Is Airline Price Dispersion the Result of Careful Planning or Competitive Forces?

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Abstract

Price dispersion can be explained by monopoly power and be labeled price discrimination. However, fare wars, which also create high variances in prices, suggest a failed attempt among the major carriers to collude tacitly. We find no conclusive evidence that price dispersion during the early 1990s is the result of price discrimination. Moreover, price dispersion is most closely associated with a lower average price, strongly suggesting that competition forces prices down rather than market power being used to exploit inelastic demand.

Key Words Price Dispersion, Price Discrimination, Airline Markets

Introduction

The persistence of fare wars in the domestic airline industry has captured the attention of economists and travelers alike. Appropriately, consumers have learned to plan in advance and postpone ticket purchases in anticipation of the next price drop. While highly publicized fare wars signify a dramatic drop in the "typical" price of a ticket, discounted fares occasionally may be found in the absence of a publicized fare war. The proliferation of such pricing policies among the major carriers continues to baffle economists. After accounting for differences in costs, such dispersion could be explained by monopoly power and be labeled price discrimination. However, fare wars, which also create high variances in prices, suggest a failed attempt among the major carriers to collude tacitly. The coexistence of these two theoretical explanations suggests a paradox within the airline industry. If price dispersion is the result of market power, then it is a carefully planned scheme to extract consumer surplus from travelers. If fare wars are the culprit, then price dispersion embodies the fragility of collusive behavior and the absence of market power. Unraveling the determinants of price dispersion is a necessary step in understanding the balance (or imbalance) of power in this industry and evaluating the relevance of market structure to market power. This study extends previous work to investigate the dichotomous origins of price dispersion. We distinguish and characterize markets where there is market power and price discrimination from those markets where oligopolistic competition has eroded efforts to collude tacitly.

The airline market's price dispersion literature was initiated by Borenstein and Rose (1994) who made several valuable contributions.[2] The current study contributes to several aspects of this literature. First, as compared to other studies, our data is more recent and more comprehensive, possibly enabling us to distinguish the characteristics of competitive and non-competitive markets. During our sample period, the early 1990s, fare wars proliferated and the

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[2] There was also a heuristic discussion of airline price dispersion in Lott and Roberts (1991). There have been numerous price dispersion studies for other industries such as retail gasoline by Borenstein (1991) and Shepard (1991).

financial difficulties of the passenger airline industry escalated. These new market conditions allow us to reexamine the factors that lead to a competitive or non-competitive market. As such, we do not expect the evidence reported in earlier work of market power leading to price discrimination to be replicated in our sample. Specifically, our price and enplanement data spans from 1990Q1 through 1992Q4.[3] Quarterly and route variation is considered in addition to carrier effects, cost differences, and peak load price effects.

Second, in contrast to earlier studies, we verify the robustness of our results by defining price dispersion under three alternative definitions. The dispersion indices we use have unique properties that provide different information about dispersion while maintaining similar rankings. While the Gini Coefficient is probably the most well-known of the dispersion indices and has several attractive properties, it is only one of many indices that have been used to measure dispersion in the inequality literature. In addition to the Gini, our analysis includes both the Atkinson and the entropy indices of inequality. We chose to utilize these three measures not to compare their appropriateness but rather to illustrate that statistical results consistent over all measures are more credible than those that are not. Therefore, those results emphasized in this study are not sensitive to the measure or the time period used.

Third, we expand the scope of analysis by including smaller airports. Moreover, geographical regions with multiple airports are identified to assess the impact of regional competition on price dispersion. Because the sample includes more airports and spans several time periods, we are able to more effectively isolate the importance of market power and competitive forces.

This research demonstrates that price dispersion in the airline industry is a result of lively competition which forces carriers to discount fares below the desired level. We do not find substantial evidence of price discrimination, allowing the carriers to extract consumer surplus. We suspect that, as much as the airlines attempt to hold prices above the competitive level, there is insufficient market power to successfully sustain such prices. The outcome of this behavior may be similar to an Edgeworth cycle.[4] Finally, our results regarding peak load and cost differences suggest that they do not have a definitive impact on dispersion.

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[3] This is in comparison to the one quarter of data from 1986 used in Borenstein and Rose.

[4] See Slade (1989) or Maskin and Tirole (1988).

In the next section, we discuss various sources of price dispersion as they have been identified in economic theory. The third section is a discussion of the measures of dispersion used in the analysis. In the fourth section we review our list of regressors. The empirical model and subsequent analyses are presented in the fifth and sixth sections, and we provide concluding remarks in the final section.

Sources of Price Dispersion

Numerous origins of price dispersion have been identified in the economic literature. Most often such dispersion is attributed to price discrimination that is strongly indicative of either monopoly or considerable market power. However, it is also possible that dispersion occurs over a period of time (as may be the case for our quarterly data) and may be attributed to Edgeworth cycles. Another prominent explanation stems from the peak load pricing literature. Such a strategy is used to smooth the utilization of very expensive capital equipment over time and reduce congestion. Further, price differentials can be associated with cost differentials. The focus of this study is to find evidence of either price discrimination or Edgeworth cycles as dichotomous explanations that cannot be directly observed with quarterly data, while controlling for both peak load effects and cost differentials.

It seems paradoxical that both non-competitive and competitive forces can lead to price dispersion. Consider first non-competitive, or planned, price dispersion. Customers may be charged differing prices when the seller has sufficient information concerning the customer's marginal utilities. This type of price dispersion may be part of a firm's carefully orchestrated plan to maximize profits vis-à-vis price discrimination. Because some airlines continuously update prices offered, we expect that some routes may be characterized by first or second degree discrimination. On these routes, it is likely that business and pleasure travelers can be distinguished and each group will be charged unique prices. Such planned price dispersion would be associated with more concentrated markets and hub dominant carriers.

Conversely, price dispersion may be unplanned when competition drives prices down over a period of time. Given the quarterly nature of airline price data, it is conceivable that differing prices are actually a reflection of competitive forces seeking an equilibrium price in a highly volatile market. If airlines attempt to collude tacitly by holding prices above the competitive level, but lack sufficient market power to sustain those prices, a possible result could be Edgeworth cycles. Such cycles occur when collusive arrangements are weak and periodically dissolve into successive price cuts until marginal cost is reached, then prices settle for a finite period of time. The cycle is over when one carrier relents and others follow its lead back to the collusive level. Given the proliferation of fare wars over the past few years, casual empiricism suggests that such cycles may be at the root of price dispersion in this industry. This dispersion would occur over a period of time and is not directly observable with quarterly data. However, cycles could be detected *ex post* if they were properly attributed to more competitive routes, lower average prices or regional competition. Figure 1 exemplifies the extreme variation in price the data exhibits for many routes in our sample.

Given the multiproduct nature of the airline industry with significant multimarket contact, price dispersion could result from various profit maximizing strategies. These strategies may vary not only across markets but also through time. Furthermore, as overall profitability of the industry has declined during our sample period, we believe that the variety and intensity of profit maximizing efforts may have changed dramatically. Our unique data set permits us to distinguish between these non-competitive and competitive markets and to weigh the importance of various strategies undertaken by the major carriers.

Measuring Price Dispersion

The measurement of inequality has a rich history in the economic literature with the bulk of it pertaining to the evaluation of income inequality. Similarly, the dispersion of prices is an example of price inequality which may be quantified into an index just as income inequality may. Given the vast number of available indices, it is appropriate to comment on the differences between the indices that are relevant to this study.

The relative importance of various index properties has created a lengthy debate. For making policy decisions regarding income inequality, the choice of an index may be the result of a preference for a particular property (Atkinson, 1970). For measuring the dispersion of ticket prices, these properties are less important. Moreover, their rankings are often consistent with each other (Basmann, Hayes and Slottje, 1994).[5] It is useful to incorporate more than one measure of dispersion into our study, not to re-rank our dependent variable, but merely to verify the robustness of our results to the type of index used. In a similar sense, Kwoka (1985) demonstrated that various concentration measures, which were highly correlated, exhibited differences in their explanatory power when used in regression analysis.

In the statistical analysis below, we estimate our model with three different measures of price dispersion (the Gini, the Atkinson inequality measure and the entropy measure). While most results from the statistical model below are consistent across index, we find cases where they are notably different. Emphasizing different portions of the price distribution is enlightening for identifying the impact of peak load pricing strategies, regional competition, and carrier effects. This analysis validates the usefulness of multiple indices and highlights the existence of some anomalies in this industry. At the same time, it brings into question the amount of faith that can be placed on any analysis that is limited to a single inequality measure. With this in mind, we review the Gini, the Atkinson, and the entropy.

The Gini coefficient tends to give more weight to the middle portion of a distribution and, therefore, is rather insensitive to the tails of the distribution. While the Gini coefficient is a well established index, the others we use are less common. The Atkinson (1970) measure is an axiomatically based index bound by zero and one. The functional form of this index is

$$(1) \qquad I = 1 - \left[\frac{1}{n} \Sigma_i \left[\frac{p_i}{\mu} \right]^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}$$

where n is the number of observations, p_i is the price of observation i, μ is the mean price and ε is a choice parameter. Unlike the Gini, the parameter ε allows the measurer to alter the portion of the distribution that is emphasized. For example a large ε would emphasize inequality in the lower end of the distribution whereas a small ε would create an index that is more sensitive to inequality in the upper end of the distribution. We chose an ε of 0.5 which is relatively small

[5]This is a reinforcement of an index's validity. If a new index were to reverse rankings on a large scale, it would not likely be accepted. When a large class of indices will yield similar rankings while providing different types of information, then those indices are valuable in a collective sense.

and will be sensitive to variations in "high" prices. Therefore, the regressions with an Atkinson dependent variable should be particularly informative about dispersion above the average price and its relationship with market power. The other index we utilize is the entropy measure which is based in information theory. The functional form of the entropy is

$$(2) \qquad I = \frac{1}{n}\sum_i \frac{p_i}{\mu}\ln\frac{p_i}{\mu}$$

The entropy index is more sensitive to variation in prices at the lower end of the distribution.[6]

Characterizing Price Dispersion

Given the numerous sources of price dispersion that have been addressed in the economic literature, a plethora of variables must be included in any empirical model designed to identify the importance of either market power or competition. For this reason, we have identified several broad categories of variables that comprise a lengthy list of regressors for our statistical model. First, we include several commonly used indicators of market concentration and market power. Second, we have a number of variables that describe the nature of the competitive situation on a given route. For example, we identify competition from a bankrupt or a failed carrier, from Southwest Airlines, from other airports in the region, etc. Third, we control for cost differentials to some extent and peak load pricing. Fourth, we have carrier dummies to absorb the impact of differing strategies among the various players in this market. Finally, we have included a variety of interaction terms because many of our independent variables may have implications for more than one category. These variables are regressed on our measures of price dispersion for 1332 quarterly carrier/route observations. The data set is a balanced panel for eleven quarters such that our pooled sample has 14,652 observations.[7]

<u>Market Power Variables</u>

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[6] All three of these measures are symmetric, replication invariant and scale invariant.

[7] Only route/carrier observations that appear in both data sources for all time periods are included.

We wish to identify the extent to which market power is associated with price dispersion. While it has been argued by Lott and Roberts that these price differentials can be attributed to peak load pricing and cost differences, Borenstein and Rose found evidence of price discrimination among monopolisticly competitive carriers. Given the dramatic changes that have occurred in the airlines since the mid 1980s, we suggest that it is appropriate to re-examine this question in light of our more current data.

To address the issue of price discrimination, our data set includes variables that are indicative of market power. We have included concentration variables, RHERF and AHERF, which are Herfindahls for the route and the average of the endpoints respectively.[8] Borenstein (1989) finds evidence that airlines have greater market power at their own hubs. Conversely, economies of scale may exist at hub operations due to airport dominance. Therefore, our hub indicator, HUB (a dummy variable that signifies a hub at either endpoint of a route) could capture both market power and cost savings. To decipher these two effects, we interact HUB with RHERF, AHERF and NUMCARR (the number of carriers serving a route). We consider these interaction terms to be indicators of the market power associated with hubs (the effect of the last one being negative) and the remaining 'hub' effect to be associated with a cost differential. Thus, we include HUB in our cost category. Since there often is a marked difference between the price of one-way and round-trip fares, we also include ROUND, a percentage of round trip tickets. As in the case of HUB, ROUND may also have a dual effect. Since round-trip fares are often discounted only if they include a Saturday night stay (and may require even more restrictions than that), ROUND may also be a strong proxy for peak load pricing. Again, we interact ROUND with RHERF, AHERF, NUMCARR and HUB to capture that aspect which is associated with market power. The ROUND variable is included with the peak load proxies. Finally, we suspect that average price, MEAN, should be higher if market power is prevalent. Therefore, we interact MEAN with RHERF, AHERF and HUB to identify price strength of market power.

Competitive Forces

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[8] Since we suspect that there is a potential for endogeneity, we instrument these variables.

In contrast to a price discrimination story, Edgeworth cycling can also create price dispersion. To find evidence of such behavior, we incorporate a number of "competition" variables into our data set. First, we consider competition from other carriers. For example, we wish to measure the impact of competition from a bankrupt carrier. Further, it is noteworthy that competition may occur on a route that is traveled by two carriers or it may occur on a route that originates from a competing airport. For example, the New York City area has numerous competing airports as does Los Angeles. Given the many large metropolitan areas in the United States with such regional competition, we have redefined an endpoint to include airports in close proximity to each other. Therefore, COMPBANK is a dummy variable that indicates either direct or regional competition from a bankrupt carrier. Similarly, COMPFAIL and COMPSW are dummy variables that indicate either direct or regional competition from a subsequently failed carrier or from Southwest Airlines, respectively. We also consider the overall impact of regional competition on price dispersion. We include dummy variables for flights with endpoints in the Chicago area, the Dallas area, the Denver area, the Detroit area, the Houston area, the Los Angeles area, the Charlotte-Greenville, SC area, the New York City area, the San Francisco area, and the Washington, D.C. area. These dummy variables are signified by REGIONYY (where "YY" signifies the endpoint). Finally, we include the number of carriers, NUMCARR, serving a route as an indicator of heavy competition. Positive coefficients on these variables would be indicative of competitive forces driving price dispersion and evidence that market power has been eroded in this industry since the mid 1980s.

Peak Load Pricing

Lott and Roberts have argued that the airlines use price dispersion to alleviate congestion at peak usage times. For example, to get a discounted fare, usually a consumer must book a round trip flight and include a Saturday night in his travel plans as airports tend to be less busy on the weekends. For this reason, we consider the percentage of round-trip fares (ROUND) to proxy peak load pricing. Moreover, we argue that peak load pricing is more likely to be practiced on routes where there is a higher variance in load factors (LVLOADF) and plane sizes (LVPSIZE). However, since we suspect a simulteneity problem with these variables, they are lagged one period. We also interact these terms with each other, PSIZLOAD.

Cost Differentials

We include three variables to control for routes that will have significant differences in costs. These variables are DIST, the length of a direct flight; HUB, since we believe that hubs represent a cost saving to the hub operating carrier; and STOP. STOP is the percentage of passengers that experience a stopover somewhere. Since this may include any number of intermediate airports, there is the possibility of various cost differentials arising from such stopovers.

Carrier Dummies

Finally, we include carrier dummies for 13 regional and national carriers.

The Statistical Model

Given the enormity of our data set, we are able to include a large number of variables in our analysis. The variables reflect the theoretically based sources of price dispersion as presented in the second section: price discrimination, competitive discounting, peak load pricing, and cost differentials. The model we estimate is as follows:

$$
\begin{aligned}
DISP_{ijt} = {} & \alpha + \delta_1 RHERF_{ijt} + \delta_2 AHERF_{ijt} + \delta_3 HUBRHERF_{ijt} + \delta_4 HUBAHERF_{ijt} \\
& + \delta_5 HUBNUMCA_{ijt} + \delta_6 RO\_RHERF_{ijt} + \delta_7 RO\_AHERF_{ijt} \\
& + \delta_8 RO\_NUMC_{ijt} + \delta_9 RO\_HUB_{ijt} + \delta_{10} MRHERF_{ijt} \\
& + \delta_{11} MAHERF_{ijt} + \delta_{12} MHUB_{ijt} \\
& + \mu_1 COMPBANK_{it} + \mu_2 COMPFAIL_{it} + \mu_3 COMPSW_{it} \qquad (3) \\
& + \mu_4 NUMCARR_{it} + \sum_c \theta_c REGIONYY_{cj} \\
& + \gamma_1 ROUND_{ijt} + \gamma_2 LVLOADF_{ijt} + \gamma_3 LVPSIZE_{ijt} + \gamma_4 PSIZLOAD_{ijt} \\
& + \beta_1 DIST_i + \beta_2 HUB_{ij} + \beta_3 STOP_{ijt} \\
& + \sum_k \varphi_k CARRIERXX_{kijt} + e_{it} + u_i + w_t
\end{aligned}
$$

The equation is estimated with the Gini log odds ratio, the Atkinson log odds ratio and the Entropy index as the dependent variable. The data employed includes fifteen carriers traveling on 973 routes from the first quarter of 1990 through the 4th quarter of 1992.[9] The data set is a balanced panel (i.e. each carrier on each route is represented for every time period in the sample). We estimate the model with random time and route/carrier effects. As several variables were lagged to reduce simulteneity bias, the observations in the regression begin with the second quarter of 1990, providing 11 time periods and 14,652 observations. Given the time series nature of the data, the error structure includes an moving average (1) process to control for autocorrelation. The model is estimated using generalized least squares with two-way random effects. The appendices contain a detailed description of the data and the variables.

The regressors are arranged by type in equation (3). The δ variable denote indicators of market power such that a positive coefficient would suggest price discrimination. The μ variables denote variables regarding various types of competition that could potentially force carriers to discount fares and the θ variables denote endpoints at various multiple airport regions. Accordingly, positive coefficients should be indicative of Edgeworth cycling by carriers that are not able to maintain collusive price levels. The γ and β variables denote proxies for peak load pricing and cost differentials, respectively. And finally, φ denotes individual carrier effects.

Results from the Statistical Model

Simple correlation tests among the independent variables were first conducted to red flag any unexpected multicollinearity problems. While the correlations were not strong enough to create such problems, some of the results from the correlation were enlightening. By and large, most carriers are somewhat correlated with other carriers having correlation coefficients between 0.2 and 0.5. In particular, Aloha Airlines and Hawaiian Airlines have correlation coefficients of 0.438, and Northwest Airlines and Trans World Airlines have correlations of 0.431. Such correlations strongly indicate multimarket contact among the major and regional

[9] This is in contrast to Borenstein and Rose who use 521 routes and 11 carriers.

carriers (see Evans and Kessides, 1994). What is more astounding is the degree to which the number of carriers serving a route, NUMCARR, is correlated with certain carriers. The carriers most closely associated with NUMCARR are Continental Airlines, Northwest, TWA, and United Airlines all with correlation coefficients above 0.5. With the exception of United, these carriers have had severe financial difficulties during this time period with both Continental and TWA declaring bankruptcy and Northwest frequently on the brink of bankruptcy. In fact, route competition from bankrupt carriers and NUMCARR have a correlation coefficient of 0.565, demonstrating further that bankrupt carriers are closely associated with routes that experience heavy competition.[10] While the other carriers in the sample seem to have a large selection of routes that they tend to dominate, these carriers do not. Possessing some routes without heavy competition is important for maintaining a competitive edge. And finally, we find that ROUND is negatively correlated with COMPSW, highlighting the commuter-flight nature of this very successful airline.

The estimation results from (3) are presented in Table 2 which reports the GLS coefficients and their marginal probabilities for all three measures of price dispersion.[11] The fitted values for RHERF and AHERF demonstrate that RHERF is endogenous while AHERF is not.

Market Power

We find no conclusive evidence of price discrimination. The coefficients for RHERF, AHERF, HUBAHERF, HUBRHERF and MRHERF are insignificant. Further, a number of the interaction terms, which are designed to capture the price discrimination in ROUND, HUB, and MEAN, are not consistently significant. The only robust results we obtain from our price discrimination proxies are from RO_AHERF which is negative and significant for all measures of price dispersion. This suggests that at small monopolized endpoints, less price dispersion exists on round trip flights. Since this is where carriers have the most potential to exploit their

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[10] Hayes and Ross (forthcoming) find that while there were notable changes in market structure following the departures of Eastern Airlines and Midway Airlines in the early 1990's, there were not unusually large changes in the mix of routes offered by the industry. This may indicate that these two carriers became insolvent simply because they could not effectively carve their own niche in the market place.

[11] Recall that the Gini emphasized the middle of the distribution, the Atkinson, the upper end and the entropy, the lower end.

market power, and they appear to opt for more uniform prices rather than disperse ones, we argue that price discrimination is not their strategy of choice for profit maximization.

Competition

The most informative results are those related to the competition variables. Carriers competing with a failed carrier failed during our sample period exhibit less disperse prices, whereas competition from a carrier that declared bankruptcy but continued to operate has no significant effect. Financially strained carriers that survive price differently from those that do not. Competition from Southwest Airlines strongly indicates more uniform pricing. Southwest remarkably impacts the pricing patterns of other carriers.

The dummy variables for multiple airport regions are by and large positive and significant. The notable exceptions are the Detroit and Washington, D. C. areas which are negative and significant, and the New York area where the lower end of the distribution is not sensitive to extra competition from competing airports. In these areas where there is both intra and interairport competition, dispersion is more prevalent which demonstrates the role of competitive forces in spreading prices down the demand curve.

Moreover, MEAN (both the first and second order effects) is negative and significant demonstrating that prices are more disperse when the average is lower. This result is our strongest evidence that price dispersion result from less, rather than more, market power.

Collectively, the market power and competition results suggest that competitive forces, rather than careful planning, are at the heart of price dispersion. However, if that competition comes from Southwest or some carrier that is on its way out, there is also the possibility of uniform pricing. High uniform prices seem to be associated with market power at small monopolized endpoints. Nonuniform prices, however, seem to be the result of healthy competition from solvent oligopolists. This point brings us back to our quarterly data problem. Many of our results point to dispersion as a result of competitive forces among oligopolists who unsuccessfully attempt to sustain prices above marginal cost. The market seems to be in a constant state of volatility which is reflective of Edgeworth cycles in airline markets.

Peak Load Pricing

Our conjecture that dispersion may be an overt attempt by the airlines to redirect traffic to less congested time slots has gained some validation from these estimations. We find that ROUND is a consistently significant and positive indicator of dispersion for all measures. Since we have removed much of the price discrimination that is exercised through round trip tickets by utilizing interaction terms, ROUND in isolation becomes a proxy for peak load pricing. However, our other proxies are less conclusive.

Cost Differences

We find limited evidence that price dispersion is the result of cost differences. HUB is not robust. This clearly reputes a cost distinction based upon savings from hubs as an explanation for dispersion. However, we note that DIST is positive and significant for the Gini and the entropy measure, whereas it is insignificant for the Atkinson. Recall that the Atkinson index gives greater weight to the upper end of the price distribution, indicating that inelastic demand is not sensitive to stage length. Those travelers who arrive at the terminal and buy last minute tickets pay the same price if they are going 300 miles or 3000 miles. Conversely, STOP is consistently positive and highly significant for all measures of dispersion. This result suggests that carriers with more direct flights have less variation in their prices, while carriers with many stopovers, and consequently more variety in their flight costs, have greater price variation.

Carrier Effects

We are particularly interested in the impact of Southwest Airlines on their competitor's pricing strategies; however, our results are not uniform. While Southwest has a remarkable impact on the lower end of the price distribution (as indicated by its significant and negative coefficient on the entropy index), it does not seem to affect the middle or upper end of the distribution. Southwest clearly caters to a different crowd than do its competitors.

Conclusions

Extraordinary price dispersion in the airline industry continues to persist -- largely stemming from competitive forces that are not likely to subside in the near future. We find no conclusive evidence that price dispersion during the early 1990s is the result of market power or price discrimination. Moreover, price dispersion is most closely associated with a lower average price, strongly suggesting that competition forces prices down, rather than market power being used to exploit inelastic demand. Cost differences and peak load pricing schemes do contribute to dispersed prices in a limited fashion; however, it seems undeniable that price dispersion is closely tied to dynamic oligopoly forces. Oligopolist carriers make consistently unsuccessful attempts to collude tacitly. Such failed collusion is theoretically based in poor market conditions which were tantamount in the early 1990s.[12] As airlines became more concerned with streamlining costs, maintaining large networks, and retaining their customer bases through frequent flier programs, the tension between traditional route dominance and heightened competition came to a head. While this period of transition is financially devastating to most carriers, it is a heyday for consumers. However, recent trends toward more favorable market conditions may gradually lead to a more consistent *ex post* price distribution at a higher equilibrium price.

To provide additional verification of our results, we estimated our model with three different, but highly correlated, measures of dispersion. We find that most results are robust to our selection of indices, although some differences arise. While there are a few changes of sign in our variable coefficients, differences often exist in the significance levels of those coefficients. This difference suggests that results from a single index might be misleading or incomplete.

In comparison to the Borenstein and Rose, we find much less evidence of price discrimination in the early 1990s than in their sample period of 1986. This difference is likely due to financial strain in the latter period, the resulting deterioration of tacit collusion, and insufficient knowledge of appropriate equilibrium pricing strategies.

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[12] See Green and Porter (1984).

Appendix A - Data

Since the airline industry is still subject to some regulation by the Department of Transportation (DOT), the accumulation of data continues on a very extensive scale. The *Origin and Destination Survey* (Databank 1A or DB1A) includes price and stage information while the *T100 Domestic Segment Data* (Databank 28DS or T100) gives information on capacity and the utilization thereof and frequency of service. These databanks are available from the Volpe National Transportation Systems Center in Cambridge, MA, or from the National Archives in Washington, DC for older data. The DB1A is a random 10% survey of all tickets issued for flights within the United States and is published on a quarterly basis. The T100 contains data reported by US carriers operating non-stop service within the United States and is published monthly. The following types of tickets are removed from the sample:

1) Any ticket with one or more segments of first class travel (with the exception of Southwest Airlines, who reports all tickets as first class).

2) Any tickets that are not either one-way or round-trip, i.e. a trip such as DFW-CLE-LGA-DFW (Dallas-Fort Worth to Cleveland to LaGuardia to Dallas-Fort Worth) is a three leg trip which does not have a clear destination and is not included, whereas, DFW-LGA-LGA-DFW does and is.

3) Any tickets with more than one change of plane per direction of travel.

4) Tickets with any origin or destination outside the United States.

5) Interline tickets (those tickets where services are provided by more than one carrier).

6) Any tickets that were less than $10 or greater than $750 each way or $20 and $1500 round-trip, respectively, as these are assumed to be frequent flier tickets, chartered flights or input errors.

There are 1,332 carrier/route observations representing 973 routes selected from these two data sets to use for these analysis. These are the only carrier/route combinations that are present in *both* data sets for *all* time periods among the top 100 airports in the US and represent roughly 30% of all itineraries in the DB1A. The use of the T100 somewhat restricts the choice set of routes since it is a segment based data source. For an observation to occur on the T100, there must be a non-stop flight between the endpoints. Conversely, the DB1A has observations on almost any combination of segments imaginable between various endpoints. It should be noted that inconsistencies in the interpretation of the variables extracted from these data sets may arise given their differences.

The most recent 12 quarters of data were used for the analysis (1990:1 through 1992:4). The equations below were estimated by observations that are aggregated by route pair and time. With the inclusion of some lagged variables, this leaves 11 data points for each of the 1,332 observations resulting in 14,652 observations in total. A route is coded by the alphabetical order of the endpoints (i.e. DFW-LGA and LGA-DFW are both DFWLGA and all data pertaining to these endpoints are aggregated into at least one carrier observation in each quarter).

Appendix B - Variable Definitions

Dependent Variables

DISP Three measures of dispersion are utilized in our model. The Atkinson measure with a parameter of 0.5, the Gini, and the entropy index are employed. However, the Atkinson and the Gini lie between zero and one, creating a limited dependent variable problem. Two alternatives are suggested for accommodating a limited dependent variable. One is to use Tobit maximum likelihood estimation rather than least squares. Since the entropy index is not bound, and least squares estimation is possible, we prefer a method that allows for a homogeneous estimation technique. The second alternative, which does allow such homogeneity, is to convert the Atkinson and the Gini to unbound variables by calculating their log odds ratios. The log odds ratio of x equals ln $x/(1-x)$ and is not bound as is the original variable.

Independent Variables

Market Power variables with δ coefficients:

RHERF: The *HH* index $(\Sigma_a S_a)$ of the route, S_a is the proportion of passengers an airline a serves on the route. Source: DB1A and author's calculations.

MKTSHARE This is the market share of the carrier for the period and route in the observation. This variable is used as an instrument for *RHERF* since it is likely to be endogenous. Source: DB1A

AHERF: (*AHERF1*+*AHERF2*)/2. Where *AHERF1* is the *HH* index $(\Sigma_a S_a)$ of the airport first listed in the route pair, S_a is the proportion of passengers an airline a serves at the airport and *AHERF2* is the *HH* index of the airport listed second in the route pair, S_a is the proportion of passengers an airline a serves at the airport. Source: DB1A and author's calculations

TSCHED This is a count of the number of scheduled non-stop flights in the quarter. This variable is used to instrument *AHERF* which may be endogenous. Source: T100.

HUBRHERF This is an interaction term with the hub indicator and *RHERF*. Source: DB1A and Bauer (1992)

HUBAHERF This is an interaction term with the hub indicator and *AHERF*. Source: DB1A and Bauer (1992)

HUBNUMCA This is an interaction term with the hub indicator and *NUMCARR*. Source: DB1A and Bauer (1992)

RO_RHERF This is an interaction term with *ROUND* (described below) and *RHERF*. Source: DB1A

RO_AHERF This is an interaction term with *ROUND* (described below) and *AHERF*. Source: DB1A

RO_NUMC This is an interaction term with *ROUND* (described below) and *NUMCARR*. Source: DB1A

RO_HUB This is an interaction term with *ROUND* (described below) and *HUB*. Source: DB1A and Bauer (1992).

MRHERF This is an interaction term with *MEAN* (described below) and *RHERF*. Source: DB1A

MAHERF This is an interaction term with *MEAN* (described below) and *RHERF*. Source: DB1A

MHUB This is an interaction term with *MEAN* (described below) and *RHERF*. Source: DB1A and Bauer (1992)

Competition variables with μ coefficients:

NUMCARR This is a count of the number of carriers serving a route during the period. Source: DB1A

COMPBANK This is a 0/1 dummy variable which indicates that a bankrupt carrier flies on the route or on a regionally competing route. Competition from bankrupt carriers should be more intense than from other carriers. Source: DB1A

COMPFAIL This is a 0/1 dummy variable which indicates that an airlines which has since failed flies on the route or on a regionally competing route. Competition from subsequently failed carriers should be more intense than from other carriers. Source: DB1A

COMPSW This is a 0/1 dummy variable which indicates that Southwest Airlines flies on the route or on a regionally competing route. We expect Southwest to be associated with less dispersion. Source: DB1A

MEAN This is the mean price a carrier charges on a route. Source: DB1A

Regional dummies with θ coefficients:

REGIONXX This is a dummy variable indicating that the observations has at least one endpoint in a multiple airport region: Chicago, Dallas, Denver, Detroit, Houston, Los Angeles, Charlotte, NC, New York City, San Francisco, or Washington, DC. In these cases, the customer has not only a choice of carrier but also a choice of airport.

Peak load variables with γ coefficients:

ROUND This is the percent of passengers flying round trip on a route. Source: DB1A

VLOADF This is a variance of *LOADF* (load factor) lagged one period which is the percent of available seats occupied on nonstop flights. This variable represents the variation in airplane occupancy. Source: T100

VPSIZE This is a variance of plane sizes (as indicated by the number of seats on a plane) lagged one period. Source: T100

PSIZLOAD This is an interaction term for *VLOADF* and *VPSIZE*. Source: T100

Cost variables with β coefficients:

DIST The great circle distance (divided by one thousand to adjust the scale) in official statute miles between the origin and destination of airports. A prediction of how this variable should affect an airline's ability to collude is not certain. Source: T100

HUB A 0/1 dummy variable indicating that one or both endpoints of a route are major hubs for at least one airport. Source: Bauer (1992)

STOP This is the percent of passengers experiencing a change of planes and indicates that a route is starting or ending at a "non-hub" airport. Source: DB1A

Carrier dummies with φ coefficients:

CARRIERXX There are dummy variables included for fourteen of the fifteen carriers included in the sample; American Airlines, Aloha Airlines, Alaska Airlines, Continental Airlines, Delta Airlines, Hawaiian Airlines, America West, Northwest Airlines, Trump Shuttle, Trans World Airlines, United Airlines, and USAir. The default airlines not represented with a dummy are two small carriers, Midwest Express and Air Wisconsin. Therefore, all carrier intercepts are in comparison to Southwest.

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Table 1
Summary Statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
Market Power				
RHERF	0.576	0.231	0.143	6.615
AHERF	0.322	0.110	0.106	0.966
HUBRHERF	0.651	0.447	0.000	6.615
HUBAHERF	0.368	0.246	0.000	1.435
HUBNCAR	7.050	4.875	0.000	28.000
RO_RHERF	0.433	0.224	0.000	2.205
RO_AHERF	0.240	0.110	0.000	0.627
RO_NUMCA	4.762	2.295	0.000	11.419
RO_HUB	0.880	0.572	0.000	1.953
MRHERF	94.432	48.484	4.944	650.256
MAHERF	53.137	25.361	5.114	171.688
MHUB	195.370	141.375	0.000	1438.000
Competition				
NUMCARR	6.107	2.140	1.000	14.000
COMPBANK	0.903	0.296	0.000	1.000
COMPFAIL	0.333	0.471	0.000	1.000
COMPSW	0.163	0.370	0.000	1.000
MEAN	169.027	65.740	20.410	719.000
Regional Dummies				
REGIONCH	0.115	0.319	0.000	1.000
REGIONDA	0.109	0.311	0.000	1.000
REGIONDE	0.078	0.268	0.000	1.000
REGIONDT	0.050	0.217	0.000	1.000
REGIONHO	0.057	0.232	0.000	1.000
REGIONLA	0.085	0.279	0.000	1.000
REGIONNC	0.041	0.197	0.000	1.000
REGIONNY	0.114	0.318	0.000	1.000
REGIONSF	0.076	0.265	0.000	1.000
REGIONWA	0.083	0.276	0.000	1.000
Peak Load Pricing				
ROUND	0.763	0.254	0.000	1.000
LVLOADF	0.020	0.016	0.000	0.341
LVPSIZE	26.181	64.481	0.000	1599.720
PSIZLOAD	0.529	1.591	0.000	65.561

Table 1 (cont'd)

Cost Differentials				
DIST	0.803	0.633	0.011	4.502
HUB	1.099	0.615	0.000	2.000
STOP	0.046	0.131	0.000	1.000
Carrier Dummies				
American Airlines	0.158	0.364	0.000	1.000
Aloha Airlines	0.002	0.047	0.000	1.000
Alaska Airlines	0.021	0.143	0.000	1.000
Continental Airlines	0.096	0.295	0.000	1.000
Delta Airlines	0.162	0.369	0.000	1.000
Hawaiian Airlines	0.004	0.061	0.000	1.000
America West Airlines	0.036	0.186	0.000	1.000
Northwest Airlines	0.096	0.295	0.000	1.000
Trump Shuttle	0.002	0.039	0.000	1.000
Trans World Airlines	0.065	0.246	0.000	1.000
United Airlines	0.131	0.338	0.000	1.000
USAir	0.158	0.365	0.000	1.000

Table 2
Results from Statistical Model[13]

Variable	Gini Coefficient Prob > |T|	Atkinson Coefficient Prob > |T|	Entropy Coefficient Prob > |T|
INTERCEPT	-1.751	-3.629	0.110
	0.000	0.000	0.000
Market Power			
RHERF	-0.025	-0.002	-0.008
	0.686	0.988	0.266
AHERF	-0.307	-0.488	0.020
	0.070	0.062	0.336
HUBRHERF	-0.041	-0.077	-0.003
	0.361	0.278	0.562
HUBAHERF	-0.136	-0.189	-0.006
	0.192	0.237	0.626
HUBNCAR	-0.003	-0.009	0.001
	0.522	0.200	0.291
RO_RHERF	0.141	0.134	0.031
	0.106	0.345	0.001
RO_AHERF	-0.530	-0.715	-0.056
	0.013	0.035	0.027
RO_NUMCAR	0.010	0.032	-0.001
	0.142	0.005	0.474
RO_HUB	-0.046	-0.083	0.002
	0.018	0.008	0.470
MAHERF	0.003	0.004	0.000
	0.001	0.009	0.744

[13]Log odds ratios were taken for the Gini and Atkinson because they are both bound by zero and one, thereby creating a limited dependent variable issue. As we wish to make a direct comparison (with identical techniques) between the results of these measures and the results from the entropy measure, which is not bound, we transformed them to their respective unbound log odds ratios.

Table 2 (cont'd)

MRHERF	-0.001	0.000	0.000
	0.168	0.670	0.492
MHUB	0.001	0.001	0.000
	0.000	0.000	0.053
Competition			
NUMCARR	0.007	0.009	0.002
	0.338	0.422	0.058
COMPBANK	-0.017	-0.034	-0.003
	0.258	0.155	0.098
COMPFAIL	-0.029	-0.054	-0.005
	0.002	0.001	0.000
COMPSW	-0.108	-0.163	-0.007
	0.000	0.000	0.025
MEAN	-0.002	-0.003	0.000
	0.000	0.000	0.000
Regional Dummies			
REGIONCH	0.173	0.265	0.018
	0.000	0.000	0.000
REGIONDA	0.206	0.294	0.018
	0.000	0.000	0.000
REGIONDE	0.137	0.151	0.009
	0.000	0.000	0.019
REGIONDT	-0.070	-0.087	-0.011
	0.041	0.079	0.015
REGIONHO	0.176	0.263	0.023
	0.000	0.000	0.000
REGIONLA	0.079	0.134	0.014
	0.003	0.001	0.000
REGIONNC	0.120	0.191	0.022
	0.002	0.001	0.000

Table 2 (cont'd)

REGIONNY	0.103	0.120	0.005
	0.000	0.000	0.100
REGIONSF	0.122	0.172	0.015
	0.000	0.000	0.000
REGIONWA	-0.052	-0.097	-0.010
	0.048	0.011	0.008
Peak Load Pricing			
ROUND	0.486	0.482	0.015
	0.000	0.003	0.192
LVPSIZE	0.000	0.000	0.000
	0.255	0.168	0.001
LVLOADF	0.406	0.575	0.008
	0.034	0.073	0.703
PSIZLOAD	0.000	0.000	0.000
	0.679	0.899	0.011
Cost Differentials			
DIST	0.028	-0.017	0.006
	0.047	0.412	0.003
HUB	0.093	0.181	0.011
	0.132	0.064	0.137
STOP	0.330	0.341	0.075
	0.000	0.000	0.000
Carrier Dummies			
American Airlines	0.289	0.504	0.049
	0.000	0.000	0.000
Alaska Airlines	0.359	0.609	0.054
	0.000	0.000	0.000
Aloha Airlines	-0.174	-0.019	0.009
	0.235	0.929	0.666
Continental Airlines	0.433	0.734	0.065
	0.000	0.000	0.000

Table 2 (cont'd)

Delta Airlines	0.385	0.661	0.053
	0.000	0.000	0.000
Hawaiian Airlines	0.005	-0.017	-0.015
	0.969	0.920	0.351
America West Airlines	0.344	0.640	0.038
	0.000	0.000	0.000
Northwest Airlines	0.534	0.895	0.083
	0.000	0.000	0.000
Trump Shuttle	0.496	0.888	0.070
	0.009	0.001	0.006
Trans World Airlines	0.384	0.724	0.068
	0.000	0.000	0.000
United Airlines	0.390	0.675	0.063
	0.000	0.000	0.000
USAir	0.317	0.582	0.047
	0.000	0.000	0.000
Southwest Airlines	-0.010	-0.038	-0.012
	0.760	0.442	0.002
Fitted Values			
AHERF(Fitted)	-0.086	-0.571	-0.139
	0.863	0.452	0.028
RHERF(Fitted)	0.147	0.210	-0.014
	0.001	0.002	0.007

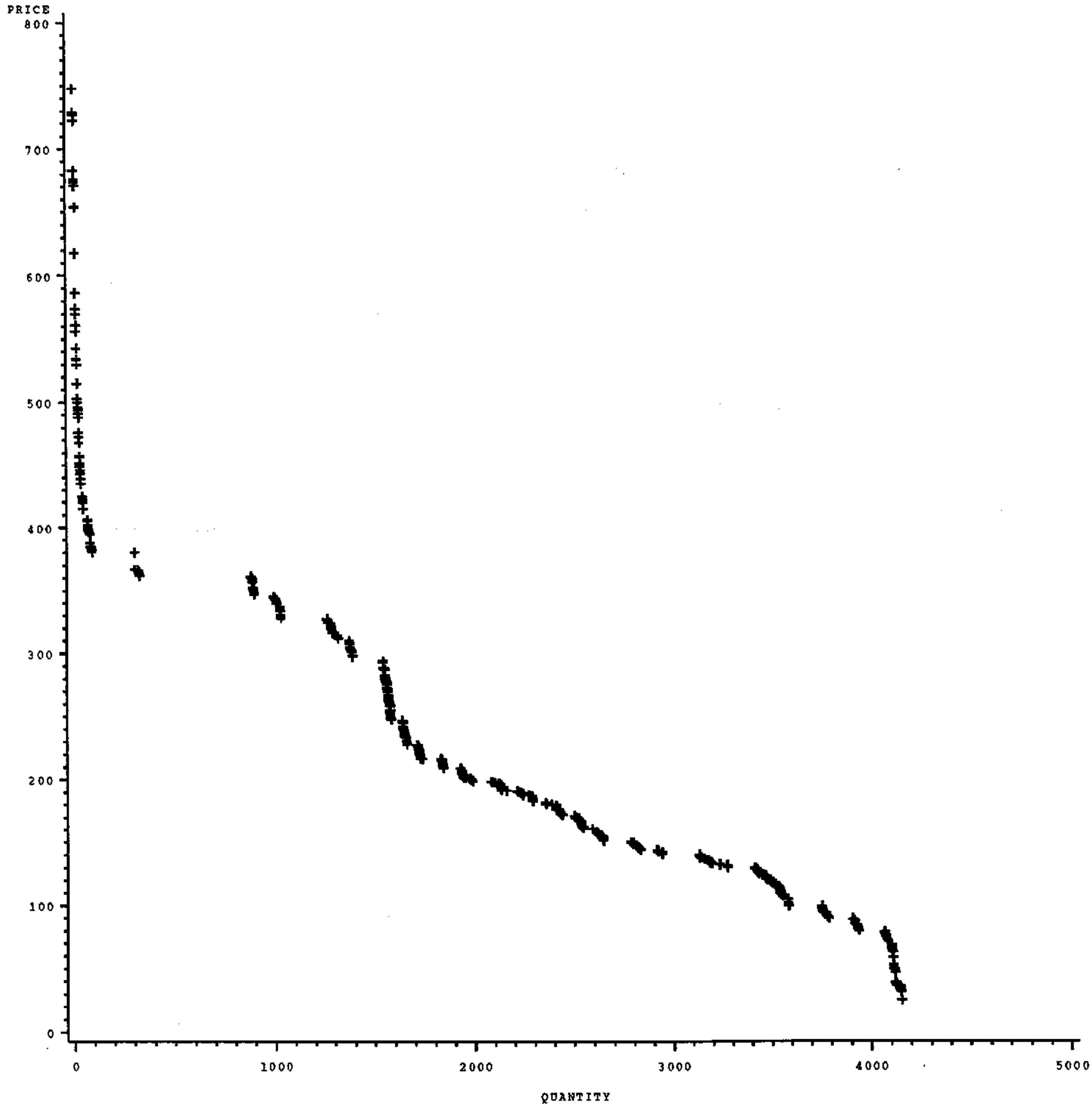

Figure 1. The Cumulative Distribution of Prices From Highest to Lowest - Dallas/Fort Worth to Atlanta, 3rd Quarter 1990.

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