Airline Merger Effects on Airline Network Characteristics and Flight Fares

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Abstract

This paper extends the models proposed in Hüschelrath and Müller (2014) and Brueckner et al. (1992) to analyze the effects of the Northwestern-Delta Airlines Merger of 2010 on airfares. The model proposed in this paper will test for the price effects of eigenvector centrality and market share as a merger is completed. A differences-in-differences approach is adopted with route and time fixed effects. Increases in market share in airports that are central in the network will give the airline more price setting control and increase the economies of density to and from other cities with low network centrality. After a the differences-in-differences regression analysis the eigenvector centrality and market share variables show decreases in prices as points along the routes become more central and a carrier gains a higher market share post merger.

1 Introduction

The airline industry has become increasingly oligarchic after several airline mergers have taken place since industry regulatory pressures have lessened. Airlines have since been able to rationalize their routes and gain more price setting power. Evidence of what the mergers have done to airfares is important in providing clarity for regulators and businesses. This paper adopts and extends the models proposed in Hüschelrath and Müller (2014) and Brueckner et al. (1992) to analyze the Northwester-Delta Airlines Merger of 2010. Competition type are controlled for in the same way as in Hüschelrath and Müller (2014). A fixed effects model is also adopted, however this paper proposes fixed effects across time and route where Hüschelrath and Müller (2014) fix effects across ex-ante carrier and route. This paper uses the hub-and-spoke model proposed in Brueckner et al. (1992), to justify the inclusion of airport centrality in the analyses of the merger effect. The data is collected from the D1B1-D100 Market Fair survey done by the Department of Transportation. This paper uses only data for quarter 1 of 2007 through quarter 4 of 2011. The D1B1 Market Data is used to construct a network for each quarter of the data set and calculate some network characteristics for use as variables in the regression analyses. The hypothesis tested is that changes in eigenvector centrality and market share will not effect the fares as airlines merge. This paper shows that increases in eigenvector centrality and market share as carriers merge result in decreases in fares. The paper starts by explaining and applying the models proposed in Brueckner et al. (1992) and Hüschelrath and Müller (2014) in section 2. The mathematical framework for the analyses done

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in this paper is given in section 3. Then the network characteristics of the airline industry as given by the D100 market data is shown and explained in 4. Then the regression analyses is carried out and the results are presented in 5.

2 Literary Review

The network composition of the airline industry is an important indicator for the consumer welfare effects of airline mergers. Deregulation of the industry has not only allowed for airlines to increase their overall share in the market but also to change routes to exploit economies of density (Brueckner and Spiller, 1991). Economies of density arise because more passengers on one flight allows for the use of larger more efficient air-crafts as opposed to those same passengers being separated to different flights. Brueckner and Spiller (1991) and Brueckner et al. (1992), find that mergers increase consumer welfare in the form of lower fares on routes that contain hub airports. Consumer welfare, however, decreases in airport pairs that do not contain a hub. Figure 1 shows the simple single carrier hub-and-spoke network first outlined in Brueckner and Spiller (1991). *H* is the hub airport and nodes *A, B, and C* are the spoke nodes. The routes between nodes are non-directional and are refered to as spokes. The model is used to outline a basic profit maximization problem for a carrier. The next section 3 will explain this model more deeply as it is adopted as a basis of this paper's hypothesis. Brueckner et al. (1992) uses the model along with data on the TWA-Ozark to illustrate that economies of density only take place and reverse the effects of a loss of competition in origin-destination pairs that include a hub airport. The loss of competition for rim flights are shown to decrease consumer welfare. This paper uses these conclusions to justify the inclusion of node characteristics as independent variables.

Merger effects on consumer welfare are also examined in Kawamori and Lin (2013) and Hüschelrath and Müller (2014), the first of which shows the effects of a merger of a Low Cost Carrier (LCC) and a major carrier. LCCs in this model are shown to operate more direct flights to smaller airports, while major airports operate more in-direct flights that use a major airport as a connection. The reason LCCs operate more point-to-point routes as opposed to hub-and-spoke routes is to avoid competition from major carriers. When major carriers and LCCs merge then the newly formed carrier begins to eliminate the point-to-point routes and converts the network to a hub-and-spoke model (Kawamori and Lin, 2013). Figure 2 shows a simple hub-and-spoke model with an additional route operated by an LCC between nodes A and B. The LCC operates this direct route which provides consumers who want to travel from A to B an alternative from the Hub-and-Spoke provided by the major carrier. Once the LCC and the major carrier merge however the direct route could be eliminated and hub and spoke could be all that is offered. Whether this happens depends on the relative market sizes of nodes A and B to the hub H and to the other node c. If nodes A and B are large enough then the airline formed post-merger may continue to service the route. IF this does not happen because A and B are not sufficiently large then even as airfares on the hub-and-spoke route go down consumer welfare may be lost in the form of longer flights, more stops, and more potential delays.

Finally, (Hüschelrath and Müller, 2014) take a look at competition and consumer welfare effects by using a differences-in-differences methodology. First it defines different types of competition along routes. When both airlines involved in the merger formerly had a direct flight between two points then that route had *direct* competition. If one of the carriers formerly had a non-stop flight and the other had a one-stop flight between two points than that is *indirect* competition. Cases where only one of the carriers offered travel from two points were listed as *no-competition*

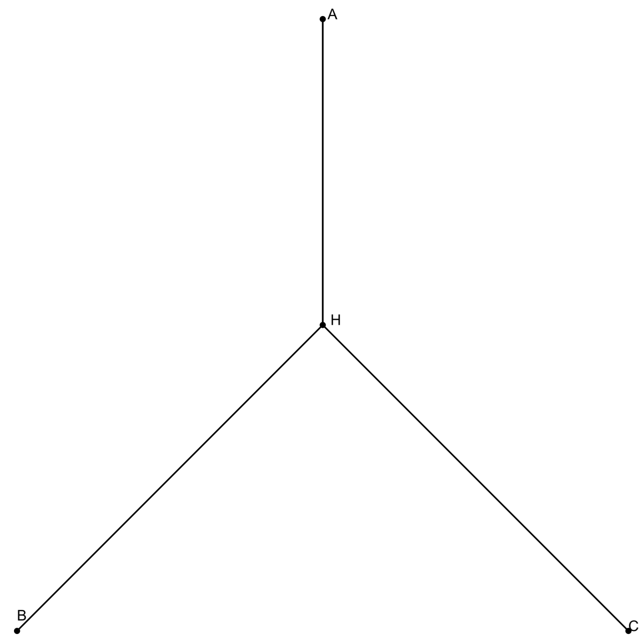

Figure (1) Single Airline Non-Directional Hub-and-Spoke Network

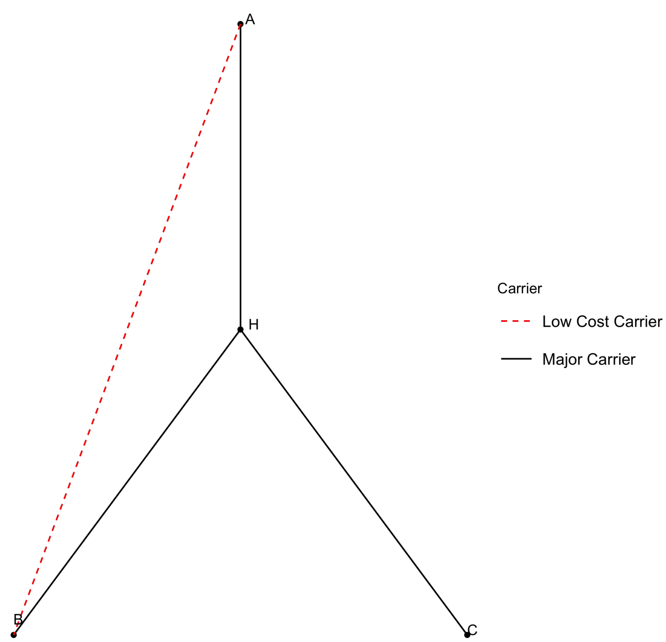

Figure (2) Major Carrier vs. Low Cost Carrier Hub-and-Spoke Network routes. Hüschelrath and Müller then group the observation by route and ex-ante carrier, and create a differences-in-differences model to assess the effects of the merger on consumer welfare with competition pre-merger along the routes as independent variables. The competition types are as follows: Carrier 1 (US Airways in Hüschelrath and Müller) routes that have no carrier 2 (Northwest in Hüschelrath) alternative are *Carrier 1 No-Comp*, those that have a one-stop carrier 2 alternative are *Carrier 1 Better*, carrier 2 routes that have no carrier 1 alternative are *Carrier 2 No-Comp*, carrier 2 routes that have a one-stop carrier 1 alternative are *Carrier 2 Better*, and routes where both carriers offer the same services are *Direct*. By fixing effects across route and carrier Hüschelrath and Müller are able to isolate the consumer effects of the merger with competition levels and find that decreases in competition do not necessarily decrease consumer welfare but there are channels where those decreases could raise airfares (Hüschelrath and Müller, 2014). Hüschelrath approaches the merger problem using the major carrier to major carrier competitor model found in Brueckner and Spiller (1991).

The model shown in figure 3 is a a hub and spoke model with two hubs at nodes A and B that are used by the two competing carriers as first proposed in Brueckner and Spiller (1991) and adopted in Hüschelrath and Müller (2014). Figure 3 shows the five categories of route type very clearly. There is direct competition on flights from the two hub nodes *A and B*, and there is indirect competition on routes *A-D, A-C, B-C, and B-D*. The first two routes (*A-D and A-C*) are direct for carrier 1 and one-stop for carrier 2, and the latter two (*B-D and B-C*) are direct for carrier 2 and one-stop for carrier 1. The routes *E-A, and B-F* are both no competition routes for carriers 1 and 2 respectively. Post merger what flights remain direct or do not depend on the relative importance of the nodes. Thus the consumer welfare of the passengers located in each hub depends on what node is chosen as the new hub for the post-merger carrier.

3 Model

The model adopted for this paper is based on the first proposed in Brueckner and Spiller (1991) and adopted for the analysis of mergers in Brueckner et al. (1992), Hüschelrath and Müller (2014), and, Kawamori and Lin (2013). The hub-and-spoke model illustrates properly how airlines can combine passengers with different origins on destinations to increase scales of density.

3.1 Monopoly

Using figure 1 that displays a simple one carrier hub and spoke model with three spoke nodes A, B, C, and a hub node H. $Q_{i,j}$, and $D(Q_{i,j})$, are the quantity of passengers, and demand function, respectively on trips from node i to node j. Revenue $R_{i,j}$ is equal to $Q_{i,j} * D(Q_{i,j})$. Total revenue ($T_{i,j}$) is defined in equation 1. Where H is the Hub node, N is the total number of spoke nodes and X_n is a spoke node that is not i or j. The summation takes into account the demand there is for flights where the legs to the hub nodes will be the same. Trips from the i to any where else start with a leg from i to H and then else where. R_{i,X_n} shows the revenue for first leg of the trip, which contains all passengers that come from node i regardless of what their final destination is. The second term in the summation, $R_{X_n,j}$, is the second leg of the trip that accounts for all the people that are going to j regardless of their starting node. Equation 1 only applies to trips between spoke nodes. Equation 2 is the total revenue equation for a hub to spoke flight and 3 is the total revenue equation for a spoke to hub flight.

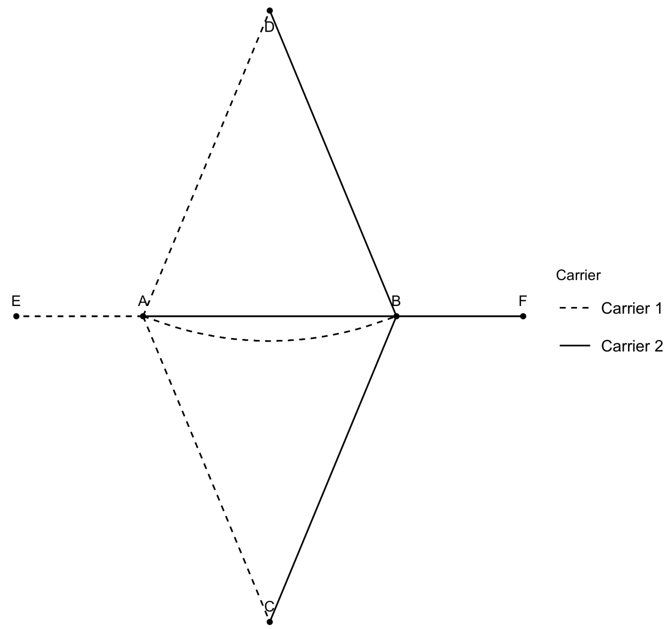

Figure (3) Two Major Carrier Hub-and-Spoke Network

$$T_{i,j} = R_{i,j} + R_{i,H} + R_{H,j} + \sum_{n=1}^{N-2} [R_{i,X_n} + R_{X_n,j}] \tag{1}$$

$$T_{H,j} = R_{H,j} + \sum_{n=1}^{N-1} [R_{X_n,j}] \tag{2}$$

$$T_{i,H} = R_{i,H} + \sum_{n=1}^{N-1} [R_{i,X_n}] \tag{3}$$

As an example take the hub-and-spoke network built in figure 4 which shows a trip from node B to node A. The main route is shown as the solid line. The dashed lines denote ancillary routes whose quantity is endogenous to the revenue of the main flight A to B. The total revenue is the sum of all revenues from each trip. So the total revenue equation for a trip from A to B is: $T_{B,A} = R_{B,A} + R_{B,H} + R_{H,A} + R_{B,C} + R_{C,A}$. The total cost of each flight is defined the same way as total revenues. Equation 5 shows the profit for a trip from i to j. To profit maximize the monopolist must maximize revenues and minimize costs.

$$C_{i,j} = c_{i,j} + c_{i,H} + c_{H,j} + \sum_{n=1}^{N-2} [c_{X_n,j} + c_{i,X_n}] \tag{4}$$

$$P_{i,j} = T_{i,j} - C_{i,j} \tag{5}$$

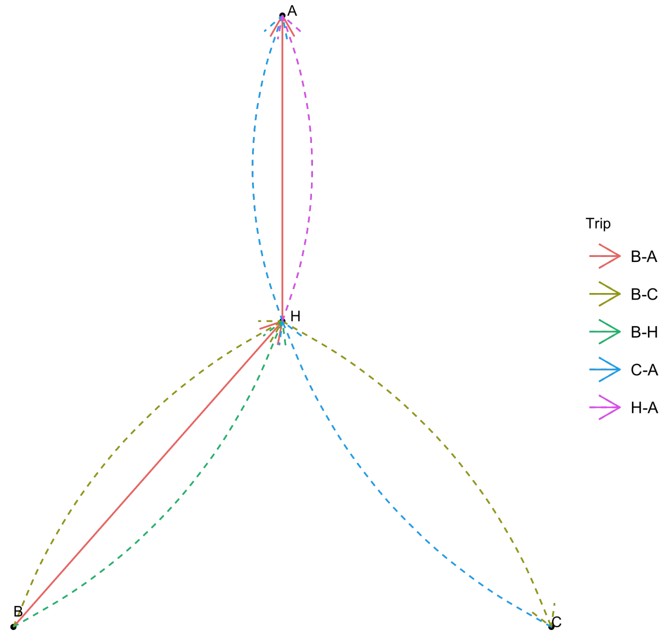

Figure (4) Trip from A to B revenue example

Intuitively costs are expenses like fuel, wages, and maintenance. All of those things are minimized with less planes and less trips. A hub and spoke model enables the monopolist to minimize planes and trips. If the monopolist gave each individual Origin Destination pair its won flight then in the four hub model there would be a total of 12 flights (A-B, B-A, A-C, C-A, A-H, H-A, B-H, H-B, B-C, C-B, C-H, H-C). All of which would have their own plane and staff of course. By using a hub and spoke model the monopolist can combine those flights to minimize the number of planes and trips, in a hub and spoke model there are only 6 flights from each spoke to the hub and back that are able to service all 12 origin-destination pairs in this example.

In the example shown in 1 the centrality of the hub node is the most central. The spokes are not central at all they are only connected to the one hub. As is intuitive from equation 1 as N increases so does the revenue. It is also clear that total revenue increases for a trip from i to j when revenue increase on a adjacent trip on the first or second leg. Revenues are then a function of not only how popular the origins and destinations are but how many adjacent trips can be combined with that trip and how popular those origin-destination pairs are. Eigenvector centrality can track the changes in how they effect each trip. Eigenvector centrality weights the amount of connection any single node has with the amount of weighted connections it's connections have.

3.2 Competition

Competition along routes and among nodes is also important to how a carrier designs the routes. First, let a direct trip between two nodes be denoted as $d_{i,j}$, and a one-stop trip be $s_{i,j}$. A one-stop is favorable if and only if $R_{d_{i,j}} < R_{s_{i,j}}$. Where R is the revenue for that route. As noted in the previous section travel between nodes can be enhanced such that marginal costs are minimized with more more one-stop trips than if the model only allowed for direct flight. The hub-and-spoke model allows the aforementioned to be true only if the eigenvector centralities of the spoke nodes are high enough. If scales of density are not improved enough by increasing the number of stops from 0 to 1 then the direct trip is favorable.

Kawamori and Lin (2013) provides an example of the competition a major airline faces by from a smaller low-cost airline. Figure 2 shows a hub and spoke model that has been disrupted by a low-cost carrier. Despite the name a low-cost carrier is not defined as a carrier that offers consistently lower ticket prices than the major carrier but rather as a carrier that operates smaller flights and less routes than the major carrier. In 2 the LCC operates a direct flight between nodes A and B. The reason it does not offer a connecting flight is because the scales of density are not such that the LCC would raise revenue by doing so. There may not be enough demand for flights other than those between A and B to aggregate with. The LCC offering this flight would lower revenues for the major carrier in that demand would be lessened on their A to B flight. And revenues would be lower because of the lost ticket sales. The degree that this competition lessens profits depends also on the eigenvalue centrality of nodes A and B. Once a merger took place the major carrier would continue to offer the direct flight only if the additional revenues to offering the only the one-stop flight were greater than 0. Notated in the terms set forth in the previous section. The LCC's revenue to operate a direct flight from any two points i and j is given by equation 6. The monopolist revenue is given in equation 1. Equation 7 shows the necessary difference in revenues for the direct flight from i to j to be offered post merger. The revenue from adjacent routes goes up with every increase in N and with every increase in the quantity demanded along those routes. An increase in eigenvector centrality shows the potential increase in revenues by aggregating the trip with a stop at a hub.

$$T_{i,j}^{LCC} = R_{i,j} \tag{6}$$

$$(R_{i,j} + R_{i,H} + R_{H,j} + \sum_{n=1}^{N-2} [R_{i,X_n} + R_{X_n,j}]) < R_{i,j}^{LCC} \tag{7}$$

Hüschelrath and Müller (2014) adopts the model that Brueckner and Spiller (1991) uses to show what a simple competitive hub and spoke market would look for two competing major airliners operating out of different hubs. That model is shown in figure 3. After a merger between the two carriers which hub would adopted as the primary hub in the hub and spoke model? The test here is also about the eigenvector centrality. The hub with the best eigenvector centrality will become the primary hub. In figure 3 carrier 1 offers a direct A to D flight while carrier 2 only offers a one-stop flight with a layover at B. Building off equation 7, the difference in revenues is shown in equation 8. The analysis is extended to all the origin-destination paring where the carriers offer asymmetrical services. If all the direct flight terms are moved to the left side of equation 8 the resulting difference is denoted as $G_{A,D}$. $G_{i,j}$ then denotes revenues of a flight from i to j for carrier 2 less the revenues for a flight from i to j for carrier 1. Then the network used by carrier 2 will only prevail as the main network with B as the hub if the inequality in equation 9 is correct.

$$(R_{A,D} + R_{A,B} + R_{B,D} + R_{A,C} + R_{A,F} + R_{C,D} + R_{F,D}) < (R_{A,D} + R_{E,D} + R_{C,D}) \tag{8}$$

$$0 > \sum_{i=1}^{N}[\sum_{j=1}^{N}(G_{i,j})], \quad where \;\; i \neq j \tag{9}$$

4 Calculations and Definitions

The data is gotten from the Department of Transportation's D1B1 market data set. The data starts with quarter 1, 2007 and ends at quarter 4, 2011. The Northwest-Delta merger was announced in 2009 but was completed only by beginning of quarter 1, 2010. These 20 quarters and the origin-destination pairs make up the panel. The data includes all flights that occurred during that period including small private flights. This analysis is restricted to the analysis for the commercial airline market so, only flights with 20 or more passengers are included. Like Hüschelrath and Müller (2014) flights that have two or more connections are removed as-well. The route competition types rely on the fact that one-stop is the maximum number of stops it is also a simplification that makes the creation of the network much easier.

The D1B1 data gives the origin, destination and route for each flight. The route contains all the airports in that trip. For flights that a direct the route is simply a combination of the origin and destination variables. For a flight with one stop the route contains the origin, the layover, then the destination. The variable layover for that reason is defined only for flights with one stop. The market fare of each trip is given as the average price paid by each passenger on the trip for that time period. The fares are directional as fare is denoted for that one-way trip.

4.1 Eigenvector Centrality

The main feature of this paper in comparison to the previous works is the inclusion of network characteristics. The other papers create a theoretical framework based on assumed network characteristics. This paper furthers this analysis by using the data to create a network so that it's characteristics can be used as variables. The network is directional meaning a flight from A to B is different from one from B to A. Each path on the network is a single pair of nodes. For direct flights this is just the origin as the starting node and the destination as the ending node. For one-stop flights the trip is separated into it's legs. The first leg where the origin is the starting node and the layover is the end node, and the second leg where the layover is the starting node and the destination is the end node. The connection between to airport pairs is weighted by the total number of passengers that have flown from the starting airport to the ending airport. The data shows the number of passengers and fares for trips not individual flights. Flights, however, contains people that have different itineraries so there trips are denoted differently. By separating the one-stop trips into legs the network puts people that went from the starting node to the ending node at any-point in their trip together. The network also combines all of the carriers trips into one set of trips. For each period of data a directional network weighted by passengers is created for every period in the data (20 networks in total).

Eigenvector centrality is a measure of importance. Eigenvector centrality is used most famously in search engine algorithms to give the most relevant results. A search engine will define each web page on the internet as a node and a connection between the nodes is a reference. The degree (number of references) of each web page is alright but may give misleading results. The degree in this way is quantity over quality. Eigenvector centrality for a web page i is it's degree weighted by the eigenvector centrality of the pages that reference i. For a flight network the idea is the same. Each airport is not just given a score for how many other airports it is connected to but the *quality* of those connections as well. The calculation for eigenvector centrality is given in chapter 2 of Jackson (2008). Here it is assumed that the eigenvalues used to calculate eigenvector centrality are always positive. The eigenvector centrality values are also always between 0 and 1. Other network characteristics could be used to discern the effects of the merger but for this paper only eigenvector centrality is used.

4.2 Competition Variables

Market share is created using data for all trips and carriers for all the years. The role (origin, destination, or layover) for each airport is removed and the number of passengers that each carrier flew in, out, or through that airport is summed for each period. The market share of each airport for each carrier is defined as the share of passengers that are flying with that carrier. The market share is another way of measuring the competition that each carrier faces in the market. A merger eliminates this competition and should increase the market share in each airport giving the carrier more price setting power. The market values are extremely low in many cases as there are many carriers that operate in each airport. To make the analysis more clear the market shares are in basis points.

The route competition variables are defined using only Delta and Northwestern flights. Competition is defined based on the alternative to any route. This paper does the calculation the same way as Hüschelrath and Müller (2014), competition is direct when both carriers offer trips to the same OD-pair for the same number of stops. In the case of one stop flights competition is still considered direct even if the layover is different, because both carrier offered a flight from the origin to the destination with one stop. *Northwest/Delta Better* are origin-destination pairs are defined as those where one of the carriers offers one-stop service, and the other carrier offers no-stop service. In cases where a Delta route is direct from origin to destination and a northwestern flight is one-stop both routes are labeled as *Delta Better* and visa versa for *Northwest Better*. The Northwest/Delta No-Comp routes are those where only Delta or only Northwest offer a flight from the origin to the destination regardless of how many stops.

A summary of the numeric variables to be used in the regression are given in table 1. The data set used to create the table is a time and origin-destination (OD) pair panel data set. All flights between the OD pair every year regardless of carrier are aggregated here. The carriers have been dropped from the panel the differences in carrier options is absorbed by the route competition variables. Preliminarily the eigenvector centrality of the layover airport being greater then the centrality of the origin or destination supports the hub-and-spoke models proposed in Brueckner and Spiller (1991), Hüschelrath and Müller (2014), and Kawamori and Lin (2013). The lower market share for the layover airport indicates that competition in the layover airports is intense. Table 2 shows, for each competition category, the number of routes the average number of passengers and the average fare for each of the flights. To do this analysis the routes were separated into the two carriers. After the merger when the Northwest terms drop out the competition type there after is defined as the competition type that existed for the most passengers prior to the merger. The market fares for better flights offered are higher than the worse flight offered by the other and prices are higher along routes where there is no competition. Table 3 shows the difference in market shares for each carrier at each airport. There were not any OD pairs where both Delta and Northwestern offered a flight prior to the merger. This is consistent with the framework built in Brueckner and

Table (1) Summary Table

Variable	Mean	Standard Deviation	Min	Max
Market Fare	150.39	93.62	0.00	1296.90
Passengers	50.75	48.97	20.00	924.00
Eigenvector Centrality				
Origin	0.58	0.23	0.00	1.00
Destination	0.58	0.23	0.00	1.00
Layover	0.64	0.23	0.01	1.00
Market Share				
Origin	4.88	15.71	0.49	5000.00
Destination	4.87	14.58	0.49	5000.00
Layover	3.11	6.61	0.74	97.94

Note: market share is in basis points

Table (2) Route Competition

		Average # Passengers		Average Fare	
Route Competition	# of Routes	Delta	Northwestern	Delta	Northwestern
Delta Better	20	27.33	31.00	125.64	5.01
Delta No-Comp	1498805	51.26	-	153.53	-
Direct	21997	43.03	42.56	139.15	134.30
Northwestern Better	21149	26.23	51.77	107.60	125.74
Northwestern No-Comp	766178	-	49.06	-	139.75

Table (3) Route Competition Market Share

Route Competition	Delta Origin	Delta Destination	Delta Layover	Northwestern Origin	Northwestern Destination	Northwestern Layover
Delta Better	4.073	4.073	-	4.620	4.620	4.212
Delta No-Comp	4.810	4.789	1.785	-	-	-
Direct	3.342	3.367	-	3.232	3.181	-
Northwestern Better	2.538	2.735	1.589	4.135	4.992	-
Northwestern No-Comp	-	-	-	5.231	5.213	7.611

Table (4) Route Competition Eigenvector Centralities

Route Competition	Delta Origin	Delta Destination	Delta Layover	Northwestern Origin	Northwestern Destination	Northwestern Layover
Delta Better	0.259	0.259	-	0.259	0.259	0.280
Delta No-Comp	0.605	0.604	0.732	-	-	-
Direct	0.548	0.548	-	0.580	0.589	-
Northwestern Better	0.489	0.458	0.674	0.532	0.502	-
Northwestern No-Comp	-	-	-	0.495	0.494	0.343

Spiller (1991) and Hüschelrath and Müller (2014) and simply displayed in figure 3. The market share that each carrier had in the airport prior to the merger are similar for both carriers in cases for *Delta Better* and *Direct* routes. *Northwest Better* routes however show that Northwestern had a much higher market share in the Origin and Destination than did Delta for those routes.

Table 4 shows the eigenvector centralities for each airport role based on competition type and carrier. The eigenvector centralities are different for OD pairs for different carrier because the eigenvector centralities for northwestern flights are averaged from the networks built from the first 12 quarter of data before Northwestern drops out from the data. The Delta eigenvector centrality numbers are averaged from all the periods. On a quarter over quarter basis however the origin and destination eigenvector centralities would be equal regardless of carrier. The eigenvector centralities of the origins and destinations for both are still not very different as the eigenvector centralities do change much quarter over quarter for each airport. *Northwestern No-Comp* is the only competition type where layover eigenvector centrality is lower for the layover than the origin destination pair on average. Which could be evidence of an inefficiency in flight plans.

For the purposes of the regression the routes on the OD pairs are aggregated to remove the carrier category and have just time and OD pair fixed effects. When this is done the eigenvector centralities remain the same as they are equivalent across carriers and OD pairs. The market share variable is averaged over the routes. Each airports market share is the average market share held by both Northwestern and Delta in the years prior to the merger and is just the market share for Delta thereafter. The post-merger competition types are the pre-merger competition types that serviced the most passengers during the pre-merger period. Otherwise the competition type would revert to *Delta No-Comp* for all the quarters post merger.

5 Regression Analysis

To analyze the effects that pre-merger competition types, Hüschelrath and Müller (2014) uses a differences-in-differences approach. This approach is adopted for this paper. Hüschelrath and Müller (2014) completes fixed effects on the route-carrier level to isolate the effects of the merger. This paper does fixed effects on OD pair and time to show how network over the process of two airlines merging effects price within origin-destination pairs. The OD pair fixed effects allows for comparisons to be done within origin-destination pairs to track the change in costs for analogous products, and compare the differences to each other. This paper proposes a model that includes additional variables for eigenvector centrality and market shares as well as an interaction term of market shares and eigenvector centrality. Hüschelrath and Müller (2014) does a regression with the natural log of market fares as the dependent variable and competition type dummies as the independent variables of interest. That model contains controls for plane size, the airport sizes and population, these controls are absorbed by the number of passengers on each flight, the eigenvector centrality, and market share calculations. The model in Hüschelrath and Müller (2014) is also built from a non-directional matrix where the order of OD pair does not matter, flights from i to j are the same as flights for j to i. This paper uses a directional matrix so that the order of the OD pair is important. Because of the nature of the eigenvector centrality calculation a directional network provides much more informative eigenvector centralities (Jackson, 2008). A directional matrix also better captures the actual flights that are taking place between nodes and allows for one-way trips to persist.

Table 5 the differences-in-differences regressions. Columns 1-3 have market fare as the dependent variable with the final column using the natural log of market fare as the dependent variable. Market Fare is used as the dependent variable in the first three regressions to show the unit change in average market fare as there are unit changes in the independent variables. The dependent variable is then switched to the natural log of market fare to mirror the analysis done in Hüschelrath and Müller (2014) and to show how much the relative change that a unit change in the independent variable causes in market fares.

Column (1) of table 5 shows the average number of passengers per flight and the competition type dummies. *Delta No-Comp* dummy is omitted to avoid a perfect multicollinearity with the rest of dummies. *Delta No-Comp* is the default dummy variable because of this. *Northwest No-Comp* is the only competition with significant results showing that a competition change does not change market fares significantly but the addition of a new routes post-merger does change the market rates significantly. *Passengers* is not significant to the 95% level in column (1) likely because the amount of passengers flying does not vary much when competition types are included as eluded to in table 2. The market share and eigenvector centrality variables should enhance the effect that the number of passengers has as the number of passengers is the weight in network and the in the market share calculations.

Columns (2) and (3) include first the market share and eigenvector centrality terms and then column (3) adds the interaction term. Column (2) shows that the market share of the layovers, and destinations are insignificant to the 95% level. However, a larger market share at the origin results in a decrease in prices that is significant. The *Eigenvector Centrality* variable shows interesting results. As the eigenvector centrality of the origin and destinations in the OD pair increase so do the market fares. This means that increases in quantity on the origin and destination are not enough for increases in scales of density holding the eigenvector centrality of a potential layover constant. However, column (2) shows that an increase in eigenvector centrality of the layover node results in

Table (5) Market Fares Regression Analysis

	Origin-Destination Pair and Time Fixed Effects			
	Market Fare[1]			Market Fare Growth[2]
	(1)	(2)	(3)	(4)
Passengers[3]	0.10^{*} (0.05)	0.06 (0.05)	0.80^{***} (0.07)	0.02^{***} (0.001)
Competition[4]				
Direct	8.76 (7.05)	6.14 (7.01)	8.89 (6.93)	0.16 (0.13)
Delta Better	10.62 (35.50)	22.82 (35.30)	14.52 (34.98)	0.47 (0.67)
Northwest No-Comp	-13.80^{**} (6.59)	-15.21^{**} (6.55)	-14.95^{**} (6.48)	-0.30^{**} (0.12)
Northwest Better	−8.31 (15.49)	16.82 (15.78)	11.32 (15.61)	0.21 (0.30)
Market Share[5]				
Origin		-0.02^{**} (0.01)	-0.01^{**} (0.01)	-0.001^{***} (0.0001)
Destination		-0.01^{*} (0.01)	−0.01 (0.01)	-0.0005^{***} (0.0001)
Layover		−0.06 (0.36)	−0.20 (0.40)	−0.001 (0.01)
Eigenvector Centrality[6]				
Origin		35.09^{***} (6.09)	52.84^{***} (6.17)	0.77^{***} (0.12)
Destination		29.37^{***} (6.10)	47.21^{***} (6.18)	0.67^{***} (0.12)
Layover		-41.72^{***} (6.19)	-39.13^{***} (8.49)	-0.79^{***} (0.16)
Centrality * Market Share[7]				
Origin			-10.12^{***} (1.30)	-0.16^{***} (0.02)
Destination			-10.82^{***} (1.29)	-0.16^{***} (0.02)
Layover			1.36 (4.17)	0.02 (0.08)
Observations	9,855	9,855	9,855	9,855
R^2	0.001	0.02	0.04	0.03
Adjusted R^2	−0.14	−0.12	−0.10	−0.10
F Statistic	2.43^{**}	13.17^{***}	25.02^{***}	21.08^{***}

Note: 1. Average market fare for any flight with each OD pair for each quarter. *p<0.1; **p<0.05; ***p<0.01
2. The natural log of average market fare.
3. The average number of passengers per itinerary for each OD-pair
4. Competition type dummies with *Delta No-Comp* as the default
5. Market shares for each airport in the itinerary for the OD-pair
6. Eigenvector centrality of each airport in the itinerary for the OD-pair
7. The interaction term for market share and eigenvector centrality

a decrease in market fares. The scales of density prevail against rises in quantity demanded as the layover can aggregate more flights.

Column (3) and (4) of table 5 include the *Centrality * Market Share* interaction term. This variable is included to show the weighted effect a change in the eigenvector centrality and market share have. It tracks the effect a unit change in centrality has on market fares as market share gets larger and visa versa. With the inclusion of *Market Share* and *Eigenvector Centrality* the coefficient on the interaction term *Centrality * Market Share* can be interpreted as the added effect that unit changes in either variable have as the other changes. Column (3) shows that as both market share and eigenvector centrality get larger the positive effect that a higher eigenvector centrality is lessened. This is because of the negative sign on the interaction terms for the origin and destination. The layover market share is still insignificant and so is the interaction term showing that eigenvector centrality of the layover drop prices regardless of the airlines market share of passengers at the layover airport. With the competition controls column (3) shows that increasing the eigenvector centrality of the potential layover increase the scales of density and lowers flight fares. Column (4) shows that a unit increase in eigenvector centrality of the layover decreases the market fare along that OD-pair by almost 80%. The coefficient on the eigenvector centrality of the layover is significant to 99% level. Showing that an airline merger effects prices only as the hub and spoke model becomes stronger.

Columns (3) and (4) also that a unit change in eigenvector centrality for the origin and destination airports creates a diminishing increase in market fares as market share increases. When market share is close to zero the coefficients on origin and destination eigenvector centrality show that a unit increase would correspond to a 77% and 67% change in market fares respectively. When market share is large however this effect can quickly turn negative. If there was a unit change in origin eigenvector centrality with a large market share market fare growth may even decrease as the eigenvector centrality increases. This shows that for airliners with a high market share of the origin and destination airports increasing scales to density prevail and lower costs when the quantity demanded from the origin to the destination increases.

6 Conclusion

After adopting the airline network framework proposed in Brueckner and Spiller (1991) and extended in Brueckner et al. (1992), Hüschelrath and Müller (2014), and Kawamori and Lin (2013), this creates a network from air travel market data to assemble network that change through time as the Northwest-Delta merger of 2010 is completed. By fixing effects across time and origin destination pair the model isolates the changes in price for routes demanded as the eigenvector centrality increases for the points along the route. The regression analysis shows that within OD pairs after controlling for competition along routes that increases in eigenvector centrality along with increases in market share can drop prices as scales to density increase. The merger effect here is clear, when the two airlines merge and the eigenvector centrality increases along with the market share at each airport fares will decrease.

Additional research analysis could be undertaken to better isolate the effects of the merger. The effects of the merger are not isolated in the model proposed in this paper as the carriers are not separated ex-ante and the regression does not control for the merger going into effect. Hüschelrath and Müller (2014) runs a fixed effects regression with carrier and route fixed effects. This paper does time and OD pair to isolate the effects changes in market fare and eigenvector centrality as two airlines merge. Additional analysis could combine the network analysis proposed here and fix effect across ex-ante carrier and route as in Hüschelrath and Müller (2014). A longer time horizon that encompasses multiple mergers could also be beneficial to show how the industry become more horizontally integrated effects the networks over time and then how that effects prices within OD pairs. This paper, however, still successfully proposes a network model and isolates the effects that network characteristics have on prices as a merger is completed.

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