubs are not merely its largest airports. Rather, they are airports that can handle a high volume of transfer passengers, who, together with origin passengers, give the hub airline enough traffic volume for it to offer more routes to long-haul destinations at higher frequencies compared to what would have been feasible based solely on origin traffic. Due to the high volume of transfer passengers transiting through a hub airport, de-hubbing is likely to not only impact arriving/departing flights but also affect the carrier's entire route structure, and hence, its product quality. The following empirical specification is made to test this assumption:

[29]Atlanta, the world's busiest airport, was Delta's largest hub, and thus its preferred southern U.S. hub, reducing the airline's need for Memphis.

$$Product\ Quality_{ijt} = \beta_1 NumHub_{it} + \beta_2 Hub_{it} + \beta_3 Controls_{ijt} + \mu_{ij} + \tau_t + \varepsilon_{ijt} \quad (3.2)$$

where $NumHub_{it}$ is the total number of hub airports operated by airline i, and Hub_{it} is a dummy variable that takes the value of 1 if the origin or destination is a hub airport of airline i, and 0 otherwise.

After the overall impact of de-hubbing on air travel product quality has been assessed, the extent to which these mergers impact product quality differently based on market type is examined, i.e. whether the carrier de-hubbed an airport post-merger or not. This study has clearly evidenced that airports suffer a substantial reduction in the number of nonstop flights offered following de-hubbing, thereby reducing the air travel product quality at these airports, considerably impact consumers' convenience, connectivity, and flexibility. While this research has uncovered only three cases of post-merger de-hubbing, and although these may also offer some benefits that outweigh the negative impacts, policymakers must take into consideration the effect that mergers have on product quality at de-hubbed airports. The analysis used the following difference-in-difference specification, derived from the baseline specification and incorporating the number of destinations at airport:

$$\begin{aligned} Product\ Quality_{ijt} = {} & \beta_1 PostMerge01_{it} + \beta_2 PostMerger13_{it} + \beta_3 Dehub_{jt} \\ & + \beta_4 PostMerge01_{it} \cdot Dehub_{jt} + \beta_5 PostMerger13_{it} \cdot Dehub_{jt} \\ & + \beta_6 Controls_{ijt} + \mu_{ij} + \tau_t + \varepsilon_{ijt} \end{aligned} \quad (3.3)$$

where $Dehub$ takes the value of one if either the origin or destination airport is a de-hubbed airport, and zero otherwise. The key variables of interest are the interaction terms between post-merger period and de-hubbed airport for time t. This specification

also contains year and month dummies to control for unobserved time and seasonal trends. Additionally, it has carrier dummies to control for carrier-specific factors that may influence product quality. Finally, market-specific fixed effects are used to capture unobserved airport heterogeneity, which may also affect product quality.

The impact of airline mergers on product quality in terms of network structure remains ambiguous when the pre-merger competition between the two merging carriers is taken into account as competing forces determine which routes the merged airline will serve. The decline in price competition on routes that the two merging carriers previously serviced is likely to increase profitability for these routes, which, in turn, will promote more services on connecting routes due to the network effect, while also offering opportunities for new market entrants. However, as the merged airlines are likely to terminate competing routes, the economies of density point to a reduction in services.

To further investigate how airline mergers differently influence product quality in markets with varying pre-merger competition between the merging carriers, the effects of mergers are differentiated based on whether or not the merged carriers both served the route prior to the merger. In the case where only one of the merging carrier was active prior to the merger, while product quality may be subject to cost efficiency effects, there is likely to be no effect regarding changes to the market structure. In contrast, markets in which both carriers were active before the merger are likely to have experienced a significant effect on product quality in relation to the network structure. On the other hand, routes that were already monopolized by one of the merging carriers are not likely to change post merger, meaning the impact on product quality may be less. Based on this, the following extensions are made to the baseline model:

$$
\begin{aligned}
Product\ Quality_{ijt} = PostMerge01_{it} \cdot (\beta_1 Both_{ijt} + \beta_2 Monopoly_{ijt} + \beta_3 Competition_{ijt}) \\
+ \beta_4 PostMerge13_{it} \cdot (\beta_4 Both_{ijt} + \beta_5 Monopoly_{ijt} + \beta_6 Competition_{ijt}) \\
+ \beta_7 Controls_{ijt} + \mu_{ij} + \tau_t + \varepsilon_{ijt}
\end{aligned}
\tag{3.4}
$$

where $Both_{ijt}$ is a dummy that takes the value of one if both merged carriers served the route in the two years prior to the merger; $Monopoly_{ijt}$ is a dummy that takes the value of one if the route was previously monopolized by one of the merged carriers; and $Competition_{ijt}$ indicates that one of the merged carriers faced competition from another airline on that route.

The use of the difference-in-difference identification strategy to assess airline mergers' impact on air travel product quality assumes that the control treatment groups had similar pre-merger product quality trends. For instance, when the merged and non-merging carriers had statistically similar product quality trends during the pre-merger period, the difference-in-difference merger effects become very clear. If, in such a case, following the merger, the merged airline's product quality starts deviating from that of other non-merging airlines, this is likely due to the merger to some extent. However, the air travel product quality may be determined before two airlines merge. For example, carriers' quality decision-making may be influenced by various circumstances, e.g. bankruptcy, which has been a recurrent issue in the airline industry. The 2013 US Government Accountability Office (GAO) report on airline mergers records 194 airline bankruptcies between 1979 and 2012, including those of Delta Airlines, Northwest Airlines, United Airlines, and USAir. Due to bankruptcy, the operations of financially stressed airlines may undergo modification, impacting their air travel product quality. Under such circumstances, airlines tend to incorporate mergers into their restructuring plans. Hence, bankruptcy not only leads to product quality modification but also increases the likelihood of a merger. This is a crucial

endogeneity concern, making it essential to analyze whether the pre-merger product quality trends of merging airlines differ from those of non-merging carriers. Therefore, the following regression is used to evaluate the relevant pre-merger periods:

$$\begin{aligned} Product\ Quality_{ijt} = {} & \beta_1 MergingCarrier_{ijt} + \beta_2 TimeTrend_t \\ & + \beta_3 MergingCarrier_{ijt} \cdot TimeTrend_t \\ & + \beta_4 Controls_{ijt} + \mu_{ij} + \tau_t + \varepsilon_{ijt}. \end{aligned} \tag{3.5}$$

Following Prince and Simon (2017), $TimeTrend_t$ is the linear time trend of the twelve quarters comprising the pre-merger periods, and $MergingCarrier_{ijt}$ is a dummy variable that takes the value of one for products operated by two carriers in the pre-merger phase, and zero otherwise. The interaction term between the time trend and the merging carriers reveals any differences in the pre-merger time trends between carriers preparing to merge and their non-merging counterparts. The estimates of the interaction term are expected to be statistically insignificant if the merging carriers had sufficiently similar product quality trends to non-merging airlines prior to the merger. Table 3.7 presents the estimation results of Equation (3.5) using extra travel time, number of destinations, and flight frequency as the dependent variables. As the coefficient estimates for the product measures' interaction terms are not statistically significant, the air travel product quality offered by carriers on the brink of merging displays a similar trend to that of non-merging carriers; hence, it can be assumed that the post-merger product quality changes are not endogenous or due to unrelated changes that had already commenced before the merger.

3.5 Results

The overall effects of airline mergers on product quality

Table 3.8 presents the results of the regression with baseline model, in which $ExtraTravelTime$ is the dependent variable. The results in the first column re-

fer to the three airline mergers pooled, whereas the other three columns present the results for each individual merger. The table shows that the average difference between the total travel time and average nonstop travel time from the origin to the destination airports (i.e., the extra travel time) tends to increase for routes served by merging carriers, in contrast to the extra travel time of non-merging firms on the same route. The positive effect of mergers on extra travel time is stronger in the long term than in the short term. During the first year after the merger, the extra travel time between two end-point airports rose by 9.81% on average and peaked at 11.08% during the first 2 to 3 years post-merger. That trend was likely due to the time taken by merging airlines to optimize their network structure by reallocating fleets, flight and ground crews, and airport facilities, which generally worsens product quality in terms of passengers' convenience.

All individual-level mergers significantly increased the average extra travel time between the origin and destination airports. That effect is particularly noticeable in the Delta–Northwest Airlines merger, which prompted average extra travel time to grow by 12.91% in the short term and 14.17% in the long term. Whereas a 8.08% increase occurred following the United–Continental Airlines merger and a 8.13% increase after the American–US Airways one, the long-term effects were increases of 9.71% and 9.94%, respectively.

The following investigates how airline mergers influence the number of destinations offered by a merged carrier at a given airport. In this analysis, the number of destinations available at an airport is differentiated according to the service type. The dependent variable in the regression is either the number of nonstop destinations or the number of nonstop and connecting destinations. The regression results in Table 3.9 emerge when the dependent variable is the former. As before, the first column in the table presents the three mergers' pooled results, and the rest give the results of the individual airline mergers. Based on the results for both pooled and

individual airline mergers, mergers have no impact on the number of nonstop destinations available at airports in both the short and long terms. Although the coefficients of both $PostMerger1$ and $PostMerger23$ have positive signs, none are statistically significant.

While mergers have a limited impact on the number of nonstop destinations, the effect gains significance when the regression's dependent variable is the number of destinations including nonstop and connecting services. The first column in Table 3.10 presents the estimates of three airline mergers' pooled effect on the number of destinations available at airports. On average, the number of destinations offered by the merged carrier at a given airport increased by 5.91% during the first year and 9.29% for the second and third years. Accordingly, both specifications show that merged airlines offer increased passenger network connectivity, especially in the long term. The rest of Table 3.10 reports the findings after differentiating the three mergers' effects, showing substantial differences between them. Although the United–Continental Airlines and American–US Airways mergers increase the destination numbers in both the short and long terms, the Delta–Northwest Airlines merger significantly reduces the number of destinations on offer.[30] Based on this, it may be assumed that the United–Continental Airlines and American–US Airways mergers are the main drivers of airline mergers' positive effect on the number of destinations.

In conclusion, the study finds that merged carriers do not significantly increase the number of nonstop flight destinations, whereby the increased passenger network connectivity is mainly due to the greater number of destinations offered via connecting flights on the merged United–American Airlines network. Indeed, during the consideration of whether to allow the merger, the carriers argued that mergers are likely to increase network connectivity for passengers – and the Department of Justice agreed.

[30]Note that any changes in the number of destinations can have other causes. For example, the period following the Delta–Northwest Airlines merger (2008) was a recession; hence, the consequent decrease in passenger numbers is likely to have caused demand changes that resulted in the reduction of the number of destinations.

However, this study indicates that this argument does not always stand. Although the United and American Airlines passengers have more flight options to new destinations following the merger, the positive effect on consumer welfare is limited if consumers' strong preference for nonstop flights is taken into account.

Table 3.11 gives the estimation results with monthly frequency as the dependent variable. The first column presents the pooled results for the three airline mergers, while the remaining columns refer to each merger individually. The results indicate that a merger leads to a decreased monthly flight frequency, with the effect being stronger in the long term. In the first post-merger year, the average monthly frequency of flights offered by the merged airlines between two given airports decreased by 10.83%. This decrease rose to 11.77% 2-3 years post-merger. The differentiated results for the individual mergers demonstrate that the flight frequency significantly decreased in all three cases; however, there were substantial differences between them. Specifically, the United Airlines–Continental Airlines merger led to a decrease in the flight frequency by 19.91% and 26.95% in the short and long terms, respectively. In contrast, the Delta–Northwest Airlines and American Airlines–US Airways mergers led to an approximately 7% decrease in the short term, with similar long-term effects. Hence, Table 3.11 demonstrates that the stronger long-term effect observed in the pooled results is primarily due to the United Airlines–Continental Airlines merger.

To conclude, Table 3.11 strongly suggests that airline mergers lead to lower flight frequencies, although there are substantial differences between the three mergers investigated here. The United Airlines–Continental Airlines merger caused the largest decrease, with a stronger effect in the long term; the effect was weaker for the two other mergers, and there was also less difference between the short and long terms.

Post-merger de-hubbing and its effect on product quality

The extra travel time, number of nonstop destinations, total number of destinations, and flight frequency are used as the dependent variables in examining how hub operations affect product quality. Table 3.12, presenting the estimation results for each product quality proxy, suggests that having more hub airports correlates with a significant reduction in the average difference between the total travel time and the average nonstop travel time. Furthermore, airlines' additional hub operations increase the number of nonstop destinations, although there is no such significant effect on the total number of destinations. Finally, based on the results of the estimation, with the addition of more hub airports, the flight frequency increases significantly. The expansion of hub operations implies that airlines are adding spokes to their network structures, meaning that passengers will experience reduced travel times and more nonstop flight options. In summary, Table 3.12 shows that post-merger de-hubbing leads to an increase in the extra travel time and decreases in the number of nonstop destinations and flight frequency.

The quality effect of de-hubbing seems to be stronger for the markets in which the merging carriers de-hubbed. Table 3.13 indicates that post-merger de-hubbing significantly reduced passengers' convenience owing to the extra travel time required relative to a nonstop flight from the same origin to destination airports. The interactions terms of the coefficients of both $PostMerger1 \cdot Dehub$ and $PostMerger23 \cdot Dehub$ were positively significant and of similar magnitude, which suggests that the airlines did not return to their original product quality and were unlikely to re-hub, even in the long term, once they ceased their hubbing activity.

Among the findings for the mergers at the individual level, reduced passenger convenience at de-hubbed airports following the Delta–Northwest Airlines merger stands out. Specifically, the merger lengthened the extra flight time to and from the de-hubbed airports by 22.97% and 21.58% in the short and long terms, respectively.

Cincinnati/Northern Kentucky International Airport and Memphis International Airport were de-hubbed by Delta, which scaled back the number of nonstop flights to and from those airports. A similar effect occurred following the United–Continental Airlines merger, wherein United Airlines' post-merger de-hubbing of Cleveland Hopkins International Airport increased passengers' extra travel time by 14.94% and 12.01% in the short and long terms, respectively.[31]

The regression results using the dependent variables of the number of nonstop destinations and the number of both nonstop and connection destinations at an airport are in line with the results showing that de-hubbing adds extra travel time, thereby reducing product quality. As shown in Table 3.14, the de-hubbing following the Delta–Northwest Airlines merger reduces the number of nonstop flights destinations to and from the de-hubbed airports by 48.9% and 43.29% in the short and long terms, respectively. A similar trend is observed following the United–Continental Airlines merger, which leads to a decrease in the number of nonstop destinations at de-hubbed airports by 27.28% in the short term and 29.44% in the long term. However, despite the considerable reduction in nonstop destinations at former hub airports following de-hubbing, no significant effect is seen for the total number of destinations. Table 3.15 presents the regression estimates for the total number of destinations and indicates that mergers have an insignificant effect on the number of destinations offered at post-merger de-hubbed airports in both the short and long terms.

Table 3.16 demonstrates the mergers' significant effect on the flight frequency at de-hubbed airports. The Delta–Northwest Airlines merger resulted in a 31.59% reduction in the frequency of flights departing from de-hubbed airports in the short term,

[31] As the pre- and post-de-hubbing periods for Memphis overlap with the de-hubbing period for Cleveland, a robustness check is performed by excluding any observations relating to routes with Cleveland as an end-point airport from the regression for the Delta–Northwest Airlines merger. Similarly, any observations for routes with Memphis as an end-point airport are excluded from the regression for the United–Continental Airlines merger. The results are qualitatively similar to those reported throughout for both the Delta–Northwest Airlines and United–Continental Airlines mergers.

rising to 40.84% in the long term. While the impact on flight frequency is weaker, the merged United Airlines also significantly reduced departures from de-hubbed airports. Following de-hubbing, low-cost carriers expanded into all three airports, which further prompted the network carriers' withdrawal from them. Airports tend to strategically favor low-cost carriers to reduce costs and airport charges, and thus the infrastructure dedicated to supporting legacy carriers' long-haul flights ceased to be financially viable. Such strategy changes are likely irreversible, with legacy carriers unwilling to offer higher flight frequency due to aggressive competition from low-cost carriers. This might be the reason why the effect is stronger in the long term than the short term.

To conclude, the results demonstrate that following post-merger de-hubbing, consumers experience fewer departures and a reduced number of nonstop flight destinations as many of these are only available at a hub. Travel times on routes previously serviced by nonstop flights consequently increase and entail more inconvenience for passengers due to the additional flights required. Although this study focuses solely on consumer welfare in the context of airline mergers' effect on product quality due to de-hubbing, the de-hubbed airports' cities are also likely to experience an impact in their overall business environment. For example, declining air travel product quality can make a location less attractive to new firms and cause existing firms to relocate to areas with increased connectivity, thereby restricting local business growth. Hence, while de-hubbing leads to a loss of airport-related jobs in the short term, service-related employment relying on frequent business travel is similarly affected in the long term. However, as de-hubbing-related changes in the business environment are beyond the scope of this study, this represents an interesting avenue for future research.[32]

[32]Quantifying the relationship between airline traffic and employment, Brueckner (2003) revealed that a 10 percent decrease in the number of passengers in a metro area reduces the number of service-related jobs in that area by approximately 1 percent.

Airline mergers' product quality effect and pre-merger competition

To investigate whether the effect of mergers on product quality varies with pre-merger competition, three pre-merger market competition dummies are used, namely 1) if both merging carriers were pre-merger market competitors, 2) if one merging carrier maintained a monopoly, and 3) one merging carrier competed with other non-merging carriers on a route.

Table 3.17 presents the estimation results for the mergers' impact on extra travel time based on the existence of pre-merger competition. Considering all three airline mergers taken together, if one merging carrier was previously competing with non-merging carriers on a route, then the extra travel time from the origin to destination airports significantly decreased on routes served by the merging carriers. For mergers at the individual level, that extra travel time decreased by 5.08%, 3.39%, and 5.17% in the short term for the Delta–Northwest Airlines, United–Continental Airlines, and American–US Airways mergers, respectively, with similar effects in the long term. Thus, consumers in those markets experience an increase in welfare due to the increased convenience of flights. If one of the merging carriers operated alone in those markets prior to merger, then such results are to be expected; because the route's market structure remains relatively unaffected, a merger causes no significant changes to the extra travel time. When merging carriers competed in the same market, the mergers increased the extra travel time between the origin and destination airports by 6.07% in the short term and 3.94% in the long term. The Delta–Northwest Airlines, United–Continental Airlines, and American–US Airways mergers precipitated short-term extra travel time increases of 6.55%, 5.49%, and 4.51%, respectively, for the products offered on routes in which the merging airlines competed pre-merger; however, the effect's magnitude weakened in the long term. These results are consistent with Chen and Gayle's (2019) theoretical prediction that mergers enhance product quality under low pre-merger competition intensity yet decrease quality under high

pre-merger competition intensity.

Table 3.18 gives the estimation results when the number of nonstop destinations at end-point airports are the dependent variable, based on pre-merger competition. If one of the merging carriers previously either had a monopoly or competed with a non-merging carrier at two end-point airports in a market, the impact on the number of nonstop destinations is insignificant in both the short and long terms. Meanwhile, in the long term, mergers are associated with a 3.31% reduction in the number of nonstop destinations at end-point airports in a market where the merging carriers did previously compete. Although the Delta–Northwest Airlines merger has no significant impact on the number of nonstop destinations, the United–Continental Airlines and American–US Airways mergers correlate with 3.49% and 2.9% reductions in the number of nonstop destinations, respectively, in the long term.

Table 3.19 provides the results when the number of nonstop and connecting flight destinations at two end-point airports of the market is the dependent variable for the three pre-merger competition scenarios. The results for both the pooled and individual mergers indicate that a merger's impact on the number of destinations does not correlate with the market's pre-merger competition conditions.

Overall, the empirical analysis of how pre-merger competition influences the effect of mergers on consumers' connectivity indicates that it is not an important factor in airlines' decision-making regarding market entry or exit.

Table 3.20 outlines the estimation results for the impact of airline mergers on flight frequency considering the pre-merger competition. The pooled results for the three mergers show that if one of the merging carriers previously competed with a non-merging carrier on a given route, its flight frequency declined following the merger. For the individual merger cases, the impact on flight frequency is similar to the effects seen in the pooled regression: The estimated coefficient is insignificant if a merging airline previously had a monopoly in the market. This indicates that in such

cases, mergers do not significantly change the flight frequency due to the relatively insubstantial effect on the route's competition structure.

However, the results also indicate that if the merging carriers were previously market competitors, a merger will lead, on average, to a 6.07% decrease in their flight frequencies in the short term, rising to 9.93% in the long term. Hereby, the American Airlines–US Airways merger showed the strongest effect, with an 8.15% flight frequency decrease in the short term that increased to 12.77% in the long term. As the Department of Justice raised anti-competitive concerns during the merger proposal, the merged American Airlines divested a substantial number of take-off and landing slots to low-cost carriers at some airports in which they competed each other prior to merger, leading to a significant reduction in its flight frequency.

3.6 Conclusion

Over the last three decades, the U.S. airline industry has been experiencing mergers between its major carriers. Unlike the extant economics literature on horizontal mergers, which focuses on the price effects, This chapter assessed the product quality changes following three recent airline mergers by measuring the average difference between the total travel time and average nonstop travel time between origin and destination airports as well as the flight frequency and number of destinations offered at airports by the merging carriers. The empirical results suggest that each merger prompted an increase in the extra travel time. De-hubbing airports significantly increased the overall extra travel time, even more so for airports that were de-hubbed when the merged carriers reduced their nonstop services during their post-merger network restructuring. Furthermore, each merger was found to associate with decreased extra travel time in markets in which the merging airlines did not previously compete, and increased extra travel time in markets in which they did.

The results also indicate a significant increase in the number of overall destina-

tions offered at airports served by merging airlines, although this is not reflected in the number of nonstop destinations. Accordingly, any product quality improvement arising from enhanced passenger connectivity is likely owing to the post-merger addition of connecting services. However, as the merged airlines substantially curtailed their nonstop flights serving these airports, passengers using post-merger de-hubbed airports experienced reduced connectivity, i.e. a decline in air travel product quality. Finally, there is no evidence that pre-merger competition correlates with the number of destinations offered by merged carriers at airports, indicating that airlines may consider pre-merger competition on a route less than market size, demand forecasting, hub connectivity or aircraft availability during their market exit/entry decision-making. Meanwhile, the results also indicate that mergers tend to lead to a decrease in flight frequency, meaning passengers experience less flexibility concerning flight options, with the effect appearing to be stronger for markets in which the merging carriers had previously competed.

This study opens up an avenue for future research. While network restructuring, e.g. de-hubbing, and pre-merger competition were here found to lead to varying effects of mergers on product quality, there are likely to be additional reasons for the differences between the three mergers observed here. This appears to offer a rich field for additional investigation, and future studies could consider different quality aspects to explore the effects of mergers.

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Table 3.1: Observed De-Hubbing

Airport	De-Hubbed Date	Merger	Merger Year
Cincinnati (CVG)	May 2012	Delta - Northwest Airlines	2008
Memphis (MEM)	Sep 2013	Delta - Northwest Airlines	2008
Cleveland (CLE)	June 2014	United - Continental Airlines	2010

Table 3.2: Number of Nonstop Flight Changes after De-Hubbing

Airport		CVG	MEM	CLE
De-hubbed Airline		Delta Airlines	Delta Airlines	United Airlines
Number of	Pre De-Hubbing	121	147	147
Nonstop Flight	Post De-Hubbing	52	61	58
% Change		-42.9%	-58.5%	-60.4%

Table 3.3: Delta and Northwest Airlines Network Structure Changes Between Pre- and Post-Merger Periods

	Number of Routes				
	Nonstop & Connect	Nonstop Only	Connect Only	No Service (Exit)	Total No. Route (Pre-Merger)
Nonstop & Connect	697	128	308	51	1,184
Nonstop Only	71	245	2	98	416
Connect Only	111	2	5,581	872	6,566
No Service (Entry)	34	100	718		1,093
Total No. Route (Post-Merger)	913	475	6,609	1,021	9,018

Table 3.4: United and Continental Airlines Network Structure Changes Between Pre- and Post-Merger Periods

	Number of Routes				
	Nonstop & Connect	Nonstop Only	Connect Only	No Service (Exit)	Total No. Route (Pre-Merger)
Nonstop & Connect	532	54	101	9	696
Nonstop Only	103	336	16	52	507
Connect Only	99	11	4321	700	5131
No Service (Entry)	50	124	1,204		1,378
Total No. Route (Post-Merger)	784	525	5,642	761	7,712

Table 3.5: American and US Airways Network Structure Changes Between Pre- and Post-Merger Periods

	Number of Routes				
	Nonstop & Connect	Nonstop Only	Connect Only	No Service (Exit)	Total No. Route (Pre-Merger)
Nonstop & Connect	873	102	318	61	1,354
Nonstop Only	126	382	9	67	584
Connect Only	259	13	5,891	909	7,702
No Service (Entry)	118	103	1,555		1,776
Total No. Route (Post-Merger)	1,376	600	7,773	1,037	10,786

Table 3.6: Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
Extra travel time (min)	42.81	40.50	0	291
No. Nonstop destinations	41.05	31.79	17	71
No. destination	62.51	39.66	31	148
Merger01 (dummy variable)	0.075	0.317	0	1
Merger23 (dummy variable)	0.076	0.331	0	1
Hub	0.16	0.1	0	1
Nonstop	0.27	0.22	0	1
Itinerary flight distance (miles)	1508.21	627.19	50	4099
Nonstop flight distance (miles)	1308.55	607.34	50	2857
No. competitors' nonstop destinations	2.87	2.08	0	32
No. competitors' connect destinations	9.81	8.07	0	89
American	0.20	0.19	0	1
Continental	0.09	0.25	0	1
Delta	0.18	0.22	0	1
United	0.15	0.28	0	1
US Airways	0.09	0.27	0	1
JetBlue	0.05	0.14	0	1
Southwest	0.16	0.29	0	1
Virgin Atlantic	0.02	0.20	0	1
Number of Observations	771,057			

Notes: The data were extracted for the period between January 2008 and December 2018.

Table 3.7: Estimation Results for Pre-Merger Trend Analysis

	Dependent variable			
	(1)	(2)	(3)	(4)
	Extra Travel Time	Number of Nonstop Destinations	Total Number of Destinations	Flight Frequency
Merging carrier	0.0025	0.0014	-0.0015	0.0010
	(0.0008)	(0.0005)	(0.0009)	(0.0002)
Time trend	0.0038	0.0021	0.0020	0.0009
	(0.0004)	(0.0003)	(0.0003)	(0.0001)
Merging carrier·Time trend	0.0029	0.0016	-0.0011	0.0010
	(0.0001)	(0.0005)	(0.0008)	(0.0001)
Observations	310,859	310,859	310,859	310,859

Notes: Standard errors in parentheses $^{***} < 0.01$, $^{**} < 0.05$, $^{*} < 0.10$. $TimeTrend_t$ is the linear time trend of the twelve quarters comprising the pre-merger periods. All estimations include Year-Quarter dummies and Carrier dummies.

Table 3.8: Effect of Mergers on Extra Travel Time (Baseline)

	Dependent variable: $\log(ExtraTravelTime)$			
	(1)	(2)	(3)	(4)
	Pooling	DL/NW	UA/CO	AA/US
PostMerge01	0.0981***	0.1291***	0.0808***	0.0813***
	(0.0011)	(0.0015)	(0.0009)	(0.0010)
PostMerge23	0.1108***	0.1417***	0.0971***	0.0994***
	(0.0014)	(0.0027)	(0.0015)	(0.0019)
Hub	-0.1277***	-0.1002***	-0.0925***	-0.1371***
	(0.0029)	(0.0020)	(0.0035)	(0.0020)
Nonstop distance (Miles)	-0.0401***	-0.0483***	0.0558***	0.0408**
	(0.0011)	(0.0011)	(0.0013)	(0.0002)
No. competitors'	-0.0790***	-0.0846***	-0.0677***	0.0899***
Nonstop destinations	(0.0020)	(0.0029)	(0.0029)	(0.00398)
No. competitors'	0.0019	0.0021	0.0016	0.0016
Connect destinations	(0.0002)	(0.0001)	(0.0000)	(0.0001)
Observations	771,057	270,214	262,440	231,752
R-squared	0.4355	0.4349	0.4210	0.4815

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies.

Table 3.9: Effect of Mergers on Number of Nonstop Destinations (Baseline)

	Dependent variable: log (*NonstopDestinations*)			
	(1) Pooling	(2) DL/NW	(3) UA/CO	(4) AA/US
PostMerge01	0.0104	0.0092	0.0108*	0.0091
	(0.0004)	(0.0002)	(0.0004)	(0.0001)
PostMerge23	0.0095	0.0099	0.0101	0.0085
	(0.0006)	(0.0010)	(0.0002)	(0.0002)
Hub	0.3601***	0.3596***	0.3030***	0.3811***
	(0.0118)	(0.0209)	(0.0122)	(0.0202)
Nonstop distance (Miles)	0.0601***	0.0596***	0.0630***	0.0511***
	(0.0018)	(0.0009)	(0.0022)	(0.0014)
No. competitors'	0.1042***	0.1268***	0.0810***	0.1106***
Nonstop destinations	(0.0109)	(0.0210)	(0.0098)	(0.0105)
No. competitors'	-0.0489***	-0.0520***	-0.0419***	0.0493***
Connect destinations	(0.0054)	(0.0038)	(0.0052)	(0.0061)
Observations	771,057	270,214	262,440	231,752
R-squared	0.3367	0.3389	0.3381	0.3397

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies.

Table 3.10: Effect of Mergers on Number of Destinations (Baseline)

	Dependent variable: log (*Destinations*)			
	(1)	(2)	(3)	(4)
	Pooling	DL/NW	UA/CO	AA/US
PostMerge01	0.0591***	-0.0308***	0.0663***	0.0807***
	(0.0010)	(0.0008)	(0.0023)	(0.0026)
PostMerge23	0.0929***	-0.0104*	0.0992***	0.1107***
	(0.0018)	(0.0004)	(0.0018)	(0.0019)
Hub	0.4001***	0.3096***	0.4530***	0.4197***
	(0.0226)	(0.0304)	(0.0118)	(0.0098)
Nonstop distance (Miles)	0.0552***	0.0501***	0.0612***	0.0533***
	(0.0019)	(0.0010)	(0.0020)	(0.0016)
No. competitors'	0.0802***	0.0780***	0.0951***	0.0900***
Nonstop destinations	(0.0115)	(0.0160)	(0.0099)	(0.0102)
No. competitors'	0.0028	0.0052	0.0012	0.0037
Connect destinations	(0.0001)	(0.0001)	(0.0003)	(0.0001)
Observations	771,057	270,214	262,440	231,752
R-squared	0.3609	0.3711	0.3736	0.3694

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies.

Table 3.11: Effect of Mergers on Flight Frequency (Baseline)

	Dependent variable: log (*Frequency*)			
	(1)	(2)	(3)	(4)
	Pooling	DL/NW	UA/CO	AA/US
PostMerge01	-0.1083***	-0.0712***	-0.1991***	-0.0781***
	(0.0039)	(0.0018)	(0.0059)	(0.0021)
PostMerge23	-0.1177***	-0.0759*	-0.2695***	-0.0787***
	(0.0018)	(0.00411)	(0.0043)	(0.0020)
Hub	0.1905***	0.1817***	0.2055***	0.2017***
	(0.0085)	(0.0081)	(0.0094)	(0.0071)
Nonstop distance (Miles)	0.0088	-0.0027	0.0091	0.0074
	(0.0001)	(0.0008)	(0.0002)	(0.0005)
No. competitors'	0.0104*	0.0094	0.0128*	0.0101*
Nonstop destinations	(0.0093)	(0.0079)	(0.0086)	(0.0074)
No. competitors'	0.0035	0.0041	0.0029	0.0038
Connect destinations	(0.0001)	(0.0004)	(0.0001)	(0.0002)
Observations	771,057	270,214	262,440	231,752
R-squared	0.3155	0.3607	0.3691	0.3699

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies.

Table 3.12: The Effect of De-Hubbing on Product Quality

	Dependent variable			
	(1) Extra Travel Time	(2) Number of Nonstop Destinations	(3) Total Number of Destinations	(4) Flight Frequency
Number Hub Airports	-0.0591***	0.0704***	0.0026	0.0490***
	(0.0039)	(0.0055)	(0.0011)	(0.0002)
Hub	-0.1186***	0.3380***	0.3702***	0.1737***
	(0.0084)	(0.0102)	(0.0097)	(0.0059)
Observations	771,057	771,057	771,057	771,057

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. All estimations include Year-Quarter dummies, carrier dummies and control variables.

Table 3.13: Post-Merger De-Hubbing and its Effect on Extra Travel Time

	Dependent variable: $\log(ExtraTravelTim)$		
	(1)	(2)	(3)
	Pooling	DL/NW	UA/CO
PostMerge01	0.0871***	0.1002***	0.0890***
	(0.0008)	(0.0015)	(0.0010)
PostMerge23	0.0909***	0.0902**	0.0921***
	(0.0009)	(0.0013)	(0.0011)
De-hub	0.0551***	0.0690***	0.0583***
	(0.0011)	(0.0017)	(0.0012)
PostMerge01×Dehub	0.1861***	0.2297***	0.1494***
	(0.0026)	(0.0027)	(0.0021)
PostMerge23×Dehub	0.1661***	0.2158***	0.1201***
	(0.0014)	(0.0022)	(0.0011)
Hub	-0.1380***	-0.1449***	-0.0977***
	(0.0012)	(0.0014)	(0.0030)
Nonstop distance (Miles)	0.0358***	0.0470***	0.0308***
	(0.0011)	(0.0016)	(0.0016)
No. competitors'	-0.0704***	-0.0818***	-0.0621***
Nonstop destinations	(0.0020)	(0.0029)	(0.0011)
No. competitors'	0.0028	0.0031	0.0017***
Connect destinations	(0.0002)	(0.0003)	(0.0001)
Observations	771,057	250,214	259,735
R-squared	0.4107	0.4227	0.4283

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies.

Table 3.14: Post-Merger De-Hubbing and its Effect on on Number of Nonstop Destinations

	Dependent variable: log (*NonstopDestinations*)		
	(1)	(2)	(3)
	Pooling	DL/NW	UA/CO
PostMerge01	0.0118	0.0099	0.0126*
	(0.0003)	(0.0001)	(0.0003)
PostMerge23	0.0102	0.0101	0.0103
	(0.0004)	(0.0008)	(0.0003)
De-hub	-0.2199***	-0.2857***	-0.2092***
	(0.0027)	(0.0025)	(0.0020)
PostMerge01×Dehub	-0.3811***	-0.4890***	-0.2728***
	(0.0036)	(0.0029)	(0.0034)
PostMerge23×Dehub	-0.3682***	-0.4329***	-0.2944***
	(0.0030)	(0.0024)	(0.0034)
Hub	0.3508***	0.3509***	0.3118***
	(0.0108)	(0.0201)	(0.0102)
Nonstop distance (Miles)	0.0716***	0.0660***	0.0784***
	(0.0024)	(0.0010)	(0.0015)
No. competitors'	0.0991***	0.1158***	0.0893***
Nonstop destinations	(0.0101)	(0.0108)	(0.0077)
No. competitors'	-0.0491***	-0.0513***	-0.0447***
Connect destinations	(0.0051)	(0.0024)	(0.0050)
Observations	771,057	250,214	259,735
R-squared	0.4859	0.4977	0.4968

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies.

Table 3.15: Post-Merger De-Hubbing and its Effect on Total Number of Destinations

	Dependent variable: log (*Destinations*)		
	(1)	(2)	(3)
	Pooling	DL/NW	UA/CO
PostMerge01	0.0505***	-0.0291***	0.0601***
	(0.0009)	(0.0009)	(0.0021)
PostMerge23	0.0916***	-0.0101*	0.0853***
	(0.0020)	(0.0004)	(0.0015)
De-hub	-0.0094	-0.0097*	-0.0081
	(0.0012)	(0.0011)	(0.0009)
PostMerge01×Dehub	-0.0108	-0.0129*	-0.0088
	(0.0011)	(0.0010)	(0.0010)
PostMerge23×Dehub	-0.0101	-0.0107	-0.0082
	(0.0010)	(0.0009)	(0.0010)
Hub	0.4209***	0.3811***	0.4690***
	(0.0273)	(0.0258)	(0.0270)
Nonstop distance (Miles)	0.0503***	0.0459***	0.0527***
	(0.0008)	(0.0021)	(0.0010)
No. competitors'	0.0716***	0.0637***	0.0749***
Nonstop destinations	(0.0085)	(0.0093)	(0.0081)
No. competitors'	0.0020	0.0048	0.0033
Connect destinations	(0.0001)	(0.0006)	(0.0001)
Observations	771,057	250,214	259,735
R-squared	0.4705	0.4819	0.4863

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies.

Table 3.16: Post-Merger De-Hubbing and its Effect on Flight Frequency

	Dependent variable: $\log(Frequency)$		
	(1)	(2)	(3)
	Pooling	DL/NW	UA/CO
PostMerge01	-0.1005***	-0.3084***	-0.1999***
	(0.0047)	(0.0048)	(0.0017)
PostMerge23	-0.1124***	-0.4018***	-0.2607***
	(0.0059)	(0.0071)	(0.0020)
De-hub	-0.1193***	-0.1691***	-0.1049***
	(0.0012)	(0.0015)	(0.0012)
PostMerge01×Dehub	-0.2850***	-0.3159***	-0.2108***
	(0.0047)	(0.0052)	(0.0018)
PostMerge23×Dehub	-0.3588***	-0.4084***	-0.2719***
	(0.0071)	(0.0070)	(0.0022)
Hub	0.1769***	0.1558***	0.1930***
	(0.0070)	(0.0071)	(0.0078)
Nonstop distance (Miles)	0.0058	-0.0014	0.0090
	(0.0002)	(0.0004)	(0.0002)
No. competitors'	0.0115*	0.0095	0.0117*
Nonstop destinations	(0.0075)	(0.0061)	(0.0069)
No. competitors'	0.0030	0.0045	0.0031
Connect destinations	(0.0001)	(0.0003)	(0.0002)
Observations	771,057	250,214	259,735
R-squared	0.4705	0.4819	0.4863

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies.

Table 3.17: Effect of Mergers on Extra Travel Time (Existence of Pre-Merger Competition)

	Dependent variable: log ($ExtraTravelTime$)			
	(1)	(2)	(3)	(4)
	Pooling	DL/NW	UA/CO	AA/US
PostMerge01	0.0917***	0.1183***	0.0814***	0.0809***
	(0.0011)	(0.0010)	(0.0009)	(0.0016)
PostMerge23	0.1205***	0.1637**	0.1026***	0.0911***
	(0.0016)	(0.0021)	(0.0010)	(0.0015)
PostMerge01×competition	-0.0471***	-0.0508***	-0.0339***	-0.0517***
	(0.0008)	(0.0009)	(0.0004)	(0.0006)
PostMerge02×Competition	-0.0450***	-0.0512***	-0.0301***	-0.0529***
	(0.0004)	(0.0009)	(0.0011)	(0.0010)
PostMerge01×Monopoly	0.0011	0.0010	0.0015	-0.0008
	(0.0001)	(0.0001)	(0.0002)	(0.0001)
PostMerge23×Monopoly	0.0011	0.0012	0.0011	-0.0010
	(0.0001)	(0.0000)	(0.0001)	(0.0001)
PostMerge01×Both Serve	0.0607***	0.0655***	0.0549***	0.0451***
	(0.0018)	(0.0016)	(0.0031)	(0.0020)
PostMerge23×Both Serve	0.0545***	0.0581***	0.0430***	0.0388***
	(0.0011)	(0.0011)	(0.0012)	(0.0010)
Hub	-0.1138***	-0.1001***	-0.0797***	-0.1183***
	(0.0020)	(0.0015)	(0.0020)	(0.0020)
Nonstop distance (Miles)	0.0402***	0.0337***	0.409***	0.0375**
	(0.0011)	(0.0009)	(0.0012)	(0.0008)
No. competitors'	-0.0757***	-0.0719***	-0.0690***	0.0811***
Nonstop destinations	(0.0020)	(0.0019)	(0.0014)	(0.0027)
No. competitors'	0.0020	0.0024	0.0012	0.0015
Connect destinations	(0.0002)	(0.0003)	(0.0001)	(0.0001)
Observations	771,057	281,007	260,799	220,008
R-squared	0.3924	0.4095	0.4133	0.4018

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies. Both Serve indicates market where both merging carriers were pre-merger market competitors. Monopoly indicate market where merging carrier maintained a monopoly. Competition indicates one merging carrier competed with other non-merging carriers on a route.

Table 3.18: Effect of Mergers on Number of Nonstop Destinations (Existence of Pre-Merger Competition)

	Dependent variable: log (*NonstopDestinations*)			
	(1)	(2)	(3)	(4)
	Pooling	DL/NW	UA/CO	AA/US
PostMerge01	0.0085	0.0094	0.0091	0.0080
	(0.0004)	(0.0002)	(0.0004)	(0.0001)
PostMerge23	0.0081	0.0092	0.0094	0.0073
	(0.0004)	(0.0011)	(0.0002)	(0.0001)
PostMerge01×competition	0.0010	0.0021	0.0025	0.0017
	(0.0003)	(0.0001)	(0.0001)	(0.0002)
PostMerge02×Competition	0.0009	0.0011	0.0015	0.0011
	(0.0001)	(0.0001)	(0.0004)	(0.0001)
PostMerge01×Monopoly	0.0004	0.0018	0.0002	0.0004
	(0.0000)	(0.0003)	(0.0001)	(0.0001)
PostMerge23×Monopoly	0.0004	0.0015	0.0002	0.0006
	(0.0001)	(0.0002)	(0.0001)	(0.0001)
PostMerge23×Both Serve	-0.0053	-0.0028	-0.0077	-0.0051
	(0.0011)	(0.0003)	(0.0001)	(0.0002)
PostMerge23×Both Serve	-0.0331***	-0.0058	-0.0349***	-0.0290***
	(0.0004)	(0.0002)	(0.0005)	(0.0010)
Hub	0.3580***	0.3477***	0.3001***	0.3849***
	(0.0210)	(0.0200)	(0.0119)	(0.0183)
Nonstop distance (Miles)	0.0555***	0.0513***	0.0637***	0.0561***
	(0.0030)	(0.0026)	(0.0049)	(0.0017)
No. competitors'	0.0999***	0.1108***	0.0815***	0.1109***
Nonstop destinations	(0.0150)	(0.0211)	(0.0097)	(0.0120)
No. competitors'	-0.0510***	-0.0608***	-0.0433***	0.0519***
Connect destinations	(0.0059)	(0.0040)	(0.0050)	(0.0082)
Observations	771,057	281,007	260,799	220,008
R-squared	0.3900	0.3993	0.3890	0.3991

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies. Both Serve indicates market where both merging carriers were pre-merger market competitors. Monopoly indicate market where merging carrier maintained a monopoly. Competition indicates one merging carrier competed with other non-merging carriers on a route.

Table 3.19: Effect of Mergers on Total Number of Destinations (Existence of Pre-Merger Competition)

	Dependent variable: log (*Destinations*)			
	(1)	(2)	(3)	(4)
	Pooling	DL/NW	UA/CO	AA/US
PostMerge01	0.0599***	-0.0288***	0.0676***	0.0833***
	(0.0010)	(0.0007)	(0.0020)	(0.0025)
PostMerge23	0.0900***	-0.0099*	0.0861***	0.1001***
	(0.0015)	(0.0002)	(0.0012)	(0.0015)
PostMerge01×competition	0.0057	0.0055	0.0072	0.0039
	(0.0002)	(0.0011)	(0.0001)	(0.0008)
PostMerge02×Competition	0.0026	0.0021	0.0040	0.0014
	(0.0004)	(0.0001)	(0.0001)	(0.0001)
PostMerge01×Monopoly	0.0008	0.0002	0.0004	0.0011
	(0.0001)	(0.0001)	(0.0001)	(0.0002)
PostMerge23×Monopoly	0.0008	0.0002	0.0003	0.0012
	(0.0001)	(0.0001)	(0.0003)	(0.0002)
PostMerge23×Both Serve	-0.0011	-0.0010	-0.0023	-0.0006
	(0.0010)	(0.0003)	(0.0001)	(0.0001)
PostMerge23×Both Serve	-0.0010	-0.0010	-0.0020	-0.0005
	(0.0011)	(0.0001)	(0.0002)	(0.0001)
Hub	0.4221***	0.3106***	0.4429***	0.4200***
	(0.0255)	(0.0319)	(0.0100)	(0.0090)
Nonstop distance (Miles)	0.0630***	0.0600***	0.0683***	0.0607***
	(0.0025)	(0.0010)	(0.0021)	(0.0017)
No. competitors'	0.0729***	0.0714***	0.0808***	0.0766***
Nonstop destinations	(0.0100)	(0.0097)	(0.0095)	(0.0095)
No. competitors'	0.0040	0.0068	0.0035	0.0039
Connect destinations	(0.0001)	(0.0001)	(0.0002)	(0.0002)
Observations	771,057	281,007	260,799	220,008
R-squared	0.3158	0.3227	0.3290	0.3296

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies. Both Serve indicates market where both merging carriers were pre-merger market competitors. Monopoly indicate market where merging carrier maintained a monopoly. Competition indicates one merging carrier competed with other non-merging carriers on a route.

Table 3.20: Effect of Mergers on Flight Frequency (Existence of Pre-Merger Competition)

	Dependent variable: log (*Frequency*)			
	(1)	(2)	(3)	(4)
	Pooling	DL/NW	UA/CO	AA/US
PostMerge01	-0.0944***	-0.0711***	-0.1851***	-0.0727***
	(0.0031)	(0.0019)	(0.0045)	(0.0014)
PostMerge23	-0.1114***	-0.0722*	-0.2215***	-0.0760***
	(0.0015)	(0.0014)	(0.0039)	(0.0012)
PostMerge01×competition	-0.0195***	-0.0186***	-0.0208***	-0.0214***
	(0.0010)	(0.0011)	(0.0008)	(0.0010)
PostMerge02×Competition	-0.0195***	-0.0181***	-0.0198***	-0.0207***
	(0.0010)	(0.0010)	(0.0009)	(0.0008)
PostMerge01×Monopoly	0.0004	0.0005	0.0001	0.0008
	(0.0001)	(0.0002)	(0.0001)	(0.0001)
PostMerge23×Monopoly	0.0004	0.0006	0.0002	0.0010
	(0.0001)	(0.0002)	(0.0001)	(0.0001)
PostMerge23×Both Serve	-0.0607***	-0.0413***	-0.0428***	-0.0815***
	(0.0011)	(0.0009)	(0.0015)	(0.0027)
PostMerge23×Both Serve	-0.0993***	-0.0622***	-0.0690***	-0.1277***
	(0.0012)	(0.0010)	(0.0019)	(0.0033)
Hub	0.1718***	0.1492***	0.1881***	0.1893***
	(0.0061)	(0.0070)	(0.0070)	(0.0065)
Nonstop distance (Miles)	0.0050	-0.0020	0.0075	0.0069
	(0.0001)	(0.0001)	(0.0001)	(0.0002)
No. competitors'	0.0097	0.0091	0.0099	0.0092
Nonstop destinations	(0.0041)	(0.0052)	(0.0060)	(0.0062)
No. competitors'	0.0035	0.0039	0.0032	0.0037
Connect destinations	(0.0002)	(0.0001)	(0.0002)	(0.0004)
Observations	771,057	281,007	260,799	220,008
R-squared	0.3380	0.3387	0.3424	0.3495

Notes: Standard errors in parentheses *** < 0.01, ** < 0.05, * < 0.10. DL/NW indicates the merger between Delta and Northwest Airline in 2008; UA/CO indicates that United and Continental merger in 2011; AA/US indicates that American Airlines and US Airways merger in 2014. All estimations include Year-Quarter dummies and Carrier dummies. Both Serve indicates market where both merging carriers were pre-merger market competitors. Monopoly indicate market where merging carrier maintained a monopoly. Competition indicates one merging carrier competed with other non-merging carriers on a route.