Mergers and Product Quality: Evidence from the Airline Industry

Yongmin Chen and Philip Gayle

University of Colorado at Boulder, Kansas State University

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Yongmin Chen†
University of Colorado at Boulder

Philip G. Gayle‡
Kansas State University

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Abstract

Retrospective studies of horizontal mergers have focused on their price effects, leaving the important question of how mergers affect product quality largely unanswered. This paper empirically investigates this issue for two recent airline mergers: Delta/Northwest and Continental/United. Consistent with the theoretical premise that mergers improve coordination but diminish competitive pressure for quality provision, we find: (i) each merger is associated with a quality increase in markets where the merging firms did not compete pre-merger, but with a quality decrease in markets where they did; and (ii) the quality change can be a U-shaped function of the pre-merger competition intensity.

JEL Classification: L13, L93

Keywords: Mergers; Product Quality; Airlines.

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†Department of Economics, University of Colorado at Boulder, Boulder, CO 80309 , Tel: (303)492-8736, email: Yongmin.Chen@colorado.edu.

‡Department of Economics, 320 Waters Hall, Kansas State University, Manhattan, KS, 66506. Tel. (785) 532-4581, Fax: (785) 532-6919, email: gaylep@ksu.edu. **Corresponding Author**.

1 Introduction

Retrospective studies of horizontal mergers tend to focus on the price effects of a merger, and often use the price effects to infer relative changes in market power and cost efficiencies associated with the merger. Such analyses implicitly assume that the quality of products do not change over the relevant pre-post merger periods.[1] However, price increases or decreases associated with a merger could be closely related to product quality changes. Given the importance of product quality to consumers, it would be imperative to understand the quality effects of mergers. In this paper, we aim to shed light on the relationship between mergers and product quality by empirically investigating two recent airline mergers — the Delta/Northwest (DL/NW) and the Continental/United (CO/UA) merger.

To motivate our empirical study, we first present a theoretical model with two firms that captures what we call the *coordination* and *incentive* effects of a merger on product quality. A horizontal merger allows two firms to share technology information and coordinate production, which can positively affect the quality of their products. However, the merger also has an incentive effect, as it eliminates the competitive pressure on the firms to provide high quality.[2] This incentive effect is usually negative, but its magnitude depends on how intense the two firms competed before the merger. While competitive pressure motivates firms to improve product quality, the diminished profit under competition, especially when competition intensity goes beyond certain point, can weaken the incentive for costly quality provision. Hence, before the merger, product quality could vary non-monotonically with competition intensity, possibly maximized at some intermediate level of competition intensity.[3] Consequently, the effect of a merger on quality can also be non-monotonic in pre-merger competition intensity, possibly most negative when the strength of pre-merger competition is at some intermediate point.

In markets where the two firms have little or no direct competition prior to the merger, the coordination effect dominates, so that the merger will increase product quality. As pre-merger competition is intensified, the negative incentive effect of the merger becomes more pronounced

[1] Notable exceptions include several studies of hospital mergers (see Mutter, Romano and Wong, 2011; Ho and Hamilton, 2000; and Romano and Balan, 2011). These studies find mixed results on the effect of hospital mergers on various measures of clinical quality, but a disproportionate portion of the evidence suggests clinical quality declines with hospital mergers.

[2] In a more general model, with only a subset of firms that merge in a market, the merger may diminish, without eliminating, the competitive pressure for quality provision. But the negative incentive effect is still likely to exist, and hence the trade off captured in our simple model will remain.

[3] This is reminiscent of the inverted-U relationship between innovation and competition, as in Aghion, etal. (2005).

and dominates the coordination effect. With further increases in competition intensity, however, it is possible that the incentive effect diminishes, alleviating the negative quality impact of the merger. Our theoretical model thus has two testable implications: (1) a merger tends to increase (or decrease) product quality in markets where the two merging firms had little (or substantial) pre-merger competition; and (2) the quality change due to the merger may vary non-monotonically as the intensity of pre-merger competition increases, possibly exhibiting a U-shaped relationship.

Equipped with the theoretical insights, we empirically explore how mergers affect product quality from two recent airline mergers, the Delta/Northwest and the Continental/United merger, where the merging firms produce in multiple markets. In some of the markets, the firms did not have pre-merger competition with each other, whereas in others they competed directly, with varying degrees of competition intensity.[4] These mergers thus offer a proper setting for our study.

Our specific measure of air travel product quality is what we refer to as *Routing Quality*. (In Section 3, we discuss in detail why we choose this measure in light of alternative measures of quality.) Related to travel convenience of the air travel product itinerary, routing quality is measured by the percentage ratio of nonstop flight distance to the product's itinerary flight distance used to get passengers from the origin to destination. Since some products have itineraries that require intermediate airport stop(s) that are not on a straight path between the origin and destination, each of these products will have an itinerary flight distance that is longer than the nonstop flight distance. The presumption here is that passengers find a nonstop itinerary most convenient to get to their destination. Therefore, the closer is the product's itinerary flight distance to the nonstop flight distance, i.e. higher values of our routing quality measure, the more desirable is the travel itinerary to passengers.

Our empirical analysis starts by estimating a discrete choice model of air travel demand. This serves two purposes. First, it verifies that passengers' choice behavior is consistent with that a higher routing quality measure is associated with a more passenger-desirable travel itinerary. Second, estimates of the pre-merger cross-price elasticities of demand between the two merging firms, in markets where they competed directly, serve as a useful indicator of the competition intensity. We then proceed to use a reduced-form regression equation of routing quality to evaluate

[4] The intensity of competiton may differ across markets, possibly because product offerings by the two firms differed across markets, or consumers have different preference diversities across markets (as, for example, in Chen and Savage, 2011). Our empirical work will estimate the cross-price elasticities of demand between the two firms' products, which serve as a measure of product differentiation and competition intensity.

effects that each of the two mergers have on product quality of the merged firms.

Consistent with theory, the regression estimates suggest that each merger is associated with an increase in routing quality in markets where the merging firms did not compete with each other prior to the merger, but with a decline in routing quality in markets where they did. Furthermore, in the case of the CO/UA merger, the change in product quality appears to exhibit a U-shaped relationship with the two firms' pre-merger competition intensity. We also find that, compared to the DL/NW merger, the CO/UA merger is associated with less severe quality declines and larger quality improvements. Thus, in terms of consumer welfare effects associated with product quality changes, our econometric analysis reveals evidence that on average consumers fared better under the CO/UA merger than under the DL/NW merger.

Since the deregulation of the US airline industry in 1978, there has been a number of mergers. Empirical studies of these mergers, similar to merger studies in other industries, have focused on price effects, and sometimes used these price effects to infer relative changes in market power and cost efficiencies associated with a merger (Werden, Joskow and Johnson, 1989; Borenstein, 1990; Kim and Singal, 1993; Peters, 2006; Luo, 2011). In case of the recent DL/NW and UA/CO mergers, Gayle and Le (2013) estimate marginal, recurrent fixed and sunk entry cost effects associated with these mergers. Even though there are several studies of the airline industry that examine the relationship between service quality and market structure/competition,[5] we are unaware of studies that explicitly analyze effects of mergers on air travel product quality.[6] Our paper contributes to this literature, as well as to understanding more generally how mergers affect product quality.

In the rest of the paper, we provide the theoretical motivation in section 2, describe the mergers and the data in section 3, and present the empirical model in section 4. Section 5 contains the empirical results, and section 6 concludes.

[5] Mazzeo (2003), Rupp, Owens and Plumly (2006), and Prince and Simon (2009) all find evidence that airlines provide worse on-time performance on less competitive routes. However, contrary to this result, Prince and Simon (2013) find that incumbents' on-time performance actually worsens in response to entry, and the threat of entry, by Southwest Airlines and other low-cost carriers.

[6] Draganska, Mazzeo and Seim (2009) and Fan (2012) constitute important methodological contributions in using econometric models to predict how mergers may influence non-price product characteristic choices. Draganska, Mazzeo and Seim (2009) applied their merger simulation analysis to the ice-cream industry, whereas Fan (2012) applied her merger simulation analysis to the newspaper industry. However, neither study is a retrospective analysis of how non-price product characteristics actually change subsequent to a merger, which is the focus of our study.

2 Theoretical Motivation

A merger by two firms allows them to share technology and coordinate production activities, which can positively affect the quality of their products. We call this the *coordination* effect of a merger. For example, an airline merger may allow the two airlines to coordinate their flight schedules to better serve consumer needs. On the other hand, a merger reduces the competitive pressure on quality improvement, which can negatively affect the quality of their products. In the context of an airline merger, this could be reduced product offerings that lessen travel convenience.[7] We call this the *incentive* effect of a merger. Our basic theoretical premise is that whether a merger will raise or lower product quality depends on the interaction of these two potential effects. When pre-merger competition between the two firms is weak, the coordination effect is likely to dominate. Otherwise, the merger is more likely to reduce product quality.

To fix ideas, consider the following simple model. Suppose that the two firms and their respective products are denoted as A and B. Their demand functions are, respectively:

$$\begin{aligned} q_A &= v_A - p_A + \beta\left(p_B - v_B\right), \\ q_B &= v_B - p_B + \beta\left(p_A - v_A\right), \end{aligned}$$

for $\beta \in [0,1)$, where β is a measure of product differentiation, and v_i represents the quality of product i for $i = A, B$. When $\beta = 0$, there is no competition between the two products, whereas a higher β indicates that the two products are closer substitutes, or the two firms have more intense pre-merger competition. Notice that for $\beta > 0$, the demand for product i is higher if the quality-adjusted price for the competing product, $p_j - v_j$, is higher.

Suppose that firm i can choose v_i at cost $\frac{1}{3}v_i^3$, and it chooses v_i and p_i at the same time.[8] Under competition, the two firms make their quality and price choices simultaneously. After merger, the merged firm M can choose v_i with cost $\alpha\frac{1}{3}v_i^3$, where $\alpha \in (1/2, 1]$ reflects the idea that M is able to coordinate its production to possibly have a lower cost for quality. Hence, a lower α indicates a stronger coordination effect. Other costs of production are normalized to zero.

[7] For example, competing airlines in a market may each provide nonstop and intermediate stop(s) products prior to merging, but find it profitable to eliminate the more travel-convenient nonstop product post-merger.

[8] It is possible to extend this analysis to allow q_i to be more general functions of v_i, v_j, p_i, and p_j, as well as to allow more general cost functions of providing v_i. With our more restrictive functional-form assumptions, we aim to obtain closed-form solutions and to illustrate the economic forces in a most transparent way.

Under competition, the firms' profit functions are:

$$\begin{aligned}\pi_A &= p_A\left[v_A - p_A - \beta\left(v_B - p_B\right)\right] - \frac{1}{3}v_A^3,\\ \pi_B &= p_B\left[v_B - p_B - \beta\left(v_A - p_A\right)\right] - \frac{1}{3}v_B^3.\end{aligned}$$

At a Nash equilibrium, firm $i's$ strategy (p_i, v_i), $i = A, B$, satisfies $\partial\pi_i/p_i = 0$ and $\partial\pi_i/v_i = 0$. The unique symmetric equilibrium, which solves these first-order conditions, give

$$p^d = \frac{(1-\beta)^2}{(2-\beta)^2}; \qquad v^d = \frac{1-\beta}{2-\beta}, \tag{1}$$

and this is also the unique Nash equilibrium when $\beta \leq 0.56$. We shall focus on the symmetric equilibrium for the rest of our analysis.

After the merger, M chooses p_A, p_B, v_A, v_B to maximize its joint profit from both products:

$$\pi_M = p_A\left[v_A - p_A - \beta\left(v_B - p_B\right)\right] + p_B\left[v_B - p_B - \beta\left(v_A - p_A\right)\right] - \frac{\alpha}{3}\left(v_A^3 + v_B^3\right).$$

From the first-order conditions, $\partial\pi_M/p_i = 0$ and $\partial\pi_M/v_i = 0$, $i = A, B$, the merged firm's optimal choices of price and quality are obtained as

$$p^M = \frac{1-\beta}{4\alpha}, \qquad v^M = \frac{1-\beta}{2\alpha}. \tag{2}$$

Notice that the change in product quality due to the merger is

$$v^M - v^d = \left(\frac{1}{2\alpha} - \frac{1}{2-\beta}\right)(1-\beta). \tag{3}$$

It follows that $v^M - v^d < (>)\ 0$ if $2(1-\alpha) < (>)\ \beta$. That is, a merger reduces product quality in markets where the coordination benefit is weak relative to the pre-merger competition incentive (i.e., $2(1-\alpha) < \beta$), but increases product quality in markets where the coordination effect dominates the competition effect (i.e., $2(1-\alpha) > \beta$). We summarize this discussion in the following:

Proposition 1. For given $\alpha \in (1/2, 1]$, a merger increases product quality when the pre-merger competition intensity is low (i.e., $\beta < 2(1-\alpha)$), but decreases quality when the pre-merger competition intensity is high (i.e., $\beta > 2(1-\alpha)$). Furthermore, the quality change from the merger, $v^M - v^d$, is a U-shaped function of β, first decreasing and then increasing, reaching its minimum at $\hat{\beta} = 2 - \sqrt{2\alpha}$.

Figure 1 provides a visual representation of the relationship between β and the change in product quality due to the merger, $v^M - v^d$, for given α. Recall that $\alpha \in (0.5, 1]$ and $\beta \in [0, 1)$.

As β increases, the curve is initially positive and falling, and it then becomes negative, reaching its minimum at $\hat{\beta} = 2 - \sqrt{2\alpha}$, before rising again. That is, the change in product quality due to the merger varies non-monotonically in β, the measure of competition intensity between the firms before merger. This suggests that the incentive to raise product quality under duopoly is often the highest at some intermediate strength of competition.[9] Intuitively, while competitive pressure motivates firms to improve product quality, the diminished profit under competition, especially when competition strength goes beyond certain point, can weaken the incentive for costly quality provision. Therefore, the change in product quality due to a merger may be a U-shaped function of the competitiveness between the two firms prior to the merger.

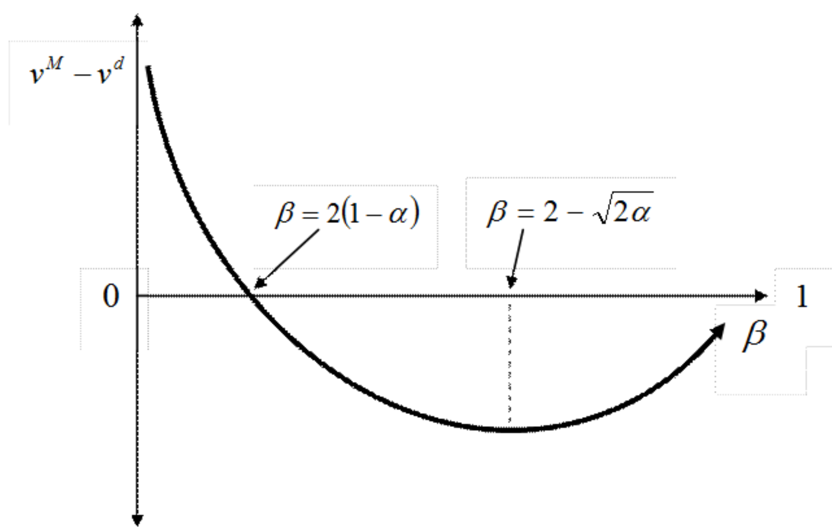

Figure 1: Relationship between β and $v^M - v^d$

An alternate interpretation of Proposition 1 is that product quality can be higher under either a multiproduct monopoly or duopoly competition, depending on the relative sizes of the coordination and incentive effects. This is related to Chen and Schwartz (2013), who find that product innovation incentives can be higher under either monopoly or (duopoly) competition, depending on the balance of what they term as the price coordination and the profit diversion effects.

To provide a clear illustration of the potential quality effects of a merger, our model has made strong assumptions on the functional forms and abstracted from considerations of other possible

[9] This has an interesting connection to the literature on the relationship between competition and innovation, where it has been found that the innovation incentive generally varies non-monotonically in competition intensity, with the highest incentive occurring at some intermediate level (Aghion, etal., 2005).

competitors in the market (which we will control for in our empirical analysis). Despite these restrictions, we believe that the economic forces illustrated here are general, and the trade-offs between the coordination and incentive effects, as well as their implications, will be valid in more general settings. This straightforward theoretical model thus serves the purpose of motivating our empirical analysis. Its first implication, that a merger increases product quality in markets where the two firms have little per-merger competition but may reduce quality when pre-merger competition is significant, does not depend on the specifics of the model. Its second implication, that there is a U-shaped relationship between pre-merger competition intensity and the quality change from the merger, is more likely to hinge on the specific functional forms we have assumed. In light of these theoretical insights, we next turn to empirical analysis.

3 The Mergers and the Data

This section describes the mergers, our quality measure, and the data.

3.1 The Mergers

Delta Airlines (DL) and Northwest Airlines (NW) announced their plan to merge on April 14, 2008. At the time of the merger, Delta and Northwest were the third and fifth largest airlines in the United States, with Delta having its primary hub in Atlanta, Georgia and Northwest having its primary hub in Minneapolis, Minnesota. On October 29, 2008, the U.S. Department of Justice (DoJ) approved the merger after being convinced that it should have minimal anti-competitive effects.[10]

The executives of the two airlines asserted that the merger will benefit customers, employees, shareholders, and the communities they serve.[11] Moreover, they argue that the merger will help create a more resilient airline for long-term success and financial stability. In terms of possible efficiency gains from the merger, they anticipate that cost synergies will be achieved by 2012. Benefits are anticipated to come from combining and improving the airlines' complementary network structure, where effective fleet optimization will account for more than half of those network benefits. Cost synergies are anticipated to come from the combining of sales agreements, vendor contracts,

[10] Department of Justice (2008), "Statement of the Department of Justice's Antitrust Division on Its Decision to Close Its Investigation of the Merger of Delta Air Lines Inc. and Northwest Airlines Corporation." 19 October 2008. <http://www.justice.gov/atr/public/press_releases/2008/238849.htm>

[11] Seeking Alpha (2008), "Delta Air Lines, Northwest Airlines Merger Call Transcript." 16 April 2008. <http://seekingalpha.com/article/72537-delta-air-lines-northwest-airlines-merger-call-transcript>

and more efficient operation of airport facilities.

United Airlines (UA) and Continental Airlines (CO) announced their plan to merge on May 3, 2010. The merger was approved by the DoJ on August 27, 2010, creating the largest U.S. passenger airline based on capacity as measured by year 2009 available seat miles. It is believed that UA and CO are compatible partners in many ways.[12] For example, both have similar fleets and operate in different geographic markets that complement each other. Flying mainly Boeing aircrafts helps reduce costs associated with multiple orders. Operating in distinct geographical markets enables them to link and expand their networks as United's strength is mainly in the western part of the United States while Continental has a larger presence in the east coast.

While cost efficiency gains are anticipated from both mergers, it is more difficult to predict whether the quality of products offered by the newly merged firms will be higher or lower.

3.2 Measuring Product Quality

A challenge that empirical work faces in studying the relationship between merger and product quality is to find reasonable measure(s) of product quality. The literature on the airline industry correctly views timeliness of service as an important dimension of air travel service quality.[13] Various papers have analyzed different aspects of timeliness. The three main quality dimensions of service timeliness analyzed in the literature are: (i) "On-time performance," measured by carrier delay time when servicing a given set of itineraries; (ii) "Schedule delay", which is a gap between a passenger's preferred departure time and actual departure time; and (iii) travel time required to complete a given itinerary in getting the passenger from the origin to destination. Studies in the literature typically measure (i) directly from available data on flight delay,[14] but quality dimensions (ii) and (iii) are typically measured indirectly using data that are posited to be correlated with these quality dimensions.[15]

Indirect measures of quality dimension (iii) used in the literature, which is the focus of our paper, are typically itinerary flight distance-based. For example, Dunn (2008) uses the flight distance

[12] Alukos, Basili. "How Long Has a Continental-United Merger Been in the Works?" Seeking Alpha. 30 April 2010. <http://seekingalpha.com/article/202056-how-long-has-a-continental-united-merger-been-in-the-works>

[13] Another important quality measure that has been considered in the literature is airline safety (e.g., Rose, 1990).

[14] Studies that analyze these direct measures of "On-time performance" include: Fare, Grosskopf and Sickles (2007); Mazzeo (2003); Mayer and Sinai (2003); Prince and Simon (2009 and 2013); Rupp, Owens and Plumly (2006); Rupp and Sayanak (2008); among others.

[15] An indirect measure of quality dimension (ii) used in the literature is flight frequency [see Brueckner (2004); Brueckner and Girvin (2008); Brueckner and Pai (2009); Brueckner and Luo (2012); Fare, Grosskopf and Sickles (2007); Girvin (2010)].

required for a product with intermediate stop relative to the nonstop flight distance between the origin and destination. A nonstop flight between the origin and destination will have the shortest itinerary flight distance. Since some products require intermediate airport stop(s) that are not on a straight path between the origin and destination, each of these products will have an itinerary flight distance that is longer than the nonstop flight distance. The rationale is that "directness" of the travel itinerary is correlated with required travel time, and the itinerary flight distance relative to nonstop flight distance is a measure of "directness". The greater the itinerary flight distance of an intermediate stop product relative to the nonstop flight distance, the lower the quality of this intermediate stop product. Other studies that have used this distance-based measure of air travel itinerary quality, which is referred to as itinerary convenience/inconvenience in some studies, include: Reiss and Spiller (1989); Borenstein (1989); Ito and Lee (2007); Fare, Grosskopf and Sickles (2007); and Gayle (2007 and 2013).

Our specific measure of air travel product quality, which we refer to as *Routing Quality*, is the percentage ratio of nonstop flight distance to the product's itinerary flight distance used to get passengers from the origin to destination. Therefore, the *Routing Quality* variable has only strictly positive values, where the maximum value is 100 in the case that the product itinerary consists of a nonstop flight. As suggested above, the presumption is that passengers find a nonstop itinerary most convenient to get to their destination, so higher values of *Routing Quality* are associated with a more passenger-desirable travel itinerary. While this seems reasonable, the structural demand model that we subsequently describe will provide empirical validation to this presumption.

Optimal integration of the merging airlines' route networks may involve elimination of some products, and creation of others. Depending on what types of products are eliminated versus what types are kept or created, the merging airlines' average routing quality in a market may either increase or decrease. Figures 2 and 3 give examples of how routing quality may change due to an airline merger.

First, consider Figure 2 which illustrates possible product offerings in origin-destination market B to C. Prior to merger there are two airlines, A1 and A2, but these airlines do not compete in market B to C since A1 is the only airline that transports passengers from city B to city C via its most travel-convenient intermediate-stop hub city H1. A2 only transports passengers from its hub city H2 to city C. In the absence of a merger, if A1 wants to improve its routing quality in market B-C, it has to undertake a costly investment of adding its own nonstop flight from B to C. It is possible that the effective cost to A1 of adding and operating such a nonstop flight is prohibitive. However, since A2 already offers service from H2 to C, by merging with A2, the merged firm only needs to undertake the investment of adding a flight from B to H2 in order to offer an intermediate-stop product of better routing quality compared to the pre-merger intermediate-stop product. To service the B-C market, it is possibly more cost-efficient for an airline to leverage an already existing network through hub city H2 by simply adding a flight from B to H2, compared to operating a new direct flight from B to C. This example directly relates to the positive *coordination effect* of a merger on product quality discussed earlier.

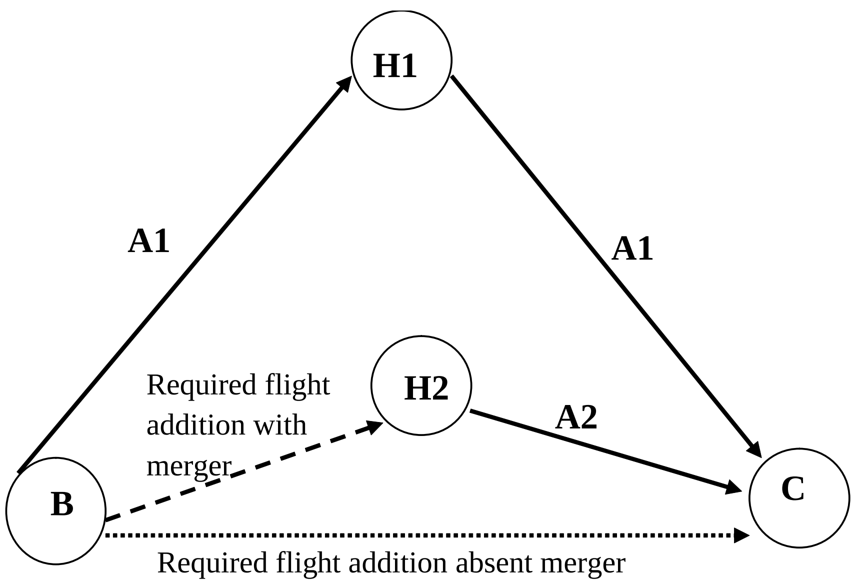

Figure 2: Options for Improvement in *Routing Quality* in origin-destination market B to C.

Second, consider Figure 3 which illustrates possible product offerings in origin-destination market D to E. Prior to merger, airline A1 is a multi-product firm in market D-E, offering a nonstop product from city D to city E, as well as a differentiated substitute intermediate-stop product via its hub city H1. Furthermore, prior to merger, airline A2 directly competes with A1 in market D-E by offering its own nonstop product between the two cities. A merger between A1 and A2 may incentivize the merged firm to eliminate the intensely competing, but travel-convenient, nonstop products. In this case the merger would reduce routing quality of the merged firm in origin-destination market D-E, due to the negative *incentive effect* discussed earlier.

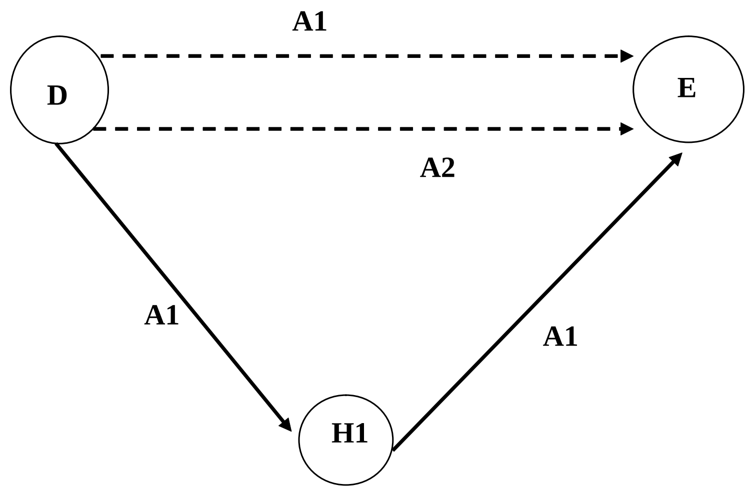

Figure 3: Potential Post-merger Decline in *Routing Quality* in origin-destination market D to E.

We believe that routing quality is one of the better measurable quality dimensions of air travel service that is more directly related to optimal choices of an airline. The task of our empirical analysis, then, is to understand how optimal integration of the merging airlines' networks influences their routing quality in a market.

3.3 Data

Data are drawn from the Origin and Destination Survey (DB1BMarket) published by the Bureau of Transportation Statistics. The data are quarterly and constitute a 10 percent sample of airline tickets from reporting carriers. An observation is a flight itinerary that provides information on: (i) the identity of airline(s) associated with the itinerary; (ii) airfare; (iii) number of passengers that purchase the specific itinerary; (iv) market miles flown in getting the passenger from the origin to destination; and (v) the identity of origin, destination and intermediate stop(s) airports. Unfortunately, the DB1B data do not contain passenger-specific information, or information on ticket restrictions such as advance-purchase and length-of-stay requirements; such information would facilitate estimation of a richer demand model than the one we use based on available data.

The time span of the data we use is the first quarter of 2005 to the third quarter of 2011. This time span covers pre and post-merger periods for each merger. A market is defined as directional origin-destination-time period combination. Directional means that Dallas to Atlanta is a different market from Atlanta to Dallas. Following Aguirregabiria and Ho (2012) among others, we focus on air travel between the 64 largest US cities, based on the Census Bureau's Population Estimates Program (PEP). Cities that belong to the same metropolitan areas and share the same airport are grouped. In Table 1, we report a list of the cities, corresponding airport groupings and population estimate in 2009. Potential market size is measured by the size of population in the origin city. Our sample has a total of 55 metropolitan areas ("cities") and 63 airports.

Table 1
Cities, Airports and Population

City, State	Airports	2009 Population	City, State	Airports	2009 Population
New York City, NY and Newark, NJ	LGA, JFK, EWR	8,912,538	Las Vegas, NV	LAS	567,641
Los, Angeles, CA	LAX, BUR	3,831,868	Louisville, KY	SDF	566,503
Chicago, IL	ORD, MDW	2,851,268	Portland, OR	PDX	566,143
Dallas, Arlington, Fort Worth and Plano, TX	DAL, DFW	2,680,817	Oklahoma City, OK	OKC	560,333
Houston, TX	HOU, IAH, EFD	2,257,926	Tucson, AZ	TUS	543,910
Phoenix-Tempe-Mesa, AZ	PHX	2,239,335	Atlanta, GA	ATL	540,922
Philadelphia, PA	PHL	1,547,297	Albuquerque, NM	ABQ	529,219
San Antonio, TX	SAT	1,373,668	Kansas City, MO	MCI	482,299
San Diego, CA	SAN	1,306,300	Sacramento, CA	SMF	466,676
San Jose, CA	SJC	964,695	Long Beach, CA	LGB	462,604
Denver-Aurora, CO	DEN	933,693	Omaha, NE	OMA	454,731
Detroit, MI	DTW	910,921	Miami, FL	MIA	433,136
San Francisco, CA	SFO	815,358	Cleveland, OH	CLE	431,369
Jacksonville, FL	JAX	813,518	Oakland, CA	OAK	409,189
Indianapolis, IN	IND	807,584	Colorado Spr., CO	COS	399,827
Austin, TX	AUS	786,386	Tula, OK	TUL	389,625
Columbus, OH	CMH	769,332	Wichita, KS	ICT	372,186
Charlotte, NC	CLT	704,422	St. Louis, MO	STL	356,587
Memphis, TN	MEM	676,640	New Orleans, LA	MSY	354,850
Minneapolis-St. Paul, MN	MSP	666,631	Tampa, FL	TPA	343,890
Boston, MA	BOS	645,169	Santa Ana, CA	SNA	340,338
Baltimore, MD	BWI	637,418	Cincinnati, OH	CVG	333,012
Raleigh-Durham, NC	RDU	634,783	Pittsburgh, PA	PIT	311,647
El Paso, TX	ELP	620,456	Lexington, KY	LEX	296,545
Seattle, WA	SEA	616,627	Buffalo, NY	BUF	270,240
Nashville, TN	BNA	605,473	Norfolk, VA	ORF	233,333
Milwaukee, WI	MKE	605,013	Ontario, CA	ONT	171,603
Washington, DC	DCA, IAD	599,657			

A product is defined as an itinerary-operating carrier combination during a particular time period. An example is a direct flight from Dallas to Atlanta operated by American Airline. We focus on products that use a single operating carrier for all segments of the trip itinerary. In Table 2 we report the names and associated code of the carriers in our sample.

Table 2
List of Airlines in the Sample

Airline Code	Airline Name	Airline Code	Airline Name
16	PSA Airlines	L3	Lynx Aviation
17	Piedmont Airlines	NK	Spirit
3C	Regions Air	NW	Northwest[4]
3M	Gulfstream	OO	SkyWest
9E	Pinnacle	QX	Horizon Air
9L	Colgan Air	RP	Chautauqua
AA	American[1]	RW	Republic
AL	Skyway	S5	Shuttle America Corp.
AQ	Aloha Air Cargo	SX	Skybus
AS	Alaska	SY	Sun Country
AX	Trans States	TZ	ATA
B6	JetBlue	U5	USA 3000
C5	Commutair	UA	United[5]
C8	Chicago Express	US	US Airways[6]
CO	Continental[2]	VX	Virgin America
CP	Compass	WN	Southwest
DH	Independence Air	XE	ExpressJet
DL	Delta[3]	YV	Mesa[7]
F9	Frontier	YX	Midwest
FL	AirTran		
G4	Allegiant Air		
G7	GoJet		

[1] American (AA) + American Eagle (MQ) + Executive (OW)
[2] Continental (CO) + Expressjet (RU)
[3] Delta (DL) + Comair (OH) + Atlantic Southwest (EV)
[4] Northwest (NW) + Mesaba (XJ)
[5] United (UA) + Air Wisconsin (ZW)
[6] US Airways (US) + America West (HP)
[7] Mesa (YV) + Freedom (F8)

An observation in the raw data is an itinerary showing airline(s), origin, destination and intermediate stop(s) airports associated with the itinerary, as well as the number of passengers that purchase this itinerary at a given price. Therefore, a given itinerary is listed multiple times in the raw data if different passengers paid different prices for the same itinerary. We construct the price and quantity variables by averaging the airfare and aggregating number of passengers, respectively, based on our product definition, and then collapse the data by product. Therefore, in the collapsed data that we use for analyses a product appears only once during a given time period. In order to avoid products that are not part of the regular offerings by an airline, we drop products that are purchased by less than 9 consumers during a quarter.

Observed product shares (denoted as upper case S_j) are constructed by dividing quantity of product j purchased (denoted as q_j) by origin city population (denoted as POP), i.e., $S_j = \frac{q_j}{POP}$. In addition to *Routing Quality*, we create two other non-price product characteristic variables: (i) *Origin Presence,* which is computed by aggregating the number of destinations that an airline connects with the origin city of the market using non-stop flights. The greater the number of different cities that an airline provides service to using non-stop flights from a given airport, the greater the "presence" the airline has at that airport. (ii) *Nonstop*, which is a zero-one dummy variable that equals to one only if the product uses a nonstop flight to get passengers from the origin to destination.

Table 3
Descriptive Statistics
Time period span of data: 2005:Q1 to 2011:Q3

Variable	Mean	Std. Dev.	Min	Max
Price[a]	165.90	50.6787	38.51	1,522.46
Quantity	213.8515	604.0482	9	11,643
Observed Product Shares	0.0003	0.00096	1.01e-06	0.0458
Origin presence	29.0576	25.8611	0	177
Destination presence	28.9186	25.5970	0	176
Nonstop (dummy variable)	0.227	0.419	0	1
Itinerary distance flown (miles)[b]	1,544.255	720.9628	36	4,099
Nonstop flight distance (miles)	1,377.951	667.414	36	2,724
Routing Quality (measured in %)	89.70	12.78	32.33	100
N_comp_nonstop	2.29	2.42	0	23
N_comp_connect	9.11	8.11	0	71
Number of Products	647,167			
Number of markets[c]	75,774			

[a] Inflation-adjusted.
[b] In DB1B database this variable is reported as "Market miles flown".
[c] A market is defined as an origin-destination-time period combination.

There are two variables we use to measure level of competition faced by a given product in a market, possibly from competitors other than a merging airline: (i) *N_comp_nonstop,* which is the number of nonstop products offered by an airline's competitors in the market; and (ii)

$N\_comp\_connect$, which is the number of products that require intermediate stop(s) offered by an airline's competitors in the market.

Summary statistics of variables used in estimation are reported in Table 3.

4 The Empirical Model

In the spirit of Peters (2006), Gayle and Le (2013), and among others, we first specify a discrete choice model of air travel demand. This demand model is used to empirically validate that consumers' choice behavior is consistent with our presumption that higher values of *Routing Quality* is associated with a more passenger-desirable travel itinerary. It also provides estimates of the pre-merger cross-price elasticities of demand between the two merging firms in markets where they competed directly. These cross-price elasticities serve as a useful indicator of their pre-merger competition intensity. A reduced-form regression model of routing quality is subsequently specified to identify the merger's quality effects.

4.1 Air Travel Demand

Air travel demand is based on a nested logit model. Potential passenger i in market m during time period t faces a choice between $J_{mt}+1$ alternatives. There are $J_{mt}+1$ alternatives because we allow passengers the option not to choose one of the J_{mt} differentiated air travel products. Products in a market are thus assumed to be organized into $G+1$ exhaustive mutually exclusive groups/nests, $g = 0, 1, ..., G$, in which the outside good, $j = 0$, is the only member of group 0.

A passenger solves the following optimization problem:

$$\underset{j\in\{0,\dots,J_{mt}\}}{Max}\left\{U_{ijmt} = \delta_{jmt} + \sigma\zeta_{imtg} + (1-\sigma)\,\varepsilon_{ijmt}\right\}, \tag{4}$$

where U_{ijmt} is the level of utility passenger i will obtain if product j is chosen, while δ_{jmt} is the mean level of utility across passengers that consume product j. δ_{jmt} is a function of the characteristics of product j, as we will describe shortly. ζ_{imtg} is a random component of utility that is common to all products in group g, whereas the random term ε_{ijmt} is specific to product j and is assumed to have an extreme value distribution.

The parameter σ, lying between 0 and 1, measures the correlation of the consumers' utility across products belonging to the same group. Since products are grouped by airlines, σ measures the correlation of the consumers' utility across products offered by a given airline. As σ increases, the correlation of preferences among products offered by the same airline within a market increases; hence, the closer σ is to 1, the more airline-loyal consumers are.

The mean utility function is specified as:

$$\begin{aligned} \delta_{jmt} &= \beta_0 + \beta_1 Price_{jmt} + \beta_2 Origin\ Presence_{jmt} + \beta_3 Nonstop_{jmt} \\ &\quad + \beta_4 Routing\ Quality_{jmt} + a_j + \eta_t + origin_m + dest_m + \xi_{jmt}, \end{aligned} \tag{5}$$

where β_1, β_2, β_3, and β_4 are consumer taste parameters (marginal utilities) associated with the measured product characteristics, a_j are airline fixed effects captured by airline dummy variables, η_t are time period fixed effects captured by quarter and year dummy variables, $origin_m$ and $dest_m$ are respectively market origin and destination fixed effects, and ξ_{jmt} captures unobserved (by the researchers but observed by passengers) product characteristics. The expected signs of the marginal utility parameters are: $\beta_1 < 0$; $\beta_2 > 0$; $\beta_3 > 0$; and $\beta_4 > 0$. A positive and statistically significant estimate of β_4 would empirically validate that consumers' choice behavior is consistent with that higher values of our *Routing Quality* measure are associated with a more desirable travel itinerary.

It is well-known in empirical industrial organization that the model above results in the following linear equation to be estimated:

$$\begin{aligned} \ln(S_{jmt}) - \ln(S_{0mt}) &= \beta_0 + \beta_1 Price_{jmt} + \beta_2 Origin\ Presence_{jmt} + \beta_3 Nonstop_{jmt} \\ &\quad + \beta_4 Routing\ Quality_{jmt} + \sigma \ln\left(S_{jmt|g}\right) \\ &\quad + a_j + \eta_t + origin_m + dest_m + \xi_{jmt}, \end{aligned} \tag{6}$$

where S_{jmt} is the observed share of product j computed from data by $S_{jmt} = \frac{q_{jmt}}{POP_{mt}}$, in which q_{jmt} is the quantity of product j purchased and POP_{mt} is the potential market size measured by origin city population. $S_{0mt} = 1 - \sum_{j \in J_{mt}} S_{jmt}$ is the observed share of the outside option; $S_{jmt|g}$ is the observed within-group share of product j; and ξ_{jmt} is the structural demand error term.

Since $Price_{jmt}$ and $\ln\left(S_{jmt|g}\right)$ are endogenous, we use two-stage least squares (2SLS) to estimate equation (6). The instruments we use for the 2SLS estimation are: (1) number of competitor products in the market; (2) number of competing products offered by other airlines with an equivalent number of intermediate stops; (3) itinerary distance; (4) the squared deviation of a product's itinerary distance from the average itinerary distance of competing products offered by other airlines; (5) number of other products offered by an airline in a market; and (6) mean number of intermediate stops across products offered by an airline in a market.

As discussed in Gayle (2007 and 2013), instruments (1)-(5) are motivated by supply theory, which predicts that a product's price and within-group product share are affected by changes in its marginal cost and markup. The number, and closeness in characteristics space, of competing products in the market influence the size of a product's markup, while a product's itinerary distance is likely to be correlated with its marginal cost. The intuition for instrument (6) is that a passenger may prefer a set of products offered by a particular airline over other airlines.

4.2 Reduced-form Routing Quality Equation

We use a reduced-form regression equation of *Routing Quality* to evaluate effects that each of the two mergers have on routing quality of the merged firms. A difference-in-differences strategy is used to identify possible merger effects on routing quality, i.e., we compare pre-post merger periods changes in routing quality of products offered by the firms that merge, relative to changes in routing quality of products offered by non-merging firms over the relevant pre-post merger periods. Recall that the full data set span the period 2005:Q1 to 2011:Q3. We use 2008:Q4 to 2011:Q3 for the DL/NW post-merger period, while 2010:Q4 to 2011:Q3 is used for the CO/UA post-merger period.

We use the following reduced-form specification of the *Routing Quality* equation:

$$\begin{aligned} Routing\ Quality_{jmt} \quad = \quad & \gamma_0 + \gamma_1 Origin\ Presence_{jmt} + \gamma_2 Destination\ Presence_{jmt} \\ & + \gamma_3 Nonstop\ Flight\ Distance_m + \gamma_4 N\_comp\_connect_{jmt} \\ & + \gamma_5 N\_comp\_nonstop_{jmt} + \gamma_6 DN_{jmt} + \gamma_7 T_t^{dn} + \gamma_8 T_t^{dn} \times DN_{jmt} \\ & + \gamma_9 CU_{jmt} + \gamma_{10} T_t^{cu} + \gamma_{11} T_t^{cu} \times CU_{jmt} + a_j + \eta_t + origin_m + dest_m + \mu_{jmt}, \end{aligned} \tag{7}$$

where DN_{jmt} is a zero-one airline-specific dummy variable that takes the value one only for products offered by Delta or Northwest, while T_t^{dn} is a zero-one time period dummy variable that takes a value of one only in the DL/NW post-merger period. Considering the entire time span of the data set, γ_6, which is the coefficient on DN_{jmt}, tells us whether the routing quality of Delta and Northwest products systematically differs from the routing quality of products offered by other airlines. γ_7, which is the coefficient on T_t^{dn}, tells us how routing quality of products offered by airlines other than Delta or Northwest change over the DL/NW pre-post merger periods. On the other hand, γ_8, which is the coefficient on the interaction variable $T_t^{dn} \times DN_{jmt}$, tells us if routing quality of products offered by Delta or Northwest changed differently relative to routing quality changes of products offered by other airlines over the DL/NW pre-post merger periods. Therefore,

γ_8 should capture changes in the routing quality of products offered by Delta and Northwest that are associated with the DL/NW merger.

Parameters γ_9, γ_{10} and γ_{11} are interpreted analogously to γ_6, γ_7 and γ_8, but relate to the CO/UA merger. For example, γ_{11} tells us if routing quality of products offered by Continental or United changed differently relative to routing quality changes of products offered by other airlines over the CO/UA pre-post merger periods. Therefore, γ_{11} should capture changes in the routing quality of products offered by Continental and United that are associated with the CO/UA merger.

As mentioned in the data section, *N_ comp_ nonstop* measures the number of nonstop products offered by an airline's competitors in the market, while *N_ comp_ connect* measures the number of products that require intermediate stop(s) offered by an airline's competitors in the market. Therefore, these two variables are used to control for the level of product-type-specific competition faced by a given product in a market. We also control for the effect of distance between the origin and destination (*Nonstop Flight Distance*), and also for the size of an airline's presence at the endpoint airports of the market (*Origin Presence* and *Destination Presence*). Note that unobserved airline-specific (a_j), time period-specific (η_t), origin-specific ($origin_m$), and destination-specific ($dest_m$) effects are controlled for in the reduced-form routing quality regression.

The reduced-form routing quality regression is estimated using ordinary least squares (OLS). The routing quality equation in (7) can be thought of as a baseline specification. We will subsequently augment the right-hand-side variables to more meticulously investigate predictions from our theoretical model.

5 Empirical Results

5.1 Estimates from Demand Equation

Recall that price and within-group product shares are endogenous variables in the demand equation. Therefore, OLS estimates of coefficients on these variables will be biased and inconsistent. To get a sense of the importance of using instruments for these endogenous variables, Table 4 reports both OLS and 2SLS estimates of the demand equation. The OLS estimates of the coefficients on *Price* and $\ln\left(S_{jmt|g}\right)$ are very different than the 2SLS estimates, in fact the OLS coefficient estimate on *Price* is positive and therefore contrary to standard demand theory. A formal Wu-Hausman statistical test of exogeneity, reported in Table 4, confirms the endogeneity of *Price* and $\ln\left(S_{jmt|g}\right)$. First-stage reduced-form regressions in which *Price* and $\ln\left(S_{jmt|g}\right)$ are regressed on exogenous regressors and the instruments produce R-squared values of 0.36 and 0.59 respectively. In addition, likelihood ratio tests confirm the joint statistical significance of the instruments in explaining variations in *Price* and $\ln\left(S_{jmt|g}\right)$. The evidence therefore suggest that the instruments do explain variations in the endogenous variables.

Given the clear need to instrument for *Price* and $\ln\left(S_{jmt|g}\right)$, the remainder of our discussion of the demand estimates focuses on the 2SLS estimates. Furthermore, since all coefficient estimates are statistically significant at conventional levels of statistical significance, the discussion focuses on the relationship between the measured product characteristic and consumer choice behavior that is implied by the sign of the relevant coefficient estimate.

Table 4
Demand Estimation Results
647,167 observations: 2005:Q1 to 2011:Q3

	OLS		**2SLS**	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
Price	0.00038***	0.00003	-0.00853***	0.00008
$\ln\left(S_{j\mid g}\right)$	0.51886***	0.00103	0.17017***	0.00228
Origin presence	0.01399***	0.00007	0.01111***	0.00008
Nonstop	0.99543***	0.00461	1.1987***	0.00442
Routing Quality	0.01836***	0.00010	0.02147***	0.00013
Constant	-12.0087***	0.02991	-11.0069***	0.03426
Carrier fixed effects	YES		YES	
Quarter and Year fixed effects	YES		YES	
Origin city fixed effects	YES		YES	
Destination city fixed effects	YES		YES	
R-squared	0.6471		0.5354	
Tests of endogeneity Ho: variables are exogenous Wu-Hausman:	23767.7*** F(2; 647,002)		Prob_Value = 0.000	

*** Statistical significance at the 1% level.

As expected, an increase in the product's price reduces the probability that the product will be chosen by a typical consumer. The coefficient estimate on $\ln\left(S_{jmt|g}\right)$, which is an estimate of σ, is closer to zero rather than one. This suggests that although consumers do exhibit some loyalty to airlines, their loyalty is not strong.

The larger the size of an airline's operations at the consumer's origin airport, as measured by the *Origin Presence* variable, the more likely the consumer is to choose one of the products offered by the airline. This result can be interpreted as capturing a "hub-size" effect on air travel demand.

Since airlines typically offer better services at their hub airports, such as frequent and convenient departure times, the positive "hub-size" demand effect is consistent with our expectation.

The positive coefficient estimate on the *Nonstop* dummy variable suggests that passengers prefer products that use a nonstop flight itinerary from the origin to destination. In fact, if we divide the coefficient estimate on the *Nonstop* dummy variable by the coefficient estimate on *Price*, this ratio suggests that consumers are willing to pay up to $141 extra, on average, to obtain a product with a nonstop itinerary in order to avoid products with intermediate stop(s).

The positive coefficient estimate on the *Routing Quality* variable suggests that consumers prefer products with itinerary flight distances as close as possible to the nonstop flight distance between the origin and destination. This provides empirical validation that higher values of our routing quality measure are associated with a more passenger-desirable travel itinerary. In fact, if we divide the coefficient estimate on the *Routing Quality* variable by the coefficient estimate on the *Price* variable, this ratio suggests that consumers are willing to pay up to $2.52, on average, for each percentage point increase that the nonstop flight distance is of the actual itinerary flight distance.

The demand model yields a mean own-price elasticity of demand estimate of -1.55. Oum, Gillen and Noble (1986) and Brander and Zhang (1990) argue that a reasonable estimate for own-price elasticity of demand in the airline industry lies in the range of -1.2 to -2.0. Therefore, the mean own-price elasticity estimate produced by our demand model appears reasonable.

Last, the demand model yields mean cross-price elasticity of demand estimates of 0.00025 between Delta and Northwest products, and 0.00033 between Continental and United products during their respective pre-merger periods; the former is smaller than the latter, and the difference is statistically significant. Recall that our theoretical model suggests that the intensity of pre-merger competition (as measured by cross-elasticity of demand) between merging firms' products matters for the quality effect of a merger. The empirical analysis in the next subsection verifies this theoretical prediction.

5.2 Estimates from Reduced-form Routing Quality Equation

Table 5 reports estimates of the reduced-form routing quality equation. The table provides four columns of coefficient estimates. Coefficient estimates in the first column can be thought of as a baseline specification of the equation (Specification 1), while the other three columns (Specifications 2, 3 and 4) incrementally assess how various factors influence the quality change from each merger.

Table 5
Estimation Results for Reduced-form Routing Quality Regression
647,167 observations: 2005:Q1 to 2011:Q3

	Dependent Variable: *Routing Quality* (in %)			
	Specification 1	**Specification 2**	**Specification 3**	**Specification 4**
	Coefficient (Robust Std. Error)	Coefficient (Robust Std. Error)	Coefficient (Robust Std. Error)	Coefficient (Robust Std. Error)
Variable				
Constant	87.599*** (0.2975)	87.606*** (0.2971)	87.556*** (0.2973)	87.557*** (0.2973)
Origin Presence	0.066*** (0.00084)	0.065*** (0.00084)	0.067*** (0.00084)	0.067*** (0.00084)
Destination Presence	0.064*** (0.00086)	0.064*** (0.00086)	0.064*** (0.00086)	0.064*** (0.00086)
Nonstop Distance (Miles)	0.005*** (0.00004)	0.005*** (0.00005)	0.005*** (0.00005)	0.005*** (0.00005)
N_comp_connect	-0.157*** (0.00328)	-0.159*** (0.00328)	-0.159*** (0.00328)	-0.159*** (0.00328)
N_comp_nonstop	0.243*** (0.01094)	0.233*** (0.01094)	0.235*** (0.01094)	0.235*** (0.01093)
MKT_{bm}^{dn}	-	-0.491*** (0.0647)	-0.504*** (0.0647)	-0.502*** (0.0647)
DN_{jmt}	-13.047*** (0.2369)	-13.006*** (0.2368)	-13.015*** (0.2371)	-13.014*** (0.2371)
T_t^{dn}	-0.541*** (0.0982)	-0.531*** (0.0981)	-0.539*** (0.0981)	-0.539*** (0.0981)
$T_t^{dn} \times DN_{jmt}$	-0.464*** (0.0785)	0.503** (0.2156)	0.487** (0.2153)	0.489** (0.2154)
$MKT_{bm}^{dn} \times T_t^{dn} \times DN_{jmt}$	-	-1.079*** (0.2177)	-0.802*** (0.2187)	-0.866*** (0.2217)
$E_{bm}^{dn} \times MKT_{bm}^{dn} \times T_t^{dn} \times DN_{jmt}$	-	-	-997.89*** (107.32)	-575.68** (256.61)
$(E_{bm}^{dn})^2 \times MKT_{bm}^{dn} \times T_t^{dn} \times DN_{jmt}$	-	-	-	-72546.67* (39995.2)
MKT_{bm}^{cu}	-	-1.097*** (0.0523)	-1.091*** (0.0522)	-1.093*** (0.0522)
CU_{jmt}	-12.232*** (0.2366)	-12.173*** (0.2363)	-12.173*** (0.2367)	-12.172*** (0.2367)
T_t^{cu}	-0.150 (0.1000)	-0.146 (0.0999)	-0.147 (0.0999)	-0.148 (0.0998)
$T_t^{cu} \times CU_{jmt}$	0.576*** (0.1182)	4.805*** (0.2927)	4.801*** (0.2927)	4.800*** (0.2927)
$MKT_{bm}^{cu} \times T_t^{cu} \times CU_{jmt}$	-	-4.969*** (0.3053)	-4.975*** (0.3084)	-4.902*** (0.3111)
$E_{bm}^{cu} \times MKT_{bm}^{cu} \times T_t^{cu} \times CU_{jmt}$	-	-	-38.858 (114.513)	-389.227* (208.476)
$(E_{bm}^{cu})^2 \times MKT_{bm}^{cu} \times T_t^{cu} \times CU_{jmt}$	-	-	-	52623.54** (25399.18)
R-squared	0.1599	0.1614	0.1617	0.1617

*** indicates statistical significance at the 1% level, ** indicates statistical significance at the 5% level, while * indicates statistical significance at the 10% level. The equations are estimated using ordinary least squares. Estimation of each regression includes fixed effects for carriers, time periods, origin cities, and destination cities, even though their associated coefficients are not reported in the table.

Estimates of the constant term across the regression specifications are approximately 87.6. Therefore, assuming all determinants of routing quality in the regressions are held at zero, the mean routing quality measure across all products in the sample is approximately 87.6. This means that nonstop flight distances between origins and destinations are on average 87.6% of the flight distances associated with product itineraries used by passengers in the sample markets. Of course, this mean routing quality will change with each of the measured routing quality determinants in the regressions. We now examine the impact of each of the measured routing quality determinants.

5.2.1 Impact of Measured Determinants of Routing Quality

Size of an airline's operations at the market endpoint airports, as measured by the *Origin Presence* and *Destination Presence* variables, positively impact routing quality of products offered by the airline in the market. In particular, the relevant coefficient estimates suggest that for each additional city that an airline connects to either endpoints of a market using nonstop service, routing quality of the airline's products within the market will increase by approximately 0.06%.

The positive coefficient estimate on the *Nonstop Flight Distance* variable suggests that products tend to have higher routing quality the longer the nonstop flight distance between a market's origin and destination. For example, assuming all other determinants of routing quality are equal, the routing quality of products in the New York City to Atlanta market (nonstop flight miles of 761) should be lower than routing quality of products in the New York City to Los Angeles market (nonstop flight miles of 2,469). The sign pattern of the coefficient estimates on variables, *N_ comp_ connect* and *N_ comp_ nonstop*, suggests that a product's routing quality tends to be higher (lower) the larger the number of competing nonstop (intermediate stop(s)) products it faces in the market.

To achieve our ultimate goal of properly identifying merger effects on routing quality, it is important to control for the determinants of routing quality discussed above. In addition, given that we will use a difference-in-differences identification strategy, it is also important to control for persistent differences in routing quality across firms. Such controls are especially important if the routing quality of products offered by the firms that merge are persistently different from routing quality of products offered by other firms in the sample. Without controlling for persistent routing quality differences, we may incorrectly attribute measured differences in routing quality to the merger. As such, we now examine potential persistent routing quality differences across the firms that merge relative to other firms in the sample.

5.2.2 Persistent Differences in Routing Quality of Products offered by the Merging Firms

The coefficient estimates on dummy variable DN are approximately -13, suggesting that throughout the time span of the data, assuming all determinants of routing quality in the regressions are held constant, the mean routing quality measure of products offered by Delta and Northwest is 13 points less than the mean routing quality measure across all products in the sample. If all determinants of routing quality in the regressions are held at their sample mean for Delta/Northwest products throughout the time span of the data, then regression coefficient estimates in Specification 1 suggest that the mean routing quality measure of Delta/Northwest products is approximately 84.73.[16] This routing quality measure suggests that nonstop flight distances between origins and destinations are on average only 84.73% of the flight distances associated with Delta/Northwest product itineraries used by passengers.

Analogously, we can use the regression coefficient estimates to compute and interpret routing quality measures for Continental/United products. The coefficient estimates on dummy variable CU are approximately -12, suggesting that throughout the time span of the data, assuming all determinants of routing quality in the regressions are held constant, the mean routing quality measure of products offered by Continental and United is 12 points less than the mean routing quality measure across all products in the sample. If all determinants of routing quality in the regressions are held at their sample mean for Continental/United products throughout the time span of the data, then regression coefficient estimates in Specification 1 suggest that the mean routing quality measure of Continental/United products is approximately 85.48.[17] Therefore, nonstop

[16] This mean routing quality measure for Delta/Northwest products is computed using the regression equation in Specification 1 as follows:

$$\begin{aligned} \textit{Routing Quality}^{dn} &= 87.599 - 13.047 + 0.066 \times (30.535) + 0.064 \times (30.404) \\ &\quad +0.005 \times (1425.973) - 0.157 \times (9.44) + 0.243 \times (2.335), \end{aligned}$$

where the numbers in parentheses are means of the regressors for DL/NW products, while the other numbers are the coefficient estimates in Specification 1 of the regression model.

[17] This mean routing quality measure for Continental/United products is computed using the regression equation in Specification 1 as follows:

$$\begin{aligned} \textit{Routing Quality}^{cu} &= 87.599 - 12.232 + 0.066 \times (26.480) + 0.064 \times (26.010) \\ &\quad +0.005 \times (1574.05) - 0.157 \times (11.358) + 0.243 \times (2.520), \end{aligned}$$

where the numbers in parentheses are means of the regressors for CO/UA products, while the other numbers are the coefficient estimates in Specification 1 of the regression model.

flight distances between origins and destinations are on average 85.48% of the flight distances associated with Continental/United product itineraries used by passengers. In summary, the evidence suggests that CO/UA products have slightly higher mean routing quality compared to mean routing quality of DL/NW products.

With the controls on routing quality discussed above in place, as well as fixed effects controls for other airlines, time periods, origin cities, and destination cities, we are now in a position to examine the effect of each merger on routing quality.

5.2.3 Overall Routing Quality Effects of each Merger

The negative coefficient estimate on T^{dn} suggests that the routing quality of products offered by airlines other than Delta or Northwest declined by 0.5% below the sample average over the DL/NW pre-post merger periods, i.e., non-DL/NW itinerary flight distances increased relative to nonstop flight distances by 0.5% over the relevant pre-post merger periods. Interestingly, the negative coefficient estimate on the interaction variable $T^{dn} \times DN$ suggests that routing quality of products offered by the merged Delta/Northwest carrier has an even larger decline of 1% ($= 0.541 + 0.464$ based on estimates in Specification 1) over the pre-post merger periods. This suggests that the merger may have precipitated an additional 0.5% decline in the routing quality of DL/NW products relative to the routing quality of products offered by other airlines. In essence, the flight distances associated with DL/NW product itineraries increased over convenient nonstop flight distances by an additional 0.5% due to the merger.

The statistically insignificant coefficient estimate on T^{cu} suggests that the routing quality of products offered by airlines other than Continental and United were unchanged over the CO/UA pre-post merger periods. However, in Specification 1, the coefficient estimate on the interaction variable $T^{cu} \times CU$ suggests that average routing quality of products offered by the merged CO/UA carrier increased by 0.6% over their pre-post merger periods. This suggests that the merger is associated with an increase in routing quality of CO/UA products. In particular, according to estimates in Specification 1, flight distances associated with CO/UA product itineraries fell towards nonstop flight distances by 0.6% due to the merger.

In summary, coefficient estimates in Specification 1 suggest that, overall, across all markets in the sample, the CO/UA merger is associated with an increase in routing quality of their products, but the DL/NW merger is associated with a decline in routing quality of DL/NW products.

However, as our theoretical model suggests, these quality effects may differ across markets based on certain pre-merger characteristics of a market. We now explore this possibility via model Specifications 2, 3, and 4.

5.2.4 Merger Effects on Routing Quality based on Existence of Pre-merger Competition between Merging Firms

MKT_{bm}^{dn} is a zero-one market-specific dummy variable that takes a value of one only for origin-destination markets in which Delta and Northwest competed prior to their merger. Similarly, MKT_{bm}^{cu} is a zero-one market-specific dummy variable that takes a value of one only for origin-destination markets in which Continental and United competed prior to their merger. These market-specific dummy variables are used in Specification 2 of the regression estimates to investigate whether routing quality merger effects differ in markets where the merging firms competed prior to the merger. In our data, Delta and Northwest simultaneously serve 1,730 directional origin-destination combinations prior to their merger, while 735 directional origin-destination combinations are served by either one or the other carrier prior to their merger. However, Continental and United simultaneously serve 1,436 directional origin-destination combinations prior to their merger, while 1,025 directional origin-destination combinations are served by either one or the other carrier prior to their merger.

The merger-specific variables in Specification 2 suggest that the DL/NW and the CO/UA mergers are associated with 1% and 5% declines, respectively, in routing quality of products offered by the merging firms in markets where the merging firms competed with each other prior to their merger. This evidence comes from the negative coefficient estimates of -1.079 and -4.969 on the interaction variables, $MKT_{bm}^{dn} \times T^{dn} \times DN$ and $MKT_{bm}^{cu} \times T^{cu} \times CU$ respectively. Based on results from our structural demand estimates, we can monetize consumer welfare effects of these routing quality declines associated with the mergers. In particular, recall that our demand estimates suggest that consumers are willing to pay \$2.52, on average, for each percentage point increase that the nonstop flight distance is of the actual itinerary flight distance. Since nonstop flight distance between an origin and destination cannot change, then actual itinerary flight distance must fall towards (increase away from) nonstop flight distance so that nonstop flight distance can account for a larger (smaller) percentage of actual itinerary flight distance. Therefore, in markets that the merging firms competed prior to merger, routing quality effects of the mergers imply that each consumers' utility falls by an average of \$2.72 (= \$2.52 $\times$ 1.079) in case of the DL/NW merger, and \$12.52 (= \$2.52 × 4.969) in case of the CO/UA merger. These consumer welfare effects are not trivial considering that many of these markets in our sample have origin city populations close to or greater than a million, e.g. Chicago, Illinois (one of United Airline's hub city).

Specification 2 coefficient estimates on the interaction variables, $T^{dn} \times DN$ and $T^{cu} \times CU$, suggest that routing quality of the merging firms' products actually increase by 0.5% and 5% with the DL/NW and CO/UA mergers, respectively, in markets where the merging firms did not compete with each other prior to the merger. So each consumer in these markets experienced increases in utility related to routing quality improvements equivalent to \$1.26 (= \$2.52 × 0.5) in case of the DL/NW merger, and \$12.60 (= \$2.52 × 5) in case of the CO/UA merger.

5.2.5 Merger Effects on Routing Quality based on Pre-merger Competition Intensity between Merging Firms

To investigate the theoretical prediction that the effect of a merger on product quality depends on the intensity of pre-merger competition (as measured by cross-elasticity of demand) between products of the merging firms, we use the demand model that was estimated in the previous section to compute pre-merger cross-price elasticities between Delta and Northwest products, and between Continental and United products. The variable, E^{dn}_{bm}, measures pre-merger cross-price elasticities of demand between Delta and Northwest products, while variable E^{cu}_{bm} measures pre-merger cross-price elasticities of demand between Continental and United products. The elasticities in each of these variables vary across origin-destination markets in which the merging firms competed prior to their respective mergers. A cross-price elasticity between the merging firms' products will only exist in markets where they are competitors prior to the merger.

We use the pre-merger cross-elasticity variables to construct interaction variables: (i) $E^{dn}_{bm} \times MKT^{dn}_{bm} \times T^{dn} \times DN$; (ii) $\left(E^{dn}_{bm}\right)^2 \times MKT^{dn}_{bm} \times T^{dn} \times DN$; (iii) $E^{cu}_{bm} \times MKT^{cu}_{bm} \times T^{cu} \times CU$; and (iv) $(E^{cu}_{bm})^2 \times MKT^{cu}_{bm} \times T^{cu} \times CU$. Specifications 3 and 4 in Table 5 incrementally add these variables to the routing quality regression.

The Delta/Northwest merger The segment of the regression equation in Specification 4 that relates to routing quality effects of the Delta/Northwest merger in markets where they directly competed prior to the merger is given by:

$$\Delta Routing\ Quality^{dn} = -0.866 - 575.68 E^{dn}_{bm} - 72546.67 \left(E^{dn}_{bm}\right)^2, \tag{8}$$

where dummy variables MKT^{dn}_{bm}, T^{dn} and DN each take the value of 1. Note that all coefficient estimates in equation (8) are negative. This suggests that the Delta/Northwest merger decreased routing quality of its products in all markets that the two airlines directly competed in prior to the merger. In addition, consistent with theory, routing quality fell by more in markets where the two airlines competed more intensely (higher E^{dn}_{bm}) prior to the merger.

Given that E^{dn}_{bm} has a mean of 0.00025, a minimum value of 1.52e-07, and a maximum value of 0.0093, equation (8) implies that routing quality of DL/NW products declined by a mean of 1.01%, a minimum of 0.866%, and a maximum of 12.49% across markets in which Delta and Northwest competed prior to their merger. So there exists a market in which a typical consumer experienced a decline in utility equivalent to \$31.47 (= \$2.52 × 12.49), due to routing quality declines associated with the DL/NW merger. In fact, Atlanta to Washington, DC; Atlanta to Philadelphia; and Atlanta to San Francisco; are examples of markets in the sample in which E^{dn}_{bm} is greater than 0.008, which implies that a typical consumer in these markets experienced a decline in utility greater than \$25 (≈ \$2.52 × 10) due to routing quality declines associated with the DL/NW merger.

Interpreting the Delta/Northwest results in the context of our theoretical model suggest that the negative competitive incentive effect of the merger dominates the positive coordination effect in all markets that the two airlines competed in prior to the merger. Note however that the coefficient on $T^{dn} \times DN$ in Specification 4 remains positive, suggesting that the positive coordination effect remains the key driver of merger quality effects in markets where Delta and Northwest did not directly compete prior to the merger.

The Continental/United merger The segment of the regression equation in Specification 4 that relates to quality effects of the Continental/United merger in markets where they directly competed prior to the merger is given by:

$$\Delta Routing\ Quality^{cu} = -4.902 - 389.23 E^{cu}_{bm} + 52623.54 \left(E^{cu}_{bm}\right)^2, \tag{9}$$

where dummy variables MKT^{cu}_{bm}, T^{cu} and CU each take the value of 1. Note that the coefficient estimate on $(E^{cu}_{bm})^2$ in equation (9) is positive, while the other coefficients in the equation are negative. This sign pattern of the coefficients in equation (9) suggests an interesting result for the Continental/United merger: the effect of the merger on routing quality varies in a U-shaped manner with pre-merger competition intensity (measured by cross-elasticity) between the two airlines, where the minimum turning point in the U-shaped relationship occurs at a cross-elasticity of 0.0037 (= 389.23/(2 × 52623.54)). Specifically, the merger appears to have decreased routing quality more in markets where the pre-merger cross-elasticities between the two airlines' products are higher, up to an intermediate pre-merger cross-elasticity of 0.0037. Markets with pre-merger cross-elasticity between CO and UA of 0.0037, experienced the largest decline in routing quality of 5.62%, which yields a decline in a typical consumer's utility equivalent to \$14.16 (= \$2.52 × 5.62). Examples of origin-destination markets in our sample in which our demand model generates pre-merger cross-elasticity between CO and UA of between 0.003 and 0.004 include: (i) Houston to Los Angeles; (ii) Pittsburgh to Houston; and (iii) Santa Ana, California to New York City/Newark, New Jersey. However, the decrease in routing quality of Continental/United products becomes smaller with pre-merger cross-elasticity higher than this intermediate cross-elasticity level.

Note that equation (9) can be used to show that routing quality decreased in markets where E_{bm}^{cu} is less than 0.014, but increased in markets where E_{bm}^{cu} is greater than 0.014. However, since the maximum value for E_{bm}^{cu} in our data set is 0.014, there are no markets in which CO and UA directly competed prior to the merger that experienced a routing quality increase of their products. Last, the coefficient on $T^{cu} \times CU$ in Specification 4 remains positive, suggesting that the positive coordination effect remains the key driver of merger quality effects in markets where Continental and United did not compete prior to their merger.

5.2.6 Summary of Empirical Results of each Merger on Routing Quality

In summary, the empirical results, taken together across both mergers, are consistent with the theoretical predictions. The evidence suggests that each merger increased routing quality of the merging firms' products - approximately 0.5% and 5% for the DL/NW and CO/UA merger respectively - in markets where the merging firms did not compete prior to their merger. In these markets, due to the merging firms' quality improvements, a typical consumer is estimated to experience an increase in utility equivalent to \$1.26 and \$12.60, respectively for the DL/NW and CO/UA merger.

In contrast, each merger decreased routing quality of the merging firms' products in markets where they competed prior to their merger, and the magnitude of the quality reductions differed across mergers, depending (non-monotonically in the case of CO/UA) on their competition intensity prior to the merger. For the DL/NW merger, routing quality of the merging firms declined by a mean of 1.01%, a minimum of 0.866%, and a maximum of 12.49% across such markets. These quality declines are estimated to yield utility decreases of a consumer in these markets ranging from a minimum of \$2.18 to as high as \$31.47. For the CO/UA merger, the largest decline in routing quality is 5.62%, which yields a decline in a typical consumer's utility equivalent to \$14.16.

In general, routing quality declined less severely for the CO/UA merger than for the DL/NW merger. Combined with the evidence that routing quality improvements are larger for the CO/UA merger, as far as quality changes are concerned, a typical consumer apparently fared better under the CO/UA merger than under the DL/NW merger. In fact, overall, across all markets in the sample, the CO/UA merger is associated with an increase, whereas the DL/NW merger is associated with a decrease, in routing quality of the respective products.

6 Conclusion

An important issue in industrial organization and antitrust is how horizontal mergers affect firm conduct and market performance. Departing from the extant literature that focuses on the price effects of mergers, this paper has investigated how mergers affect product quality. Empirical analysis of two recent airline mergers finds that, averaging across all markets, the Delta/Northwest merger is associated with a quality decrease while the Continental/United merger with a quality increase. However, the quality effects of mergers differ greatly between markets: each merger is associated with a quality *increase* in markets where the merging firms did not compete prior to their merger, while each merger is associated with a quality *decrease* in markets where they did. Furthermore, the quality change across markets from the Continental/United merger exhibited a U-shaped curve as the pre-merger competition intensity between the two firms increased. These findings are consistent with the theory that mergers improve coordination but diminish competitive pressure for firms to provide high quality products.

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