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What if the European Airline Industry had **Deregulated in 1979?: A Counterfactual Dynamic Simulation***

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ABSTRACT

Studies in industrial organization predict rapid consolidation following deregulation to seize economies of scale. The European airlines, while witnessing some strategic movement, have remained remarkably stable in the wake of deregulation. By contrast, the US industry underwent deregulation beginning in late 1978 and experienced a vigorous shakeout. This begs the question: if Europe had deregulated in 1979 alongside the US, how would have the European industry fared without the American experience in hindsight?

We developed a dynamic industry model to answer this question, simulating for optimal levels of operational variables, namely level of employment, network size, and fleet size for the period 1979–1990. The study reveals which European airlines were operating most inefficiently by comparing the simulation results with the actual numbers. Our findings point to several sources of forgone profits, in particular to the need for the European carriers to adopt policies which allow them to take advantage of returns to density by network reconfigurations brought about by code-sharing arrangements.

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^{*} The findings and interpretations reflected in this article do not reflect in any way those of Ernst and Young, LLP, Houston, Texas.

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1 INTRODUCTION

The European airline industry was traditionally sheltered from competition due to its state-owned national carriers and inflexible bilateral agreements. Consequently, the market structure developed brought with it market distortions and inefficiencies. The airfares proved it – fares were consistently higher than those charged for equidistant routes in the US. Case in point: When the Federation of European Consumers planned a conference in 1984, they calculated it would be cheaper to fly all their delegates to Washington, DC than to convene anywhere in Europe (Sampson, 1984).

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10 The liberalization movement, achieved in three reform packages between 1987 and 11 1992, successively eased the airline industry's straight jacket, creating a competitive mar-12 ketplace centered on a profit-maximizing business model rather than the old rent-seeking 13 one. History has shown us that rapid consolidation follows on the heels of deregulation, 14 as firms exploit economies of scale (Bannerman, 2002). Yet, while witnessing some 15 strategic movement, the European industry has remained remarkably stable in the wake 16 of deregulation. By contrast, the US industry underwent deregulation beginning in late 17 1978 and experienced a vigorous shakeout. This begs the question: if Europe had dereg-18 ulated in 1979 alongside the United States, how would have the European industry fared 19 without the American experience in hindsight? 20

We developed a dynamic model of the industry in response, simulating for optimal levels of operational variables, namely employment, network size, and fleet size for the period after the US deregulatory initiatives took hold and before the European deregulatory transition began, the period from 1979 to 1990. The study reveals which European airlines were operating most inefficiently by comparing the simulation results with the actual levels of input use.

A number of dynamic industry models have been proposed and estimated. Early work by Jovanovic (1982) modeled a perfect foresight equilibrium industry structure in which efficient firms grow and survive, while the inefficient firms decline and exit the industry. In this model, firms learn about their efficiency as they operate in the industry. Firms decide to enter or exit the industry based on a comparison of the value of staying in the industry and behaving optimally with the discounted present value of the opportunity cost associated with the firm's fixed factor, such as managerial ability or advantageous location. The latter example of a fixed factor is clearly applicable to the European airline industry, where congestion at most major airports has made gates and landing slots coveted fixed factors. Research on industrial evolution has since focused on the relationship between firm size and growth (Evans, 1987a,b; Hall, 1987), endogenous learning (Pakes and Ericson, 1998), and in endogenizing firm strategies (Berry, 1992).

This chapter's approach builds on the intertemporally nonseparable model introduced by Hotz et al. (1988) and utilized and extended Sickles and Yazbeck (1998) and Sickles and Williams (2006). It is organized as follows. Section 2 gives an international regulatory history, for the relevant years of the study. Section 3 outlines the dynamic model and discusses the specification and estimation of its relevant components: demand, production, and cost. Section 4 discusses the data sources; Section 6 interprets the simulation results and section 6 concludes.

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2 INTERNATIONAL REGULATORY HISTORY

The Paris Convention of 1919 first gave rise to the regulation of international aviation. There it was decreed that states have the sovereign rights over the air space of their territory, which immediately involved national governments in the regulation of the industry. Fifty-two countries met at the Chicago conference of 1944 to spar over Five Freedoms of Air, the fundamental set of rights in airline economics.

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The First Freedom gave the right to fly over a third country's airspace while on an agreed service and the Second Freedom permitted the airline to land in a third country for fuel and maintenance but not pick up or discharge traffic. The Third Freedom allowed an airline to carry traffic from its own country to a second country in a bilateral. The Fourth Freedom permitted an airline to carry traffic back from that country to its own country. The Fifth Freedom permitted the transportation of traffic by the first country's airline between the second country and a third country not party to a bilateral (Taneja, 1988).

15 The key parties at the conference, the US and the UK, were at opposite ends of the economic spectrum. The US, whose civil aviation industry emerged from World 16 17 War II unscathed, sought operating freedom for its airlines under a multilateral "open skies" agreement. Smaller European countries like the Netherlands and Sweden flanked 18 this policy because they would depend heavily on Fifth Freedom traffic. The UK and 19 20 other large European countries, devastated by the war, proposed the formation of an international authority, which would regulate capacity and fares on routes, thereby giving 21 their aviation industries a chance to rebuild. 22

These opposing views could not be reconciled at the conference, and the convention ended with concordance only on the first two Freedoms. The US and the UK met in Bermuda in 1946 in an effort to resolve differences on the next three freedoms. The two countries agreed to these freedoms in a bilateral agreement (Bermuda I) on flights to and from the US and the UK. This bilateral became a model for the other countries and their respective aviation partners. It also assured that the aviation industry would be heavily regulated and quagmire in political uncertainty (Williams, 1994).

Meanwhile, the other participants of the Chicago conference created the International Air Transport Association (IATA) in Havana in 1945. The proposed plan was to fix fares jointly and submit it to governments for approval, instead of either multilateral or unilateral government imposition of fares on airlines. These fares required a unanimous vote from all members and were binding to all of these members. The US Civil Aeronautics Board (CAB) reluctantly agreed to this fare-setting environment, which remained an international fixture for the next 30 years.

The system worked fairly smoothly in Europe. The airlines were government-owned 37 and strongly opposed to any form of competition; the fare submission procedure 38 amounted to little more than a formality. The CAB was never comfortable with this 39 arrangement and often protested fare structures set by IATA. In the late 1970s, frustrated 40 by its efforts to liberalize the structure through IATA, the CAB actively began its attempt 41 to liberalize the transatlantic market by forming bilateral agreements with European 42 nations. CAB's strategy of penetrating one national market at a time and then forcing 43 liberal agreements on others through the threat of traffic diversion was successful in 44 45 opening the transatlantic market. The level of competition increased substantially with 46 the entry of new airlines into the market.

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While the CAB pried the transatlantic market open, the internal European market remained strictly protected until the mid-1980s. The European airlines were mostly public airlines or majority government-owned; they enjoyed the duopolistic situation created by the bilateral agreements and prevented new entry in the intra-European market. Pooling revenue and sharing capacity, the airlines eliminated any competition among themselves in the internal market.

The European Commission (EC) recommended opening aviation to competition as 07 early as 1972, but strong objections from the European governments tabled discussions 08 09 until 1979 when the EC published Civil Aviation Memorandum Number I. The memo recommended that (1) airlines offer cheaper fares; (2) there was a need to develop new 10 11 cross-frontier services connecting regional centers within the community; (3) a clear universal policy on government subsidies was required; and (4) full freedom of access 12 to all markets was desirable. The transportation ministers adopted these measures in 13 limited form in the early 1980s, which did marginally improve competition and lower 14 15 fares (Balassa, 1985).

The larger European nations, however, were very reluctant through the mid-1980s 16 17 to abandon the protected status of their national carriers by advocating more liberal competition policies. These governments directly or indirectly subsidized their carriers, 18 the extent of which varied from country to country. Financial assistance was provided to 19 20 (1) compensate airlines for the imposition of a public service obligation; (2) develop and 21 operate domestic services; (3) provide service to economically underdeveloped regions; (4) encourage the acquisition and operation of specific airplanes (airbus); or (5) simply 22 23 cover an airline's operating loss (Taneja, 1988).

24 EC commissioner Peter Sutherland provided the catalyst for change, threatening to 25 take the airlines to the European Court in 1987 for violation of the competition rules 26 of the Treaty of Rome. The European transport ministers met thereafter in Brussels 27 to negotiate for flexibility in setting fares. The deal allowed airlines to offer discount 28 fares - ranging between 65 and 90 per cent of the economy class fares - provided this 29 was accepted by the member states. It also allowed for an increase in capacity shares on 30 a route provided that the shares split between two countries were not outside the range of 55 to 45 per cent up to 1 October 1989, and 60-40 per cent thereafter. 31

The next round of liberalization talks ended in 1992 in Luxembourg where after 10 years of hard negotiations, the European Union finally agreed on issues that would establish a more competitive environment in European skies. The five major provisions in the deal were the following:

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 Fares: Airlines would be able to set their own prices, subject to two major controls. Brussels was empowered to limit excessive prices from being charged, following notification from national aviation authorities. It would also be able to set a baseline under fares on a specific route if prices free-fall, foisting losses to all carriers. These mechanisms were designed to obviate predatory pricing.

Routes: Consecutive cabotage rights to add a domestic leg onto a flight originating
from a carrier's home base to a foreign destination, provided that the load factor on
the domestic leg did not exceed 50 per cent of the total on the main flight. Thus, a
KLM flight from Amsterdam to Paris can pick up passengers in Paris and fly to Nice
provided that the 50 per cent rule is satisfied.

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01 3. Flights: Agreement to the Sixth Freedom (which had been in dispute since the Chicago Convention) where airlines could fly passengers to two destinations while stopping 02 at a third country, which was the airline's base. With this in place, Air France, on 03 a flight from Rome to London, could stop in Paris en route and pick up passengers. 04 The Seventh Freedom was introduced, whereby any carrier could fly between any 05 06 two EC states without the need to start or end in the home country. For example,

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ending at the two destinations. 4. Domestic services: Starting on 1 April 1997, any carrier from any EC country could operate internal flights in any of the 12 member states.

British Airways could fly between Paris and Frankfurt, with the flight originating and

5. Licensing: Common rules governing safety and financial requirements on capital adequacy for new entrants to the market. Once satisfied, they would be able to fly on any EC route under the above package (Schipper et al., 2002).

The final accord of 1992 established a beachhead in the gradual deregulation of the airline industry. Conducting reform in gradual packages was Europe's attempt to avert the "big bang" of US reform (Button and Johnson, 1998). Our dynamic industry model attempts to explain how European airline firms would have operated from 1979 to 1990 had they transitioned to deregulation in 1979, as did the US airlines.¹

THE DYNAMIC INDUSTRY MODEL 3

Our dynamic model analyzes the long-run strategies of the firms and simulates the optimal profit-maximizing levels of the operational variables for different scenarios. We assume that the airline chooses the level of employment (L), network size (N) and capital (K) to maximize the flow of expected profits

$$\operatorname{Max} E_{t} \sum_{t=\tau}^{T} \beta^{\tau-t} \Pi_{t} \left(L_{t}, N_{t}, K_{t} \right)$$

subject to a per-period asset accumulation constraint

$$A_{t+1} = \gamma_t (A_t + P_t Q_t - w_t L_t - r_t I_t)$$

where

$$O_{i} = F(K_{i}, L_{i}, N_{i}, \dots)$$

The output price is set by the inverse demand equation that is specified below. A_t are the firm's real assets in the beginning of period t, β is the discount factor, $\gamma_t = (1 + r_t)$ where r_i is the real interest rate, P_i is the price of output, and I_i is the level of investment. Other inputs such as materials are assumed to be state variables in our simulations and

A COUNTERFACTUAL DYNAMIC SIMULATION

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¹ For an extensive study of airline deregulation in Europe, see Button (1990, 2003).

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are thus not directly introduced through the production function. We assume that T is 01 finite and $Q_t = 0$ when the firm exits the industry. 02 Capital accumulation is written in terms of a perpetual inventory model: 03 04 $K_t = I_t + \alpha a_t$ 05 06 where the law of motion for a_t is 07 08 $a_t = (1 - \eta)a_{t-1} + K_{t-1}$ 09 10 Here η measures the rate of depreciation of past levels of capital stock to its current 11 level, while α is the constant capital depreciation rate. Temporal nonseparability in the 12 dynamic optimization problem comes in through the distributed lag of current and past 13 investment decisions. The dynamic programming problem is characterized by the value 14 function at time *t*: 15 16 $V_t(A_t, a_t, P_t, w_t, r_t) = \text{Max}_{I,N,K} \{ \prod_{t \in I} (L_t, N_t, K_t) + \beta E_t V_{t+1}(A_{t+1}, a_{t+1}, P_{t+1}) \}$ 17 18 The use of standard solution techniques for maximizing the value function with respect 19 to the control variables labor (L), network size (N), and fleet size (K) provides us with 20 a set of three highly nonlinear equations – Euler equations. The first-order conditions 21 expressed in the Euler equations are 22 23 $\prod_{I}(t) - \beta \gamma_{t} E_{t} \prod_{I}(t+1) \{ [w_{t} + L_{t} w_{I}(t) - P_{t} Q_{I}(t) - Q_{t} P_{O}(t) Q_{I}(t)] /$ 24 $[w_{t+1} + L_{t+1}w_{I}(t+1) - P_{t+1}Q_{I}(t+1) - Q_{t+1}P_{O}(t+1)Q_{I}(t+1)] = 0$ 25 26 27 $\prod_{N}(t) + \prod_{I}(t) \{ [P_{I}Q_{N} + Q_{I}P_{O}(t)Q_{I}(t)] / [w_{I} + L_{I}w_{I}(t) - P_{I}Q_{I}(t)] \}$ 28 29 $-Q_t P_0(t) Q_I(t)] = 0$ 30 31 32 $\Pi_{k}(t) - \Pi_{I}(t)[r_{t} + K_{t}r_{K}(t) - P_{t}Q_{K}(t) - Q_{t}P_{O}(t)Q_{K}(t)]/[w_{t} + L_{t}w_{I}(t)]$ 33 $-P_{t}Q_{I}(t) - Q_{t}P_{O}(t)Q_{I}(t)] + \alpha\beta E_{t}\prod_{K}(t+1) + [(1-\eta+\alpha)\beta]$ 34 $\times \{ \{ E_t [r_{t+1} + K_{t+1} r_K(t+1) - P_{t+1} Q_K(t+1) - Q_{t+1} P_O(t+1) Q_K(t+1)] / \}$ 35 36 $[w_{t+1} + L_{t+1}w_{L}(t+1) - P_{t+1}Q_{L}(t+1) - Q_{t+1}P_{Q}(t+1)Q_{L}(t+1)]\}$ 37 $\times E_t \prod_{I} (t+1) - E_t \prod_{K} (t+1) = 0$ 38 39 The production function is specified as a Cobb–Douglas stochastic frontier (Cornwell 40 et al., 1990) of the form: 41 42

 $\ln Q_{kt} = \ln X_{kt}\beta + \ln Z_k\gamma + \ln W_{kt}\delta_K + \varepsilon_{kt}$

 $\delta_{\kappa} = \delta_0 + u_{\mu}$

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where the subscripts $k = 1, \ldots, N$ and $t = 1, \ldots, T$ refer to firm and time, respec-01 tively. X_{kt} is a vector of inputs, W_{kt} is a vector of other firm characteristics, and Z_k 02 is a vector of explanatory variables, which have different effects for different firms. 03 The unobservable effects, δ_k , can be correlated with other explanatory variables and 04 can interact with selected slope and intercept terms. This allows for the endogeneity of 05 variables such as load factor and network size with respect to the firm specific statistical 06 error. The disturbance term u_{kt} is assumed to be an independent and identically dis-07 tributed (i.i.d.) zero mean random vector with covariance matrix Σ_u . The disturbances 08 ε_{kt} are taken to be i.i.d. with zero mean, constant variance σ_{k}^{2} , and uncorrelated with 09 both the regressors and u_{kt} . Total revenues can then be calculated at time t by specifying 10 the factor market demand equation while total profits at time t can be obtained by 11 specifying a total cost function. 12

To close our dynamic model, we must specify the demand and cost equations. We use the approach adopted by Captain and Sickles (1997). For an alternative dynamic two-stage game for the European industry, see Roeller and Sickles (2000).

First, consider the cost function. Suppose an industry in which N firms produce a differentiated output, q, using n inputs, $x = (x_1, \ldots, x_n)$. The market demand function facing firm k at time t is of the form²:

$$q_{kt} = q_k(p_t, p_{mt}, Y_t, \delta, e_{dt})$$

where p_{mt} is an index of all the other firms' prices, Y_t are the other variables (measured on the country level) shifting demand, δ are unknown parameters of the demand function and e_{dt} are the disturbances. Perceived marginal revenue is

$$PMR = p_t + D_1 q_{kt}$$

The cost function facing firm k is

 $C_{kt} = C_k(q_{kt}, W_{lt}, Z_t, \gamma, e_{ct})$

where W_{lt} is the vector of factor prices paid by firm k at time t, Z_t are the other industry variables shifting cost, γ are unknown parameters of the cost function, and where $D_1 = \partial p_{kt} / \partial q_{kt}$. Marginal cost is written as:

$$MC = C_1(q_{kt}, W_t, Z_t, \gamma)$$

The firm chooses optimal output where MC is equal to perceived marginal revenue in an oligopolistic industry (PMR = p in a perfectly competitive setting). Thus, the quantity-setting condition is

$$C_1(q_{kt}, W_t, Z_t, \gamma) = p_t + D_1(p_{kt}, p_{mt}, Y_t, \gamma, e_{dt})q_{it}\theta$$

The parameter θ is an index of the competitive nature of the firm. If $\theta = 0$, price equals marginal cost and the industry is perfectly competitive, while $\theta = 1$ is consistent with

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² For different forms of this model, see Bresnahan (1989).

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Nash behavior. In a price-setting game, the first-order conditions for profit maximization imply

$$\frac{\partial q_{kt}}{\partial p_{kt}} p_t + q_{kt} - \frac{\partial C_{kt}}{\partial q_{kt}} \frac{\partial q_{kt}}{\partial p_{kt}} = 0$$

Summing over the N firms, we have $Q_t = \sum_k q_{kt}$ and thus

 $\frac{\partial Q_t}{\partial p_t} P_t + Q_t - \sum_k \frac{\partial C_{kt}}{\partial q_{kt}} \frac{\partial q_{kt}}{\partial p_{kt}} = 0$

$$P_t = \frac{\partial C_{kt}}{\partial q_{kt}} - \frac{Q_t}{\frac{\partial Q_t}{\partial p_t}}\theta$$

The market demand function is specified as semilogarithmic,

 $\ln q = d_0 + d_1 P + d_2 P_{\text{index}} + d_3 \text{ GDP} + D_4 \text{ GASP} + d_5 \text{ GCONS} + d_6 \text{ PRAIL} + e_d$

where q is the output of firm k, P is the price of firm k, P_{index} is an index of the other N-1 firms' prices, GDP is Gross Domestic Product, GASP is the retail price of gasoline (inclusive of taxes) and PRAIL is the price of rail travel. The behavioral equation which identifies the degree of competition is $P = \text{MC} - \Theta/d_1 + e_B^3$.

The costs are specified using the translog cost function:

$$\ln C(p, q) = \ln a_0 + \sum_i a_i \ln(P_i) + \frac{1}{2} \sum_i \sum_j b_{ij} \ln(P_i) \ln(P_j) + b_q \ln(q)$$
$$+ \frac{1}{2} b_{qq} \ln(q)^2 + \frac{1}{2} \sum_i b_{qi} \ln(q) \ln(P_i) + \Gamma + e_c$$

Here, the inputs are capital (*K*), labor (*L*), and materials (*M*). The prices of the inputs are P_K , P_L , and P_{M} , respectively. The term Γ contains heterogeneity controls for service and capital characteristics, which are added linearly and include the (natural logarithm) ln(average stage length), ln(network size), ln(load factor), percentage of planes that are wide-bodied, and percentage of planes that are turbo prop. Applying Shephard's Lemma, the factor share equations are linear functions in the parameters. Since the sum of the cost shares over all equations always equals 1, and only two of the three share equations are linearly independent, for each observation the sum of the disturbances across equations must always equal zero. Linear homogeneity and symmetry are imposed parametrically. The system of five equations – translog cost, labor share, capital share, demand and behavior – are estimated by iterative nonlinear three-stage least squares, treating output price and quantity (*p*, *q*), cost (*C*), labor share (lshare), capital share (kshare), and the

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⁴⁴ ⁴⁵ ³ The behavioral equation is $p_t = \frac{\partial C_t}{\partial q_t} - \frac{q_t}{\frac{\partial q_t}{\partial p_t}} \theta$. Given the semi-log demand specification, $\frac{\partial \ln q_t}{\partial p_t} = d_1 \Rightarrow \frac{\partial q_t}{\partial p_t} = d_1$ ⁴⁶ $q_t d_1 \Rightarrow p_t = \text{MC} - \frac{\theta}{d_1}$.

01 price of labor (p_1) as endogenous and all others as exogenous (the standard panel data firm fixed effects has been specified in the cost equation). Endogeneity of the 02 labor's price is due to the strong national carrier status of the European carriers over the 03 sample period and the use of the national carriers to pursue macroeconomic employment 04 stabilization policies. Based on the parameter estimates obtained from these production, 05 06 cost, and demand equations, the Euler equations were simulated with the Gauss-Newton 07 algorithm in the SAS system, for optimal levels of labor, network, and fleet. Data sources are discussed in the next section. 08

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4 DATA

This study uses a panel of seven European carriers with their ticket codes: Air France (AF), Alitalia (AZ), British Airways (BA), Iberia (IB), Royal Dutch Airline, KLM (KL), Lufthansa (LH), Scandinavian Airlines System, SAS (SK), and Sabena (SN), with annual data from 1976 to 1990. The series follows these carriers during the period just following the deregulation of airlines in the US and prior to the beginning of deregulation in Europe. Network alliances in Europe were just beginning to take shape in 1989 and 1990 (e.g., the Northwest Airlines KLM alliance). These alliances have become a standard in the international airline industry (see Table 1). Our measures for system size based solely on the carrier's physical network begins to lose validity as the alliance provides benefits of network size (passenger feed) without the accounting for the resources necessary to produce it.

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Table 1	Airline	Alliances	in	2006
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29	oneworld	SkyTeam	Star Alliance
30	Aer Lingus	AeroFlot	Air Canada
31	American Airlines	AeroMexico	Air New Zealand
32	British Airways	Air France	Asiana
33	Cathay Pacific	KLM	Austrian
34	Finnair	Alitalia	bmi British Midland
35	Iberia	Continental	LOT Polish Airlines
36	LAN Chile	CSA Czech Airlines	Lufthansa
37	Qantas	Delta	SAS Scandanavian Airlines
38		Korean Air	Singapore Airlines
39		Northwest Airlines	South African Airlines
40			Spanair
11			SWISS
			TAPPortugal
-2			Thai
3			US Airways
4			United
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Source: oneworld, Sky Team, Star Alliance websites May 31, 2006

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The primary source for the input, output, expense, and revenue data was the *Digest* of *Statistics* from the International Civil Aviation Organization (ICAO). This was augmented using output characteristic data from IATA *World Air Transport Statistics*, asset valuation data from the *Avmark Newsletter*, purchasing power parity information from the Penn World Table, and demand data from the Organization for Economic Cooperation and Development (OECD) publication *Historical Statistics*. The data is sketched in this section with readers interested in reconstructing or extending this series directed to Good et al. (1993a). The data can be organized into three broad categories: inputs and expenses, outputs and their characteristics, and demand side market conditions.

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4.1 Input and Expense Data

14 The primary source for the input data was the *Digest of Statistics* from the ICAO. 15 It is important to note that ICAO data is voluntarily reported rather than being an artifact of international regulatory requirement. When carriers decline to submit their 16 17 information, we obtained data from alternative sources, often carrier annual reports. The model assumes airline production is a function of three inputs: labor, materials, and 18 19 aircraft fleet. The labor input is an aggregate of five separate categories of employment 20 used in the production of air travel. Included in these categories are all cockpit crew, flight attendants, mechanics, sales and promotional personnel, and other employees 21 22 including general administration and aircraft and passenger handlers. Expenses for these categories included fringe benefits in addition to salaries. Quantity and implicit price 23 24 indices, L and PL, were constructed based on these five subcomponents using a Divisia 25 multilateral index number procedure (Caves et al., 1982). So that our simulations are 26 more interpretable as number of employees, these indices have been rescaled so that the average quantity index is equal to the average number of employees. 27

We are primarily interested in the portion of capital that comprises the carrier's fleet. 28 Ground-based capital is incorporated into the aggregate materials indices described later. 29 30 The number of aircraft by type is obtained from the *Digest of Statistics* for the beginning and end of year. Our quantity measure is the average of these two values. An effective 31 rental price for this fleet is constructed by valuing each type of aircraft at its used 32 equipment price (the average for each year of the Avmark Newsletter), and using the 33 Jorgenson-Hall user price formula, the carrier's home country's short-term commercial 34 35 paper interest rate, and a declining balance depreciation schedule with a remaining asset life of 20 years. In addition, two characteristics that summarize the potential productivity 36 of the fleet are provided: the per cent of the fleet, which is wide bodied, and the per 37 cent using turboprop propulsion. The proportion of fleet that is wide-bodied, PWIDEB, 38 provides a crude measure of average equipment size. We define wide-bodied aircraft as 39 those having two aisles. It is generally accepted that there are economies of equipment 40 size as resources for flight crews, passenger and aircraft handlers, landing slots, and 41 so on do not increase proportionately. The per cent turboprops, PTURBO, provides 42 another measure of the mix of capital available to the carrier. Together, our three capital 43 variables describe both the quantity of capital and the kinds of missions they are suited 44 45 to serve: turboprop aircraft ideal for low-density short haul routes, wide-bodied aircraft ideal for high-density long haul routes, and narrow-body jets, ideal for medium-haul 46

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- routes. We should note that by the beginning of our time frame, long-haul narrow-bodied
 jets (1950s vintage aircraft like the Boeing 707, Douglas DC-8, SUD Caravelle and
 de Havilland Comets) were in the process of being phased out, and regional jets had
 not yet been widely adopted (the smallest jets in our sample being the BAC-111 and
 Fokker F28).
- The purchase of equipment over the study period was dominated by strong brand 06 loyalty: SAS, Iberia, and Alitalia continued to purchase mostly Douglas aircraft while 07 Air France, British Air, KLM, and Lufthansa continued to purchase predominately 08 equipment from Boeing. It is important to note that Airbus was essentially a one aircraft 09 type manufacturer (the A300) over the bulk of our study period. The A310 introduced 10 in 1985 was essentially a modified version of the same plane. In that regard, Airbus 11 was much more like Lockheed than it was like Douglas or Boeing. It was not until the 12 mid-1990s with the introduction of the A320, A330, and A340 families of equipment 13 that they spanned the range of small narrow bodied to large wide-bodied equipment 14 and became the across the board competitors that they now are. Even given this severe 15 limitation, they made significant inroads in European fleets. When one considers all 16 acquisitions (purchases or leases) compared to retirements (sales, retirement, or returns 17 to the leasing company), Airbus was able to add 127 aircraft to the fleets of these eight 18 carriers (155–28). At the same time, Boeing was able to add net 206 aircraft (547–341). 19 Douglas added only 6 aircraft (269–263), while there was a loss of 27 from all other 20 manufacturers (185-212). 21
- The materials component is summarized as price and quantity indices that aggre-22 gate several subcomponents. The source for expense information is ICAO's Digest of 23 Statistics, Financial Data. This is supplemented with either physical quantity or price 24 information from another source to identify price quantity pairs for each material's sub-25 component at each year for each carrier. The largest component of materials is aviation 26 fuel with price information provided by ICAO's Regional Differences in Fares and 27 Costs Report, under the presumption that a carrier will purchase fuel at many differ-28 ent countries in the European region. Expenses for landing fees and en route traffic 29 control facilities are paired with aircraft departures from ICAO's Commercial Airline 30 Traffic Series. The resulting prices can be considered rental expenses for this publicly 31 owned capital. Expenses for carrier owned ground-based capital services are based on 32 a Jorgensen-Hall user price using depreciated book value, for nonflight capital from 33 ICAO's Digest of Statistics, Financial Data, a 7 per cent annual depreciation rate, and 34 the individual carrier's interest rate on long-term debt. The remaining materials and 35 services including passenger food, maintenance materials, and outside services including 36 commissions and other services are pooled into a residual materials category using the 37 carrier's home country purchasing power parity (Summers and Heston, 1991) from the 38 Penn World Table Mark 5.2 as a price deflator. The price index for materials, PM, is 39 normalized to 1 for the sample average and consequently the implicit quantity index, 40 *M*, is normalized for average materials expenditures. 41
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4.2 Output, Revenue, and Output Characteristics

The airline services actually sold (revenue output) are based on three subcomponents: scheduled passenger and excess baggage, scheduled freight and mail, and nonscheduled

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01 services. Sources for revenue and physical output are based on ICAO's Digest of Statistics, Financial Data and Commercial Airline Traffic Series. Unfortunately, data 02 availability leaves us with aggregate revenues for small amounts of cargo services (e.g., 03 excess baggage or charter cargo) with passenger traffic for some carriers. This aggre-04 gation is carried out under the widely used convention that one revenue passenger 05 kilometer is equivalent to 0.090 t km (or one passenger and standard baggage averages 06 approximately 200 lbs). This has the effect of combining the three subcomponents into 07 the same physical units, which are then aggregated using a multilateral index process 08 normalized to an average price of 1 across the sample. 09

Three characteristics of output are also used in our analysis. The load factor, LOADF, 10 is the ratio of passenger output sold to total passenger output produced. In the American 11 context, low load factors are a traditional indication the level of service is too high. 12 Since the structure of European competition is more collusive, one might expect that 13 load factors might be higher than optimal and that the price is too high and level of 14 service is too low. As Figure 1 points out, trends for load factor among European carriers 15 closely follow that for their American counter parts. Among US carriers, load factor 16 increased from approximately 52 per cent in the beginning of our study period to roughly 17 67 per cent in 1990. This is as one would expect given that the European system had 18 no competition on inter-European routes with revenue sharing, resulting in, few flights, 19 high fares, and relatively full planes. 20

Stage length, STAGEL, is the ratio of aircraft miles flown to aircraft departures. Typically, longer routes require fewer resources per amount of output produced. Finally, a measure of overall network size, NETSIZE, is the number of route kilometers and is provided by the International Air Transport Association (IATA) *World Air Transport Statistics*. NETSIZE is the only systematic measure across carriers and over time that





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we access from publicly available data sources. The measure is the sum of the distances
 for all unique routes in the carriers network. When used in an estimated equation that
 incorporates both lnQ and lnNETSIZE, it has the implicit effect of including network
 density in the model.

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4.3 Demand Data

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Data important for describing the demand for travel was collected for the home countries of each of our carriers. A weighted sum of the three Scandinavian countries, Denmark, Sweden, and Norway, was used to represent the home country of SAS with GDP used to form the weights.

The Gross Domestic Product, GDP, was obtained from the Main Economic Indi-12 cators publication of the Economics and Statistics Department of the Organization 13 for Economic Co-Operation and Development (OECD) and provides an overall scale 14 for economic activity in the demand equation. They were reported for the above 15 countries in billions of dollars. The OECD Economic Outlook publication Histori-16 cal Statistics was the source of the growth in private consumption expenditure data. 17 They are reported as an implicit price index with year-to-year percentage changes. 18 The annual short-term interest rates, INTRATES, were also obtained from this publi-19 cation. The rates are reported by the respective countries on the basis of the follow-20 ing financial instruments: Belgium (3-month Treasury certificates), Denmark (3-month 21 interbank rate), France (3-month Pibor), Germany (3-month Fibor), Italy (interbank 22 sight deposits), Netherlands (3-month Aibor), Norway (3-month Nibor), Spain (3-month 23 interbank loans), Sweden (3-month Treasury discount notes), and the UK (3-month 24 interbank loans). 25

The European airline industry differs from the US industry in that the continent's 26 small size makes autos and rail a feasible alternative to air travel (Captain and Sickles, 27 1997).⁴ Jane's World Railways was the source of the rail data. The rail price, PRAIL, was 28 calculated as the ratio of passenger (and baggage) revenue to passenger tons-kilometers. 29 The retail gasoline price (prices plus taxes), PGASP, was obtained from the International 30 Energy Agency's publication, Energy Prices and Taxes. Finally, to capture the effects 31 of competition from other airlines, an index of the "other" airlines' prices was com-32 puted by weighting the individual prices their respective revenue shares in the market, 33 PINDEX. 34

Summary statistics for different carriers/countries are provided in Table 2.

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5 SIMULATION RESULTS

The results of the dynamic simulation are presented in graphical form in Figures 2a–c. The simulations were run with two values for α (constant capital depreciation rate), 0.12 and 0.08, β (discount factor) of 0.95, and η (rate of depreciation of past levels of capital stock to its current level) of 0.08 to solve for optimal levels of operational

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⁴⁶ Morrison and Winston (1990) and Borenstein (1992).

⁴⁵ ⁴ For a discussion of the history of US airline competition and the industry's response to deregulation see

Table 2 Carrier Spendor	scific Sample Me	an Values for M	odel Variables					
	Air France AF	Alitalia AZ	British Air BA	Iberia IB	KLM KL	Lufthansa LH	SAS SK	Sabena SN
Inputs:								
L PL (000)	34877.000 21.266	18974.000 29.480	45725.000 17.160	25127.000 19.666	20238.000 27.266	34013.000 26.253	17761.000 31.953	8971.000 23.253
M (00000) PM	1901.2 0.9718	760.6 0.8738	2631.7 0.9419	1244.7 0.7955	1100.5 0.9930	1727.7 1.0629	806.6 1.1821	586.8 0.9388
K	109.067	76.667	172.733	87.200	52.800	109.533	91.467	27.200
PWIDEB	0.4703	0.2612	0.2628	0.1729	0.4628	0.3206	0.1418	0.2771
PTURBO	0.1366	0.0275	0.1100	0.0326	0.0381	0.0155	0.0365	0.0217
Outputs:	7567 66	1269.44	3563 75	1436 13	1811 02	7534 33	1005 33	746 75
e (occord) P	1.0992	1.1777	1.1037	1.0693	0.9152	1.2503	1.4942	1.0982
LOADF	0.6586	0.6143	0.6641	0.6351	0.6444	0.6185	0.6390	0.6302
NETSIZE (000)	748.210	332.511	621.877	350.562	370.913	509.879	225.556	215.300
Demand:	0.0474	0.0367	0.0742	0.0254	0.0461	0.0517	0.0689	0.0369
PRAIL	1.1645	1.1517	1.1696	1.1621	1.1789	1.1322	1.1169	1.0192
PINDEX	0.6901	0.7995	0.5575	0.6067	0.6459	0.5474	0.6558	0.6292
GASP	653.549	495.572	527.681	224.405	162.287	819.314	259.728	108.503
GDP	0.1044	0.1459	0.1155	0.1348	0.0744	0.0624	0.0972	0.1035
INTRATES								

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A COUNTERFACTUAL DYNAMIC SIMULATION





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variables during the time period 1979–1990.⁵ The chosen parameters were consistent with industry estimates.

The simulation exposes Sabena, Alitalia, and Iberia as the carriers least primed for a deregulated airline market. Both Iberia and Alitalia have recently flirted with bankruptcy. Moreover, Iberia has also had a recent spate of what would appear to be predatory pricing, pushing partners like Viasa into bankruptcy. Sabena sold a large minority position to Air France in 1993. But shortly thereafter Air France, itself struggling mightily, divested its interest, and Swiss Air bought a 49 per cent interest in Sabena in 1995. Swissair liquidated in 2001 partially because it was unable to halt Sabena's trail of red ink.⁶ Iberia struggled with poor management and financial performance until it privatized by selling 49 per cent, including a 9 per cent stake to British Airways in 1999. Alitalia foundered in the twenty-first century, undergoing major restructuring despite compacting with Air France-KLM (itself an agreed-upon acquisition by Air France, creating the world's largest airline by revenues). It remains to be seen if Alitalia can return to profitability; more broadly, if smaller, state-owned carriers can survive in a unified European market.

To analyze the results of the simulation in-depth, the airline market in Europe should be divided according to scale of operation. Air France, British Airways, and Lufthansa were larger with similar scales of operation, while Alitalia, Iberia, Sabena, and SAS were smaller. The airlines with levels closest to the simulation results were best prepared for the competitive milieu ahead. The main stylized fact from the simulation was that the larger carriers were better prepared for deregulation than the smaller ones.

All airlines, excepting Lufthansa, employed too few workers. At first blush, growing the workforce hardly seems the way to maximize profits. A possible justification relates to powerful labor unions negotiating wages above competitive levels reducing employment below optimal levels (Captain, 1997; Good et al., 1993b). The McGowan and Seabright (1989) study evinced this phenomenon, finding labor costs for many European carriers to have been more than double the US rates.⁷

The simulation solution for fleet size suggested Air France, British Airways, Lufthansa, and SAS possessed a sizeable fleet relative to the optimal solutions, at times even exceeding the values. Conversely, Iberia and Sabena purchased few or no planes during the period studied, but should have purchased more.

As for network size, KLM and Lufthansa operated at levels close to optimal. However, for all other airlines, networks were suboptimal because they were too small over much of the sample period. Increasing the size of the network, ceteris paribus, lowers the total

⁶ See http://www.sabena.com/EN/Historique_FR.htm

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⁵ A note about the solutions: the solutions predict optimal levels of the operational variables with the assumptions that planes, people, and networks can be increased and decreased without costs.

⁴⁰ ⁷ As pointed out by a referee, staffing of flight personnel is based on regulatory requirements for particular 41 aircraft types. To address this further institutional fact, we could have allowed labor also to be quasi-fixed but this would add substantial complexity to an already complex modeling scenario. Our labor input is an 42 aggregate of five separate categories of employment used in the production of air travel. Our finding that 43 there is generally understaffing is consistent with the need for European carriers to expand their operations 44 and thus their labor requirements in general. Our model is not detailed enough to point to specific classes of 45 labor that should expand nor is it detailed enough to allow differentiation of demand for own and outsourced

⁴⁶ labor and/or endogenous wage outcomes of union/firm negotiations.

cost of the airline. This is the sine qua non of operating a viable airline, for the following
 reasons:

Hub-and-spoke operations allow airlines to concentrate traffic on certain routes, allowing both larger, more efficient planes and more frequent service. In addition, hub-and-spoke operation allows for a greater range of destinations and city-pair combinations to be served, including city-pair combinations, which would not normally generate enough traffic to justify a regular service. The addition of a new spoke to a hub-and-spoke network significantly increases the city-pair combinations served by the network, at minimal additional cost (OECD, 2000).

10 Achieving scale economies has to be through alliances because outright acquisition 11 is largely proscribed by further restrictions on foreign ownership (Staniland, 1996). 12 Integrating networks through alliances offers efficiency gains from passenger pooling 13 agreements and fungible airport gate and slot rights. Large networks also exploit cost 14 advantages, as airlines discard linear route systems in favor of the hub and spoke network 15 configuration. This adjustment derives economies of density, and higher load factors on 16 spoke routes radiating from the hub (OECD, 1988). Without alliances, deregulation in 17 Europe has the effect of reducing load factors drastically, as it did in the US failing 18 an acquisition or alliance, and deregulated markets can sink an airline, for example, 19 Pan-Am (Brueckner, 2003; Brueckner and Whalen, 2000; Levine, 1987).^{8,9}

20 As an example of Europe's first intercontinental alliance, in December 1986, British 21 Airways, with its equity wiped out by a debt burden reaching over £1 billion at one time, 22 was sold to the private sector, thus joining Swissair as the only privately owned airlines 23 at the time. To stave off its declining profitability, BA signed an alliance with United 24 Airlines. The agreement integrated United's flight schedules and networks in America 25 with BA's transatlantic services to American cities. The agreement enabled the airlines 26 to share passengers and increased the quality of service for time conscious (and high 27 margin) business travelers. As noted in the simulation, 1988 was a watershed year for 28 British Airways, as privatization quickly resuscitated the airline. Other airlines followed 29 suit and formed alliances to brace themselves for the onset of competition, learning from 30 the experience of American deregulation.

Despite deregulating, barriers remain in the aviation sector. The march towards complete deregulation in both the US and Europe is hindered by three factors: (1) limitations to existing "open sky" agreements, (2) ownership restrictions, and (3) and barriers to entry. While "open skies" means increased international competition, domestic markets

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⁸ For further research on US Domestic codesharing that closely parallels the experiences of intra-European codesharing, see Ito and Lee (2005) and Bamberger et al. (2004).

⁹ Substantial variation in the dynamic simulations occurs because the Euler equations are highly nonlinear. 39 We didn't feel "adjustment factors," such as those commonly used in dynamic nonlinear forecasts from large 40 macro models (e.g., the WEFA Quarterly Forecasts), were appropriate since they are difficult to justify on 41 any other than ad hoc grounds. That said our results make economic sense because they point out that most European airlines suffered in their ability to maximize the present value of discounted profits because their 42 networks and operational capacity were too limited during the period we studied. European airline networks 43 (excluding those for carriers that exited the industry) expanded substantially after accelerating industry reforms 44 that began around 1990. Lost profits for many of the European airlines in our sample appeared to be most 45 pronounced during the early and middle part of our sample period and by in large were trending toward 46 equilibrium at the end of the 1990s.

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remain off-limits to foreign carriers. In other words, British Airways cannot fly from New York to Los Angeles, even as a continuing flight from London (Staniland, 1996). 02 US law dictates that foreign citizens may not own more than 25 per cent of voting stock, and Europe permits no more than 49 per cent foreign ownership (Economist, 2005). Lastly, landing rights and gates at airports often are not traded freely, preventing access for new entrants (Captain, 1993). Further liberalization in these areas is needed to attain 06 more perfect competition (Postert and Sickles, 1998).

The expressed concern during the early liberalization talks was that the rush to acquire and ally could lead to the development of mega-carriers that would dominate the market – a reversion to oligopoly, without the stability needed from a vital transportation service. Nearly 10 years removed from 1997, the three factors – "open skies" or lack thereof, ownership restrictions, and barriers to entry - still impede full deregulation. Taken together with firm anti-trust laws in Europe, a reversion to oligopoly is an improbable outcome.

CONCLUSIONS, LIMITATIONS AND FUTURE 6 RESEARCH

This chapter has focused on an integrated dynamic model of the European airline 21 industry. We use the dynamic structural model to examine the extent to which the 22 European industry allocated its factor inputs during the period 1979-1990, beginning 23 with US airline deregulation and ending with the period of transition to deregulation 24 of carriers in the European Union in keeping with a goal of long-run profitability. We 25 26 have allowed for a fairly rich menu of strategic decision-making among the carriers and for relatively general production and cost structures. Our findings point to several 27 sources of forgone profits, in particular, the need for European carriers to adopt policies 28 for expansion of their networks. This would allow them to take advantage of returns to 29 density by expanding and reconfiguring their networks and were realized in the years 30 subsequent to our after the sample period, in part by forming the alliances summarized in 31 Table 1. Interestingly, just these sorts of changes characterized the competitive policies 32 undertaken by European carriers in their code-sharing agreements and in their often-33 bitter union confrontations as the carriers transitioned from national flag carriers to 34 35 competitive international companies.

This chapter presented a methodology and modeling approach that can be used in other 36 settings to better understand the potential impacts of regulatory changes in an industry. 37 As with any such new approach to study such an issue, our model does have limitations. 38 For example, the use of relatively simple functional forms such as the Cobb–Douglas 39 imposes a degree of substitutability that might exaggerate the swings in our dynamic 40 and may be a reason for such temporal patterns in our simulations. Another limitation 41 is that we applied this model in the European context where there are data limitations 42 and inconsistencies in reporting protocols across time. These are more severe than with 43 US data from the Department of Transportation. Future work could focus on utilizing 44 45 our methodology and modeling approach for US, Canadian or Australian carriers where prior regulation made for more extensive and consistent data. To that end, one might be 46

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able to use better measures of network size, such as cities served, or measures of network structure. Our methodology also places an increasing burden of complexity for adding more details – adding more control variables implies adding more Euler equations.

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