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An Empirical Analysis of Global Airline Alliances: Cases in North Atlantic Markets

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Abstract. This paper empirically investigates the effects on air fares, passenger volume, and consumer surplus of four major alliances in North Atlantic aviation markets. The four alliances are British Airways/USAir, Delta/Sabena/Swissair, KLM/Northwest, and Lufthansa/United Airlines. We find that equilibrium passenger volume increased by some 36,000 passengers annually and equilibrium air fares decreased by an average of $41 on the routes served by the allying carriers, and that consumers were generally better off due to the alliances.

Key words: International airline alliances, market outcome, North Atlantic markets, welfare.

JEL Classification: L13, L93, L40, L51.

I. Introduction

The amount of international air travel has grown rapidly in recent years. Total passenger traffic between the U.S. and the rest of the world increased to 92.6 million passengers in 1993 from 39.5 million in 1980. The International Air Transport Association (IATA) estimated that this number would increase to 226 million by 2010. Despite recent growth, however, the international aviation market remains heavily regulated. Under a framework established by most countries gathered at the Chicago Conference in 1944, international air travel is largely governed by restrictive bilateral air service agreements. In addition, there are legal, political, and institutional constraints on mergers and takeovers between airlines of different countries. Taken together, these two observations suggest that it would be almost

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impossible for a single airline to create a global network to serve passengers from all over the world. Instead, airlines have increasingly formed strategic alliances with foreign carriers, as a means of forming global networks.

In the last few years, there has been much discussion in the popular press and government policy-making circles on whether economic welfare is enhanced by international airline alliances. Alliances provide opportunities for the partner airlines to reduce costs by integrating activities in various fields (e.g., joint advertising, joint promotion, and joint purchase of fuel) and by linking their existing networks. The partners may just reschedule their existing fleet to serve new markets, thereby avoiding investment in new aircraft and hubs.

Alliances can also have a positive impact on services through better coordination of their connecting traffic. A key feature of the international airline alliances is a codesharing agreement between the partners whereby one airline's designator code is shown on flights operated by its partner airline. For example, as of December 1994, Lufthansa codeshared on United Airline's flights between Frankfurt and 25 U.S. interior cities via two of United's hubs. Typically, schedule coordination between the partners and airport gate proximity at their hubs are a part of codesharing agreements, both of which improve convenience for connecting travel. The improvement in service quality further increases demand for travel on the partner airlines not only in the connecting markets, but also in the markets linking "gateway" cities (most of which are also airlines' hubs in their "hub-and-spoke" networks) where international connecting passengers get transfer on the way to their final domestic endpoints. Such demand increases could, other things being equal, reduce carriers' unit costs on the gateway routes owing to increasing returns to traffic density (Caves et al., 1984; Brueckner and Spiller, 1994). These cost reduction effects, if realized, would put downward pressure on fares in all markets.

Most international airline routes have a few competitors. Thus, an alliance between any two significant competitors on an international route may adversely affect the degree of competition on the route. For example, European Union officials recently expressed concerns about the increase in concentration on some trans-Atlantic gateway routes after major alliances, and seem bent on pushing ahead with measures to restrict them (e.g., *Business Week*, 2 March 1998). In a recent study, Brueckner (1997) analyzed the effects of international airline codesharing agreements on traffic levels and welfare. He showed that the beneficial effect of codesharing outweighs its harmful effect for most parameter values in his theoretical model.

This paper attempts to empirically investigate the effects of four major alliances on fares, volume, and consumer surplus in gateway markets so as to shed light on whether the increase in post-alliance route concentration should be viewed as a cause for concern. The four alliances are British Airways/USAir, Delta/Sabena/Swissair, KLM/Northwest, and Lufthansa/United Airlines. Specifically, using panel data from the 1990–1994 period we investigate the following questions: how does each of the four alliances influence passenger volume and air fares on the alliance routes? What if the alliances had not occurred in these markets? Are consumers generally better off due to each of the alliances?

The effects of international airline alliances have previously been empirically investigated elsewhere. Gellman Research Associates (USDOT, 1994), under the request of the U.S. Department of Transportation, measured the impact of code-sharing of the British Airways/USAir and KLM/Northwest alliances on market share and welfare using the first quarter of 1994 data. They conducted a counterfactual scenario analysis based on a model estimated using the post-alliance period only and estimated that the two alliances increased consumer surplus by $10.3 million and $27.1 million, respectively, during the first quarter of 1994. The U.S. General Accounting Office (USGAO, 1995) concluded, mainly based on interviews with representatives from governments and airlines, that alliances between U.S. and foreign airlines have generated large gains for the participating carriers in terms of passengers and revenues. Oum et al. (1996) examined the effect of codesharing agreements on firm conduct and air fares by focusing on trans-Pacific markets. They estimated the impacts of a codesharing agreement between small carriers ("non-leaders") on the market leader's price and passenger volume. They found that a codesharing agreement increased the annual equilibrium quantity of the market leader by 10,052 passengers while reducing its equilibrium price by $83 per passenger.

What distinguishes the present study from its predecessors is that the four major alliances are investigated through a structural estimation of oligopolistic international airline markets. In addition, we include data for both pre- and post-alliance periods. This allows a comparison of with- and without-alliance equilibria, taking into account possible structural changes caused by an alliance.[1]

The structure of the paper is as follows. Section II provides more detailed information on the four major alliances in the North Atlantic market. Section III derives a structural model for an empirical analysis, describes the data used, and addresses the main econometric issues faced. Section IV presents and interprets the estimation results of alliance effects on air fares, passenger volume, and consumer surplus. Section V concludes.

II. Four Major Alliances

The North Atlantic market is the largest intercontinental market: it accounted for 12.6 per cent of total international scheduled revenue passengers in 1994 (IATA, 1994). The four alliances accounted for more than 60 per cent of the entire North

[1] In the process of revising this paper, we became aware of a recent study by Brueckner and Whalen (1998). By using a different approach (estimation of a reduced fare equation) and a different data set, they focus on the question of whether alliance partners charge lower interline fares than nonallied carriers. They also find that while the point estimates show that an alliance between two previously-competitive carriers would raise fares by 4–6 per cent in their gateway markets, this effect is not statistically significant.

Atlantic market in terms of scheduled revenue passenger kilometres: Delta (DL), Sabena (SN), Swissair (SR), and Austrian accounts for 16.5 per cent; United Airlines (UA) and Lufthansa (LH) 15.6 per cent; British Airways (BA) and USAir 15.3 per cent; and KLM and Northwest (NW) 13.0 per cent (*Air Transport World*, May 1996). [2]

BA formed an alliance with USAir on January 21, 1993. BA invested $300 million in USAir, which was in poor financial condition, in exchange for 22 per cent of its equity. BA also obtained three seats on USAir's 16-member Board of Directors. As a condition for government approval of the alliance, USAir was required to divest all of its route authorities between the U.S. and U.K. to other U.S. carriers in order to comply with antitrust laws. As a consequence, BA had USAir feed its domestic traffic onto BA's international flights between U.S. gateways and London. For example, BA could codeshare flights from Phoenix to London by combining codeshared USAir flights from Phoenix to Philadelphia with its own flights from Philadelphia to London. Since this alliance involved only one-sided codesharing by BA on USAir's flights within the U.S. and all of the alliance routes were long-haul flights across the Atlantic, BA kept most revenues from the alliance (USGAO, 1995).

The DL/SN/SR alliance is considered one alliance in this study since DL and SR made an equity swap of about 5 per cent and SR invested in SN. This alliance reduced the combined number of flights offered, in that one partner stopped flying on a particular route and bought a block of seats in the other partner's flights on the same route. For example, DL and SR codeshared on non-stop flights from Cincinnati, New York, and Atlanta to Zurich, and non-stop flights from New York to Geneva. DL offered the non-stop flights between Cincinnati and Zurich, with SR reserving blocks of seats, while SR provided the non-stop flights on the Atlanta-Zurich, New York-Zurich and New York-Geneva routes, with DL reserving blocks of seats. Another example is that DL purchased a block of seats on SN's non-stop flights between New York and Brussels where DL had provided non-stop services before the alliance.

KLM invested in 25 per cent of NW's voting shares and 49 per cent of its equity as of March 1993. This alliance was the first alliance granted antitrust immunity by the U.S. Department of Transportation in November 1992, shortly after the Netherlands and the U.S. signed an open-skies agreement in September 1992. Although each carrier's management remains separable owing to foreign-ownership restrictions, the carriers can closely coordinate. They can discuss market strategies and pricing, develop formulas to set fares in all markets, and quickly change fares in response to changing market conditions. As of December 31, 1994, they provided codesharing flights between a total of 88 North American cities beyond NW's hubs and 30 European, Middle Eastern and African cities beyond KLM's hub (USGAO, 1995).

[2] DL and Austrian (OS) started a codesharing and block space arrangement on Vienna-New York in late 1994. Thus, OS is not included in the DL/SN/SR alliance for this study.

The LH/UA partnership, formed on June 1, 1994, is a commercial alliance without equity investment. As of December 1994, LH codeshared on UA flights serving 25 U.S. cities beyond UA hubs, while UA codeshared on LH flights serving 30 European and Middle Eastern cities beyond LH hub. They also codeshared on their flights between their hubs. Each partner offered the same number of flights on the non-stop routes as before the alliance. For example, each partner provided 31 flights between Washington, D.C. and Frankfurt in July 1993 (pre-alliance) and July 1994 (post-alliance). Due to the codesharing, both partners offered 62 flights because each put its flight codes on the other's flights.

III. Structural Estimation

1. Structural Model

Consider an international city-pair market where airlines produce a homogenous service. Firm i produces output Q_i in the market and total output, denoted by Q, is the sum of Q_i An alliance between airlines may cause an exogenous demand shift in the market. Consequently, we may express the market demand function as:

$$Q = Q(P, A, X), \tag{1}$$

where P is market price, A is a vector of alliance variables, and X is a vector of other exogenous variables that affect the demand function.

As indicated above, alliances may affect the partner airlines' costs. Denote airline i's total cost by $C_i(Q_i, B, Y)$, where B is a vector of alliance variables and Y are other variables that shift cost. We can write firm i's profit function as $\Pi^i = Q_i P(Q, \cdot) - C_i(Q_i, B, Y)$, where $P(Q, \cdot)$ is the inverse demand function. If we regard Q_i as the choice variable, then the Cournot–Nash equilibrium is represented by the first-order conditions:

$$P = \mathrm{MC}_i(Q_i, B, Y) \cdot [1 + (1/\eta)\mathrm{MS}_i(Q_i)]^{-1}, \tag{2}$$

where MC_i is firm i's marginal cost, $\eta \equiv (\partial Q/\partial P)(P/Q)$ is the price elasticity of market demand, and $\mathrm{MS}_i(Q_i) \equiv Q_i/Q$ is firm i's market share. Equation (2) holds for each carrier (aligned or non-aligned) that serves the city-pair market. It shows that the market price can be expressed as the multiplication of a serving carrier's marginal cost and its markup ratio, with the markup ratio being positively correlated with the firm's market share.

Since (1) and (2) can be affected by alliances and both air fare and passenger volume mutually influence each other in these equations, we shall estimate the two equations as a system of demand and price equations, so as to examine the effects of alliances on market outcome and consumer surplus. This approach is within the general framework of empirical studies of oligopolistic industries discussed by Bresnahan (1989).

2. Econometric Issues

In estimating the system of demand and price equations, we encounter a number of econometric issues. Of these, the most significant are functional specification, estimation method, appropriate treatment of error structures, and specification of fixed effects. We now address each of these issues.

As shown above, a common price elasticity needs to be imposed on both demand and price equations. Since the log-linear specification allows us to embed an explicit form of the price elasticity into the system, we apply the log-linear specification to the demand equation. Based on the assumption that the four major alliances may have an impact on demand in individual North Atlantic markets, we express the demand equation as:[3]

$$\begin{aligned} \ln Q \;=\; & \alpha_0 + \alpha_1 \ln P + \alpha_2 \ln \mathrm{POP} + \alpha_3 \ln \mathrm{INC} + \alpha_4 \mathrm{BAUS} + \alpha_5 \mathrm{DLNR} \\ & + \alpha_6 \mathrm{KLNW} + \alpha_7 \mathrm{LHUA}, \end{aligned} \tag{3}$$

where Q is the aggregate annual traffic in a given city-pair market, P is the weighted average fare on the route, and BAUS, DLNR, KLNW and LHUA are post-alliance dummy variables for each of the four alliances, respectively. A route dummy, say BAUS, is coded one for *all carriers* on the route on which, and/or beyond which, BA and USAir had codesharing during the post-alliance period, and zero otherwise. In addition to the route dummies, two variables measure the demand for travel in a city-pair market. The first is POP which is defined as origin city population multiplied by destination city population; this variable is a measure of the size of the market. The second demand variable is INC, which equals origin country's per capita income multiplied by destination country's per capita income. The population and income variables are also used by, among others, Graham et al. (1983) and Brueckner and Spiller (1994).

For consistency of functional structure, (2) is transformed into the logarithmic form:

$$\ln P = \ln \mathrm{MC}_i(Q_i, B, Y) - \ln[1 + (1/\alpha_1)\mathrm{MS}_i(Q_i)]. \tag{4}$$

We may further express the marginal cost functions as:[4]

[3] We used the likelihood ratio test to test whether the slope and intercept of the route demand function are changed by each of the four alliances. The test results showed that the post-alliance slope of the demand equation is not statistically significantly different from the pre-alliance slope, but the demand is significantly shifted by the alliances. Thus, we estimated the demand equation based on the assumption that its slope is not affected by the alliances.

[4] Initially, Equation (5) included post-alliance dummy variables for non-aligned carriers in order to examine whether the marginal cost functions for the non-aligned carriers are affected by the alliances. All of the coefficients of the post-alliance dummies for the non-aligned carriers were estimated as statistically insignificant. Using the likelihood ratio test, we tested the null hypothesis that the coefficients of the post-alliance dummies for the non-aligned carriers are zero. Since the log-likelihood values of unrestricted and restricted models were estimated as −238.75 and −238.98, respectively, the test did not reject the restriction. For the simplicity of the exposition, we exclude the post-alliance dummies for the non-aligned carriers in (5).

$$\ln \mathrm{MC}_i = \beta_0 + \beta_1 \ln Q_i + \beta_2 \ln \mathrm{INP}_i + \beta_3 \ln \mathrm{DST} + \beta_4 \ln \mathrm{SIZE}_i + \beta_5 \mathrm{BPAR} + \beta_6 \mathrm{DPAR} + \beta_7 \mathrm{KPAR} + \beta_8 \mathrm{LPAR}, \tag{5}$$

where Q_i is firm i's annual traffic on the route, INP_i is i's overall input price index, DST is the route distance, SIZE_i is firm i's average aircraft size used on the route, and BPAR, DPAR, KPAR and LPAR are post-alliance dummy variables for the partner airlines for each of the alliances, respectively. These dummies are coded one only for *alliance partners* on the route on which, and/or beyond which, the partner airlines codeshared during the post-alliance period.

The second term of the right-hand side of Equation (4) is firm i's markup ratio. With this markup ratio term excluded, estimating the system of Equations (3) and (4) will result in biased and inconsistent estimates. Thus, this markup ratio must be properly handled when both demand and price equations are simultaneously estimated. To do so, we impose the following two restrictions on the system of equations: (i) $[1 + (1/\alpha_1)\mathrm{MS}_i(Q_i)]^{-1}$ should be estimated as greater than or equal to one; and (ii) coefficient α_1 should be estimated as the same negative value in both equations. The problem is how to properly estimate coefficient α_1 in the price equation. Since the coefficient is implanted within the markup ratio term, it is necessary to use a nonlinear estimation method. This method, however, fails to yield reliable estimates. During the iterations, the term often goes out of the proper range and thus is replaced by zero which is an irrelevant number in our context. To avoid this problem, we approximate $\ln[1 + (1/\alpha_1)\mathrm{MS}_i(Q_i)]$ by $(1/\alpha_1)\mathrm{MS}_i(Q_i)$ using a Taylor's first-order expansion of the function $\ln(1 + x)$ at $x = 0$.

We assume that Equations (3) and (4) have an additive error structure:

$$\ln Q_{jt} = D(P_{jt}, \mathrm{POP}_{jt}, \mathrm{INC}_{jt}, \mathrm{BAUS}, \mathrm{DLNR}, \mathrm{KLNW}, \mathrm{LHUA}; \alpha) + \varepsilon_{jt}$$

$$\ln P_{ijt} = P(Q_{ijt}, \mathrm{INP}_{it}, \mathrm{DST}_{jt}, \mathrm{SIZE}_{ijt}, \mathrm{BPAR}, \mathrm{DPAR}, \mathrm{KPAR}, \mathrm{LPAR}, \mathrm{MS}_{ijt}; \beta) + u_{ijt}, \tag{6}$$

where α and β are the parameter vectors to be estimated and subscripts i, j and t represent carrier, route and year indices, respectively. The error term in the demand equation is further decomposed into three components, while the error term in the price equation into four components: $\varepsilon_{jt} = \delta_j + \zeta_t + \omega_{jt}$ and $u_{ijt} = \mu_i + \sigma_j + \xi_t + e_{ijt}$ where μ_i is a carrier-specific component, δ_j and σ_j are route-specific components, ζ_t and ξ_t are year-specific errors, and ω_{jt} and e_{ijt} are normally distributed errors which may be contemporaneously correlated across equations only.

The carrier-specific error term reflects unobserved fundamental differences across airlines. For example, network structure, management style, and fleet composition may be different across airlines. Introducing dummy variables for each carrier controls for the carrier-specific effect. The route-specific effect is designed to capture demand and cost (or price) differences that are unmeasured and constant for all airlines that serve a route, but may vary across routes. Demand and price may differ across routes, *ceteris paribus*, for various reasons: for example, whether a route is under a "restricted" or "liberal" bilateral agreement. Similarly, we capture the year-specific effect by employing year dummy variables. American Airlines, the Atlanta-Amsterdam route, and year 1990 are used as a base carrier, a base route, and a base year, respectively.

Following the above stochastic specification, we can transform (3) and (4) into:

$$\begin{aligned} \ln P_{ijt} &= P(Q_{ijt}, \cdot, \text{BPAR}, \text{DPAR}, \text{KPAR}, \text{LPAR}; \beta) \\ &\quad + \sum f_1 F_1 + \sum R_j RT_j + \sum Y_t YR_t + e_{ijt} \end{aligned} \tag{7}$$

$$\begin{aligned} \ln Q_{jt} &= D(P_{jt}, \cdot, \text{BAUS}, \text{DLNR}, \text{KLNW}, \text{LHUA}; \alpha) \\ &\quad + \sum R_j RT_j + \sum Y_t YR_t + \omega_{jt}, \end{aligned} \tag{8}$$

where F_i is a firm-specific dummy for carrier i, RT_j is a route-specific dummy for route j, and YR_t is a year-specific dummy variable for year t. Notice that (4) holds for each individual carrier serving a given city-pair market. To allow for possible measurement errors in market price, (4) is estimated using fares for individual firms, while the route demand function (3) is estimated using the weighted average fare for the route.

3. Data and Variables

In order to identify North Atlantic alliance routes, we selected 19 North American and 12 European gateway cities. Among the routes from the combination of these cities, alliances between North American and European carriers were formed on 21 routes. Two routes (Atlanta-Zurich and Cincinnati-Zurich) were excluded due to lack of data. Another two routes (Toronto–Paris and Montreal–Paris) were eliminated, because they were related to simple alliances (in which partner airlines codeshared only on a few isolated, regional routes) and the number of observations is insufficient to distinguish the effects of major strategic alliances from those of the simple alliances.

The major alliances in North Atlantic markets were formed in the early 1990s. Annual data for the remaining 17 alliance routes were collected for the 1990–1994 period to compare pre- and post-alliance outcomes. Observations were collected for all carriers, aligned and non-aligned, operating on those 17 routes. Those observations were removed in which a carrier's annual flight frequency was reported to be less than 50 and/or a carrier's market share was less than 10 per cent.[5] The remaining 368 observations were used to estimate demand and price equations.

[5] Removing those data enables us to control the effects of "fifth freedom" carriers who have the rights to pick up additional traffic in a first foreign country and carry it to a second foreign country. Furthermore, removing airlines that provided less-than-one-weekly service helps eliminate unreliable data.

Data associated with alliances were mainly taken from the *Official Airline Guides (OAG): Worldwide Edition*. Airlines joining alliances were identified by the symbol "★" and their flight numbers in the *OAG*. The February and July issues for the 1989–1994 period were used to check whether a particular alliance was still ongoing. Monthly flight frequency for each alliance was determined from these issues of *OAG*. To clarify unclear cases, we also used the *Airline Business* (1994), *International Civil Aviation Organization (ICAO) Journal* (1990–1994), *USDOT* (1994), and *USGAO* (1995).

We gathered each airline's excursion air fares on each route in each year from the summer (mostly July) and winter (mostly February) issues of the *OAG* and computed equally weighted averages between summer fares and winter fares. Since the *OAG* reports each airline's air fares in its home currency, the official exchange rates, collected from the *International Financial Statistics*, were used to convert them into U.S. dollars. The weighted average fare was used as the fare variable in the equations. We admit potential problems in using the published fares rather than the actual fares (that is, average yield per passenger). Unfortunately, the route-specific data on average yields are not available. In the trans-Atlantic markets, however, the lowest fares are similar to the discount fares widely used in North American markets since European carriers have not practised yield management using dynamic seat allocation methods.

To conform with the theoretical model, we need data on each airline's local traffic in a city pair, Q_i, as well as the sum of firm outputs in that market, Q. Unfortunately, reliable data for them are not available at the international level. We were thus forced to make an approximation. Specifically, we gathered segment passenger volume between cities from ICAO's *Traffic by Flight Stage* which lists the scheduled passenger volume for each airline in each year. This segment passenger volume, however, may include both connecting traffic and local traffic on a route.[6]

The data on the population and income variables were collected from various sources such as the *U.N.'s Demographic Yearbook*, *Europa World Year Book*, *Statistical Abstract of the U.S.*, and *World Almanac*. The input price index for each airline was obtained from Oum and Yu (1995) for the 1990–1993 period, but the index for 1994 was not available in their study. Instead, we estimated, based on their results for the 1980–1993 period, the 1994 input price index for each airline. The data on both an airline's average aircraft size on each route in each year and distance between cities in each year were computed from *Traffic by Flight Stage*. Table I shows descriptive statistics for the variables considered.

[6] The U.S. Department of Transportation's Origin-Destination survey data can be considered as an alternative database. This survey is a 10 per cent random sample of all tickets that originate within the U.S. on U.S. carriers. The critical problem of these data, however, is that they do not contain information on passengers to and from the U.S. when their entire trips are on foreign carriers.

Table I. Descriptive statistics

Variable	Mean	Standard deviation	Maximum	Minimum
Air fare (US$)	551	126	947	274
Route total passenger	331,950	349,030	1,382,900	15,086
Average passengers per carrier	90,675	79,854	480,110	7,461
Average flights per carrier	467	398	2,552	74
Route distance (km)	6,440	1,009	8,809	5,254
Market share (%)	0.31	0.19	1.00	0.10
No. of carriers	3.66	1.68	8	1

IV. Estimation Results

1. Variables in the Demand Equation

The model, consisting of Equations (7) and (8), is estimated using Nonlinear Three-Stage Least Squares. The estimation results are provided in Table II. Since the demand equation is specified as log-linear, the coefficient of $\ln P$ is the average price elasticity of aggregate demand on the gateway routes under consideration. The price elasticity is estimated as -1.074 and highly statistically significant, indicating that, on average, a one per cent increase in fare results in a 1.074 per cent decrease in demand on the route. The population elasticity is estimated as 1.433. Most route dummy coefficients are estimated as statistically significant, implying that unobserved variations across routes are controlled by incorporating these dummy variables into the model.

The coefficient of BAUS is estimated as 0.126 and significant at the 5% level. This means that the aggregate demand function on the trans-Atlantic routes, onto which USAir fed its domestic traffic for BA during the post-alliance period, was shifted upward by about 13 per cent over the pre-alliance demand level. This estimation result is consistent with BA's argument that connecting traffic between BA and USAir doubled in 1994–1995 and amounted to about 375 passengers every day on average (*BA Fact Book*, 1995). Since USAir fed its domestic traffic onto BA's flights between U.S. gateways and London, BA could take advantage of high traffic density on the trans-Atlantic routes.

The coefficient of DLNR is estimated as -0.250, implying that the post-alliance demand on the alliance routes decreased by 25 per cent on average from the pre-alliance demand. The reason may be explained from the following observations. First, until recently, each of the partners had not fed its domestic or intra-continental traffic onto its partner's trans-Atlantic flights between the U.S.

Table II. The estimation results[a]

Variable	Estimate	*t*-stat	Variable	Estimate	*t*-stat
Demand Equation			*Price Equation*		
Constant	−21.170	−0.93	Constant	98.083	2.75***
ln (P)	−1.074	−6.50***	ln (Q_i)	0.299	0.95
ln (POP)	1.433	1.90*	ln (INP)	0.009	0.86
ln (INC)	−0.036	−0.06	ln (DST)	−10.421	−2.49***
			ln (SIZE)	−0.558	−1.82*
BAUS	0.126	2.04**	BPAR	−0.117	−1.33
DLNR	−0.250	−3.39***	DPAR	−0.189	−2.09**
KLNW	0.354	5.16***	KPAR	−0.218	−1.94*
LHUA	0.132	1.84*	LPAR	0.092	1.40
			BA	−0.234	−1.78*
			CO	0.381	1.43
			DL	0.060	1.63
			KL	0.147	2.37***
			LH	0.146	2.14***
			NW	−0.272	−2.08***
			PA	0.157	1.84*
			SN	0.170	2.67***
			SR	−0.006	0.08
			TW	0.226	3.47***
			UA	0.026	0.74
			VS	0.154	1.56
YR91	−0.033	−0.81	YR91	0.121	3.38***
YR92	0.003	0.03	YR92	0.031	1.04
YR93	−0.115	−0.81	YR93	−0.066	−2.05**
YR94	−0.084	−0.40	YR94	−0.047	−0.97
R^2		0.99	R^2		0.98

[a] To conserve space, the estimates of route-dummy variables are reported here. The results are available upon request.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

and Belgian (or Swiss) gateways.[7] Second, the partners reduced the number of their combined flights in such a way that one carrier stopped flying on a route and bought a block of seats in its partner's flights on the route. For example, both DL and SR provided daily non-stop service on the New York-Zurich route in July 1992

[7] Checking the July 1996 issue of OAG, we found that DL/SN/SR partners expanded their trans-Atlantic alliance routes to a number of destinations in Belgium, Germany, and Switzerland via Brussels, Geneva, and Zurich and that they did not expand their trans-Atlantic alliance routes to U.S. domestic cities via DL's hubs.

(pre-alliance), but only SR continued to provide daily flights in the market in July 1993 (post-alliance).

The coefficients of KLNW and LHUA are estimated as 0.354 and 0.132, respectively, implying that aggregate demands increased by 35 per cent and 13 per cent on the respective alliance routes. These alliance partners linked up their existing networks so that each partner was able to reach further distant points through its partner's hub(s). Furthermore, they provided at least the same number of flights as before their alliance. The successful network linkage and enhanced frequency would allow the partners to feed more traffic to each other, resulting in increases in demand for travel on the partner airlines and thus increases in aggregate demand on the routes.

2. Variables in the Price Equation

As shown in the price equation of Table II, many of the coefficients of the carrier-specific, year-specific, and route-specific dummy variables are estimated as statistically significant, implying that unobserved variations across carriers, years, and/or routes are captured by these dummy variables.

One interesting piece of information is obtainable from the estimated price equation. As shown in Equation (4), we can estimate an airline's markup ratio on a route on the basis of the estimate of the price elasticity and its market share on the route. Evaluating the market share at the mean, we estimated the average markup ratio as 1.41. This indicates that the North Atlantic airlines charged a markup of 41 per cent above their marginal costs.

Turning to the alliance variables, the estimated coefficient of DPAR is −0.189 and significant at the 5% level. This means that the partners decreased fares by about 19 per cent on the alliance routes during the post-alliance period. To better understand the sources behind the fall in fares, we conduct a scenario analysis for each observation for the DS/SN/SR alliance. First, using the estimation result in the price equation, we generate with- and without-alliance fares and decompose them into corresponding marginal-cost and markup-ratio parts, respectively. Next, we compute the changes in alliance fares, marginal cost, and markup ratio due to the alliance. Finally, we compare the changes before and after the alliance. Following this scenario analysis, we find that the marginal cost decreased by 46 per cent while the markup ratio increased by 51 per cent during the post-alliance period. Notice that the collusive pricing behavior showing up in the markup term is revealed through an increase in the market share of the partner carriers after the alliance (with the alliance being treated as a single carrier): the alliance had experienced a 21 per cent increase in market share. Since decreases in the marginal cost dominate increases in the markup ratio, the fares are estimated to decrease by about 19 per cent during the post-alliance period.

One channel through which the DL/SN/SR partners could reduce their combined cost on the existing alliance routes is to utilize their "extra" resources such as aircraft and flight attendants freed from one alliance route to serve another alliance route. For example, in July 1992, both DL and SN provided daily non-stop services on the New York-Brussels route, but neither of them provided non-stop services on the Atlanta-Brussels route. After the alliance, DL stopped flying non-stop services on the New York-Brussels route, but still served the route by using SN's block of seats. In addition, DL could provide new daily non-stop services on the Atlanta-Brussels route where SN could also provide new daily non-stop services by using DL's block of seats.

The coefficient of KPAR is estimated as -0.218 and significant at the 10% level, showing that the partners decreased fares by about 22 per cent on the alliance routes. Further examination of the marginal cost and markup ratio, similar to the DL/SN/SR case, reveals that following the alliance, the marginal cost decreased while the markup ratio increased (associated with a 23 per cent increase in market shares). This again is a case in which after the alliance, decreases in the marginal cost dominate increases in the markup ratio. Recall that until 1996, this alliance was the only alliance granted antitrust immunity by the U.S. The immunity allows the partners to enjoy greater integration of their operations in various areas than would be obtainable without antitrust immunity. The partners may also take advantage of higher traffic density through the linkage of their existing network and codesharing operations. To check this, we compare pre- and post-alliance load factors on the alliance routes. We find that the partners significantly increased their combined load factor from 71 per cent to 76 per cent after the alliance.

The estimated coefficients of BPAR and LPAR are statistically insignificant. As discussed earlier, the BA/USAir alliance is a one-sided alliance by BA on USAir's flights within the U.S. The insignificance of the estimated coefficient of BPAR may be because the partners did not significantly integrate their operations on the trans-Atlantic routes. The insignificance of the LPAR coefficient may be related to the fact that this alliance had been recently formed. Although the LH/UA alliance is similar to the KLM/NW alliance in the sense that the partners link their existing networks, the number of observations for the LH/UA alliance may be insufficient to examine the price effect of structural changes.

3. Effects on Equilibrium Fares and Passenger Volume

Since the KLM/NW alliance shifts the aggregate demand function upward and the price function downward, passenger volume increases after the alliance. Their fares, on the other hand, may increase or decrease depending on the slope of the price equation. Given that the estimated price equation has a positive slope but is fairly flat, the fares are likely to fall. As for the BA/USAir and LH/UA alliances, equilibrium fares are likely to rise since these alliances shift up aggregate demand functions. Whether equilibrium passenger volume increases or decreases due to the DL/SN/SR alliance is unclear, since this alliance shifts the aggregate demand and price equations downward simultaneously.

In order to measure changes in equilibrium air fares and passenger volume due to the four alliances, we thus need to compare the equilibrium with the alliance (Q_1 and P_1) to one without it (Q_0 and P_0). The without-alliance equilibrium in a particular market is what would have happened if no such alliance had existed in the market. To accomplish this, we rearrange (7) and (8) to yield equilibrium air fares and passenger volume:

$$\begin{aligned} \Delta Q &\equiv Q_1 - Q_0 = [\exp(A_1) - \exp(A_0)] \exp(\alpha_0 + A_c) P^{\alpha_1} \\ \Delta P &\equiv P_1 - P_0 = [\exp(B_1) - \exp(B_0)] \exp(\alpha_0 + B_c) P^{\alpha_1} \end{aligned} \quad (9)$$

where A_1 and B_1 are the terms where variables associated with alliances in the aggregate demand and price equations are units, A_0 and B_0 are the terms where variables associated with alliances in the two equations are zero's,

$$A_c \equiv \alpha_2 \ln \mathrm{POP} + \alpha_3 \ln \mathrm{INC} + \sum R_j RT_j + \sum Y_t YR_t,$$

and

$$B_c \equiv \beta_2 \ln \mathrm{INP} + \beta_3 \ln \mathrm{DST} + \beta_4 \ln \mathrm{SIZE} + \sum f_i F_i + \sum r_j RT_j + \sum y_t YR_t.$$

We calculate ΔP and B_1 values for each of 100 post-alliance data points based on the previous estimation results, and then treat each of these calculated values as an "observation" consisting of a common element and an error. We therefore convert (9) into the following stochastic specifications: $\Delta Q = \Delta q + u_q$ and $\Delta P = \Delta p + u_p$ where Δq and Δp are the expected values of passenger volume and price differences between with- and without-alliance equilibria, and u_q and u_p are random deviations of ΔQ and ΔP from their expected values with mean zero. We estimate the mean and standard deviation of Δq and Δp, and then test the null hypotheses that there are no changes between with- and without-alliance equilibria. The test results are reported in Table III.

For the BA/USAir and LH/UA alliances, the mean values for Δq are estimated as 65,626 and 25,616, respectively. This means that equilibrium passenger volume increased by 65,626 and 25,616 annually in the markets where these alliances occurred. For the KLM/NW alliance, the mean values for Δq and Δp are estimated to increase annual volume by 46,866 passengers and to decrease fares by \$99 in the markets where the alliance occurred. For the DL/SN/SR alliance, however, the mean values for both Δp and Δq are estimated as negative. Although this alliance lowers fares by taking advantage of the "integrated" operation, the traffic rise stimulated from lower fares is not enough to outweigh the demand loss resulting from the reduction in their combined flight frequency. As a result, this alliance decreased annual passenger volume by 28,863 on average.

Without distinguishing alliances, total Δp and Δq are also estimated to see the overall pattern of changes in equilibrium passenger volume and air fares. Overall,

Table III. Changes in price, output, and consumer surplus due to the alliances[a]

Alliance	Mean	Standard deviation	t-stat
BA/USAir ($n = 41$)			
Δq	65,626	53,020	7.9***
ΔCS (thousand)	229,260	27,407	8.4***
DL/SN/SR ($n = 20$)			
Δq	−28,863	13,276	−9.7***
Δp	−89.7	66.9	−6.0***
ΔCS (thousand)	−120,720	11,443	−10.5***
KLM/NW ($n = 23$)			
Δq	46,866	46,663	4.8***
Δp	−98.8	70.9	6.7***
ΔCS (thousand)	193,510	31,544	6.1***
LH/UA ($n = 16$)			
Δq	25,616	2,348	43.6***
ΔCS (thousand)	122,380	1,392	87.9***
TOTAL ($n = 100$)			
Δq	35,998	53,971	6.7***
Δp	−40.7	64.8	−6.3***
ΔCS (thousand)	130,210	18,852	6.9***

[a] $\Delta p = 0$ for BA/USAir and LH/UA since the coefficients of BPAR and LPAR in the price equation are estimated as insignificant.
*** $p < 0.01$.

the equilibrium annual passenger volume increased by an average of 35,998 passengers, while the equilibrium air fares decreased, on average, by $41 on the routes under consideration.

4. Effects on Consumer Surplus

Since the KLM/NW alliance is estimated to increase passenger volume and decrease air fares on the alliance routes, consumers in these markets are better off due to the alliance. Similarly, it is expected that consumers are better off in the markets where the BA/USAir and LH/UA alliances occurred. It is not clear, however, whether consumers are better off due to the DL/SN/SR alliance as compared to the without-alliance situation.

Defining ΔCS as the consumer-surplus difference between with- (CS_1) and without-alliance equilibria (CS_0), we can derive:

$$\Delta CS \equiv CS_1 - CS_0 = [\exp(A_1) - \exp(A_0)]\exp(\alpha_0 + A_c) \times \left[\int_{p_1}^{\overline{p_1}} x^{\alpha_1}\,\mathrm{d}x - \int_{p_0}^{\overline{p_0}} y^{\alpha_1}\,\mathrm{d}y\right], \quad (10)$$

where $\overline{p_1}$ and $\overline{p_0}$ are upper-bound prices satisfying $\exp(\alpha_0 + A_c)\exp(A_1)p^{\alpha_1} = 1$, respectively.[8]

As shown in Table III, the four alliances as a whole resulted in additional consumer benefits of \$130 million per year during the post-alliance period. This increase in consumer surplus amounts to a 12 per cent increase as compared to the without-alliance situation (about \$1.01 billion). But, not every alliance increased consumer surplus when one examines the change in consumer surplus affected by each alliance. The alliances of BA/USAir, KLM/NW and LH/UA are estimated to increase consumer benefits by \$223 million, \$193 million, and \$122 million respectively, while consumer surplus is estimated to fall by \$120 million due to the DL/SN/SR alliance.

V. Concluding Remarks

Bilateral air service agreements perhaps are the most serious impediments to the expansion of international aviation today. Air carriers cannot simply fly wherever they want and buy whichever carriers they like, owing to bilateral restrictions and foreign-ownership laws. The observed response by air carriers appears to form strategic alliances with foreign carriers. Using panel data for the 1990–1994 period, this study examines the effects of four major strategic alliances on air fares, passenger volume, and consumer surplus in the gateway markets so as to shed light on whether the increase in post-alliance route concentration should be viewed as a cause for concern.

Our main findings are as follows. First, the alliances of BA/USAir, KLM/NW and LH/UA increased aggregate demand on the routes where these alliances occurred, during the post-alliance period. The DL/SN/SR alliance, however, decreased aggregate demand on the alliance routes during the post-alliance period. Second, the KLM/NW and DL/SN/SR alliances reduced the partners' air fares by 22 per cent and 19 per cent on their alliance routes, respectively, during the post-alliance period. In both cases, the partners' market power appeared to increase in the gateway markets following the alliances, but it was dominated by the reduction in costs, resulting in the decreases in fares. Third, by comparing with-

8 We note that the increase in consumer surplus may be overestimated because of the specification of the demand equation. The slope of the constant-price-elasticity demand approaches infinity in magnitude as Q, the number of passengers, approaches zero, causing a very large consumer surplus for small values of Q. To alleviate this problem, we truncated the consumer surplus expression at $Q = 1$.

and without-alliance equilibria it was found that, on average, the annual passenger volume increased by some 36,000 passengers and the fares decreased by $41 on the alliance routes. Finally, the nature of an alliance may determine whether it is beneficial to consumers. In particular, if an alliance is largely a complementary alliance (BA/USAir, KLM/NW, LH/UA), it is likely to increase total output and consumer surplus. On the other hand, if an alliance is a parallel alliance (DL/SN/SR), it is likely to reduce total output and consumer surplus. Taken as a whole, consumers in the North Atlantic alliance markets were generally better off due to the four alliances under examination.

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