Multimarket contact and the antitrust settlement in Airline Tariff Publishing Co (1994) [†]

Gary M. Fournier [a,*] and Thomas W. Zuehlke [b]

[a] *Department of Economics, Florida State University, Tel (850) 644-5001*

[b] *Department of Economics, Florida State University, Tel (850) 644-5001*

January 5, 2008

Abstract

In the *Airline Tariff Publishing Co*(1994) case, the government documented facilitating practices that were used by carriers to link routes as part of concerted actions. Evidence in that case brought to light rapid exchange of fare information among carriers using footnote designators and fare basis codes. Remarkably, the evidence pointed to coordination among particular "reciprocal pairs" of routes. This term refers to a specific form of multimarket contact that recognizes simple paired links between the routes of major carriers at dominant hub airports that can reinforce or facilitate the type of coordination described in Borenstein (2004). Borenstein's conjecture suggests an interesting empirical test for fare differences on routes characterized by the presence of a reciprocal pairing among the carriers. We examine evidence about the fare performance of reciprocal pairs before and after the antitrust litigation. We ask whether higher fares remain in a selected set of markets after 1993, during the ban on specific practices alleged in the case. The theory linking the banned practices with coordination effects require their ongoing use, so the effects should be expected to cease after the case is settled. We find that, when route level fixed effects are included in the model, the higher fares attributed to reciprocal pairs are confined to the pre-settlement period. This evidence may suggest that, in this instance, antitrust enforcement was effective and that tacit collusion was restrained by the conditions of the settlement.

Key words: *Airline Tariff Publishing Co.*, Multimarket Contact, Antitrust effectiveness, Assortivity

JEL Classification: C23, L40, L93

[†]We wish to thank participants at the International Industrial Organization Conference, Chicago IL, April 2004, for comments on an earlier draft of this paper. Please do not cite without permission of the authors.

[*]Corresponding author (Fax (850) 644-4535)

Email addresses: gfournier@fsu.edu (Gary M. Fournier), tzuehlke@mailer.fsu.edu (Thomas W. Zuehlke).

Multimarket contact and the antitrust settlement in *Airline Tariff Publishing Co* (1994)

Abstract

In the *Airline Tariff Publishing Co*(1994) case, the government documented facilitating practices that were used by carriers to link routes as part of concerted actions. Evidence in that case brought to light rapid exchange of fare information among carriers using footnote designators and fare basis codes. Remarkably, the evidence pointed to coordination among particular "reciprocal pairs" of routes. This term refers to a specific form of multimarket contact that recognizes simple paired links between the routes of major carriers at dominant hub airports that can reinforce or facilitate the type of coordination described in Borenstein (2004). Borenstein's conjecture suggests an interesting empirical test for fare differences on routes characterized by the presence of a reciprocal pairing among the carriers. We examine evidence about the fare performance of reciprocal pairs before and after the antitrust litigation. We ask whether higher fares remain in a selected set of markets after 1993, during the ban on specific practices alleged in the case. The theory linking the banned practices with coordination effects require their ongoing use, so the effects should be expected to cease after the case is settled. We find that, when route level fixed effects are included in the model, the higher fares attributed to reciprocal pairs are confined to the pre-settlement period. This evidence may suggest that, in this instance, antitrust enforcement was effective and that tacit collusion was restrained by the conditions of the settlement.

1. Introduction

Recent studies of the airline industry recognize that multimarket contact and the route network features of carriers have important effects on pricing dynamics (Busse, 2002; Ross, 1997). In the *Airline Tariff Publishing Co* (ATPCo) case[1], the government documented facilitating practices that were used by carriers to link routes as part of concerted actions to "trade fare changes in certain markets in exchange for fare changes in other markets" (U. S. Department of Justice, 1994b). Furthermore, the evidence pointed to coordination among particular pairs of routes that were identified by "fare basis codes" in data systems used jointly by carriers.

Prospects may have been favorable for tacit collusion in concentrated markets typical of many airline routes during the late 1980s and 1990s. The advantages of communicating price announcements safely in advance are analyzed in Blair and Romano (2002). Because of the network structure of airline routes, multimarket contact among major carriers is a particularly extensive feature of the industry and one that is known to facilitate tacit collusion. But, there are also problems that undermine tacit collusion. Airlines face conditions of demand and cost volatility and high fixed costs and are often stuck with excess capacity during downturns in the economy that dampen the demand for air travel.[2] In addition, the heterogeneity of firms traced to cost differences among the carriers has been an important factor in price determination in recent years. A carrier operating direct flights out of its own hub has distinct advantages over non-hub carriers. The cost advantage a carrier enjoys in its own hub may be nullified on alternative routes originating or ending at a rival carrier's hub.[3]

Specific practices in the ATPCo case involved the use of electronic data systems containing "footnote designators" and "fare basis codes" that participants could observe and that allowed the rapid exchange of fare information among carriers to coordinate fare setting in linked markets. Borenstein (2004) notes that certain routes would benefit most by ATPCo communication, and hence, would be most affected in the aftermath of a settlement. These routes would be ones where non-stop flights from a carrier's hub airport compete with a second carrier offering with one-stop

[1](U. S. Department of Justice, 1994a).

[2]In a repeated game framework, it is possible show that economic booms can work either way to make fare wars less likely or more likely than in busts. (Busse, 2002; Rotemberg and Saloner, 1986; Ellison, 1994; Levenstein and Suslow, 2006). In Blair and Romano (2002), advance notification of price changes facilitates collusion by revealing private information about demand shocks.

[3]More recently, entry by low cost carriers has proliferated and made collusion substantially less likely. (Borenstein and Rose, forthcoming).

service to the same destination. In these markets, carriers would have different perceptions about the optimal fare and would face greater risks of coordination failures without the mechanisms afforded under ATPCo.

Borenstein's conjecture about carrier conduct[4] suggests an interesting empirical test for fare differences on routes characterized by the presence of a strong reciprocal pairing among the carriers. If the collusive story is correct, the information exchange and informal negotiations made possible by information systems are essential for multimarket coordination. But these alleged practices were eliminated under the terms of the settlement, so their coordinative effects should be expected to cease along with the practices.[5] We ask whether higher fares remain in a selected set of markets after 1993, during the ban on specific practices alleged in the case. Alternatively, Carlton et al. (1997) argues that despite the legal settlement, fares may still be affected by the tacit recognition of the strong, swift and certain retaliation available to rivals in a reciprocal relation.

In the next section, the basic idea is discussed in greater detail and specific examples are given. Section 3 provides a discussion of the data and its sources, Section 4 considers the econometric methodology employed, Sections 5 and 6 present the results, followed by our conclusions.

[4]As Borenstein (2004) put it,"I won't cut fares on flights out of your hub if you won't cut fares on flights out of my hub."

[5]Among the terms of the settlement, restrictions were placed on the use of fare basis codes and footnote designators to prevent recognition of route-pair linkages.(U. S. Department of Justice, 1994a).

2. Reciprocal Pairs

To look for evidence of the effects of multimarket contact in the circumstance posed by ATPCo, it makes sense to find the most obvious instances where carrier coordination would have the greatest benefit. A central issue to be considered here is the effect of overlap in the network structure of major carriers on fares for the specific routes where they are jointly competing. Multimarket contact has been measured with a variety of indicators. In this study, we first adapt an overall measure of multimarket contact from the literature on assortative mixing in social networks (Newman, 2002; Newman et al., 2002). This measure incorporates the full dimensions of all mutual contact points between carrier pairs.[6] While overall measures of multimarket contact among the airlines reflect the pervasiveness of overlapping markets, they may be subject to the criticism that carriers' management cannot readily incorporate such information into decisions concerning pricing policy. Thus, further consideration of how rivals come into contact across routes is justified.

An alternative approach suggests that, if multimarket signaling were to be put into practice, it would be most likely to involve trading concessions with rivals among markets that are easy for carriers to recognize and that are quantitatively substantial from a revenue standpoint. Borenstein (2004) suggests testing for fare differences on hubs characterized by the presence of a strong reciprocal pairing among the carriers.

To implement this idea, we define "reciprocal pair" multimarket contact by a specific pair of routes and a pair of carriers having the characteristics that (a) one carrier has direct flight service to or from its hub, (b) the other carrier offers one-stop service through its own hub on the same route, (c) the route meets a substantial revenue threshold for the hub carrier, and (d) carriers have reversed roles on a different route. Thus, reciprocal pairs involve one-stop service competing with non-stop hub service. These routes may form a focal point for tacit collusion, if mechanisms exist for firms to link the route pairs and fend off price cuts by signaling with rivals. Of course, the effectiveness of price coordination by major carriers is likely to be limited by the number of major carriers serving the routes, and by the presence of low-cost carriers.

Figure 1 illustrates routes linked by a reciprocal pair relationship. The first route, Atlanta to Austin (and the opposite direction, Austin to Atlanta), involves direct service at a major hub airport by the dominant carrier, Delta. American Airlines is also serving the route with one-stop

[6] The characteristics of this measure are explained in Appendix A.

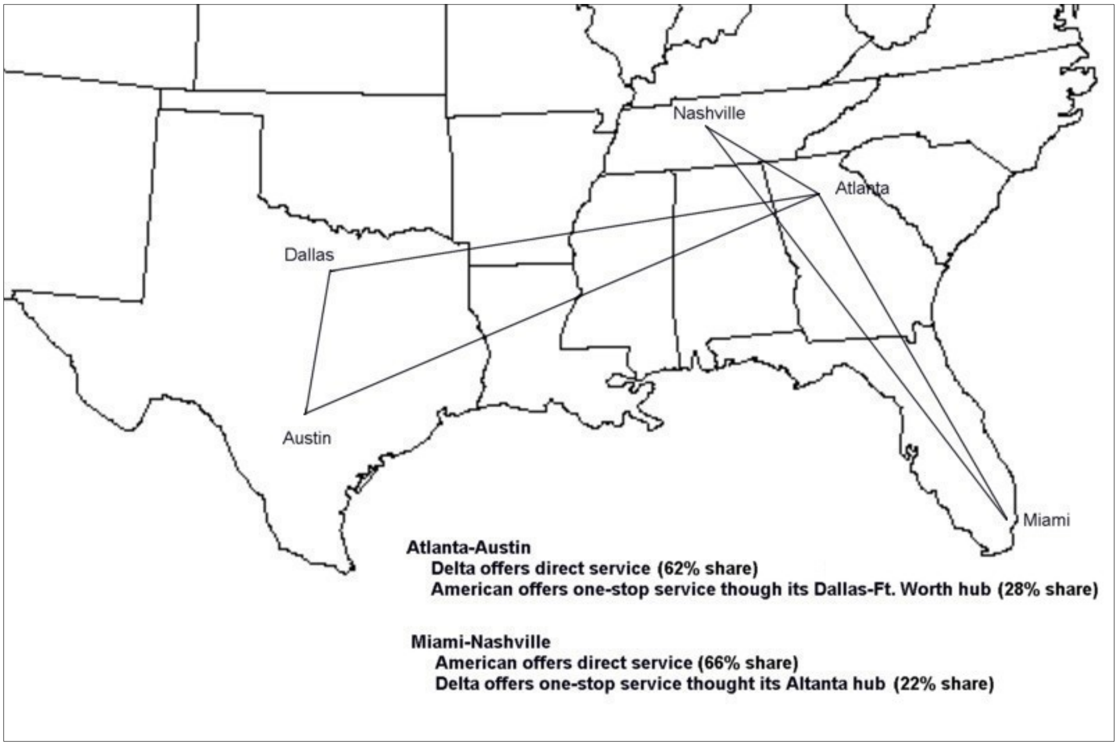

FIGURE 1. Example of Reciprocal Pair Markets

service through its hub in Dallas. There are appreciable revenue dollars at stake on this route. The second route, Miami to Nashville (and the opposite direction, Nashville to Miami) has direct service from American's hub in Miami, and one-stop service through Delta's hub in Atlanta. This time, however, the roles are reversed, with American having the dominant share on the direct service and Delta having a smaller share with its one-stop service. These circumstances are readily understood by the carriers and may afford greater opportunities for pricing dynamics that favor cooperation. Some smaller carriers, including at that time Southwest Air and America West, did not have any reciprocal pairs in their route system, a reflection of their strategy of avoiding direct confrontation with major carriers. The largest carriers, on the other hand, had many cases of this type of multimarket contact. In our sample, approximately 5% of the routes meet the conditions for reciprocal pairs. In terms of the number of instances (route-quarters) in which each carrier faces a rival in a reciprocal pair, we identified 643 instances, including Delta (213), U.S. Air (150), American (101), Continental (94), and United (85). Thus, it should be possible to test for the effects of reciprocal pairs on average fares, relative to markets without these linkages.

Moreover, observations in the data for this study span both the pre-and post-settlement periods. Under the terms of the settlement, the information exchange, advance price announcements, and other facilitating practices were largely eliminated. We ask whether higher fares remain in a selected set of reciprocal pairs markets after 1993, during the ban on specific practices alleged in the case. This conjecture may be tested against the alternative hypothesis that, despite the legal settlement, fares may still be affected by the tacit recognition of the strong, swift and certain retaliation available to rivals in a reciprocal relation (Carlton et al., 1997).

3. Data Sources

The data used in this study are a compilation of two principal sources. The *Origin and Destination Survey* (O&D) is a ten percent random sample of all domestic airline tickets and is available on a quarterly basis.[7] The survey contains information on fares and coupon segments for individual itineraries, but information on the date of the flight is confined to the quarter of use. The *T100 Domestic Segment* data is a monthly census of service by US carriers in the domestic market. This data is aggregated to the carrier level and reported by non-stop segments.[8] This data source provides useful measures of market and cost conditions, including the load factor for the route.

The sample period consists of the second quarter of each year from 1991 through 2001, excluding 1992. Analysis is confined to the second quarter in order to control for the seasonal nature of air travel. The sample period terminates in 2001 in order to exclude the impact of the September 11 disaster on air travel. The first year of publicly available O&D data is 1993. The date of the Department of Justice settlement was March 1994. For reasons or data availability, the pre-settlement period includes observations on 1991 and 1993.[9]

The sampling process involves several steps. It is now common practice to screen the O&D data for certain types of fare anomalies thought to involve coding errors, trips paid with frequent flying miles, etc.[10] Tickets reporting fares less than $20 and more than $2000 are eliminated. Likewise, itineraries with no discernible destination, more than two coupons in each direction, and those involving international travel are deleted. It is hypothesized that airlines have an incentive to engage in strategic price coordination on reciprocal pairs of routes that involve significant revenue and relatively few direct competitors. Consequently, routes with an origin or destination outside the largest 100 airports in the continental U.S. (ranked by passenger emplanements) are excluded, as are routes served by more than 4 major carriers. Metropolitan areas with multiple airports are grouped as a single origin or destination. Table 1 provides a list of the metropolitan area/airport groupings. For inclusion in the final sample, we required that each route: a) provide at least daily service for the quarter, and b) have at least 150 O&D observations per quarter. Finally, routes are

[7] This data is publicly available for the first quarter of 1993 through the fourth quarter of 2006 on the Department of Transportation's Transtat web site at: http://www.transtats.bts.gov/.

[8] For example, a one-stop flight is composed of two non-stop segments, each of which are reported separately.

[9] While the Transtat data, provided from 1993 and later are sufficient for analysis, we felt it desirable to try and obtain additional data for the pre-settlement period. We were unable to get data for 1992, but did acquire data for the second quarter of 1991. We have included the 1991 data even though it leaves a gap in the sample period. None of the results are changed when 1991 is excluded.

[10] See, for example, the appendices of Borenstein and Rose (1994) and Hayes and Ross (1996).

treated uni-directionally, e.g., Chicago O'Hare (ORD) to Los Angeles (LAX) and LAX to ORD are recorded as distinct routes. Round trip tickets are split into two equally priced observations; one for the outgoing segment of the itinerary and a second for the return segment.

Hub service plays a critical role in defining reciprocal pairs. A list of the specific airline hubs in service during the sample period is provided in Table 2. An initial pass through the data extracted all tickets written for direct flights in or out of these hubs. A second pass extracted all records involving one-stop service through a hub. A "primary carrier" offers direct service to the destination, has a dominant market share (exceeding 50 percent), and has a hub at either the origin or destination. A "secondary carrier" offers one-stop service is through its hub, and a significant market share (exceeding 10 percent) on the route. Given these definitions, a reciprocal pairing exists between carriers A and B if we can find a pair of routes such that: 1) on some route carrier A is the primary carrier while carrier B is the secondary carrier, 2) on another route their roles are reversed, and 3) there in no low-cost carrier on the route. The final condition is included since the presence of a low-cost carrier would limit opportunities to engage in strategic price coordination.

The final sample is an unbalanced panel of 4451 observations consisting of 810 routes observed for an average of 5.5 periods. A list of the variables compiled from these sources is provided in Table 3. The list includes the mean fare on the route, the Herfindahl index, total market revenue on the route, the assortativity based measure of multimarket contact, a binary variable indicating the presence of a low-cost carrier, the carrier's load factor for the route, and the reciprocal pairs binary. Sample moments are provided in Table 4.

Borenstein (2004) employs difference in means tests to determine whether fares in reciprocal-pair markets are higher than in other markets.[11] The relevant test statistic is

$$\frac{\left|\bar{F}_1 - \bar{F}_0\right|}{\sqrt{\left(\frac{n_1 s_1^2 + n_0 s_0^2}{n_1 + n_0 - 2}\right)\left(\frac{1}{n_1} + \frac{1}{n_0}\right)}} \tag{1}$$

where F denotes fares, the subscript 1 refers to the set of reciprocal pair routes, and the subscript 0 refers to the set of non-reciprocal pair routes.[12] This statistic is t distributed with $n_1 - n_0 - 2$ degrees of freedom. Perhaps the simplest way to obtain this statistic is to regress price on a binary variable indicating reciprocal pair routes. With a cross-section sample,

$$F_j = \mu + \delta RP_j + \varepsilon_j \tag{2}$$

where F_j denotes the fare on route j, and RP_j is a binary variable indicating reciprocal pair routes. The intercept, μ, is the mean fare for non-reciprocal pair routes. The coefficient δ is the estimated difference in mean fares between reciprocal pair and non-reciprocal pair routes, and the corresponding t-statistic is equal to that given in equation (1) above.

In the context of panel data, the difference in means test can be conducted using the model

$$F_{jt} = \mu + \delta RP_{jt} + \varepsilon_{jt} \tag{3}$$

where F_{jt} denotes the price on route j at time t, and RP_{jt} is a binary variable that indicates route j was part of a reciprocal pair at time t. This simple specification imposes a temporally common mean fare, μ, for non-reciprocal pair routes, a temporally common reciprocal pair effect, δ, and a temporally common error variance. The t-statistic of the coefficient δ is the difference in means test statistic that one would obtain by simply pooling the cross sections and treating them as independent draws from a common population.

This model is easily generalized to allow a different mean fare and different reciprocal pair effects for each period by adding a set of time-specific binary variables and a set of interaction terms for the time-specific and reciprocal pair binaries. This would be equivalent to conducting a

[11] Borenstein constructs distance-adjusted fares and compares them to national average fares.

[12] This statistic assumes that the two populations have common variance. There is no universally accepted solution to the Behrens-Fisher problem; the problem of testing for differences in means with non-common variances.

difference in means test for each time period while imposing a common variance. If Y_t is a binary variable that equals one in time period t, then the model is

$$F_{jt} = \mu_t Y_t + \delta_t (RP_{jt} Y_t) + \varepsilon_{jt} \tag{4}$$

where μ_t denotes the mean fare on non-reciprocal pair routes at time t, and δ_t denotes the difference in mean fares associated with reciprocal pair routes at time t.[13] The t-statistic corresponding to δ_t is the difference in means test statistic for period t.

Even if significant differences in mean fares are found for reciprocal pair markets, the question remains whether these differences are due to strategic pricing or to differences in the underlying characteristics of the routes. For example, if reciprocal pairs are more common on longer routes, then fare differences could be due to cost differences. The model in equation (4) may be generalized to include route-specific effects and regressors that control for variation in market conditions on the routes. If R_j is a binary that equals one for route j, then the form of this model is:

$$F_{jt} = \alpha_j R_j + \mu_t Y_t + \delta_t (RP_{jt} Y_t) + X_{jt} \beta + \varepsilon_{jt} \tag{5}$$

for j=1,...,J and t=1,...,T. The α_j denote route-specific effects and the μ_t are the time-specific effects. Note that any factors that exhibit only cross-sectional variation, such as route distance, are subsumed into the route-specific effects. Likewise, any factors that exhibits only temporal variation are subsumed into the time-specific effects. It is temporal variation in the reciprocal pairs binaries that allows identification of a model with both route-specific effects and reciprocal pairs effects. Absent temporal variation, the reciprocal pairs effects could not be distinguished from the route-specific effects. The vector X_{jt} denotes other regressors that vary with both route and time. Finally, the route-specific effects will be estimated as both random effect and fixed effects, with the final specification determined by the outcome of a Hausman (1978) test.

[13] The specification here omits the intercept. Obviously, one of the time period binaries could be omitted instead.

5. Results

Equation (4) provides a framework for the estimation of various "difference in means" tests. Included among the results are specifications that provide a difference in means test: 1) for each time period separately, 2) for the pre and post settlement periods, and 3) for the pooled sample. Estimates of these models are presented in Table 5. The first set of columns of Table 5, listed under the heading of "year specific," includes a dummy variable for each time period and an interaction term for the reciprocal pairs dummy and each time period dummy. This model allows a separate mean fare for non-reciprocal pair routes for each period, and a separate reciprocal pairs effect for each year. This specification is equivalent to conducting a "difference in means" test for each time period while imposing a common error variance over time.[14] The second set of columns, listed under the heading "common pre / common post," includes a dummy variable for each time period, the reciprocal pairs dummy, and an interaction term for the reciprocal pairs dummy and the sum of the time dummies in the pre-settlement period, Y_{pre}. This specification allows a separate mean fare for the non-reciprocal pair routes for each period, a common reciprocal pairs effect in the post-settlement period (given by the coefficient of the RP variable), and a common reciprocal pairs effect in the pre-settlement period (given as the sum of the coefficients of the RP variable and the interaction term). The final set of columns, listed under the heading of "common rp," includes the dummy variables for each time period and the reciprocal pairs dummy. This specification allows a different mean fare for the non-reciprocal pair routes for each time period, but imposes a common reciprocal pairs effect over time.

The estimates of the "year specific" model in Table 5 show significantly higher fares on reciprocal pair routes for every year except 1994; the year of the airline settlement with the Department of Justice. These results would suggest that the impact of the settlement on the pricing decisions of airlines was fleeting at best. The "common pre / common post" model impose a common reciprocal pairs effect in the pre and post settlement periods. The estimates of this model show that fares on reciprocal pairs routes averaged \$41 higher (\$82 higher round trip) over the course of the decade. In addition, there is no evidence of any difference in fares in the pre-settlement period, as the coefficient of $\mathrm{RP}\cdot\mathrm{Y}_{pre}$ is estimated at \$2.64 with a P-value of 0.83. The Likelihood Ratio test of the null hypothesis of a common reciprocal pairs effect in the pre-settlement period and a

[14] When the assumption of a common variance is relaxed, the coefficient estimates are unchanged since the regressor blocks [Y_t $\mathrm{RP}\cdot\mathrm{Y}_t$] are orthogonal across time, and the corresponding t-statistics and p-values are quantitatively similar to those reported in Table 5.

common effect in the post-settlement period finds that the null hypothesis cannot be rejected. The final set of columns provide estimates of the "common rp" model. The estimate of the common reciprocal pairs effect is $41.54 and is highly significant. Likelihood ratio tests of the null hypothesis of a common reciprocal pairs effect for all periods cannot be rejected. This is true regardless of whether the alternative hypothesis is taken to be the "year specific" or "common pre / common post" model.

Taken as a whole, these estimates suggest that the settlement has had little impact on the pricing decisions of airlines. Borenstein (2004) found quite similar results, a positive difference in means effect of RP markets of about 20 percent over a period spanning 1990-1996, prior to and after the antitrust settlement.

Equation (5) generalizes the "difference in means" tests to control for route-specific effects and measures of market conditions and cost. We will refer to these as "regression tests." As with the difference in means tests, we will consider "year specific," "common pre / common post," and "common rp" specifications. Table 6 reports the estimates for the regression tests when route-specific effects are added, while Table 7 presents the estimates that result when both route-specific effects and control variables are included.

The introduction of route-specific fixed effects has a dramatic impact on the nature of the estimates.[15] In the "year-specific" model, the only reciprocal pairs effect in the post-settlement period found to be significant at conventional levels is that of 1995, where fares are on average $13 higher. The estimates of the "common pre / common post" model find mean fares to be approximately $30 higher ($60 higher round trip) on reciprocal pairs routes in the pre-settlement period, while no significant difference in fares is found in the post-settlement period. A likelihood ratio test of the null hypothesis of the "common pre / common post" reciprocal pairs effect would be rejected at the 5% level, but not at the 1% level. Finally, the mean fare difference in the "common rp" model is $8.12. This estimate is significant at conventional levels, but a likelihood ratio test of the null hypothesis of a "common rp" effect is strongly rejected for both the "year specific" and "common pre / common post" alternatives. These estimates provide a very different picture than the simple "difference in means" tests. After allowing for route-specific fixed effects, the airlines appear to be abiding by the terms of the Department of Justice settlement.

[15] Airline-specific fixed effects are also included in this model, but the difference in results is due to the route-level fixed effects.

The results in Table 7 reinforce the conclusions from Table 6. The inclusion of measures of market and cost conditions results in estimates of the reciprocal pairs effects that are qualitatively and quantitatively similar to those obtained without regressors. In the "year specific" model, only the reciprocal pairs effect for 1996 comes close to significance at the 5% level, and in that case, the coefficient is negative! The "common pre / common post" model finds mean fares to be approximately $23 higher ($46 higher round trip) on reciprocal pairs routes in the pre-settlement period, while no significant difference in fares is found in the post-settlement period. With the regressors included, however, the likelihood ratio test of the null hypothesis of the "common pre / common post" reciprocal pairs effect cannot be rejected at the 5% level. As was the case when the regressors were excluded, a likelihood ratio test of the null hypothesis of a "common rp" effect is strongly rejected for both the "year specific" and "common pre / common post" alternatives.

Turning to the measures of market and cost conditions, all are strongly significant except for total market revenue (REV). The estimated coefficient of the scaled Herfindahl measure (HERF)is positive, suggesting that greater market concentration is associated with higher mean fares. The point estimate indicates that a one-standard deviation (.191) increase in the Herfindahl is associated with a $12.64 increase in one-way fare. The coefficient of total market revenue is positive, but nowhere near significant at conventional levels. The coefficient of the multimarket contact measure (MMC) is positive, suggesting a greater degree of mutual forbearance, and higher average fares, when carriers have greater degrees of multimarket contact. The estimated impact of a one-standard deviation increase in MMC is $3.97. The presence of a low-cost carrier (LCC) results in fares that are, on average, $34 lower ($68 lower round trip) than in comparable market without a low-cost carrier. Finally, the coefficient of the carrier's load factor (LOAD) is negative, suggesting that higher load factors, and hence lower per-passenger costs, are associated with lower average fares. The point estimates indicates that a one-standard deviation increase in the load factor, i.e. a change from the mean of 0.615 to 0.747, would be associated with a $5.15 decrease in the one-way fare. A likelihood ratio test of the joint significance of the regressors is highly significant for all specifications in Table 7. Finally, Hausman tests strongly reject the random effects estimates (not reported) in favor of the fixed effects estimates for all specifications in both Table 6 and Table 7. In summary, the estimates of the reciprocal pairs effects from these specifications are qualitatively and quantitatively similar to those obtained without these market structure and cost shift regressors.

6. Conclusions

The legal settlement in the *Airline Tariff Publishing Co* case prohibited specific business practices alleged to have facilitated tacit collusion among major carriers using electronic systems to exchange information, negotiate fares and other collusive actions. Our study examines how fares were affected on major hub routes where multimarket coordination was most likely to be feasible during the time period when antitrust violations were said to be occurring, and whether those fares became more competitive in the post-settlement period.

Starting with simple difference in means tests, we confirm the informal observation in Borenstein (2004) and find a persistently positive effect of reciprocal pairs on airfares over the entire sample period, spanning before and after the settlement with the Department of Justice. This result would suggest that airlines have ignored the settlement and continued to use a selected set of multimarket contacts, reciprocal pairs, to coordinate prices. In contrast, using panel data methods we reach a very different conclusion. When route level fixed effects are introduced, the reciprocal pair effect is confined to the pre-settlement period, but disappears in periods following it. We argue that the panel models are better specified and come closer to revealing the impact on airfares.

Previous studies have expressed concerns about whether antitrust enforcement has its intended effect. For example, Crandall and Winston (2003) and Baker (2003) debate the evidence about whether antitrust enforcement is effective. Although this study is confined to a single legal case, our results further suggest that the earlier practices in the airline industry were probably facilitating coordination and raising fare levels in selected routes, that the settlement was having its intended effects during 1994-2001, and that throughout this time the airlines are abiding by the conditions of the settlement.

Table 1. Metropolitan Area/Airport Groupings

Metropolitan Area	Airport (Code)		
Washington D.C.	Baltimore-Washington (BWI)	Reagan National (DCA)	Dulles (IAD)
Dallas/Fort Worth	Love (DAL)	Dallas/Fort Worth (DFW)	
New York City	Newark Liberty (EWR)	John F. Kennedy (JFK)	La Guardia (LGA)
Houston	Hobby (HOU)	Bush (IAH)	
Chicago	Midway (MDW)	O'Hare (ORD)	

Table 2. Airline Hubs

Airport Code	Airport	Metro Area	Hub Carriers	
ATL	Hartsfield-Jackson	Atlanta	Delta	
BWI	Baltimore-Washington	Washington D.C.	U.S. Air	
CLE	Hopkins	Cleveland	Continental	
CLT	Charlotte Douglas	Charlotte	U.S. Air	
CVG	Cincinnati/Northern Kentucky	Cincinnati	Delta	
DAL	Love	Dallas	Southwest	
DEN	Denver	Denver	United	
DFW	Dallas/Fort Worth	Dallas/Fort Worth	American	Delta
DTW	Detroit Metro Wayne County	Detroit	Northwest	
EWR	Newark Liberty	New York City	Continental	
HOU	Hobby	Houston	Southwest	
IAD	Dulles	Washington D.C.	United	
IAH	Bush	Houston	Continental	
LAS	McCarran	Las Vegas	American West	
LAX	Los Angeles	Los Angeles	United	Delta
MEM	Memphis	Memphis	Northwest	
MIA	Miami	Miami	American	
MSP	Minneapolis/St. Paul	Minneapolis/St. Paul	Northwest	
ORD	O'Hare	Chicago	American	United
PHL	Philadelphia	Philadelphia	U.S. Air	
PHX	Sky Harbor	Phoenix	Southwest	American West
PIT	Pittsburgh	Pittsburgh	U.S. Air	
SEA	Seattle/Tacoma	Seattle/Tacoma	Alaska Air	
SFO	San Francisco	San Francisco	United	
SLC	Salt Lake City	Salt Lake City	Delta	
STL	Lambert	St. Louis	Northwest	Trans World

Table 3. Variable Definitions

Variable	Definition
F	mean fare for the route
HERF	Herfindahl index for the route, divided by 10,000
REV	total revenue for the route in millions of dollars
MMC	index of an airline's system-wide multimarket contact
LCC	binary that indicates the presence of a low-cost carrier on the route
LOAD	the airline's load factor for the route
RP	binary indicating an airline is part of a reciprocal pair on the route
Y_t	a set of yearly binaries for t=91,93,94, ...,01
$Y_{pre}=Y_{91}+Y_{93}$	a binary for the period preceding the settlement between the airlines and the DOJ

Table 4. Sample Statistics

Variable [a]	Mean	Std. Dev.	Min	Max
F	190.882	71.396	48.894	400.233
HERF	0.738	0.191	0.256	0.999
REV	0.216	0.235	0.001	2.872
MMC	0.870	0.062	0.381	0.944
LCC	0.376	0.484	0	1
LOAD	0.615	0.132	0	1
RP	0.051	0.220	0	1
N. of Obs.	4451			

[a] Labels for variables are defined in Table 3.

Table 5. Difference in means tests.[a]

	year specific			common pre / common post			common rp		
Variable	Coeff.	Std. Err.	p-value	Coeff.	Std. Err.	p-value	Coeff.	Std. Err.	p-value
RP·Y_{91}	39.159	16.891	0.020						
RP·Y_{93}	47.318	15.065	0.002						
RP·Y_{94}	16.536	19.021	0.385						
RP·Y_{95}	51.639	12.164	0.001						
RP·Y_{96}	44.897	19.625	0.022						
RP·Y_{97}	62.678	18.919	0.001						
RP·Y_{98}	24.596	12.389	0.047						
RP·Y_{99}	53.082	12.270	0.001						
RP·Y_{00}	41.427	17.801	0.020						
RP·Y_{01}	30.400	14.948	0.042						
RP·Y_{pre}				2.641	12.425	0.832			
RP				41.063	5.292	0.001	41.542	4.787	0.001
H_0:{δ_{91}=δ_{93} and δ_{94}=δ_{95}= ... = δ_{01}}				LR $\chi^2(8) = 7.15$ p-value = 0.5201					
H_0:δ_{pre}=0							LR $\chi^2(1) = 0.05$ p-value = 0.8315		
H_0:δ_{91}=δ_{93}=δ_{94}= ... = δ_{01}							LR $\chi^2(9) = 7.20$ p-value = 0.6164		

[a] Each of the specifications above include year-specific fixed effects which allow a different mean fare for each year. These are not of direct interest and are not reported here.

Table 6. Regression tests.[a]

Variable	year specific			common pre / common post			common rp		
	Coeff.	Std. Err.	p-value	Coeff.	Std. Err.	p-value	Coeff.	Std. Err.	p-value
RP·Y_{91}	15.152	9.135	0.097						
RP·Y_{93}	43.379	7.2425	0.001						
RP·Y_{94}	2.878	8.800	0.744						
RP·Y_{95}	12.823	5.977	0.032						
RP·Y_{96}	-1.200	9.500	0.899						
RP·Y_{97}	4.937	8.909	0.580						
RP·Y_{98}	-0.422	6.068	0.945						
RP·Y_{99}	4.679	5.840	0.423						
RP·Y_{00}	7.776	8.214	0.344						
RP·Y_{01}	-9.719	7.215	0.178						
RP·Y_{pre}				29.574	6.299	0.001			
RP				3.201	2.859	0.263	8.121	2.667	0.002
Hausman H_0: RE	$\chi^2(29) = 161.25$ p-value = 0.001			$\chi^2(21) = 225.17$ p-value = 0.001			$\chi^2(20) = 233.72$ p-value = 0.001		
H_0:{δ_{91}=δ_{93} and δ_{94}=δ_{95}= ... = δ_{01}}				$\chi^2(8) = 16.68$ p-value = 0.034					
H_0:δ_{pre}=0							LR $\chi^2(1) = 27.02$ p-value = 0.001		
H_0:δ_{91}=δ_{93}=δ_{94}= ... = δ_{01}							LR $\chi^2(9) = 43.71$ p-value = 0.001		

[a] Each of the specifications above include year, route, and airline fixed effects. These are not of direct interest and are not reported here.

Table 7. Regression tests.[a]

Variable	year specific Coeff.	Std. Err.	p-value	common pre / common post Coeff.	Std. Err.	p-value	common rp Coeff.	Std. Err.	p-value
RP·Y_{91}	9.494	8.594	0.269						
RP·Y_{93}	28.582	6.833	0.001						
RP·Y_{94}	-5.188	8.274	0.531						
RP·Y_{95}	7.903	5.646	0.162						
RP·Y_{96}	-17.431	8.927	0.051						
RP·Y_{97}	0.183	8.364	0.983						
RP·Y_{98}	-5.456	5.726	0.341						
RP·Y_{99}	-0.539	5.490	0.922						
RP·Y_{00}	2.529	7.694	0.742						
RP·Y_{01}	-5.766	6.801	0.397						
RP·Y_{pre}				23.109	5.897	0.001			
RP				-1.509	2.767	0.586	2.265	2.599	0.384
HERF	66.076	5.112	0.001	66.177	5.097	0.001	66.341	5.107	0.001
REV	7.979	8.312	0.337	9.005	8.304	0.278	8.568	8.320	0.303
MMC	64.024	20.736	0.002	65.067	20.706	0.002	69.056	20.722	0.001
LCC	-33.899	2.461	0.001	-33.789	2.459	0.001	-34.116	2.462	0.001
LOAD	-38.901	5.524	0.001	-39.165	5.515	0.001	-39.562	5.525	0.001
H_0:β=0	LR $\chi^2(5) = 611.33$ p-value = 0.001			LR $\chi^2(5) = 613.63$ p-value = 0.001			LR $\chi^2(5) = 621.78$ p-value = 0.001		
Hausman H_0: RE	$\chi^2(34) = 231.74$ p-value = 0.001			$\chi^2(26) = 324.44$ p-value = 0.001			$\chi^2(25) = 292.26$ p-value = 0.001		
H_0:{δ_{91}=δ_{93} and δ_{94}=δ_{95}= ... = δ_{01}}				LR $\chi^2(8) = 14.38$ p-value = 0.072					
H_0:δ_{pre}=0							LR $\chi^2(1) = 18.87$ p-value = 0.001		
H_0:δ_{91}=δ_{93}=δ_{94}= ... = δ_{01}							LR $\chi^2(9) = 33.25$ p-value = 0.001		

[a] Each of the specifications above include year, route, and airline fixed effects. These are not of direct interest and are not reported here.

Appendix A. Assortivity Based Multimarket Contact Measure.

Multimarket contact has been measured with a variety of indicators. We adopt a measure of multimarket contact that was developed in the literature on assortative mixing in social networks (Newman, 2002; Newman et al., 2002). The assortativity index measures the degree of interaction among two groups by comparing the degree of contact within groups and between groups. In the current context, if we let J_A and J_B denote a pair of binary variables that indicate the presence of airlines A and B on each route, and form the matrix X=[J_A J_B], then the 2x2 matrix V=X'X summarizes the degree of overlap in the route structures of the two airlines. The diagonal elements of V are the number of routes served by A and B respectively, and the off diagonal elements are the number of routes in common. Let $\|V\|$ denote the sum of the elements of V, and normalize V as $Z = (\|V\|)^{-1}V$, then the index of multimarket contact may be defined as:

$$MMC = \frac{[1 - tr(Z)]}{[1 - \|ZZ'\|]}$$

where tr(Z) is the sum of the diagonal elements of Z. It may be shown that this measure: a) varies on the unit interval, b) increases as the number of common routes increases, c) increases as the scale of the airlines equalize, d) takes the value zero if there are no common routes, and e) takes the value one if the route structures are identical. Given these properties, greater multimarket contact is reflected as larger values of the index.

A few examples may help illustrate the properties of the MMC measure. First consider a pair of airlines of equal scale, say 200 routes served each, but disjoint route structures. The matrix V is diagonal, with equal diagonal elements. For example,

$$V = \begin{bmatrix} 200 & 0 \\ 0 & 200 \end{bmatrix}$$

where $\|V\|$=400. The normalized value of V is

$$Z = \begin{bmatrix} 1/2 & 0 \\ 0 & 1/2 \end{bmatrix}$$

where tr(Z)=1 and $\|ZZ'\|$=1/2. In this case, the value of the multimarket contact index is

$$MMC = \frac{[1 - tr(Z)]}{[1 - \|ZZ'\|]} = \frac{[1 - 1]}{[1 - (1/2)]} = 0$$

This index will always be zero when the route structures are disjoint. That is, when there is no multimarket contact.

At the other extreme, consider a pair of airlines with identical route structures. Assume that they both serve the same 200 routes. The matrix V is

$$V = \begin{bmatrix} 200 & 200 \\ 200 & 200 \end{bmatrix}$$

where $\|V\|$=800. The normalized value of V is

$$Z = \begin{bmatrix} 1/4 & 1/4 \\ 1/4 & 1/4 \end{bmatrix}$$

where tr(Z)=1/2 and $\|ZZ'\|$=1/2. Consequently, the value of the multimarket contact index is

$$MMC = \frac{[1 - tr(Z)]}{[1 - \|ZZ'\|]} = \frac{[1 - (1/2)]}{[1 - (1/2)]} = 1$$

The index will always be one for airlines with coincident route structures.

As the scale of the airlines diverge, the off diagonal elements of V cannot exceed the smaller of the two diagonal elements. That is, if one airline serves 400 routes, and the other serves 200 routes, at most, they can have 200 routes in common. In this case,

$$V = \begin{bmatrix} 400 & 200 \\ 200 & 200 \end{bmatrix}$$

where $\|V\|$=1,000. The normalized value of V is

$$Z = \begin{bmatrix} 2/5 & 1/5 \\ 1/5 & 1/5 \end{bmatrix}$$

where tr(Z)=3/5 and $\|ZZ'\|$=13/25. The value of the multimarket contact index is

$$MMC = \frac{[1 - tr(Z)]}{[1 - \|ZZ'\|]} = \frac{[1 - (3/5)]}{[1 - (13/25)]} = 5/6$$

In general, differences in the scale of the airlines will decrease the degree of multimarket contact.

Finally, consider a pair of airlines of equal scale, whose route structures overlap randomly. From among the routes served by the first airline, the probability that the route is common with the second airline is one half. On average, half their routes in common.

$$V = \begin{bmatrix} 200 & 100 \\ 100 & 200 \end{bmatrix}$$

where $\|V\|$=600. The normalized value of V is

$$Z = \begin{bmatrix} 1/3 & 1/6 \\ 1/6 & 1/3 \end{bmatrix}$$

where tr(Z)=2/3 and $\|ZZ'\|$=1/2. The value of the multimarket contact index is

$$MMC = \frac{[1 - tr(Z)]}{[1 - \|ZZ'\|]} = \frac{[1 - (2/3)]}{[1 - (1/2)]} = 2/3$$

The multimarket contact index increases as the number of common markets increases, and as the scale of the airlines equalize. This measure is easily generalized to the case of more than two airlines on a route, by simply adding the appropriate market presence binaries to the original matrix X.

References

Baker, Jonathan B., "The Case for Antitrust Enforcement," *Journal of Economic Perspectives*, Fall 2003, *17* (No. 4), 27–50.

Blair, Roger D. and Richard E. Romano, "Advance price anouncements and antitrust policy," *International Review of Law and Economics*, 2002, *21*, 435–452.

Borenstein, Severin, "Rapid Price Communication and Coordination: The Airline Tariff Publishing Case," in John E. Kwoka Jr. and Lawrence J. White, eds., *The Antitrust Revolution: Economics, Competition, and Policy 4th ed.*, Oxford University Press, 2004.

_______ **and Nancy L. Rose**, "Competition and Price Dispersion in the U.S. Airline Industry," *Journal of Political Economy*, August 1994, *102* (4), 653–683.

_______ **and** _______ , *Economic Regulation and Its Reform: What Have We Learned?*, University of Chicago Press, forthcoming.

Busse, Meghan, "Firm Financial Condition and Airline Price Wars," *Rand Journal of Economics*, Summer 2002, *33* (2), 298–318.

Carlton, Dennis W., Robert H. Gertner, and Andrew M. Rosenfield, "Communication Among Competitiors: Game Theory and Antitrust," *George Mason Law Review*, 1997, *5* (3), 423–440.

Crandall, Robert W. and Clifford Winston, "Does Antitrust Policy Improve Consumer Welfare? Assessing the Evidence," *Journal of Economic Perspectives*, Fall 2003, *17* (No. 4), 3–26. Available on file.

Ellison, Glenn, "Theories of Cartel Stability and the Joint Economic Committee," *Rand Journal of Economics*, Spring 1994, *25* (1), 37–57.

Hausman, Jerry A., "Specification Tests in Econometrics," *Econometrica*, November 1978, *46* (6), 1251–1271.

Hayes, Kathy J. and Leola B. Ross, "Measuring Changes in Multiproduct Market Structure: An Application to U.S. Airlines," *Review of Industrial Organization*, August 1996, *11* (4), 493–509.

Levenstein, Margaret C. and Valerie Y. Suslow, "What Determines Cartel Success?," *Journal of Economic Literature*, March 2006, *44* (1), 43–95.

Newman, M. E. J., "Assortative Mixing in Networks," *Physical Review Letters*, 2002, *89* (20), 208701.1–208701.4.

———, **D. J. Watts, and S. H. Strogatz**, "Random Graph Models of Social Networks," *Proceedings of the National Academy of Science*, 2002, *99*, 2566–2572.

Ross, Leona B., "When Will an Airline Stand its Ground? An Analysis of Fare Wars," *International Journal of Economics and Business*, 1997, *4* (2), 109–127.

Rotemberg, Julio J. and Garth Saloner, "A Supergame-Theoretic Model of Price Wars during Booms," *American Economic Review*, June 1986, *76* (3), 390–407.

U. S. Department of Justice, "United States v. Airline Tariff Publishing Company, et al., Final Judgment," *Federal Register*, August 1994, *59.*

———, "United States v. Airline Tariff Publishing Company, et al., Proposed Final Judgment and Competitive Impact Statement," *Federal Register*, 31 March 1994, *59*, 15225–15237.