Mergers and Product Quality: Evidence from the Airline Industry*

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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. Consistent with the theory that mergers facilitate coordination but diminish competitive pressure for quality improvement, we find that each merger is associated with a quality decrease (increase) in markets where the merging firms had (had no) pre-merger competition with each other, and the quality change can have a U-shaped relationship with pre-merger competition intensity. Consumer gains/losses associated with quality changes, which we monetize, are substantial.

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1 Introduction

A long-standing interest in economics and public policy discussions is the competitive effects of horizontal mergers. To evaluate these effects, one natural approach is to study actual mergers retrospectively. Such studies in the economics literature have focused on a merger’s price effects, which are often used to infer relative changes in market power and cost efficiencies associated with the merger (See, for example, Whinston (2006) for a discussion of this literature). 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 is surprising that little attention has been directed to 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 guide the empirical analysis, we first present a theoretical model that captures what we term as 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. On the other hand, the merger also reduces the competitive pressure on the merging firms. This tends to reduce their incentive to improve product quality, but the magnitude of this negative incentive effect may not monotonically increase with the pre-merger competition intensity, because the diminished profit under competition, especially when competition intensity goes beyond a certain point, can weaken the incentive for costly quality provision. Exploring these possibilities, the model generates two predictions. First, a merger will increase the product quality of the merging firms if they had little pre-merger competition with each other, but will likely reduce quality if they had substantial pre-merger competition with each other. Second, 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.

The Delta/Northwest and the Continental/United mergers offer an interesting opportunity for us to study a merger’s quality effect. In each case, the merging firms produce in multiple markets.

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1 Also see Kwoka (2015); Kwoka (2013); Kwoka and Gu (2013); Ashenfelter and Hosken (2008); Ashenfelter, Hosken, Vita and Weinberg (2011); and Weinberg (2008).

2 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. Also see Kwoka and Pollitt (2010) for an analysis of measuring merger efficiencies in US electric power sector.
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. Therefore, we can examine not only how the overall product quality is affected by a merger, but also how the quality effects differ across markets, in light of our theoretical predictions.

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 view 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 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, on average 0.5% and 4.8% for DL/NW and CO/UA respectively, in markets where the merging firms did not compete with each other prior to the merger; but with a decline in routing quality, on average 0.58% and 0.16% respectively for the two mergers, in markets where they did. Moreover, 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.

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3 The intensity of competition 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.

4 See Chen and Gayle (2013) for an earlier version of the discussion in this paper.
Our structural demand estimates further allow us to monetize the consumer gains and losses associated with quality changes. Specifically, in markets where the merging firms had no pre-merger competition, due to their quality improvements, a typical consumer is estimated to experience an increase in utility equivalent to $1.18 and $11.38 for the DL/NW and CO/UA mergers, respectively. In contrast, in markets the merging firms competed prior to their merger, due to their quality declines, a typical consumer is estimated to experience a decrease in utility equivalent to $1.37 and $0.38 respectively for the DL/NW and CO/UA mergers. There are several markets in the sample in which the estimates suggest a typical consumer in these markets experienced a decline in utility greater than $21.42 due to routing quality declines associated with the merger. These consumer welfare effects are substantial, considering that many of the markets in our sample have populations greater than a million.

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, 2014). 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, we are unaware of studies that explicitly analyze effects of mergers on air travel product quality. 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.

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5 Mazzeo (2003) and Rupp, Owens and Plumly (2006) all find evidence that airlines provide worse on-time performance on less competitive routes.

6 Draganska, Mazzeo and Seim (2009) and Fan (2013) 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 (2013) 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 \textit{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.\footnote{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.} We call this the \textit{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:

\[
q_A = v_A - p_A + \beta (p_B - v_B),
\]
\[
q_B = v_B - p_B + \beta (p_A - v_A),
\]

for \(\beta \in [0, 1]\), where \(\beta\) 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 \(\beta\) 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.\footnote{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 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 \(\alpha\) indicates a stronger coordination effect. Other costs of production are normalized to zero.
Under competition, the firms’ profit functions are:

$$\pi_A = p_A [v_A - p_A - \beta (v_B - p_B)] - \frac{1}{3} v_A^3,$$

$$\pi_B = p_B [v_B - p_B - \beta (v_A - p_A)] - \frac{1}{3} v_B^3.$$ 

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

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

(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:

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

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

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

(2)

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

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

(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 $\beta,$ 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 $\beta$ and the change in product quality due to the merger, $v^M - v^d,$ for given $\alpha.$ Recall that $\alpha \in (0.5, 1]$ and $\beta \in [0, 1].$
As $\beta$ 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 $\beta$, 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.\footnote{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, et al., 2005).} 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.

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
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 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 pre-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,


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. 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. 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, but quality dimensions (ii) and (iii) are typically measured indirectly using data that are posited to be correlated with these quality dimensions.

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

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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); 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 (2014); 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, an outcome we would attribute to the negative incentive effect discussed earlier.
A reason it may be optimal to eliminate the nonstop products post-merger in Figure 3 is owing to a combination of two reinforcing economic forces: (1) the intermediate-stop product may offer the newly merged airline better opportunities to exploit economies of passenger-traffic densities - i.e. achieve lower transport cost per passenger when transporting a higher volume of passengers - since the airline can better fill a single plane with passengers that have either city H1 or city E as their final destination; and (2) the competitive pressure from airline A2 that incentivized airline A1 to offer the potentially more transport-costly nonstop product in the pre-merger period is now absent in the post-merger period due to the merger. So the merger reduces the competitive intensity, which may consequently expand opportunities for the merged firm to better exploit economies of passenger-traffic densities.

A reasonable question to raise at this point is: In the post-merger period why not choose to eliminate the intermediate-stop product instead and use the non-stop product to exploit economies of passenger-traffic density?\textsuperscript{16} The reason is that, holding all other factors constant, the intermediate-stop product is likely better for exploiting economies of passenger-traffic density compared to the nonstop product because the intermediate-stop product has an extra city on the itinerary that itself is a destination of interest for a set of passengers that the airline can use for increasing the volume of passengers it transports on a segment of the intermediate-stop itinerary. So the lower routing quality product may offer better opportunities for the airline to exploit economies of passenger-traffic density, but from a consumer perspective these products are less convenient for travel.\textsuperscript{17}

\textsuperscript{16}We thank an anonymous referee for raising this question.
\textsuperscript{17}Absent economies of passenger-traffic densities considerations, in situations depicted in Figure 3 it is conceivable that the merged airline may choose to eliminate the lower routing quality product.
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 random 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). Airports that serve a common metropolitan area are grouped to constitute a single endpoint for a defined market. Therefore, our defined markets better correspond to "city" pairs rather than airport pairs, where the term "city" is loosely used in the sense that it corresponds to a metropolitan area at the endpoint of some markets in our sample. 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

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<th>Airports</th>
<th>2009 Population</th>
<th>City, State</th>
<th>Airports</th>
<th>2009 Population</th>
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<td>813,518</td>
<td>Oakland, CA</td>
<td>OAK</td>
<td>409,189</td>
</tr>
<tr>
<td>Indianapolis, IN</td>
<td>IND</td>
<td>807,584</td>
<td>Colorado Spr., CO</td>
<td>COS</td>
<td>399,827</td>
</tr>
<tr>
<td>Austin, TX</td>
<td>AUS</td>
<td>786,386</td>
<td>Tula, OK</td>
<td>TUL</td>
<td>389,625</td>
</tr>
<tr>
<td>Columbus, OH</td>
<td>CMH</td>
<td>769,332</td>
<td>Wichita, KS</td>
<td>ICT</td>
<td>372,186</td>
</tr>
<tr>
<td>Charlotte, NC</td>
<td>CLT</td>
<td>704,422</td>
<td>St. Louis, MO</td>
<td>STL</td>
<td>356,587</td>
</tr>
<tr>
<td>Memphis, TN</td>
<td>MEM</td>
<td>676,640</td>
<td>New Orleans, LA</td>
<td>MSY</td>
<td>354,850</td>
</tr>
<tr>
<td>Minneapolis-St. Paul, MN</td>
<td>MSP</td>
<td>666,631</td>
<td>Tampa, FL</td>
<td>TPA</td>
<td>343,890</td>
</tr>
<tr>
<td>Boston, MA</td>
<td>BOS</td>
<td>645,169</td>
<td>Santa Ana, CA</td>
<td>SNA</td>
<td>340,338</td>
</tr>
<tr>
<td>Baltimore, MD</td>
<td>BWI</td>
<td>637,418</td>
<td>Cincinnati, OH</td>
<td>CVG</td>
<td>333,012</td>
</tr>
<tr>
<td>Raleigh-Durham, NC</td>
<td>RDU</td>
<td>634,783</td>
<td>Pittsburgh, PA</td>
<td>PIT</td>
<td>311,647</td>
</tr>
<tr>
<td>El Paso, TX</td>
<td>ELP</td>
<td>620,456</td>
<td>Lexington, KY</td>
<td>LEX</td>
<td>296,545</td>
</tr>
<tr>
<td>Seattle, WA</td>
<td>SEA</td>
<td>616,627</td>
<td>Buffalo, NY</td>
<td>BUF</td>
<td>270,240</td>
</tr>
<tr>
<td>Nashville, TN</td>
<td>BNA</td>
<td>605,473</td>
<td>Norfolk, VA</td>
<td>ORF</td>
<td>233,333</td>
</tr>
<tr>
<td>Milwaukee, WI</td>
<td>MKE</td>
<td>605,013</td>
<td>Ontario, CA</td>
<td>ONT</td>
<td>171,603</td>
</tr>
<tr>
<td>Washington, DC</td>
<td>DCA, IAD</td>
<td>599,657</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
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.

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) $N_{\text{comp\_nonstop}}$, which is the number of nonstop products offered by an airline’s competitors in the market; and (ii) $N_{\text{comp\_connect}}$, 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.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price$^a$</td>
<td>165.90</td>
<td>50.6787</td>
<td>7</td>
<td>1,522.46</td>
</tr>
<tr>
<td>Quantity (Number of passengers per product)</td>
<td>213.8515</td>
<td>604.0482</td>
<td>9</td>
<td>11,643</td>
</tr>
<tr>
<td>Observed Product Shares ($S_j$)</td>
<td>0.0003</td>
<td>0.00096</td>
<td>1.01e-06</td>
<td>0.0458</td>
</tr>
<tr>
<td>Origin presence</td>
<td>29.0576</td>
<td>25.8611</td>
<td>0</td>
<td>177</td>
</tr>
<tr>
<td>Destination presence</td>
<td>28.9186</td>
<td>25.5970</td>
<td>0</td>
<td>176</td>
</tr>
<tr>
<td>Nonstop (dummy variable)</td>
<td>0.227</td>
<td>0.419</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Itinerary distance flown (miles)$^b$</td>
<td>1,544.255</td>
<td>720.9628</td>
<td>36</td>
<td>4,099</td>
</tr>
<tr>
<td>Nonstop flight distance (miles)</td>
<td>1,377.951</td>
<td>667.414</td>
<td>36</td>
<td>2,724</td>
</tr>
<tr>
<td>Routing Quality (measured in %)</td>
<td>89.70</td>
<td>12.78</td>
<td>32.33</td>
<td>100</td>
</tr>
<tr>
<td>$N_{\text{comp_nonstop}}$</td>
<td>2.29</td>
<td>2.42</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>$N_{\text{comp_connect}}$</td>
<td>9.11</td>
<td>8.11</td>
<td>0</td>
<td>71</td>
</tr>
<tr>
<td>Number of Products</td>
<td>647,167</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of markets$^c$</td>
<td>75,774</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$ 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.
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:

$$\text{Max}_{j \in \{0, ..., J_{mt}\}} \left\{ U_{ijmt} = \delta_{jmt} + \sigma \zeta_{imtg} + (1 - \sigma) \varepsilon_{ijmt} \right\},$$

(4)

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

The parameter $\sigma$, 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, $\sigma$ measures the correlation of the consumers’ utility across products offered by a given airline. As $\sigma$ increases, the correlation of preferences among products offered by the same airline within a market increases; hence, the closer $\sigma$ is to 1, the more airline-loyal consumers are.
The mean utility function is specified as:

\[ \delta_{jmt} = \beta_0 + \beta_1 Price_{jmt} + \beta_2 Origin\ Presence_{jmt} + \beta_3 Nonstop_{jmt} \]
\[ + \beta_4 Routing\ Quality_{jmt} + \lambda_a + \eta_t + origin_m + dest_m + \xi_{jmt}, \]

where \( \beta_1, \beta_2, \beta_3, \) and \( \beta_4 \) are consumer taste parameters (marginal utilities) associated with the measured product characteristics, \( \lambda_a \) are airline fixed effects captured by airline dummy variables, \( \eta_t \) 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 \( \xi_{jmt} \) 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 \( \beta_4 \) 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:

\[ \ln \left( S_{jmt}\right) - \ln \left( S_{0mt}\right) = \beta_0 + \beta_1 Price_{jmt} + \beta_2 Origin\ Presence_{jmt} + \beta_3 Nonstop_{jmt} \]
\[ + \beta_4 Routing\ Quality_{jmt} + \sigma \ln \left( S_{jmt|g}\right) \]
\[ + \lambda_a + \eta_t + origin_m + dest_m + \xi_{jmt}, \]

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. \( S_{0mt} = 1 - \sum_{j \in Jmt} S_{jmt} \) is the observed share of the outside option; \( S_{jmt|g} \) is the observed within-group share of product \( j \); and \( \xi_{jmt} \) is the structural demand error term.

4.1.1 Instruments

Since \( Price_{jmt} \) and \( \ln \left( S_{jmt|g}\right) \) are endogenous, we use two-stage least squares (2SLS) to estimate equation (6). We use a product’s itinerary flying distance to instrument for its price. As discussed in Gayle (2007 and 2013), this instrument is motivated by the fact that a product’s price is influenced by the marginal cost of providing the product, and flying distance covered by an air travel product is likely to be correlated with the marginal cost of providing the product.

To instrument for within group product share, \( \ln \left( S_{jmt|g}\right) \), we use a variable that measures the deviation of a products’ routing quality from the mean routing quality of the set of products offered
by the airline in the market. Recall that the nested logit demand model we use is constructed based on grouping/nesting products by airlines in a market. This means that a product’s within group share is based on how attractive it is to passengers relative to the other products offered by the airline, which is why a product’s within group share should be correlated with the deviation of the products’ routing quality measure from the mean routing quality of the set of products offered by the airline in the market.\footnote{In situations where the airline only offers a single product in the market, which implies that this product has a within group share of 1, the deviation of routing quality instrument variable is constructed to take the maximum value of the routing quality measure of 100.}

The previous discussion of the instruments suggests why the instruments are likely correlated with the endogenous variables, but to be useful, we need these instrument to be uncorrelated with the shocks to demand captured by $\xi_{jmt}$. The fact that the menu of products offered by airlines in a market is predetermined at the time of shocks to demand is likely to make our choice of instruments uncorrelated with shocks to demand. Furthermore, unlike price and within group product share, the menu of products offered and their associated non-price characteristics are not routinely and easily changed during a short period of time, which mitigates the influence of demand shocks on the menu of products offered and their non-price characteristics. Therefore, a product’s itinerary flying distance and its routing quality measure are predetermined during the short-run period of price-setting by airlines and product choice by passengers, which makes these valid non-price product characteristics to use for constructing instruments.

### 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:

\[
Routing\ Quality_{jmt} = \gamma_0 + \gamma_1 \text{Origin Presence}_{jmt} + \gamma_2 \text{Destination Presence}_{jmt} \\
+ \gamma_3 \text{Nonstop Flight Distance}_m + \gamma_4 \text{N_comp_connect}_{jmt} \\
+ \gamma_5 \text{N_comp_nonstop}_{jmt} + \gamma_6 \text{DN}_{jmt} + \gamma_7 T_{tn}^d + \gamma_8 T_{tn}^d \times \text{DN}_{jmt} \\
+ \gamma_9 \text{CU}_{jmt} + \gamma_{10} T_{cu}^d + \gamma_{11} T_{cu}^d \times \text{CU}_{jmt} + \lambda_a + \eta_t + \text{origin}_m + \text{dest}_m + \mu_{jmt},
\]

where \( \text{DN}_{jmt} \) is a zero-one airline-specific dummy variable that takes the value one only for products offered by Delta or Northwest, while \( T_{tn}^d \) 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, \( \gamma_6 \), which is the coefficient on \( \text{DN}_{jmt} \), tells us whether the routing quality of Delta and Northwest products systematically differs from the routing quality of products offered by other airlines. \( \gamma_7 \), which is the coefficient on \( T_{tn}^d \), 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, \( \gamma_8 \), which is the coefficient on the interaction variable \( T_{tn}^d \times \text{DN}_{jmt} \), 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, \( \gamma_8 \) should capture changes in the routing quality of products offered by Delta and Northwest that are associated with the DL/NW merger.

Parameters \( \gamma_9 \), \( \gamma_{10} \) and \( \gamma_{11} \) are interpreted analogously to \( \gamma_6 \), \( \gamma_7 \) and \( \gamma_8 \), but relate to the CO/UA merger. For example, \( \gamma_{11} \) 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, \( \gamma_{11} \) should capture changes in the routing quality of products offered by Continental and United that are associated with the CO/UA merger.

In the subsequent empirical analysis we do augment the interaction variables, \( T_{tn}^d \times \text{DN}_{jmt} \) and \( T_{cu}^d \times \text{CU}_{jmt} \), to investigate how the quality effects of each merger vary across markets with different levels of pre-merger competition intensity between the firms that merge. Therefore, the routing quality equation in (7) can be thought of as a baseline specification, which we meticulously augment to investigate predictions from our theoretical model.

As mentioned in the data section, \( \text{N_comp_nonstop} \) measures the number of nonstop products offered by an airline’s competitors in the market, while \( \text{N_comp_connect} \) 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 ($\lambda_a$), time period-specific ($\eta_t$), 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).

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 $\ln(S_{jmt|g})$ 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 $\ln(S_{jmt|g})$.

Simple regressions in which Price is regressed on its instrument, and $\ln(S_{jmt|g})$ regressed on its instrument produce R-squared values of 0.15 and 0.38 respectively. In addition, the coefficient estimate on the instrument variable in each of these regressions is statistically significant at the 1% level, indicating that the instruments do explain variations in the endogenous variables.\textsuperscript{19}

Given the clear need to instrument for Price and $\ln(S_{jmt|g})$, 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.

\textsuperscript{19}Since there are two endogenous variables and two instruments, the demand equation is exactly identified.
## Table 4
Demand Estimation Results
647,167 observations: 2005:Q1 to 2011:Q3

<table>
<thead>
<tr>
<th>Variable</th>
<th>OLS</th>
<th>2SLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>Std. Error</td>
</tr>
<tr>
<td>Price</td>
<td>0.00038***</td>
<td>0.00003</td>
</tr>
<tr>
<td>( \ln(S_{jltg}) )</td>
<td>0.51886***</td>
<td>0.00103</td>
</tr>
<tr>
<td>Origin presence</td>
<td>0.01399***</td>
<td>0.00007</td>
</tr>
<tr>
<td>Nonstop</td>
<td>0.99543***</td>
<td>0.00461</td>
</tr>
<tr>
<td>Routing Quality</td>
<td>0.01836***</td>
<td>0.00010</td>
</tr>
<tr>
<td>Constant</td>
<td>-12.0087***</td>
<td>0.02991</td>
</tr>
<tr>
<td>Carrier fixed effects</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Quarter and Year fixed effects</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Origin city fixed effects</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Destination city fixed effects</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.6471</td>
<td>0.5382</td>
</tr>
<tr>
<td>Tests of endogeneity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ho: variables are exogenous</td>
<td>19234.10***</td>
<td>F(2; 647,002)</td>
</tr>
</tbody>
</table>

*** 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 \( \ln(S_{jltg}) \), which is an estimate of \( \sigma \), 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.\(^{20}\)

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 $131.62 extra, on average, to obtain a product with a nonstop itinerary in order to avoid products with intermediate stop(s).

\(^{20}\)Instead of using the Origin Presence variable, we also estimated the demand equation using a dummy variable (\( HUB_{origin} \)) for whether or not the origin airport is a hub for the airline offering the product. The qualitative results are robust to using either Origin Presence or \( HUB_{origin} \) to capture the size of an airline’s operations at the origin airport. Since airlines typically have multiple hub airports, and the size of an airline’s operations may differ across its hub airports, we favor using Origin Presence since it is a continuous variable and therefore better able to capture heterogeneity in the size of an airline’s operations across different airports.
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 $2.37, 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 -1.64. 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 0.00027 between Delta and Northwest products, and 0.00034 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, 4 and 5) 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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient (Robust Std. Error)</td>
<td>Coefficient (Robust Std. Error)</td>
<td>Coefficient (Robust Std. Error)</td>
<td>Coefficient (Robust Std. Error)</td>
<td>Coefficient (Robust Std. Error)</td>
</tr>
<tr>
<td>Constant</td>
<td>87.599*** (0.2975)</td>
<td>87.606*** (0.2971)</td>
<td>87.557*** (0.2973)</td>
<td>87.094*** (0.2988)</td>
<td>90.608*** (1.5931)</td>
</tr>
<tr>
<td>Origin Presence</td>
<td>0.066*** (0.00084)</td>
<td>0.065*** (0.00084)</td>
<td>0.067*** (0.00084)</td>
<td>0.071*** (0.00084)</td>
<td>0.074*** (0.00012)</td>
</tr>
<tr>
<td>Destination Presence</td>
<td>0.064*** (0.00086)</td>
<td>0.064*** (0.00086)</td>
<td>0.064*** (0.00086)</td>
<td>0.069*** (0.00086)</td>
<td>0.071*** (0.0014)</td>
</tr>
<tr>
<td>Nonstop Distance (Miles)</td>
<td>0.005*** (0.00004)</td>
<td>0.005*** (0.00005)</td>
<td>0.005*** (0.00005)</td>
<td>0.006*** (0.00005)</td>
<td>0.005*** (0.00004)</td>
</tr>
<tr>
<td>N_comp_connect</td>
<td>-0.157*** (0.00328)</td>
<td>-0.159*** (0.00328)</td>
<td>-0.159*** (0.00328)</td>
<td>0.038*** (0.0057)</td>
<td>-0.189 (0.1519)</td>
</tr>
<tr>
<td>N_comp_nonstop</td>
<td>0.243*** (0.01094)</td>
<td>0.233*** (0.01094)</td>
<td>0.235*** (0.01093)</td>
<td>0.295*** (0.0111)</td>
<td>0.226*** (0.0476)</td>
</tr>
<tr>
<td>$MKT_{dn}^{t}$</td>
<td>-0.491*** (0.0647)</td>
<td>-0.502*** (0.0647)</td>
<td>-0.502*** (0.0647)</td>
<td>-0.580*** (0.0649)</td>
<td>-2.550*** (0.7824)</td>
</tr>
<tr>
<td>$DN_{jmt}$</td>
<td>-13.047*** (0.2369)</td>
<td>-13.014*** (0.2371)</td>
<td>-12.940*** (0.2386)</td>
<td>-16.748*** (1.5883)</td>
<td>-16.463*** (1.1144)</td>
</tr>
<tr>
<td>$T_{i}^{dn}$</td>
<td>-0.541*** (0.0982)</td>
<td>-0.531*** (0.0981)</td>
<td>-0.539*** (0.0981)</td>
<td>-0.553*** (0.0979)</td>
<td>-0.4636*** (0.1144)</td>
</tr>
<tr>
<td>$T_{i}^{dn} \times DN_{jmt}$</td>
<td>-0.464*** (0.0785)</td>
<td>0.503*** (0.2156)</td>
<td>0.489*** (0.2154)</td>
<td>0.507*** (0.2147)</td>
<td>0.781*** (0.2524)</td>
</tr>
<tr>
<td>$MKT_{bn}^{t} \times T_{i}^{dn} \times DN_{jmt}$</td>
<td>-1.079*** (0.2177)</td>
<td>-0.866*** (0.2217)</td>
<td>-0.776*** (0.2211)</td>
<td>-0.528*** (0.2491)</td>
<td>-0.294*** (0.6425)</td>
</tr>
<tr>
<td>$E_{bn}^{t} \times MKT_{bn}^{t} \times T_{i}^{dn} \times DN_{jmt}$</td>
<td>-0.551*** (0.2368)</td>
<td>-0.531*** (0.0981)</td>
<td>-0.539*** (0.0981)</td>
<td>-0.553*** (0.0979)</td>
<td>-0.4636*** (0.1144)</td>
</tr>
<tr>
<td>($E_{bn}^{t}^{2}) \times MKT_{bn}^{t} \times T_{i}^{dn} \times DN_{jmt}$</td>
<td>-654.703*** (2456.64)</td>
<td>-654.703*** (2456.64)</td>
<td>-654.703*** (2456.64)</td>
<td>-654.703*** (2456.64)</td>
<td>-654.703*** (2456.64)</td>
</tr>
<tr>
<td>$MKT_{bn}^{cu}$</td>
<td>-12.233*** (0.2366)</td>
<td>-12.173*** (0.2363)</td>
<td>-12.173*** (0.2367)</td>
<td>-11.922*** (0.2378)</td>
<td>-12.504*** (0.4035)</td>
</tr>
<tr>
<td>$CU_{jmt}$</td>
<td>-0.150 (0.1000)</td>
<td>-0.146 (0.0999)</td>
<td>-0.148 (0.0998)</td>
<td>-0.081 (0.0998)</td>
<td>-0.267 (0.1447)</td>
</tr>
<tr>
<td>$T_{i}^{cu} \times CU_{jmt}$</td>
<td>0.576*** (0.1182)</td>
<td>4.805*** (0.2927)</td>
<td>4.800*** (0.2927)</td>
<td>4.764*** (0.2934)</td>
<td>4.024*** (0.4185)</td>
</tr>
<tr>
<td>$MKT_{bn}^{cu} \times T_{i}^{cu} \times CU_{jmt}$</td>
<td>-4.969*** (0.3053)</td>
<td>-4.902*** (0.3111)</td>
<td>-4.902*** (0.3111)</td>
<td>-4.902*** (0.3116)</td>
<td>-3.807*** (0.5476)</td>
</tr>
<tr>
<td>$E_{bn}^{cu} \times MKT_{bn}^{cu} \times T_{i}^{cu} \times CU_{jmt}$</td>
<td>-372.583*** (199561)</td>
<td>-372.583*** (199561)</td>
<td>-372.583*** (199561)</td>
<td>-518.946*** (197386)</td>
<td>-656.109*** (215269)</td>
</tr>
<tr>
<td>($E_{bn}^{cu}^{2}) \times MKT_{bn}^{cu} \times T_{i}^{cu} \times CU_{jmt}$</td>
<td>-48219.08*** (23273.34)</td>
<td>51160.65*** (23731.41)</td>
<td>36493.25 (23134.71)</td>
<td>36493.25 (23134.71)</td>
<td>36493.25 (23134.71)</td>
</tr>
<tr>
<td>$N_{-DN_{mt}}$</td>
<td>-0.207*** (0.0122)</td>
<td>3.294*** (1.4822)</td>
<td>-0.207*** (0.0122)</td>
<td>3.294*** (1.4822)</td>
<td>3.294*** (1.4822)</td>
</tr>
<tr>
<td>$N_{-CU_{mt}}$</td>
<td>-0.521*** (0.0115)</td>
<td>-2.792*** (0.7795)</td>
<td>-0.521*** (0.0115)</td>
<td>-2.792*** (0.7795)</td>
<td>-2.792*** (0.7795)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.1599</td>
<td>0.1614</td>
<td>0.1617</td>
<td>0.1646</td>
<td>0.1646</td>
</tr>
</tbody>
</table>

*** indicates statistical significance at the 1% level, ** indicates statistical significance at the 5% level, * indicates statistical significance at the 10% level. 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. OLS: Ordinary least squares. 2SLS: Two-stage least squares.
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. A reasonable inference that can be drawn from these results is that an airline contemplating what type of products to enter a market with is more likely to offer products with characteristics closer to the characteristics of competing products in the market. Such non-price product characteristic choice behavior of airlines leads to more intense short-run price competition than if competing airlines chose greater differentiation of non-price product characteristics.

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.\(^{21}\) 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 for Delta/Northwest products is computed using the regression equation in Specification 1 as follows:

\[
Routing \ Quality^{DN} = 87.599 - 13.047 + 0.066 \times (30.535) + 0.064 \times (30.404) + 0.005 \times (1425.973) - 0.157 \times (9.44) + 0.243 \times (2.335),
\]

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.
quality measure of Continental/United products is approximately 85.48. Therefore, nonstop 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

\[ \text{Routing Quality}_{cu} = 87.599 - 12.232 + 0.066 \times (26.480) + 0.064 \times (26.010) \\
+ 0.005 \times (1574.05) - 0.157 \times (11.358) + 0.243 \times (2.520), \]

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.

\(^{22}\) This mean routing quality measure for Continental/United products is computed using the regression equation in Specification 1 as follows:
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 and 3.

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

$MKT_{dn}^{bm}$ 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, $MKT_{cu}^{bm}$ 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. Therefore, $MKT_{dn}^{bm}$ and $MKT_{cu}^{bm}$ are discrete indicators of the existence of pre-merger competition between the merging firms, and serve as discrete counterparts to $\beta$ in the theoretical model, with no pre-merger competition meaning $\beta = 0$.

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 0.58% ($= |−1.079 + 0.503|)$ and 0.16% ($= |−4.969 + 4.805|)$ 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 is based on the sum of the coefficients on interaction variables $T_{dn}^{bm} \times DN$ and $MKT_{dn}^{bm} \times T_{dn}^{bm} \times DN$ in case of the DL/NW merger, and the sum of the coefficients on interaction variables $T_{cu}^{bm} \times CU$ and $MKT_{bm}^{cu}$. 

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in case of the CO/UA merger. The negative coefficient estimates of -1.079 and -4.969 on the interaction variables, $MKT_{bm}^T \times T_{dn} \times DN$ and $MKT_{bm}^{cu} \times T_{cu} \times CU$, respectively, are the drivers of the evidence of routing quality declines associated with the mergers.

Based on results from our structural demand estimates, we can monetize consumer welfare effects of the routing quality declines associated with the mergers. In particular, recall that our demand estimates suggest that consumers are willing to pay $2.37, 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 $1.37 (= 2.37 \times 0.58)$ in case of the DL/NW merger, and $0.38 (= 2.37 \times 0.16)$ 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 4.8% 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 $1.18 (= 2.37 \times 0.5)$ in case of the DL/NW merger, and $11.38 (= 2.37 \times 4.8)$ 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, $E_{bm}^{dn}$, measures pre-merger cross-price elasticities

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23 This method of computing a welfare effect associated with routing quality changes abstracts from second-order welfare effects that can occur due to routing quality influencing other variables (e.g. price) that in turn affect welfare.
of demand between Delta and Northwest products, while variable $E_{bm}^{cu}$ 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. In this section of the empirical analysis, $E_{bm}^{dn}$ and $E_{bm}^{cu}$ serve as continuous indexes of $\beta$ in the theoretical model.

We use the pre-merger cross-elasticity variables to construct interaction variables: (i) $E_{bm}^{dn} \times MKT_{bm}^{dn} \times T^{dn} \times DN$; (ii) $(E_{bm}^{dn})^2 \times MKT_{bm}^{dn} \times T^{dn} \times DN$; (iii) $E_{bm}^{cu} \times MKT_{bm}^{cu} \times T^{cu} \times CU$; and (iv) $(E_{bm}^{cu})^2 \times MKT_{bm}^{cu} \times T^{cu} \times CU$. Specification 3 in Table 5 adds these variables to the routing quality regression.

The Delta/Northwest merger The segment of the regression equation in Specification 3 that relates to routing quality effects of the Delta/Northwest merger in markets where they directly competed prior to the merger is given by:

$$\Delta \text{Routing Quality}^{dn} = 0.489 - 0.866 - 551.06E_{bm}^{dn} - 66474.70 \left( E_{bm}^{dn} \right)^2,$$

where dummy variables $MKT_{bm}^{dn}$, $T^{dn}$ and $DN$ each take the value of 1. Note that the coefficient estimates in equation (8) imply that $\Delta \text{Routing Quality}^{dn}$ is negative for all permissible values of $E_{bm}^{dn}$. 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 $E_{bm}^{dn}$) prior to the merger.

Given that $E_{bm}^{dn}$ has a mean of 0.00027, a minimum value of 1.59e-07, and a maximum value of 0.0097, equation (8) implies that routing quality of DL/NW products declined by a mean of 0.53%, a minimum of 0.377%, and a maximum of 11.98% 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 $28.39 (= 2.37 \times 11.98)$, 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 $E_{bm}^{dn}$ is greater than 0.008, which implies that a typical consumer in these markets experienced a decline in utility

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$E_{bm}^{dn}$ can only take positive values since it measures cross-elasticities.
greater than $21.42 (≈ $2.37 \times 9.04) 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 3 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 3 that relates to quality effects of the Continental/United merger in markets where they directly competed prior to the merger is given by:

\[
\Delta Routing \ Quality^{cu} = 4.80 - 4.902 - 372.58E^{cu}_{bm} + 48219.08 (E^{cu}_{bm})^2,
\]

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 coefficient on $E^{cu}_{bm}$ is 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 0.0039 (= 372.58/(2 \times 48219.08)). 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 0.0039. Markets with pre-merger cross-elasticity between CO and UA of 0.0039, experienced the largest decline in routing quality of 0.82%, which yields a decline in a typical consumer’s utility equivalent to $1.94 (≈ 2.37 \times 0.82). 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 $E^{cu}_{bm}$ is less than 0.00799, but increased in markets where $E^{cu}_{bm}$ is greater than 0.00799. In other words,
the coefficient estimates in equation (9) provide evidence suggesting that the Continental/United merger increased routing quality of their products in markets where pre-merger cross-elasticity between the two airlines' products are greater than 0.00799. Examples of origin-destination markets in our sample in which our demand model generates pre-merger cross-elasticity between CO and UA that is greater than 0.00799 include: (i) Cleveland, OH to Las Vegas, NV; (ii) Washington, DC to Houston, TX; and (iii) Tampa, FL to New York City/Newark. In these markets pre-merger competition intensity between Continental and United is sufficiently high such that the positive coordination effect of the merger on product quality again dominates the negative competitive incentive effect. A rationale for such merger quality effects is, even though competitive pressure motivates firms to improve product quality, the diminished profit under competition, especially when competition intensity goes beyond certain point, can reduce the incentive for costly quality provision. Thus when competition intensity is sufficiently high prior to a merger, the coordination effect can again be the dominant driver of quality changes, resulting in quality improvements when firms merge.

Last, the coefficient on $T^{cu} \times CU$ in Specification 3 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 Do Merger Results Persist after Controlling for Number of Products Offered by Merging Firms?

It can be argued that the "routing quality" effects measured thus far may not be linked to "real" changes in routing quality of products being offered. A reason is that the regression coefficients used to draw inference on routing quality effects only measure average changes in our routing quality measure associated with an airline. For example, suppose prior to merging an airline offered multiple products with different routing quality measures in a given market, but post-merger eliminates the product with the lowest routing quality. In this case the post-merger average routing quality associated with product(s) offered by the merged airline in the market will be higher than the pre-merger average routing quality associated with its products. However, the increase in average routing quality in this case is purely driven by the elimination of a lower quality product rather than improved routing quality of the products being offered. In other words, we need to check if the measured merger effects are robust to controlling for the number of products being

25 We thank an anonymous referee for raising this issue.
offered by the merging firms across the pre-post merger periods. As such, we add the following two variables to the right-hand-side of the routing quality regression: (i) $N_{DN_{mt}}$; and (ii) $N_{CU_{mt}}$.

Variable $N_{DN_{mt}}$ counts the number of Delta/Northwest products offered in a given market during a given time period. Analogously, $N_{CU_{mt}}$ counts the number of Continental/United products offered in a given market during a given time period. Specification 4 in Table 5 reports results when variables $N_{DN_{mt}}$ and $N_{CU_{mt}}$ are added to the routing quality regression. The key "take-away" message from the estimates in Specification 4 is that the qualitative merger results we previously found are robust to controlling for number of products being offered by the merging firms across the pre-post merger periods.

It is reasonable to argue that $N_{DN_{mt}}$ and $N_{CU_{mt}}$ are themselves influenced by the mergers and therefore endogenous. As such, if we want to use $N_{DN_{mt}}$ and $N_{CU_{mt}}$ on the right-hand-side of a regression, appropriate instruments for these variables are required to achieve unbiased and consistent coefficient estimates. However, it is difficult to find valid instrument variables for these endogenous variables since a valid instrument must be correlated with $N_{DN_{mt}}$ and $N_{CU_{mt}}$ but uncorrelated with the merger events. To instrument for these endogenous variables we use population sizes of the origin and destination cities of a market, as well as the geometric mean between these population sizes of a market. We believe that population sizes of a market’s endpoints are reasonable instrument variables since they influence the number of products offered in a market via their correlation with market size, but are likely uncorrelated with the merger events.\footnote{The three instrument variables are: (1) $Pop_{origin_{mt}}$; (2) $Pop_{dest_{mt}}$; and (3) $Pop_{mean_{mt}}$, which correspond to the population sizes of the market origin city, market destination city, and the geometric mean between the endpoint population sizes of the market, respectively. A regression in which $N_{DN_{mt}}$ ($N_{CU_{mt}}$) is the dependent variable with these three instrument variables on the right-hand-side produces an R-squared of 0.32 (0.27). However, when the dependent variable of the regression is $T_{dn}$ ($T_{cu}$), where $T_{dn}$ and $T_{cu}$ are dummies that define the timing of the respective mergers, then the R-squared is substantially smaller, 0.0003 (0.0001). The substantially small R-squared values when $T_{dn}$ or $T_{cu}$ is the dependent variable, but relatively high R-squared values when $N_{DN_{mt}}$ or $N_{CU_{mt}}$ is the dependent variable suggest that our instrument variables are uncorrelated with the merger events, but correlated with the endogenous variables.}

Specification 5 in Table 5 reports routing quality equation estimates when $N_{DN_{mt}}$ and $N_{CU_{mt}}$ are included on the right-hand-side of the regression, but treated as endogenous using the two-stage least squares (2SLS) estimation procedure.\footnote{A formal Wu-Hausman statistical test of exogeneity, reported in the last row of Table 5, confirms the endogeneity of $N_{DN_{mt}}$ and $N_{CU_{mt}}$.} The only qualitative difference in the merger results when $N_{DN_{mt}}$ and $N_{CU_{mt}}$ are treated as endogenous is that the coefficient estimates when $E^{dn}_{b_{mt}}$ and $E^{cu}_{b_{mt}}$ enter quadratically on the right-hand-side of the routing quality re-

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gression, i.e. the coefficients on \( (E_{bm}^{dn})^2 \times MKT_{bn}^{dn} \times T^{dn} \times DN \) and \( (E_{bn}^{cu})^2 \times MKT_{bn}^{cu} \times T^{cu} \times CU \) respectively, are not statistically significant at conventional levels of statistical significance. Importantly however, the coefficient estimates on \( E_{bm}^{dn} \times MKT_{bn}^{dn} \times T^{dn} \times DN \) and \( E_{bn}^{cu} \times MKT_{bn}^{cu} \times T^{cu} \times CU \) remain statistically significant and therefore suggest that quality change due to each merger depends on pre-merger competition intensity between the merging firms.

### 5.2.7 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 - 0.5% and 4.8% 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 $1.18 and $11.38 for the DL/NW and CO/UA mergers, respectively.

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 0.53%, a minimum of 0.377%, and a maximum of 11.98% across such markets. These quality declines are estimated to yield utility decreases of a consumer in these markets ranging from a minimum of $0.89 to as high as $28.39. For the CO/UA merger, the largest decline in routing quality is 0.82%, which yields a decline in a typical consumer’s utility equivalent to $1.94.

### 6 Conclusion

Departing from the extant economics literature on horizontal mergers that focuses on their price effects, this paper has investigated how mergers affect the merging firms’ product quality. Consistent with the theoretical predictions, the empirical analysis of two recent airline mergers finds: (1) each merger is associated with a quality *increase* in markets where the merging firms did not compete prior to their merger, but with a quality *decrease* in markets where they did; and (2) the quality change across markets from the Continental/United merger exhibited a U-shaped curve as the pre-merger competition intensity increased.

Our results further indicate that the consumer gains or losses from the quality changes associated
with mergers can be substantial. This suggests that the standard practice in merger reviews that consider mainly the price effects may lead to substantial under- or over-estimate of a merger’s consumer benefit or harm. It would thus be desirable to explicitly incorporate product quality considerations into merger review, and the insights from this paper may help stimulate further research and policy discussions towards this direction.
References


