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DETERMINANTS OF AIRLINE CARRIER CONDUCT

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I. INTRODUCTION

Since Joe Bain's seminal work[1] in 1959, industrial organization research has focused on structure, conduct, and performance. Bain thought that, aside from feedbacks of second order, structural variables determined industry conduct and that, in turn, structure and conduct determined industry performance. Subsequent scholars seized upon the structure–conduct relationship to suggest that structural theories could be used in antitrust analysis.[2] If structural variables (such as concentration) influence the likelihood of collusive conduct, an understanding of structural characteristics could then be used to (1) focus investigative resources on markets in which collusion is likely, (2) detect actual instances of collusion, and (3) reduce the likelihood of collusion by changing the structure itself.[3]

Empirical tests of the ways in which structural variables influence collusion, however, have only been indirect. Dozens of econometric articles have examined the structure–performance relationship[4] by regressing structural variables (such as concentration) on performance variables (such as profits). But these "structure on profits" regressions have only indirectly tested the relationship between structure and collusion—by assuming, often implicitly, that abnormal profits stem from collusion. Demsetz[5] noted that often such indirect tests of conduct are unidentified, because firm-specific efficiency as well as collusion could induce a positive correlation between profits and concentration.

This article represents a first attempt to overcome the problems inherent in inferring conduct from performance by regressing estimates of conduct itself on the structural variables that theory suggests induce collusive behavior. Directly examining the relationship between conduct and structure can test not only traditional structural theories—such as Stigler's hypothesis[6] that the number of sellers influences the degree of collusive behavior and Posner's hypothesis[7] that collusion is likely to take place in markets in which the gains from collusion are the greatest—but also newer structural theories that have been explicitly advanced in the airline context, such as the hypothesis that airline routes are "contestable markets" that will be competitive regardless of concentration.[8]

The tests in this article have important policy implications in detecting and deterring collusion. The analysis not only indicates where collusion has taken or will take place, but it also quantifies *the extent* to which structure influences behavior. While many theories predict that more competitors will induce more

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competition, theory has little to say about the size of the competitive gain. Thus, empirical analysis not only can confirm existing theories, but also can provide policymakers with information about the possible benefits of changing structure.

Calculating quantitative estimates of behavior is the crucial starting point. Following Iwata,[9] marginal cost and elasticity estimates were combined with price and market share data to estimate conjectural variations in the airline industry both before and after deregulation. As derived below, the conjectural variation measures how competitively a firm reacts to changes in the output of its rivals: Firms that reduce their output in response to output reductions of their rivals are acting collusively; firms that increase their output to offset output reductions of their rivals are acting competitively.

The conjectural variation approach to modeling airline carrier conduct has both important strengths and weaknesses as an analytic tool. As elaborated below, collapsing an airline's behavior into a scalar strategy variable places restrictive assumptions on the model. Studying the airline industry, however, allowed the estimation of over two thousand conjectural variations (by carrier and route) using similar marginal cost data. The conjectural variation of a firm is an especially appealing measure of market conduct because it not only represents the firm's expectations of other firms' conduct, but also, by feeding back into its own reaction function, determines the firm's own conduct (its non-cooperative strategy).

Section II of the paper describes the calculation of the conjectural variations and tests whether carriers displayed competitive, collusive, or Cournot behavior. Section III forms the central part of the paper: There I describe the structure/conduct regressions and test whether specific structural variables influence conduct. In section IV slopes of the firms' reaction curves are estimated. Tests for the equality of the conjectured and actual reaction curve slopes are made. Such tests are shown to test not only for the presence of Bresnahan consistency[10] but also for a generalized form of Stackelberg leadership.

II. CONJECTURAL VARIATION ESTIMATES

To maximize profits, a firm must make a conjecture about how its behavior will affect its rivals. In producing up to the point at which marginal revenue equals marginal cost, each firm will therefore account for its rivals' reactions because marginal revenue will be affected by the rivals' response. In a market with n firms producing a homogeneous product, the marginal revenue of the ith firm equals:

$$MR_i = P - P(S_i/e)(1 + k_i), \qquad (1)^{11}$$

where P = price, q_i = firm i's output, q_{-i} = output of firm i's rivals, e = market price elasticity, and S_i = firm i's market share; k_i (= $E_i[dq_{-i}/dq_i]$) is firm i's conjectural variation—its expectation (E_i) of how its rivals will react to changes in its output. Each rival's actual response is defined by its reaction function $[q_j(q_i)]$. A firm's conjectural variation is its (local) estimate of its rivals' aggregate reaction function. By setting marginal revenue equal to marginal cost, MC_i, Iwata[12] derived a measure of conjectural variation in terms of the Lerner index ($[P - MC_i]/P$), market share and elasticity of demand:

$$k_i = ((eL_i)/S_i) - 1 \qquad (2)^{13}$$

The conjectural variation measure is a firm's expectation of how competitively its rivals will react to a change in its output.[14] A higher value of k_i indicates that (1) a firm expects its competition to act more collusively, and (2) the firm itself will act more collusively (the slope of its reaction function changes). Under the competitive (or Bertrand) assumption, $k_i = -1$; under Cournot, $k_i = 0$; and under perfect collusion, $k_i = (1/S_i) - 1$.[15] More generally, since positive conjectures reflect the expectation that output restrictions will be matched by competitors, Anderson has suggested that such "matching" conjectures imply at least an attempt at collusion.[16]

Conjectural variations were calculated for the regulated year 1975 and the deregulated year 1982 by substituting price, marginal cost, market share, and elasticity data into Equation 2.[17] The conjectural variation estimates for 1975, a year in which the Civil Aeronautics Board set fares, are used as a regulatory benchmark in analyzing the effect of deregulation and should be interpreted "as if" firms had these conjectures. This derivation of the conjectures implies a single price and a single quality. In the airline industry such assumptions are suspect. Fares vary not only between firms but also within firms.[18] Frequency competition and other types of quality characteristics increase the dimensionality of the strategy space. The emergence of "hub" competition also interjects important strategic interactions that are suppressed in this simplified model.[19] Finally, conjectural variations are assumed to be exogenous to the determination of price and market share.[20] These assumptions, while necessary for tractability, are highly restrictive and necessarily qualify the direct usefulness of estimates.

The variance of the conjectures was also estimated. Using a first-degree Taylor expansion, Equation 2 becomes:

$$(\hat{k}_i - k_i) = (dk_i/de)(\hat{e} - e) + (dk_i/dMC_i)(\hat{MC}_i - MC_i) \qquad (3)$$

where hatted and unhatted symbols represent estimated and true values, respectively. If we assume that the marginal costs and elasticity estimates are unrelated, squaring and taking the expectation of this equation yields an expression for the variance of the conjectural variation estimate:

$$\mathrm{Var}(k_i) = (dk_i/de)^2\mathrm{Var}(e) + (dk_i/dMC)^2\mathrm{Var}(MC). \qquad (4)$$[21]

Results. The 2089 estimates of conjectural variation in 1982 were distributed:

	$k<-4$	$-4<k<-2$	$-2<k<-1$	$-1<k<0$	$0<k<1$	$1<k<2$	$2<k<4$	$4<k$
No.	7	29	103	518	682	307	306	137

The mean conjecture for 1982 was .885, roughly halfway between Cournot conduct and the average perfectly collusive conjecture of 1.86 (derived from the average carrier share of .34). Twenty-four percent of the carriers had relatively competitive conjectures between Cournot and Competitive conduct ($-1 < k < 0$). While the conjectures less than -1 imply, by Equation 2, that price was below the estimate for marginal cost, such observed shortfalls (6 percent of the sample) were never significantly different from zero.

T-tests (reported in Table 1) clearly rejected (at 1 percent significance) the extreme behaviors of perfect competition or collusion for any carrier. The average conduct for each carrier was more collusive than Cournot and for eleven of the sixteen carriers significantly so (at 5 percent level). Trunk carriers appeared to act more collusively than the local carriers, whose average conjectures were .969 and .610, respectively. Indeed, the equality of the trunk and local means was rejected ($F(1,2087) = 31.5$). This result is not unexpected given that the trunks are larger and more firmly established.

Table 1. Average conjectural variations and T-tests for competitive (-1), Cournot (0), and perfectly collusive ($(1/S) - 1$) behavior

Carrier	*Average Conjecture*	*Perfectly Competitive*	*Cournot*	*Perfectly Collusive*
All Carriers	.885	5.927*	2.782*	−6.899*
Trunk	*.969*	*6.194**	*3.048**	*−6.993**
United	.719	5.406*	2.260**	−5.791*
Eastern	1.306	7.254*	4.109*	−5.472*
Delta	.867	5.872*	2.726*	−6.129*
American	1.138	6.723*	3.578*	−7.448*
TWA	.777	5.588*	2.443**	−8.109*
Braniff	2.855	12.109*	8.968*	−6.951*
Northwest	1.526	7.944*	4.799*	−6.039*
Western	.354	4.260*	1.116	−9.079*
Continental	.472	4.627*	1.483	−10.826*
Local	*.610*	*5.074**	*1.922***	*−6.584**
US Air	.258	3.959*	.811	−5.766*
Ozark	.287	4.051*	.905	−4.988*
Piedmont	.369	4.307*	1.162	−7.379*
Republic	1.001	6.294*	3.149*	−5.776*
Texas Int.	.631	5.126*	1.983**	−7.824*
Frontier	.797	5.651*	2.507**	−9.887*

* 1 percent significance level
** 5 percent significance level

In Table 2 the results of individual t-tests reinforce this picture of a matching behavior more collusive than Cournot but less than perfect collusion. In only 14 percent of the sample can matching conduct be rejected.

The estimates of 1822 conjectures in 1975 were distributed:

	$k<-4$	$-4<k<-2$	$-2<k<-1$	$-1<k<0$	$0<k<1$	$1<k<2$	$2<k<4$	$4<k$
No.	0	0	0	183	902	554	157	26

A comparison of the regulated and unregulated conjectures support common theories about deregulation. The mean conjecture was higher under regulation (.982) than on the same routes in 1982 (.680), indicating that, as we might expect, there was more competition after deregulation. An F-test of each year's mean strongly rejected their equality ($F(1,3652) = 74.13$). The variance of the conjectures, moreover, increased with deregulation (from .896 in 1975 to 1.35 in 1982). Thus, regulated conduct was less competitive but more uniform. This result suggests the possibility that regulation, while in general impeding competition, may have improved conduct on certain routes that were particularly susceptible to collusion (for example, because of high barriers to entry or concentration).

III. THE DETERMINATION OF CONJECTURAL VARIATIONS

The central analysis of this paper is an attempt to estimate how conjectural variations are determined—that is, how firms form expectations about how their rivals will act. Within the model used in this paper, the concentration of an industry

Table 2. The number of carrier routes for which the estimated conjectures were consistent with competitive (– 1), Cournot (0), matching (>0) and perfectly collusive ((1/S) – 1) behavior*

Carrier	*Perfectly Competitive*	*Cournot*	*Matching*	*Perfectly Collusive*
All Carriers	916(1773)	891(1198)	1791(298)	434(1655)
Trunk	*273(1350)*	*650(943)*	*1364(229)*	*308(1285)*
United	65(224)	137(152)	231(58)	57(232)
Eastern	15(235)	91(159)	233(17)	65(185)
Delta	52(259)	142(169)	269(42)	81(230)
American	32(191)	90(133)	198(25)	29(194)
TWA	28(123)	61(90)	122(29)	26(125)
Braniff	0(41)	4(37)	41(0)	4(37)
Northwest	5(60)	28(37)	62(3)	21(44)
Western	17(73)	30(60)	67(23)	13(77)
Continental	27(112)	55(84)	108(31)	9(130)
Local	*75(423)*	*243(255)*	*429(69)*	*128(370)*
US Air	25(92)	61(56)	92(25)	42(75)
Ozark	2(34)	19(17)	32(4)	12(24)
Piedmont	9(73)	51(31)	76(6)	22(60)
Republic	23(139)	73(89)	145(17)	40(122)
Texas Int.	7(42)	23(26)	41(8)	6(43)
Frontier	7(43)	14(36)	41(9)	4(46)

*A conjecture is considered consistent with a given behavior if its value is not significantly different from the postulated behavior at a 5 percent significance level. The number of observations in which the behavior is not consistent is in parentheses

cannot determine the conjecture. In this model the first-order equations of the n firms in the market determine the price and the $n - 1$ market shares:

$$MC_i = P(1 - (S_i/e)(1 + k_i)) \text{ for } i = 1, n$$

The conjectural variations are assumed to be exogenous to these equations. The conjectures, then, determine the price and market shares; the market shares (and combinations of them such as the Herfindahl index) do not determine the conjectural variation. The determination of conjectural variations may be part of a larger simultaneous system in which market share and conjectures are jointly determined. This would especially make sense in a dynamic system. For the purposes of this paper, however, I assume that the variations are determined by a set of variables that are exogenous to the firm.

In searching for the appropriate set of exogenous variables, it is important to realize that the firm in forming its expectation is analytically in the same position as the economist in forming her expectation about which structural characteristics will lead to collusive behavior. Armed with this insight, we can then look to see if theories of how structure affects conduct coincide with the expectations of the firms themselves.

(A) From Stigler's "A Theory of Oligopoly,"[22] firms should expect more collusive behavior from their rivals when the number of sellers is small. The greater the number of sellers, the greater the gains from deviating from collusive behavior, and the harder it is to detect cheating. Like Stigler, I have assumed the number of sellers to be exogenous.

(B) Following Posner,[23] firms should expect more collusion on routes in which the gains from collusion are greater. The routes with large potential monopoly rents are those with relatively inelastic demand. Tourist and long-haul demand has been found to be more elastic than business and short-haul demand.[24] Accordingly, route distance and a tourism measure were hypothesized to influence firm behavior.

(C) Because excluding new entry is necessary for successful collusion, I included a dummy variable for slot constrained airports and the number of newly certified carriers. In 1982 the runways at four airports (New York's Kennedy and Laguardia, Chicago's O'Hare, and Washington's National) were so congested that the Federal Aviation Administration limited the number of takeoffs and landings (constrained the number of slots).[25] Slot constraints, by excluding willing competitors, should have allowed carriers to collect scarcity rents. More generally, barriers to entry were proxied by the number of newly certified carriers serving a route under the theory that the absence of new competition should have allowed more collusive conduct.[26]

(D) Both empirical and theoretical studies of the airline industry have concluded that non-price competition tended to replace price competition during the regulated era.[27] To test whether non-price competition continued to be a substitute for price competition, the number of flights per week was included in the regression.[28]

(E) Finally, the conjectured response of rivals may hinge on the identity of either the carrier making the expectation or the rivals whose response is being predicted. For example, as noted by Gollop and Roberts,[29] different rivals may have different capacities to respond to changes in output. Conversely, different firms might correctly expect different responses from a given rival.[30] The identities of the firms making the expectations and the identities of their route-specific rivals also might capture interroute reputational effects. Carriers may systematically misestimate their rivals' behavior or attempt to establish "tough" reputations themselves. For these reasons, dummy variables for both the carrier forming the expectation (the *i*th carrier) and for its route-specific rivals were included in the regression. The final specification of the conduct equation was:

$$k = a_c\text{C} + a_r\text{R} + \text{a}_s\text{SLOT} + \text{b}_1\#\text{CARRIER} + \text{b}_2\#\text{NEW} +$$
$$\text{b}_3\text{TOURISM} + \text{b}_4\text{DIST} + \text{b}_5\text{FLIGHTS} + \epsilon,$$

where:

C = carrier dummies
R = rival dummies
SLOT = slot dummy
#CARRIERS = number of carriers serving route
#NEW = number of newly certified carriers serving route
TOURISM = index of tourism
DIST = route distance
FLIGHTS = number of non-stop flights per week
ϵ = random disturbance term.[31]

Results. The slope coefficients (excluding carrier and rival dummies, which are reported in Table 3) for the 1982 structural regression were:

Regressor	*Coefficient*
SLOT	.1074
	(1.26)
#CARRIERS	−.4655
	(−4.22)
#NEW	−.0170
	(−.16)
TOURISM	−2.4654
	(−1.24)
DIST	−.0013
	(−15.51)
FLIGHTS	.0020
	(1.98)

All estimates from both regressions are of the expected sign. The number of carriers is not only significant but large. The addition of two carriers would cause virtually competitive conduct on a route that otherwise would be Cournot.

The competitive impact of the number of firms on carrier conduct is direct evidence to support Stigler's collusion and refute Demsetz's efficiency hypotheses. Its size is also a rejection of Baumol, Panzar, and Willig's concept of contestability.[32] While Bailey has used airlines as an illustration of a contestable industry,[33] contestability should lead not only to more competitive conduct but also to conduct that is insensitive to the number of carriers actually serving a route. In a contestable market those waiting in the wings should exert as great a pro-competitive force as actual rivals. This lack of contestability in 1982 may, however, reflect a transition to a deregulated equilibrium.[34]

While the presence of newly certified carriers has the expected sign, it is neither large nor significant, implying that their competitive influence is largely captured through the #CARRIERS variable. Although casual empiricism might suggest that certain new carriers (for example, People's Express) behave quite competitively, this tendency has a large variance. The slope estimates of the elasticity variables (tourism and distance) seem to indicate that, as Posner predicted, carriers collude more on less elastic routes. Route distance, however, is by far more important than tourism in influencing behavior. Not only is the distance coefficient estimated more accurately, but also it contributes much more to changes in route conduct. For example, the conjecture for the Denver-Phoenix route (589 miles) should, *ceteris paribus*, be 1.3 less than for the Denver-Philadelphia (1569 miles). The impact of tourism, however, even on relatively different routes, is negligible. For example, the conjecture for the Detroit-Dayton route (a low tourism route) should be, focusing only on tourism, only .05 less than for Detroit–Fort Lauderdale (a high tourism route). The number of nonstop flights per week, a proxy for nonprice competition, was found to depress price competition significantly. A route with many nonstop flights (300 per week) should have a conjecture .5 higher than a route with relatively few nonstop flights (50 per week). Finally, an F-test ($F(29,2053) = 9.75$) decisively rejected equality of the carrier and rival dummies. The trunk carriers have systematically less competitive conjectures (and therefore behavior) than those of the locals.

The regression results were robust to the use of alternative elasticity and marginal cost estimates. The signs, magnitudes, and significance of all the structural coefficients were robust to the use of other elasticity measures ranging from Borenstein's estimate[35] of −2 to Devany's estimate[36] of −1.07. The conduct

Table 3. Structural regression results

Regressor	*Coefficient*	
SLOT	.1074	
	(1.26)	
#CARRIERS	−.4655	
	(−4.22)	
#NEW	−.0170	
	(−.16)	
TOURISM	−2.4654	
	(−1.24)	
DIST	−.0013	
	(−15.51)	
FLIGHTS	.0020	
	(1.98)	
Trunks	*As Carrier Forming Expectation*	*As Rival*
United	2.7955	.5226
	(16.73)	(3.70)
Eastern	2.7148	.3967
	(14.53)	(2.87)
Delta	2.5049	.6444
	(14.69)	(4.72)
American	3.3636	.6947
	(17.53)	(4.87)
TWA	2.6067	.4476
	(14.24)	(3.01)
Braniff	3.8087	.3171
	(13.71)	(2.14)
Northwest	3.0468	.5749
	(12.16)	(4.05)
Western	2.3262	.4573
	(11.17)	(3.36)
Continental	2.4402	.3103
	(13.25)	(2.13)
Locals	*As Carrier Forming Expectation*	*As Rival*
US Air	1.3252	.7093
	(8.19)	(4.71)
Ozark	1.3495	.6938
	(4.90)	(3.99)
Piedmont	1.3883	.5180
	(8.02)	(3.31)
Republic	2.2449	.5489
	(14.13)	(3.93)
Texas Int.	1.7949	.4452
	(1.19)	(2.37)
Frontier	2.4187	.3489
	(10.78)	(2.31)

R-squared, 0.3334; Number of Observations, 2089; Heteroskedastic-consistent *t*-statistics in parentheses

regression was similarly robust to two alternative estimates of marginal cost which controlled for quality[37] and endogeneity of output,[38] respectively.

IV. TESTS OF CONSISTENCY AND STACKELBERG LEADERSHIP

Conjectural models of oligopoly generate a plethora of behavioral equilibria.[39] The structural approach to oligopoly, outlined above, seeks in a sense to reduce this multiplicity by tying behavior to structural characteristics of markets. Bresnahan has suggested alternatively that the set of equilibria could be reduced by imposing the behavioral restriction that rivals' conjectures be "consistent."[40] Consistency mandates that, in equilibrium, each firm correctly conjectures how its rivals react. This behavioral restriction is an important one that rules out a broad class of conjectural equilibria including Cournot conjectures.[41]

This section tests Bresnahan's consistency hypothesis by comparing firms' conjectures with their rivals' actual reactions. The test is important because collusion will be easier to identify and deter, if only consistent collusion is feasible. Moreover, consistency is shown to be a generalized form of Stackelberg leadership, in which only the leaders make consistent conjectures. Identifying the presence of Stackelberg leadership could be especially useful for policymakers seeking to promote competition by allowing them to target the collusive ringleaders.

If we maintain our implicit assumption of constant demand elasticity,[42] it is relatively straightforward to show that the slope of the reaction function equals:

$$\text{SLOPE}_i = dq_i/dq_{-i} = -P'(1 - B)/(P'(2 + k_i - B) - MC') \quad (5)$$

where

$$q_{-i} = \Sigma_{j \neq i}\, q_j,$$

$$P' = (dP/dQ) = -(1/e)(P/Q)$$

$$B = S_i(1 + k_i)(1 + e)/e$$

$$MC' = [AC_i d + (MC_i/AC_i)(MC_i - AC_i)]/q_i \text{ [43]}$$

The slope of the reaction function is the actual response of a firm to its competitors' actions. The reaction function expresses a firm's strategy, and the firm's conjectures of rivals' behavior (k_i) directly affect this strategy.

In a consistent equilibrium, each firm's conjecture about how its rivals will respond equals the rivals' actual response. The slope of rivals' aggregate reaction curve is locally the same as the conjectural variation:

$$k_i = \text{SLOPE}_{-i}$$

In other words, a firm's expectation about how its rivals will react to a change in its output must equal the rivals' actual reaction, the sum of the slopes of the rivals' actual reaction curves. For example, as Bresnahan showed for duopoly,[44] Bertrand conjectures (equaling -1) with constant returns to scale are consistent. This can be seen in equation 5 when the slope equals -1 for k_i equal to -1.

The concept of consistency can also be used heuristically to shed light on Stackelberg leadership. To be consistent is, in a sense, to know your rival's reaction function. This in essence is what a Stackelberg leader knows.[45] In a Cournot–duopoly model with linear demand and constant marginal cost, Figure 1 shows that if firm A changes to a consistent conjecture (from $k = 0$ to $k = -1/2$, entailing a shift of firm A's reaction curve from AA to AA'), the Stackelberg outputs (and price) are duplicated. If rivals' expectations are inconsistently fixed, a firm has a powerful incentive to make a consistent conjecture; the incentive is the profits of a Stackelberg leader. The striving of all firms to be consistent may be interpreted as the desire to be a Stackelberg leader and the behavioral assumption of consistency can then be seen as an extension or refinement of the assumption that firms seek to maximize profits. Consistency, however, generalizes the Stackelberg concept because it allows "leadership" even when rivals act more or less collusively than Cournot.

Results. The mean of the estimated aggregate slope parameter for 1982 was .119, while the mean conjecture was .885. This result (that the conjectured reaction of rivals was systematically more collusive than the rivals' actual reactions) parallels the linear Cournot model in which firms expect relatively collusive conducts ($k = 0$) when in fact the rivals respond more competitively (slope $= -.5$). This tendency to systematically expect overly collusive behavior might be explained as a temporary effect of deregulation and is an area for further research.

The variance of the slope was approximated using the same method used to estimate the variance of k_i in equation 4[46] and heuristic tests for the difference between the actual and conjectured slope were made.[47]

The null hypothesis of conjectural consistency is strongly rejected. As reported in Table 4, the difference between the mean conjecture and the mean slope was significantly different from zero at more than 1 percent confidence level ($t = 20.32$). More generally, the local carriers came closer to being consistent—with four of the six failing to reject the possibility, while all the trunks rejected the null at a 1 percent significance level. The size and competitive reputation of the trunk carriers may make it easier to predict their responses and partly explain why local carriers more consistently estimate their rivals' reactions. This result also illuminates the relationship between consistency and Stackelberg leadership. Under the conjectural reformulation, large and established firms like the trunk

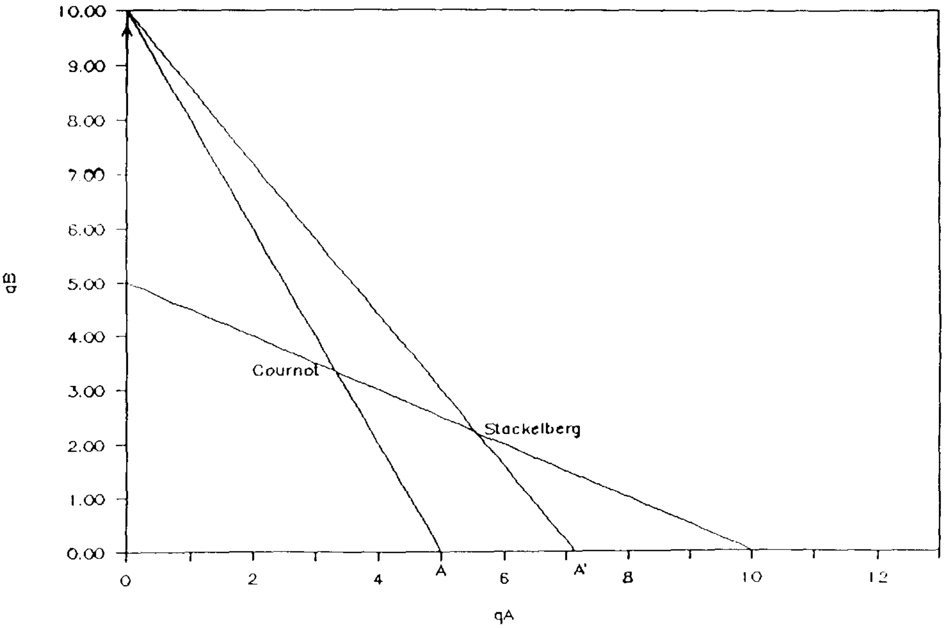

FIGURE 1.

Table 4. Test for consistent conjectures and Stackelberg leadership

Carrier	*t-Statistic*
All Carriers	20.3*
Trunk	
United	5.3*
Eastern	20.0*
Delta	9.2*
American	8.4*
TWA	5.3*
Braniff	30.9*
Northwest	6.3*
Western	2.3*
Continental	2.3*
Local	
US Air	.3
Ozark	1.3
Piedmont	1.1
Republic	6.2*
Texas Int.	1.4
Frontier	6.7*

* 1 percent significance level

carriers have no natural advantage in being Stackelberg leaders. All firms have incentives to make consistent conjectures.

V. CONCLUSION

This paper has attempted to test directly structure-conduct relationships. Reducing the conduct space to scalar strategies requires extreme assumptions that, as noted above, suppress important aspects of the deregulated industry, including the rise of hub competition and price discrimination. While the conjectural application implemented in this article has promise, the severity of the simplifying assumptions necessarily limits specific policy applications of the results.

Despite the extreme assumptions of the model, the regressions confirm our intuitions that:

(1) The number of sellers has a dramatic procompetitive impact on firm behavior;
(2) Routes with larger potential monopoly rents tend to have more collusive behavior; and
(3) Deregulated conduct is more competitive but less uniform than regulated conduct.

These results strongly refute the hypothesis that airline routes are contestable markets. The regressions thus reinforce the noncontestable results of other works,[48] but do so directly by examining the effect of structure on competitive behavior. Other studies of the airline industry have analyzed the effects of structure and deregulation on profitability and fares,[49] but this article makes the first attempt at connecting the deregulated structure of the airline industry to the strategic behavior of market participants.

The final section moved beyond the structural approach to test the behavioral hypotheses of Bresnahan consistency and Stackelberg leadership. Both hypotheses were rejected as descriptions of airline competition. The estimates of the firms' reaction functions indicate that conjectures were not consistent but were overly collusive.

While direct policy implications are limited by the simplifying assumptions of the model, structural information of this kind could be used to promote competition in many ways. By focusing enforcement effort in markets that are most likely to fail, government agencies can drive collusion from the markets in which it is most profitable. Understanding the impact of the number of sellers on firm behavior can also inform Clayton Act analysis of whether the recent wave of airline mergers is likely "to substantially lessen competition."[50] Policymakers could also use this analysis to begin to estimate the collusive costs of slot constraints in deciding whether airport expansion was cost-justified. Finally, the analysis could be used to combat the inefficiency of tacit collusion or oligopolistic interdependence. While current antitrust laws do not prohibit this type of market behavior,[51] society bears real costs from supracompetitive prices whatever their cause. That our antitrust laws do not address the problem is all the more reason to consider remedies that would lessen the effects of tacit collusion by structurally making it less feasible. Empirical efforts to pinpoint the structural causes and extent of collusion are a necessary link between academic theories and policy applications.

NOTES AND REFERENCES

1. J. S. Bain, *Industrial Organization*, Wiley (1959).
2. See, e.g., L. W. Weiss, "The Structure-Conduct-Performance Paradigm and Antitrust" (1979) **127** *U. Pa. L. Rev.* 1104.
3. For examples of these antitrust applications of the structural approach, see I. Ayres, "How Cartels Punish: A Structural Theory of Self-Enforcing Collusion" (1987) **87** *Columbia Law Review* 295; D. Pender & M. Coate, "Case Generation and Remedies" (June 29, 1984) F. T. C. Collusion Project Working Paper No. 3; R. A. Posner, *Antitrust Law: An Economic Perspective*, University of Chicago Press (1976), p. 55.
4. See, e.g., A. Phillips, "A Critique of Empirical Studies of Relations between Market Structure and Profitability" (1976) **24** *J. Ind. Econ.* 241–49.
5. H. Demsetz, "Industry Structure, Market Rivalry and Public Policy" (1973) **16** *J. Law & Econ.* 1.
6. G. J. Stigler, "A Theory of Oligopoly" (1964) **72** *J. Pol. Econ.* 44–61.
7. R. A. Posner, "The Social Cost of Monopoly and Regulation" (1975) **83** *J. Pol. Econ.* 807–27.
8. E. E. Bailey and J. Panzar, "The Contestability of Airline Markets during the Transition to Deregulation" (1981) **44** *L. & Contemporary Problems* 125.
9. G. Iwata, "Measurement of Conjectural Variations in Oligopoly," (1974) **42** *Econometrica* 947–66.
10. T. Bresnahan, "Duopoly Models with Consistent Conjectures" (1981) **71** *Am. Econ. Rev.* 934–52.

11. This expression for marginal revenue, the derivative of total revenue with respect to output, is derived:

$$
\begin{aligned}
MR_i &= P + q_i(\mathrm{d}P/\mathrm{d}q_i) = P + q_i(\mathrm{d}P/\mathrm{d}Q)(\mathrm{d}Q/\mathrm{d}q_i) \\
&= P + q_i(\mathrm{d}P/\mathrm{d}Q)(1 + E_i[\mathrm{d}q_{-i}/\mathrm{d}q_i]) \\
&= P + q_i(\mathrm{d}P/\mathrm{d}Q)(1 + k_i) \\
&= P - P(S_i/\mathrm{e})(1 + k_i)
\end{aligned}
$$

12. Iwata, *supra* note 9.
13. With simple algebraic manipulation, this expression derives from equation 1:

$$MC_i = P(1 - (S_i/e)(1 + k_i))$$

$$(P - MC_i)/P = L_i = (S_i(1 + k_i))/e$$

$$k_i = ((eL_i)/S_i) - 1.$$

14. Conjectural variations are derived from single period models and are thus static measures of firm conduct. Some game theorists have eschewed the use of conjectural measures because rivals cannot react in a one-period game. R. L. Schmalensee and R. D. Willig (eds.), *Handbook of Industrial Organization*, North Holland (1988). Conjectural modeling, while theoretically impure for game theorists, captures aspects of dynamic competition within a (tractable) static framework.
15. Such collusive conjectures maximize total industry profit, if firms have constant marginal cost, by insuring that the marginal revenue of each firm equals marginal cost. Robert Rogers, "The Behavior of Firms in an Oligopoly Industry: A Study of Conjectural Variations" (1983) George Washington University, Ph.D. dissertation. If carriers' marginal costs vary, perfect collusion would entail producing output only from the low-cost producer and side payments to the other firms.
16. J. E. Anderson, "Market Performance and Conjectural Variation" (1977) **44** *S. Econ. J.* 173–98.
17. DESCRIPTION OF CONJECTURAL DATA. All route-specific data come from CAB, Origin and Destination Survey, DB1 Summary Computer Tape, a 10 percent sample of all airline tickets. The sample includes connecting as well as direct (nonstop and stopover) flights, so that indirect "hub" competition is also analyzed. A more detailed appendix is available from the author.

Fares. Fares for 1975 and 1982 were estimated as the average fare in the different passenger classes (Y, K, etc.) weighted by the proportion of passengers flying in each class.

Route Market Share. Market shares were not available for 1975. Using the fact, however, that shares add to one, an average route conjecture ($k_i = k_j = k$) was derived. Summing equation 2:

$$\Sigma_i(S_i) = 1 = e\Sigma_i(L_i/k + 1)$$

$$k = [e\Sigma_i(L_i)] - 1$$

Elasticity of Demand. An elasticity of 1.3 was taken from an estimate of S. R. Brown and W. S. Watkins, "Measuring Elasticities of Air Travel Demand from New Cross-Sectional Data" (1971), a paper delivered at the annual meeting of the American Statistical Association. This measure was bounded by several airline demand studies. A. S. Devany, "The Effect of Price and Entry Regulation on Airline Output, Capacity and Efficiency" (1975) **6** *Bell J. Econ.* 327, estimated an elasticity of demand of 1.07; S. Borenstein, "Price Discrimination in Free-Entry Markets" (1983) M.I.T. Ph.D. dissertation, estimated a demand elasticity of 2. The elasticity measurement suffers from its invariance between routes. Several studies—M. Abrahams, "A Service Quality Model of Air Travel Demand: An Empirical Study" (1983) **17A** *Transportation Research*—A385–93; S. A. Morrison and C. Winston, "An Econometric Analysis of the Demand for Intercity Passenger Transportation" (1983) Working Paper, M.I.T. #327; J. E. Anderson and M. Kraus, "Quality of Service and the Demand for Air Travel," (1981) **63** *Rev. Econ. & Stat.* 533–40—have indicated that (1) tourist routes have more elastic demand than business routes and (2) long-hauls have more elastic demand than short-haul.

Marginal Cost. Marginal cost was derived from D. W. Caves, L. R. Christensen, and M. W. Tretheway, "Economies of Density versus Economies of Scale: Why Trunk and Local Service Airline Costs Differ" (1984) **15** *Rand J. Econ.* 471–89. Using the

Caves, Christensen and Tretheway parameter estimates (shown below), marginal costs per passenger mile was calculated from the analytic derivatives of their translog specification:

$$MC = (CT/q)[a + d\ln q + \Sigma_j(r_{q,j}\ln W_j) + \Sigma_j(m_{q,j}\ln Z_j)] \quad (3)$$

where

CT = total annual costs of carrier
q = total passenger-miles of carrier
W_j = input prices (fuel, labor and capital)
Z_j = airline characteristics (load factor, route distance, and points served).

Variable	*Coefficient Estimate*	*Standard Deviation*
a	.804	.034
d-Passenger miles	.034	.054
r-Labor	−.009	.005
r-Fuel	.018	.003
r-Capital	−.010	.004
m-Route distance	−.050	.085
m-Load factor	.036	.119
m-Points served	−.123	.064

The 1982 marginal costs (by carrier and route) were then estimated by plugging in the individual carrier characteristics and the individual route distances.

18. See Borenstein, *supra* note 17. On-line reservations systems have allowed airlines to increasingly use capacity-based pricing systems. S. A. Morrison and C. Winston, *The Economic Effects of Airline Deregulation* (1986), p. 68. Using average fares treats a carrier that sells all of its seats at $200 as having the same price as a carrier that sells half its seats at $100 and half at $300. Ignoring such price dispersions significantly qualifies the results as constructing favorable fare structures (i.e., price discrimination) is central to the current competitive process.
19. See J. Meyer, C. Oster, I. Morgan, B. Berman, and D. Strassmann, *Airline Deregulation: The Early Experience*, Auburn House (1981), p. 93. Consumers, especially business travelers, may demand multiroute service. I. Ayres, "Rationalizing Antitrust Cluster Markets" (1985) **95** *Yale L. J.* 109 (multiproduct firms can be caused by transactional complementarity). This is especially true with the increasing prevalence of "frequent flyer" programs and the "switching costs" that they entail. See P. Klemperer, "Collusion via Switching Costs: How 'Frequent-Flyer' Programs, Trading Stamps and Technology Choices Aid Collusion" (May 1984), Stanford Working Paper 786.

    The effects of hub competition are partially controlled for in the cost estimation by including number of points served in the translog cost regression. See *supra* note 17. However, other information about route system configurations (including, for example, plane size) are omitted. Intercarrier strategic effects are partially controlled for in the conduct regressions, reported *infra* Table 3, by including carrier dummies to distinguish systematic differences in the response of rivals to particular carriers. For other empirical attempts to capture the difficult problem of hub competition, see E. E. Bailey, D. R. Graham, and D. P. Kaplan, *Deregulating the Airlines: An Economic Analysis*, M.I.T. Press (1984); D. L. Strassmann, "Potential Competition in the Deregulated Airline Industry" (Feb. 1988) Institute for Policy Analysis, Rice University, Working Paper #10.
20. The conjectural measure of conduct is also related to the Lerner measure of performance. From equation 2, a firm's conjectural variation estimate is a function of the market demand elasticity, the firm's Lerner index, and the firm's market share. Since the estimation of equation 2 assumed a constant elasticity across routes, the deregulated conjecture for a firm can be reinterpreted as a monotonic transformation of a firm's Lerner index weighted by its market share.

21. The variance of the demand elasticity, also taken from the Brown and Watkins study, *supra* note 17, was .10. The variance of marginal cost (from the coefficients in the Caves Christensen and Tretheway translog regression, *supra* note 17) was, evaluated at the sample mean, .13.
22. Stigler, *supra* note 6.
23. Posner, *supra* note 7.
24. See Anderson and Kraus, *supra* note 17; Morrison and Winston, *supra* note 17; Abrahams, *supra* note 17.
25. S. E. Creager, "Airline Deregulation and Airport Regulation" (1983) **93** *Yale L. J.* 319.
26. The number of newly certified carriers is an imperfect proxy for barriers to entry. Non-newly certified carriers may have entered some of the sampled routes. Moreover, the absence of new entry does not entail the absence of potential competition and does not theoretically explain why barriers differed between routes.
27. G. W. Douglas and J. C. Miller III, *Economic Regulation of Domestic Air Transportation: Theory and Practice*, The Brookings Institute (1974).
28. Because frequency competition is likely to be endogenously determined, the number of route flights may induce simultaneity bias. It is assumed to be exogenous.
29. F. M. Gollop and M. J. Roberts, "Firm Interdependence in Oligopolistic Markets" (1979) **10** *J. Econometrics* 313–31.
30. For example, a given rival might respond less aggressively to increased output from a fringe competitor.
31. DESCRIPTION OF STRUCTURAL DATA.

    Carrier Dummy = 1 for carrier forming conjecture, 0 otherwise. Source: CAB, DB1 Computer Tape.

    Rival Dummy = 1 if rival carrier serves route, 0 otherwise. Source: CAB, DB1 Computer Tape.

    Slot Dummy = 1 if one endpoint is slot constrained, 2 if both endpoints are slot constrained, 0 otherwise. In 1982 the FAA had imposed slot constraints (limited the number of takeoffs and landings) at New York's Kennedy and Laguardia, Washington's National, and Chicago's O'Hare airports. Source: 14 C.F.R. 93.123 (1976) also see D. R. Graham, D. P. Kaplan, and D. S. Sibley, "Efficiency and Competition in the Airline Industry," (1983) **14** *Bell J. Econ.* 118.

    #CARRIERS. Source: CAB, DB1 Computer Tape.

    #NEW = the number of carriers serving the route who were certified for interstate service after passage of the Airline Deregulation Act of 1978. Source: DB1 Computer Tape.

    TOURISM. Following Borenstein, *supra* note 17, this index is a weighted average of 1977 tourist hotel revenues as a percentage of total business revenues in each endpoint city. The weight for each endpoint is the proportion of trips on the route that originates at the other endpoint. For instance, since most trips on the Albany-Miami route originate in Albany, the tourist attractiveness of Miami gets greater weight than that of Albany. Source: U.S. Census of Service Industries, 1977.

    FLIGHTS = number of non-stop flights per week. Source, *Official Airline Guide*, North American Edition, May 1, 1982.
32. W. J. Baumol, J. C. Panzar, and R. D. Willig, *Contestable Markets and the Theory of Industry Structure*, Harcourt, Brace and Jovanovich (1982).
33. E. E. Bailey, "Contestability and the Design of Regulatory and Antitrust Policy" (1981 papers and proceedings) **71** *Am. Econ. Rev.* 178–83; see also Bailey & Panzar, *supra* note 8.
34. E. E. Bailey and W. J. Baumol, "Deregulation and the Theory of Contestable Markets" (1984) **1** *Yale J. Reg.* 111; Bailey and Panzar, *supra* note 8.
35. Borenstein, *supra* note 17.
36. Devany, *supra* note 17.
37. Recent studies of airline demand—R. A. Ippolito, "Estimating Airline Demand with Quality of Service Variables" (1981) **15** *J. Trans. Econ.* 7; Abrahams, *supra* note 17; Anderson and Kraus, *supra* note 17—have controlled for airline quality with frequency delay measures. The average number of flights per city pair was included in the translog

specification, equation 3, as a measure of the frequency delay quality. The SUR estimate of the frequency delay coefficient was negative (−.118), indicating economies to increasing the number of flights per route) and significant ($t = -2.6$).

38. Output was instrumented with price indices for other modes of transportation (car, bus, train) as well as general macroactivity aggregates (per capita disposable income, unemployment rate) and transportation complements (hotel revenues). Instrument data were taken from the *Statistical Abstracts of the United States*. All data are national aggregates. The transportation indices were measured in price per passenger mile. A Hausman test, however, could not reject a null hypothesis of output exogeneity (chi-squared (60 d.f.) = 0.63).
39. J. Ordover, A. Sykes, and R. Willig, "Herfindahl Concentration, Rivalry, and Mergers," (1982) **95** *Harv. L. Rev.* 1857.
40. Bresnahan, *supra* note 10.
41. In Cournot equilibrium, each firm expects that its rivals will not react to changes in its output, $k_i = 0$, but each firm in fact will increase its output in response to a rival's output reduction.
42. Let the inverse demand function be:

$$P = aQ^{1/e}$$

so that the constant elasticity of demand is:

$$e = -(dQ/dP)(P/Q).$$

43. By setting marginal cost equal to marginal revenue and using the implicit function theorem, it can be shown that the slope of firm i's reaction curve equals equation 5. Marginal cost parameter estimates, such as "d" the passenger miles coefficient, are again taken from Caves, Christensen, and Tretheway's translog specification, *see supra* note 17, equation 3:

$$MC_i = (CT_i/q_i)[a + d\ln q_i + \Sigma_j(r_{qj}\ln W_j) + \Sigma_j(m_{qj}\ln Z_j)].$$

44. Bresnahan, *supra* note 10.
45. This connection between consistency and Stackelberg leadership is suggestive at best. The concepts relate to different games (one and two period, respectively) with different strategies. But as noted above, conjectural variation models are static models striving to be dynamic. These repressed dynamics bolster the comparison with the Stackelberg model.
46. The slope variance was estimated under the assumption that the covariance of k_i with MC_i and e was zero.
47. The form of the t-test:

$$\Sigma_i\,(k_i - \text{SLOPE}_{-i})/(\text{Var}(k_i) + \text{Var}(\text{SLOPE}_{-i}))^{.5}$$

assumes that the SLOPE_{-i} and k_i estimates are independently distributed. Because a positive covariance is more likely, the estimate of the denominator may be too large and the test may be biased toward accepting the null of consistency (equality).

48. See, e.g., G. D. Call and T. E. Keeler, "Airline Deregulation, Fares and Market Behavior: Some Evidence" (1985), in *Analytical Studies In Transport Economics*, Andrew F. Daugherty, ed. (Cambridge University Press); Morrison and Winston, *supra* note 17; D. L. Strassmann, *supra* note 19.
49. See, e.g., Graham, Kaplan, and Sibley, *supra* note 31; Bailey, Graham, and Kaplan, *supra* note 19; Call and Keeler, *supra* note 47.
50. 15 U.S.C. 13(a).
51. Theatre Enterprises v. Paramount Film Dist. Corp., 346 U.S. 537, 541 (1954).