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# MEASURING COMPETITION IN THE U.S. AIRLINE INDUSTRY USING THE ROSSE-PANZAR TEST AND CROSS-SECTIONAL REGRESSION ANALYSES

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We employ the Rosse-Panzar test to assess market performance in selected airport-pairs originating from Atlanta. The Rosse-Panzar test stands in the tradition of the New Empirical Industrial Organization. It is based on the comparative statics of a reduced form revenue equation. Therefore, it is less powerful than structural models, but it offers the advantage of less stringent data requirements and reduces the risk of model misspecifications. The test statistic allows us in most airport-pairs to reject both conducts consistent with the Bertrand outcome, which is equivalent to perfect competition, and the collusive outcome, which is equivalent to joint profit-maximization. Rather, the test statistic suggests that behavior is consistent with a range of intermediate outcomes between the two extremes, including, but not limited to the Cournot oligopoly. In the second part of the paper, a cross-section pricing regression complements the Rosse-Panzar test. It shows that the presence of low-cost competition in an airport-pair reduces the average fare significantly.

JEL classification codes: L00, L40, L93

Key words: airlines, oligopoly, conduct, price-cost margins, Lerner index, Rosse-Panzar test

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## I. Introduction

The U.S. airline industry has experienced revolutionary change in the last two decades moving from strict regulation to modest regulation, now allowing airlines to decide such things as their pricing strategies, frequency of schedule, and entry into and exit from markets. However, access to some key inputs, such as airport boarding sites, is still determined by non-market or regulatory conditions. Proponents of deregulation expected better performance through enhanced competition, resulting in higher productivity, lower costs, lower fares, and better service. This optimism has been largely fulfilled as the U.S. airline industry in recent years has had steady growth, falling prices, more convenient schedules, and moderate concentration, although profits have been rather volatile (see, e.g., Bailey, 2002, Gowrisankaran, 2002). It can be argued that since the late 1980s and early 1990s, the industry has settled into a new equilibrium. The vital and challenging question is whether this (less than ideal) deregulated market performed better than before, or whether there still exists market power and market conduct that are less optimal than previously.

This paper examines the economics underlying the U.S. airline industry, and its development and evolution since deregulation. More specifically, this paper studies the pricing strategy, market conduct, and market performance in the U.S. airline industry in recent years. Two empirical models are employed, each with a different focus and methodology. The level of analysis is on the micro-level, concentrating on the firm and airport-pair level. This enables a more detailed and precise approach to the study of market conduct than would be feasible with more aggregated data.

The statistical analysis is restricted to airport-pairs originating in Atlanta. Atlanta is an appropriate choice for conducting such a study for several reasons. First, Atlanta serves as a major hub for Delta Air Lines, one of the nation's largest carriers. Delta accounts for more than eighty percent of all departures and arrivals at Atlanta's Hartsfield International airport. Therefore, any effects that a dominant firm may have on the market's competitiveness are captured. Second, Atlanta is an important market for all other major U.S. carriers that compete with Delta by offering one-stop service to most cities connecting through their respective hubs. Third, Atlanta has experienced entry by a remarkably successful lowcost carrier, ValuJet Airlines, which started in 1993 and grew rapidly. At its peak, it served almost 30 markets and used more than 50 aircraft. After the loss of one of its planes in May 1996, ValuJet was grounded for approximately three months and is still struggling to rebuild its former position. ValuJet faced severe restrictions imposed by regulators on its growth opportunities. Furthermore, consumer confidence in its safety and reliability suffered immensely. In July 1997, Valujet Inc., the parent of ValuJet Airlines, announced plans to merge with Florida-based Airways Corp., parent of AirTran Airways. The merger took effect with the larger carrier, ValuJet, adopting the smaller carrier's name, AirTran, to eliminate any association with the crash. The Orlando-based AirTran Airways with its hub in Atlanta has experienced steady growth and consolidated its position as a successful provider of lowcost air travel. Early in 2000, it took delivery of the first of 50 new-generation Boeing 717 aircraft, in pursuit of its strategy of growth and modernization of its fleet. In 2002, AirTran was named Airline of the Year for the fourth consecutive year by the American Society of Travel Agents. The trade group said it honored the discount airline for creating an Internet booking engine aimed at travel agents, and for continuing to provide competition in the industry. Most big carriers, including Delta, eliminated base travel agent commissions in 2002. Of course, what long-run impact the terrorist attacks on the U.S. on September 11, 2001, will have on AirTran and indeed the entire U.S. airline industry is hard to predict at this time.

Our format provides an interesting opportunity to study market conduct in different competitive environments: markets where Delta is the only carrier, markets where Delta competes with other majors, and finally markets where Delta competes against a lowcost, start-up carrier. Anecdotal evidence suggests that after the grounding of ValuJet, airfares in certain markets rose sharply. One well-publicized example is the route linking Atlanta and Mobile, AL, where the coach fare rose from $79 to more than $400. Some communities in the Southeast provided financial incentives to ValuJet to induce the carrier to serve their airports.

New Empirical Industrial Organization (NEIO) research identifies and estimates the degree of market power, specifies and estimates the behavioral equations that drive price and quantity, and often infers marginal cost or measures market power without it. NEIO studies emphasize individual industries, because institutional details make broad cross-section studies of industries of limited value. NEIO provides techniques to execute studies on market conduct and market power of individual industries by estimating empirically parameters of conduct that identify well-defined models of oligopoly. The estimated values in conduct studies such as this one cover the range of distinct behavior from the Bertrand case on one end, through the Cournot oligopoly, to the collusive cartel outcome on the other end. Thus, the estimates thus provide a numerical equivalent to oligopoly conduct ranging from perfect competition to joint profit-maximizing monopoly.

Structural models, based on oligopoly theory, can be tailored to the idiosyncrasies of the particular market under investigation, obviating restrictive assumptions about symmetry across industries. Moreover, the degree of market power is directly estimated from the data. This permits explicit hypothesis testing of the degree of market power and industry conduct. Where structural models are not feasible because the relevant data are not available, or the validity of the specified structural model is in question, reduced-form approaches are useful to distinguish firm conduct and market power. These reduced-form approaches are generally less powerful than structural models, but they impose less demanding data requirements, and reduce the risk of employing an ill-specified model. Reduced-form approaches are often non-parametric, and rely on the comparative statics of some economically relevant function.

This paper investigates market conduct and performance by employing a non-structural model in the tradition of the NEIO. The so-called Rosse-Panzar test is based on the reduced revenue function of the firm and determines market structure by analyzing comparative statics of the total revenue function with respect to cost. The study uses firm-level data aggregated from raw balance-sheet data, employing index number theory, thereby obtaining very accurate measures of input prices. An improved approach is used to compute the price of capital. The Capital Asset Pricing Model (CAPM) is employed to obtain a reasonably accurate measure of the opportunity cost of capital. This measure is superior to conventional measures that rely on accounting rather than economic concepts of capital pricing. The paper also employs airport-pair-level data on airfares, thus allowing a degree of detail that renders the study very valuable for investigators interested in specific competitive set-ups rather than a broader and more general framework. The sample extends over the 24 quarters from January 1991 to December 1996. Finally, a cross-section regression model is employed to supplement the studies on market structure, to provide additional insight into pricing strategies, and to explore the factors that influence the price of air travel.

Section II presents an approach to testing for monopoly behavior, the Rosse-Panzar test, which allows for a first impression regarding market conduct. Section III implements the Rosse-Panzar test empirically and presents the results. Section IV presents a cross-section regression for the Atlanta market to assess the impact of a lowcost carrier on fares. Section V briefly concludes with the major findings.

## II. Theoretical Background

Rosse and Panzar (1977) and Panzar and Rosse (1987) introduce a series of tests based on properties of reduced-form revenue equations at the firm level on which the hypothesis of monopoly or oligopoly profit maximization places testable restrictions.[1] The data requirements, consisting of revenues and factor prices, are relatively modest. The following model is taken from Panzar and Rosse (1987) and follows their development of the test closely.

Let q be a vector of decision variables that affect a firm's revenue. In the most natural case q would describe a vector of output quantities. Let z denote a vector of variables that are exogenous to the firm and shift the firm's revenue function. The firm's cost function also depends on q, so that C = C (q, w, t), where w is a vector of factor prices also taken as given by the firm and t is a vector of exogenous variables that shift the firm's cost curve.[2] It follows that the firm's profit function is given by

$$\pi = R - C = \pi(q, \quad z, \quad w, \quad t) \tag{1}$$

Let $q^0$ be the argument that maximizes this profit function. Also, let $q^1$ be

[1] For an extension of the Rosse and Panzar test when variables besides the firms' revenues are observable, see Sullivan (1985) and Ashenfelter and Sullivan (1987).

[2] While this cost function ignores efficiencies generated by hubs, these cost complementaries do not make the Rosse-Panzar result inapplicable.

the output quantity that maximizes $\pi$ (q, z, (1 + h) w, t) where the scalar h is greater or equal to zero. Define $R^o$ as R ($q^o$, z) $\equiv$ $R^*$ (z, w, t) and $R^1$ = R ($q^1$, z) $\equiv$ $R^*$ (z, (1 + h) w, t), where $R^*$ is the firm's reduced form revenue function. It follows by definition that

$$R^1 - C(q^1, (1+h)\ w,\ t)\ \geq R^0 - C(q^0, (1+h)\ w,\ t) \tag{2}$$

Using the fact that the cost function is linearly homogeneous in w, this can be written as

$$R^1 -\ (1+h)\ C(q^1, w,\ t)\ \geq R^0 -\ (1+h)\ C(q^0, w, t) \tag{3}$$

and that

$$(R^1 - R^0)/h\ =\ [R^*(z,\ (1+h)\ w,\ t)\ -\ R^*(z,\ w,\ t)/h]\ \leq\ 0 \tag{4}$$

This is the non-parametric result that indicates that a proportional cost increase will result in a decrease of the firm's revenues. Assuming that the reduced-form revenue equation is differentiable, taking the limit of (4) for h $\rightarrow$ 0 and dividing by $R^*$ yields

$$\Psi^* \equiv\ \Sigma\ w_i\ \ (\delta R^* / \delta w_i) / R^* \leq\ 0 \tag{5}$$

where the $w_i$ are the components of the vector w, so that $w_i$ denotes the price of the ith input factor.

This describes a restriction imposed on a profit-maximizing monopoly. The sum of the factor price elasticities of the reduced-form revenue equation cannot be positive. Intuitively, the question that the test statistic $\psi^*$ tries to answer is what is the percentage change in the firm's equilibrium revenue resulting from a one-percent increase in all factor prices. An increase in factor prices shifts all cost curves, including the marginal cost curve, up. Consequently, the price charged by the monopolist goes up and the quantity decreases. Since the monopolist operates on the elastic portion of the demand curve, total revenue decreases. Hence, $\psi^*$ is non-positive. The generality of the result causes one drawback for the test. Even for "monopolies" facing a perfectly elastic demand curve, the value for $\psi^*$ is less than zero. All firms which operate in isolation, that is, all firms whose structural revenue functions do not depend on any other agent's decisions, will show a test statistic that is non-positive. Therefore, a rejection of the hypothesis that $\psi^*$ is less than zero must indicate that the firm is affected by other agents' actions.

The next question, then, is whether there exist any models consistent with an estimate for $\psi$ greater than zero. Fortunately, this is the case. Rosse and Panzar cite three models of equilibrium consistent with a positive value for $\psi$. In all three models, the revenue function facing the firm depends on the action of potential or actual rivals. In other words, the firm no longer acts in isolation. The results for the models depend crucially on the assumption that the observed firms be in long-run equilibrium. We will restrict our attention to two additional models that are interesting with respect to airlines. First, the benchmark case of the long-run competitive equilibrium is examined, and subsequently the conjectural variation oligopoly is explored. Unless some kind of interaction between firms is introduced into the model dealing with perfect competition, price-taking behavior will lead to a $\psi^*$ less than zero. The output price that a firm faces, therefore, is endogenized by allowing for competitive entry and exit. This model has been discussed most prominently by Silberberg (1974). The reasoning is as follows. Changes in factor prices will, at least in the longrun, lead to exit or entry and consequently to changes in output prices. These changes in turn will affect input demand and output supply decisions of the firm.

For firms observed in long-run equilibrium, the sum of the elasticities of reduced form revenues with respect to factor prices equals unity (Rosse and Panzar, 1987). The intuition behind this result is that a one-percent increase in all factor prices will result in an equal-proportional that is one-percent, increase in total revenue. Because average cost is homogeneous of degree one in w, a one-percent increase in all factor prices will shift the average cost curve up by one percent for all output levels. Consequently, the minimum point is unchanged. Since in long-run competitive equilibrium the firm operates at minimum average cost, the competitive output $q^c$ remains unchanged. However, in equilibrium, the competitive price $p^c$ must be equal to minimum average cost, which has increased by one percent. Therefore, $p^c$ must have increased by one per cent also, driving up total revenues by the same percentage. Therefore the condition that $\psi^c$ be equal to one is established.

Contrast this with the result if firms are not in long-run equilibrium. More specifically, assume we observe a firm after the one-percent increase in all factor prices, but before any firms have exited from the market. The firm will respond by reducing output while the price remains initially unchanged, thus resulting in a decrease in total revenues. Hence, in the shortrun, $\psi$ is less or equal to zero. Only after some firms exit does the price go up to the new long-run equilibrium level and is output restored to its original level. This should underline the importance of the long-run equilibrium assumption.

The final point to be made is that a conjectural variations oligopoly model that exhibits strategic interactions among a fixed number of rivals may also be consistent with positive values of $\psi$. Only if the oligopoly behaves close to a joint monopoly, that is, if firms collude, is the marginal industry revenue positive.

In summary, we have provided a non-structural test for the existence of monopoly power, and we have derived three important results.[3] First, the sum of elasticities of revenue with respect to each input price is negative in monopoly or collusive (joint monopoly) equilibrium. It is also negative in short-run competitive equilibrium. Moreover, it is equal to unity in long-run competitive equilibrium and indeterminate in a general conjectural variation oligopoly equilibrium. These implications can be tested empirically. For instance, a finding of a test statistic $\Psi$ that is positive, would rule out monopoly or a collusive cartel equilibrium.

A profit-maximizing monopolist operating on the elastic portion ($\eta < -1$) will exhibit a negative value for $\Psi$. It also demonstrates that a negative sign cannot rule out competition since a competitive firm tends to face an even more elastic demand curve. Using the result obtained previously, Shaffer (1982a), Shaffer (1983a) derives the Lerner index ($L_j$) in terms of the Rosse-Panzar test statistic where $s_j$ is firm j's market share.

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[3] While the focus of empirical IO has shifted away from identifying conjectures parameters in simply quantity-setting models to identifying demand and costs in differentiated price-setting models, we think the conjectures equilibrium framework with quantity competition and the cross-sectional regressions are still a useful methodology. To see the newer focus, see, e.g., Berry's 1992 paper on airline competition where he estimates a model of customer heterogeneity (business vs. leisure) which is important in this industry because of price discrimination.

We obtain the Lerner index for an individual firm and for the industry as a whole, respectively.

$$L_j = 1/(1 - \Psi_j) \tag{6}$$

and

$$L = (H + \Sigma\ s_j^2\ \lambda_j)\ /\ \left[ s_j (1 + \lambda_j)\ (1 - \Psi_j \right] \tag{7}$$

Equations (6) and (7) express the firm and industry Lerner indices, respectively, as a function of market share, the conjectural variation parameter λ and the Rosse-Panzar test statistic *H*. The firm's Lerner index depends only on the test statistic, which is independent of market share or the conduct parameter. The result is valid only as long as the short-run equilibrium is considered, that is, changes in total revenue due to changes in factor prices before entry and exit occur. In a further paper, Shaffer (1983b) extends his result found in 1982 to a more general connection between the Rosse-Panzar statistic and the price elasticity of demand.

The reduced-form revenue equation has been used as a test of market power among others by Shaffer (1982b), Nathan and Neave (1989), and Shaffer and DiSalvo (1994). In all cases, the test has been applied to the banking industry. Furthermore, Shaffer and DiSalvo apply both tests, i.e. the conjectural variations oligopoly and the Rosse-Panzar test, to a duopoly banking market in Pennsylvania. This is a procedure we follow.

## III. Empirical Strategy

### A. Implementation of the Rosse-Panzar Test

To apply the Rosse-Panzar test, we need to derive a reduced-form revenue equation. However, we must also consider the underlying structural model in developing the reduced form. Following Shaffer and DiSalvo, we propose the estimation of the following equation, taking into account that output quantity is endogenous. The demand equation is given by (8), and a total revenue equation is added in loglinear form. Alternatively, the translog specification could be used. The loglinear revenue equation is given as

$$\ln TR = b_0 + b_1 \ln q_j + \Sigma c_i \ln w_{ij} \tag{8}$$

where i = 1,..., 4 denotes inputs and the subscript j denotes airlines. *TR* denotes total revenue, *q* denotes output and *w* denotes factor prices. The parameters to be estimated are $b_0$, $b_1$ and $c_1$ through $c_i$.

The equations are estimated separately for each carrier using a generalized methods of moments approach. We employ price and quantity data for outbound traffic, year dummies and their interaction term as instruments for inbound traffic, and inbound data as instruments for outbound data. The instruments make for a very good fit, since they are highly correlated with the right-hand variables and almost uncorrelated with the error term. It is clear from equation (8) that the sum of the estimates for $c_i$ yields the required test statistic $\Psi$.

**Table 1. Estimates of the Rosse-Panzar Test Statistic for Outbound Traffic, Ranked from Lowest to Highest**

| | City - Pair | RP-Statistic (outbound) | Standard errors* |
|---|---|---|---|
| 1 | Washington Dulles Intl. - United (IAD-UA) | -20.2920 | 2.56568 |
| 2 | Miami Intl. - American (MIA-AA) | -6.03789 | 2.45715 |
| 3 | Philadelphia Intl. - Delta (PHL-DL) | -5.70006 | 2.49875 |
| 4 | Memphis Intl. - Delta (MEM-DL) | -5.51766 | 1.44122 |
| 5 | Chicago O'Hare Intl. - American (ORD-AA) | -4.79100 | 2.20212 |
| 6 | Miami Intl. - Delta (MIA-DL) | -4.50376 | 1.82038 |
| 7 | Chicago O'Hare Intl. - Delta (ORD-DL) | -3.98305 | 1.18051 |
| 8 | George Bush Intl. Continental/Houston - Delta (IAH-DL) | -1.89520 | 1.22414 |
| 9 | Detroit Metropolitan Wayne County Intl. - Delta (DTW-DL) | 0.071092 | 1.82740 |
| 10 | Newark Intl. - Delta ( EWR-DL) | 1.87128 | 2.22949 |
| 11 | Boston Intl. - Delta (BOS-DL) | 2.7669 | 2.65899 |
| 12 | Lambert St Louis Intl. - Delta (STL-DL) | 3.80627 | 1.66572 |
| 13 | Pittsburgh Intl. - US Air (PIT-US) | 3.89118 | 2.51419 |

**Table 1. (Continued) Estimates of the Rosse-Panzar Test Statistic for Outbound Traffic, Ranked from Lowest to Highest**

| City - Pair | RP-Statistic (outbound) | Standard errors* |
|---|---|---|
| 14 Minneapolis St Paul Intl/Wold-Chamb. - Delta (MSP-DL) | 4.07826 | 1.18344 |
| 15 Washington Dulles Intl. - Delta (IAD-DL) | 4.59163 | 2.10702 |
| 16 Pittsburgh Intl. - Delta (PIT-DL) | 4.67703 | 1.22940 |
| 17 Memphis Intl. - Northwest (MEM-NW) | 4.81010 | 1.28097 |
| 18 La Guardia - Delta (LGA-DL) | 7.55154 | 1.70849 |
| 19 Ronald Reagan Washington Natl. - Delta (DCA-DL) | 7.69299 | 1.07561 |
| 20 Philadelphia Intl. - US Air (PHL-US) | 9.73294 | 2.72694 |
| 21 Detroit Metrop.Wayne County Intl-Northwest (DTW-NW) | 10.6878 | 1.55307 |
| 22 Newark Int. - Continental (EWR-CO) | 10.7625 | 4.21756 |
| 23 Charlotte Intl. - Delta (CLT-DL) | 12.2199 | 2.64956 |
| 24 G. Bush Intl. Continental/Houston - Continental (IAH-CO) | 13.0914 | 2.09673 |
| 25 Dallas Ft. Worth - American (DFW-AA) | 13.3728 | 1.73529 |
| 26 Minneapolis St Paul/Wold-Chamb.- Northwest (MSP-NW) | 13.6637 | 2.73482 |
| 27 Charlotte Intl. - US Air (CLT-US) | 15.1083 | 3.85622 |
| 28 Chicago O'Hare Intl. - United (ORD-UA) | 16.8336 | 4.38717 |
| 29 Dallas Ft. Worth - Delta (DFW-DL) | 17.1838 | 2.86400 |

Note: *All coefficients have a significantly positive test statistic, which is also significantly different from one.

**Table 2. Estimates of the Rosse-Panzar Test Statistic for Inbound Traffic, Ranked from Lowest to Highest**

| | City - Pair | RP-Statistic (inbound) | Standard errors* |
|---|---|---|---|
| 1 | Washington Dulles Intl. - United (IAD-UA) | -23.999 | 4.62528 |
| 2 | Philadelphia Intl. - Delta (PHL-DL) | -7.12364 | 2.68764 |
| 3 | Miami Intl. - American (MIA-AA) | -4.73940 | 2.63880 |
| 4 | Memphis Intl. - Delta (MEM-DL) | -4.15026 | 1.91954 |
| 5 | Chicago O'Hare Intl. - Delta (ORD-DL) | -4.14051 | 1.04254 |
| 6 | George Bush Intl. Continental/Houston - Delta (IAH-DL) | -3.94652 | 1.27333 |
| 7 | Chicago O'Hare Intl. - American (ORD-AA) | -3.73036 | 1.67664 |
| 8 | Miami Intl. - Delta (MIA-DL) | -3.48789 | 2.16008 |
| 9 | Detroit Metropolitan Wayne County Intl. - Delta (DTW-DL) | -0.465805 | 1.75467 |
| 10 | Pittsburgh Intl - US Air (PIT-US) | -0.262022 | 2.47935 |
| 11 | Charlotte Intl.- Delta (CLT-DL) | 0.000039 | 0.000013 |
| 12 | Charlotte Intl. - US Air (CLT-US) | 0.00032 | 0.000013 |
| 13 | Pittsburgh Intl. - Delta (PIT-DL) | 1.47711 | 1.68889 |
| 14 | Newark Intl. - Delta ( EWR-DL) | 2.21861 | 2.16485 |
| 15 | Boston Intl. - Delta (BOS-DL) | 2.51153 | 2.15238 |
| 16 | Lambert St Louis Intl. - Delta (STL-DL) | 3.78565 | 1.67995 |
| 17 | Minneapolis St Paul Intl/Wold-Chamb. - Delta (MSP-DL) | 3.80256 | 1.27049 |
| 18 | Memphis Intl. - Northwest (MEM-NW) | 4.81165 | 1.48858 |
| 19 | Washington Dulles Intl. - Delta (IAD-DL) | 5.80216 | 2.18200 |
| 20 | La Guardia - Delta (LGA-DL) | 6.25637 | 1.30126 |
| 21 | Ronald Reagan Washington Natl. - Delta (DCA-DL) | 6.64213 | 1.10359 |
| 22 | Detroit Metrop. Wayne County Intl-Northwest (DTW-NW) | 8.63238 | 1.34562 |
| 23 | Philadelphia Intl. - US Air (PHL-US) | 9.13158 | 2.85095 |

**Table 2. (Continued) Estimates of the Rosse-Panzar Test Statistic for Inbound Traffic, Ranked from Lowest to Highest**

| City - Pair | RP-Statistic (inbound) | Standard errors* |
|---|---|---|
| 24 Minneapolis St Paul/Wold-Chamb.- Northwest (MSP-NW) | 9.17014 | 1.70015 |
| 25 Newark Int. - Continental (EWR-CO) | 10.2999 | 3.93423 |
| 26 Dallas Ft. Worth - American (DFW-AA) | 13.2785 | 1.85012 |
| 27 G. Bush Intl. Continental/Houston - Continental (IAH-CO) | 14.8425 | 2.17619 |
| 28 Chicago O'Hare Intl. - United (ORD-UA) | 16.6315 | 4.24272 |
| 29 Dallas Ft. Worth - Delta (DFW-DL) | 18.6381 | 3.86058 |

Note: *All coefficients have a significantly positive test statistic, which is also significantly different from one.

Tables 1 and 2 present the Rosse-Panzar test statistic and its standard error for the 29 airport-pairs by outbound traffic and inbound traffic, respectively. In our empirical testing for Rosse-Panzar and for cross-sectional regressions in the next section, we employ quarterly price indices constructed from raw data provided by the DOT's Form 41 as Air Carrier Financial Statistics, and Air Carrier Traffic Statistics. The price indices for labor, fuel, and materials are constructed using index number theory. The price of capital in contrast is constructed by employing the Capital Asset Pricing Model (CAPM). The CAPM computes the correct risk-adjusted return for a risky asset within the framework of mean-variance portfolio theory. Since it provides an economic measure of the price of capital and reflects the true risk-adjusted opportunity cost, it is vastly superior to conventional accounting measures for the price of capital.[4] Price data were derived from Database 1A of the DOT's origin and destination survey (O&D). The sample period

[4] For a more detailed discussion of how the price of capital is calculated, see Fischer and Kamerschen (2002).

covers the 24 quarters between the first quarter of 1991 and the fourth quarter of 1996.

Church and Ware (1999) point out that the Rosse-Panzar test shows what the market structure or degree of monopoly is not and does not suggest what is. Following this approach, we can rule out monopoly and perfect competition for all airport-pairs that have a significantly positive test statistic, which is also significantly different from 1. This is clearly the case for the majority of the airport-pairs. Thus, the finding for these airport-pairs is consistent with the structural model, which indicates conduct somewhere in between the collusive solution, i.e. monopoly, and perfect competition. A closer look at the airport-pairs with significantly negative estimates for the test statistic is warranted. Recall that a negative test statistic can imply both competition or monopoly. The airport-pairs that require closer scrutiny are Delta in the Detroit market (inbound only), Memphis, Miami, Chicago O'Hare, and Philadelphia; United in the Washington-Dulles market, US Air in Pittsburgh (inbound only) and American for Miami and Chicago O' Hare. Any further investigation into market structure with the Rosse-Panzar test statistic remains inconclusive. Finally, the magnitude of the estimates seems too large if one wants to follow Shaffer's suggestion regarding the estimation of the Lerner index. The estimates obtained seem to preclude this estimation. However, the estimates are very robust to changes in the specification of the model. Any potential explanation of the magnitude of the estimates will have to explore in greater detail two assumptions that could lead to implausibly high values for the test statistic. The first is the assumption that the air carrier is a price taker on the input side. There is some evidence that this is not the case, particularly for the input labor. Heavy unionization and widespread collective bargaining suggest that airlines face a less than competitive market for their labor inputs. The second is the assumption that the industry is in long-run equilibrium. Recall that such an assumption is crucial for the Rosse-Panzar test to work. Shaffer (1982a, b) explicitly points to the almost contradictory nature of the assumptions that all observations are identified, and controlled for as being in long-run equilibrium. In particular, when working with a time-series sample like the airport-pair markets, any change in factor prices involves some adjustment, which is unlikely to be completed exactly by the end of the observed period. However, it is precisely this variation in prices that is needed to identify the test statistic.

**B. A Cross-Section Regression**

This section presents a different approach to the investigation of pricing strategies employed by airlines. The section develops a cross-section regression model employing price data and route characteristics for a cross-section sample of airline routes originating in Atlanta. The objective is to assess how particular route characteristics affect the price on a given route. In developing the model, we closely follow Peteraf and Reed (1994) and Borenstein (1989), adjusting the model according to the requirements of the investigation and availability of data. Observations are for the four quarters of 1996. Each observation consists of one carrier serving one airport-pair. Both nonstop and one-stop service are included. The equation to be estimated is specified as follows

$$\begin{aligned}\ln \mathit{YIELD} = \; & a_0 + b_1 \ln \mathit{PASSENGER} + b_2 \ln \mathit{DISTANCE} \\ & + b_3 \ln \mathit{AVERANGE\ COST} + b_4 \ln \mathit{INCOME} \\ & + b_5\, \mathit{MARKETSHARE} + b_6\, \mathit{HHI} + b_7\, \mathit{VALUJET} \\ & + b_8\, \mathit{VACATION}\end{aligned} \tag{9}$$

where YIELD is defined as price divided by distance. That is, YIELD measures the average fare charged by the observed carrier on the given route, divided by stage length so as to obtain the price per mile and normalize across different stage lengths. PASSENGERS is equal to the number of passengers transported on the route during a quarter. It measures the total number of all local origin-to-destination passenger. DISTANCE measures the stage length between the departure and arrival cities. AVERAGECOST is a proxy for the cost-competitiveness of the airline offering the service and is measured in average cost per seat mile. Adjustments are made to account for different average stage lengths across carriers. INCOME is a measure of disposable personal income for the metropolitan statistical area of the destination. It is included to capture aggregate income at the destination. MARKETSHARE captures the market share that the airline commands on a given route. It measures the share of all local origin-to-destination passengers for the observed carrier on a given route. Thus, it is constructed by dividing PASSENGERS by the total number of local origin-to-destination passengers. HHI is the Herfindahl-Hirschman index for the route under consideration; it ranges from 0 to 1. Finally VALUJET is an indicator variable taking the value of one if a particular airport-pair is served by ValuJet airlines and zero otherwise. It is designed to measure whether the presence of a discount carrier has a depressing effect on prices. Finally, VACATION is a dummy variable indicating whether a destination is primarily a vacation spot. Price data are obtained from the DOT's origin and destination (O&D) survey for the four quarters of 1996, along with information on passengers. The O&D survey also indicates whether ValuJet is serving a particular airport-pair market. Using the quantity data, the measures for market share and concentration are constructed. Distance is taken from Delta Air Line's worldwide timetable, effective June 1, 1997. Data on population and income for the Metropolitan Statistical Areas have been compiled by the Bureau of Labor statistics.

The expected sign for PASSENGERS is negative since with a larger number of passengers the load factor increases, and therefore unit costs per passenger should decrease. DISTANCE is one of the most important determinants of airline cost. As distance increases, cost per mile decreases as discussed previously. Since aircraft burn most fuel during take-off and landing, and fixed cost can be spread over more miles, we expect unit cost per mile to decrease as stage length increases. Therefore, the overall effect of DISTANCE on YIELD is hypothesized to be negative. AVERAGECOST serves as a proxy for a carrier's cost efficiency. AVERAGECOST is calculated for the entire domestic system, but adjusted with respect to distance. For example a carrier with relatively high system-wide average cost, but a short average stage length may still be more cost efficient than a carrier with slightly lower average cost, but longer average stage length. The adjustment renders the AVERAGECOST proxies comparable for any given route. The expected sign for AVERAGECOST is positive, since less efficient firms are hypothesized to demand higher fares. Since air travel is a normal good, an increase in disposable income should increase the price of air travel. Hence, the sign for INCOME is expected to be positive. Controlling for concentration, a firm with a higher market share is expected to realize a higher yield. Therefore, the expected sign for MARKETSHARE is positive. The sign for HHI is theoretically ambiguous. A dominant firm could find it more convenient and easier to maintain high prices if it competes against a fringe of small firms rather than a fairly large and well-established rival. In the first scenario the HHI would be smaller than in the second. The predicted sign would be negative. However, holding market share constant, a higher HHI may make it more feasible for firms to collude, hence raising prices. On the other hand if dominance stems from technological advantages of the dominant firm such as cost efficiency or effective marketing, rather than anti-competitive conduct, yields for other firms should decrease. In the former case the sign is positive, whereas the latter scenario suggests a negative sign. Overall, the sign depends on the sources of concentration. The presence of a lowcost competitor such as ValuJet in any given market should provide for increased and more vigorous competition, and therefore should bring yields down. Therefore, the expected sign for VALUJET is negative. Finally, leisure travelers are more price sensitive; their demand for air travel is consequently more elastic. A market to a destination that comprises a large share of leisure travelers therefore should, ceteris paribus, afford lower yields. The portion of leisure travelers is assumed to be higher on routes to vacation spots. Therefore, the hypothesized sign for VACATION is negative.

Before we carried out the regression, some econometric issues were addressed. First there is a potential problem regarding the possible endogeneity of PASSENGERS, MARKETSHARE, and HHI. Indeed, a Haussmann specification test rejects exogeneity for PASSENGERS and MARKETSHARE. Therefore, we proceed with estimation using instruments and 2-stage least squares. As the preferred set of instrument, we include all the exogenous variables and their interactions with the dummies, as well as the carrier's share of all origin and destination passengers in Atlanta. We also include the overall population of the destination's metropolitan area, its square, and distance squared.

Table 3 presents the coefficient estimates, along with their standard errors. All coefficients have the expected sign where there existed unambiguous predictions regarding the sign. Moreover, all coefficient estimates are highly significant at better than the one-percent level. The coefficient estimates imply that a 10 percent increase in local origin-and destination passengers decreases fares by 1 percent. An increase in distance by 10 percent decreases fares by 7

**Table 3. Cross-Section Regression Parameter Estimates for the Dependent Variable Yield**

| Variable | Coefficient | Standard error* |
|---|---|---|
| CONSTANT | 3.63783 | 0.111927 |
| PASSENGERS | -0.099404 | 0.00711 |
| DISTANCE | -0.702309 | 0.015092 |
| MARKETSHARE | 1.00035 | 0.058172 |
| HERFINDAHL-HIRSCHMAN INDEX (HHI) | -0.347235 | 0.042411 |
| AVERAGE COST | 0.332542 | 0.055287 |
| INCOME | 0.15879 | 0.034166 |
| VACATION | -0.121219 | 0.017988 |
| VALUJET | -0.160558 | 0.015952 |
| $R^2$ | 0.774 | |

Note: * Examining the p-values corresponding to the appropriate t-value shows that all coefficients are significant at the 1% or better level.

percent on average. Furthermore, a one-point increase in the observed carrier's market share increases fares by 1 percent. Moreover, the estimates suggest that a 10 percent increase in average cost translates into a 3.3 percent increase in fare. The income elasticity of demand is approximately 16 percent. An increase in concentration as measured by the HHI index reduces the yield. Therefore, the model suggests that the dominant carrier Delta enjoys technological advantages over its rivals or that there is some degree of competition provided by another carrier. Most important for advocates of vigorous competition is the coefficient for VALUJET, indicating that fares in airport-pair markets served by ValuJet were on average 16 percent lower than on routes where such competition was absent. This is a ringing endorsement for low-cost carriers. It strongly suggests that in the interest of the traveling public, competition in the airline industry should be encouraged, promoted, and facilitated wherever possible.

## IV. Conclusions

We employ a reduced form model called the Rosse-Panzar test to calculate price-cost margins in selected airport-pair markets originating from Atlanta. The statistics are generally positive and quite large, indicating that carriers are neither in perfect competition nor perfectly colluding. Unlike structural models, the Rosse-Panzar test is only sufficiently powerful to reject certain outcomes of market conduct. We find that in all airport-pairs, the existence of the Bertrand outcome, which is equivalent to perfect competition, is resoundingly and consistently rejected, as is the outcome describing perfect collusion, which is equivalent to the joint monopoly outcome.

In contrast, the Cournot solution cannot be rejected. In most markets, conduct is consistent with the Cournot solution. However, the Rosse-Panzar test is not powerful enough to identify a specific model of conduct. Our findings show that conduct in most airport-pairs is also consistent with a range of conduct deviating from the Cournot oligopoly both to the more and less competitive behavior. That is, conduct is consistent with a wide range of intermediate solutions between the monopoly outcome and perfect competition. A cross-section pricing regression model to study pricing behavior supplements the Rosse-Panzar approach. We find that all variables affect the dependent variable as hypothesized and that all parameter estimates are highly significant. We find that yield or price per mile traveled is positively correlated with the airline's average costs, its market share in a given airport-pair market and the income in the metropolitan area where the airport is located. Yield is negatively correlated with enplaned passengers, since, as the load factor rises, the cost per passenger is declining. It is negatively correlated with the Herfindah-Hirschmann-Index for a given market and with the distance between airports. It is also significantly lower in markets that are considered primarily destinations for vacationers. Most importantly, we find that the presence of lowcost competition has a significant and substantial impact on average yields. For 1996, the period under investigation, other things being the same, average fares were about 16 percent lower in markets where ValuJet was present than in those in which it did not operate. In summary, we find sufficient evidence that the industry, at least as it relates to airport-pair markets originating from Atlanta, has some way to go to reach the benchmark of perfect competition.

## References

*Air Carrier Financial Statistics*, reported on Form 41, provided by Database Products, Dallas, TX., 1991:1-1996:4.

Ashenfelter, O., and D. Sullivan (1987), "Nonparametric Tests of Market Structure: An Application to the Cigarette Industry," *Journal of Industrial Economics* **35**: 483-498.

Bailey, E.E. (2002), "Aviation Policy: Past and Present," *Southern Economic Journal* **69**: 12-20.

Berry, S. (1992), "Estimation of a Model of Entry in the Airline Industry," *Econometrica* **60**: 889-917.

Borenstein, S. (1989), "Hub Dominance and High Fares: Airport Dominance and Market Power in the U.S. Airline Industry," *Rand Journal of Economics* **20**: 344-365.

Church, J., and R. Ware (1999), *Industrial Organization: A Strategic Approach*, Boston, Massachusetts, Irwin McGraw-Hill.

Fischer, T., and D.R. Kamerschen (2002), "Price-Cost Margins in the Airline Industry Using a Conjectural Variation Approach," *Journal of Transport Economics and Policy,* forthcoming.

Gowrisankaran, G. (2002), "Competition and Regulation in the Airline Industry," *Federal Reserve Bank of San Francisco Economic Letter 2002-01*: 1-3.

Nathan, A., and E.H. Neave (1989), "Competition and Contestability in Canada's Financial System: Empirical Results," *Canadian Journal of Economics* **22** (3): 576-594.

Panzar, J.C., and J.N. Rosse J.N. (1987), "Testing for 'Monopoly' Equilibrium," *Journal of Industrial Economics* **35**: 443-457.

Peteraf, M., and R. Reed (1994), "Pricing and Performance in Monopoly Airline Markets," *Journal of Law and Economics* **37**: 193-213.

Rosse, J.N., and J.C. Panzar (1977), "Chamberlin vs. Robinson: An Empirical Test for Monopoly Rents," *Bell Laboratory Economics Discussion Paper 90*, and *Stanford University Studies in Industry Economics* 77.

Seade, J.E. (1980), "On the Effects of Entry," *Econometrica* **48**: 479-489.

Shaffer, S. (1982a), "Competition, Conduct and Demand Elasticity," *Economics Letters* **10**:167-171.

Shaffer, S. (1982b), "A Nonstructural Test for Competition in Financial Markets," Proceedings of a Conference on Bank Structure and Competition, Federal Reserve Bank of Chicago, April 12-14: 225-243.

Shaffer, S. (1983a), "The Rosse-Panzar Statistic and the Lerner Index in the Short Run," *Economic Letters* **11**: 175-178.

Shaffer, S. (1983b), "Non-Structural Measures of Competition Toward a Synthesis of Alternatives," *Economics Letters* **12**: 349-353.

Shaffer, S., and J. Di Salvo (1994), "Conduct in a Banking Duopoly," *Journal of Banking & Finance* **18**: 1063-1082.

Sharpe, W. F. (1964), "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk," *Journal of Finance* **19**: 425-442.

Silberberg, E. (1974), "The Theory of the Firm in 'Long-Run' Equilibrium," *American Economic Review* **84**: 734-741.

Sullivan, D. (1985), "Testing Hypotheses About Firm Behavior in the Cigarette Industry," *Journal of Political Economy* **93**: 586-598.

United States Department of Transportation (DOT), "Origin and Destination Survey," Database 1A. Hub-Study ATL, provided by Database Products, Inc., Dallas, TX., 1991:1-1996:4.