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Open skies and open gates

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Abstract. Airline alliances are a global transportation issue which is the subject of increasing attention in the literature. A simple simulation model of air carrier competition in a network is constructed to examine the economic welfare effects of different levels of alliance between the carriers serving the network. The simulations confirm that consumers derive benefits from improved access to passenger markets. However, in many cases, carriers tend to gain from a limited alliance such as code-sharing. This suggests that closer alliances may be driven by other considerations such as raising barriers to entry or the cross-subsidisation of international routes through greater control of the domestic market.

1. Introduction

> "Airline passengers flying between Toulouse and London to connect with long-haul international services should be careful when choosing an airline . . . BA's Gatwick service is flown by French operator Air Liberte, while UK regional Jersey European Airways flies the Air France service. This now means that those who prefer British service book Air France, and those who prefer French style book BA!" (Goold 1998)

Airline liberalization around the globe has been one of the truly successful examples of transportation de-regulation in the past twenty years. Adaptations to de-regulation in US and European markets have stabilized somewhat over time, but structural changes in the industry appear to be far from complete. The recent wave of global carrier alliances has clearly generated some confusion, not to mention significant concern about the continued strength of airline competition throughout the world. But partnership agreements are not a recent innovation in the airline industry; they date back to the ill-fated Pan Am/W.R. Grace alliance of the 1920's (Shifrin 1997). Structural change in the operating environment, both economic and regulatory, has stimulated a trend toward supranational alliances that will have a significant impact on how the industry operates in the future.

Using a simple network simulation model of airline competition, this paper offers some preliminary evidence about the nature and consequences of airline alliances, particularly with respect to their implications for economic welfare.

Section 2 discusses the recent trends towards alliances in the airline industry. Section 3 outlines the consequences of alliances for both airlines and the travelling public. Sections 4 and 5 describe in detail the basic modeling environment, including demand and supply assumptions for each air carrier. Section 6 covers the simulation scenarios used in this paper. These scenarios progress from limited competition to full co-operation between two air carriers. To extract the economic consequences of international mergers, the welfare impacts arising from varying each carrier's gate allocation at an international hub are examined. Section 7 discusses the implications of the simulation results and Section 8 provides concluding comments.

2. The movement towards alliances in the airline industry

The 1944 Chicago Convention established an international aviation framework designed to benefit competitors' as opposed to consumers' interests. It led to carrier regulation that effectively blocked international mergers, and regulated inter-country competitors (ICAO 1994). Over time the emphasis of national regulation has changed, leading to:

a) increased inter-country carrier competition through the 1960's and 1970's;
b) rationalization within countries, building hub and spoke routings served by partnerships between regional and national carriers. Thus competition focused on hub versus hub in the 1980's to 1990's (Brueckner et al. 1991);
c) global alliances, the industry response to international merger blockages. These recent alliances create a market where competition is based on alliance versus alliance. (Sparaco 1997).

The continued deregulation of the airline industry in the European Union, and the provision of anti-trust immunity in the United States, has recently provided the impetus for these supranational alliances. Three of the most important are (Brock 2000):

1) STAR ALLIANCE – *Lufthansa*, *United*, *Air Canada*, *SAS*. Code-sharing partners: *Thai Airways, Varig (Brazil).*
2) ATLANTIC EXCELLENCE – *Delta*, *Swissair*, *Austrian Airlines*, *Sabena*. Code sharing partners include: *Aeromexico*, *Finnair*, *Aer Lingus*, *Air Jamaica*, *Malev*, *TAP Air Portugal*, *Transbrasil*.

3) One World Alliance – *American, BA, Quantas, Cathay Pacific.* Other partners include: *Alitalia, British Midland, Gulf Air, South African Airways, LOT (Poland), Singapore.*

The economic benefits that drive regional-national linkages are also the major drivers for global alliances: reduced costs, access to world distribution systems, brand recognition and new market penetration (Morrocco 1997). But the anti-trust and monopoly concerns that arose during the 1980's – 1990's merger wave in many transportation industries have become an issue in global airline alliances (Shifrin 1997; Brock 2000). In response, industry participants cite compelling advantages to the alliances including increased competition in the behind-to-beyond routes, major cost savings leading to reduced fares, enhanced safety, and better customer service.

3. Consequences of airline alliances

The benefits available to alliance members arise from numerous shared operations, generating large economies of scale and scope. Examples include training facilities, joint purchasing, slot and gate access, and information management or code sharing (Goold 1998). By sharing training facilities, alliance members reduce costs because the alliance can eliminate duplicative training facilities. Alliances can also provide incentives to improve safety and service quality through the requirement that all member partners meet the same standards.[1]

It is also argued that international alliances permit carriers to extend these benefits across international networks in spite of the "legal, political and institutional constraints on mergers and takeovers between airlines of different countries." (Park and Zhang 2000).

By agreeing on common materials, sizes and quality, alliance members also reduce overall costs of purchasing. Although aircraft livery differs, production costs are reduced through these agreements so that service can be increased. Such cost reductions are passed on to alliance members, who have more flexibility to reduce fares in other markets where necessary. To date, joint purchasing agreements have generally applied to food, trays, blankets, and similar on-board items. However, some alliances are now exploring joint equipment purchases (Phillips 1997).

Another important consequence of alliances is that they facilitate sharing of gate space among members at international airports. This usually leads to significant cost savings since one set of ground crew and equipment can service all member flights. Furthermore, an alliance need only maintain one set of gates which can be assigned as needed to each carrier. Customers benefit from this arrangement since the termination of one leg of their journey often occurs in the same terminal area as the next leg originates.

While exact terms and conditions may differ between alliances, in general alliance members "code share". Travelers are ticketed through on one carrier code though they may change planes and airlines during the journey. In this way, all ticketing, boarding passes and baggage handling can be done at the point of origin. Alliance partners benefit by scheduling only sufficient flights to meet demand, thus reducing inefficient use of flight equipment and crew. This strategy also increases load factors on each flight. Operations rationalization reduces costs and releases equipment needed on denser routes or to penetrate new markets.

Code sharing agreements may also be seen as a response to the traveler's desire to remain with the same carrier from home to final destination (Morrison & Winston 1999). One reason for this stems from the perception that staying with one carrier improves the probability of seeing something familiar on the baggage carousel. If both partners show similar flight numbers, it becomes difficult to distinguish hybrid itineraries in the timetable. Code sharing may also increase the prominence of one partner's flights on a reservation system owned by the other (Viscusi et al. 1996).

4. Measuring the social impact of alliances

The social implications of alliances are complex and not fully understood. In this paper a simple model of competition in an air travel network is constructed in order to examine the impact of an alliance decision as it relates to market and airport access (see Figure 1). The network is constructed with a hub airport serving local spokes and a single "trunk" route to an overseas gateway. A single international carrier competing for domestic traffic with a "regional" carrier using smaller aircraft serves the gateway. Also, each carrier is assumed to have its own dedicated space at the hub.

In the basic simulation scenario examined below, the desire for "same carrier service" by passengers excludes the regional airline from providing feeder service to the hub for international travelers. Relaxing this assumption creates a situation that approximates the act of code sharing between the airlines. Code sharing is then extended to a full alliance between the carriers. This permits free sharing of gate capacity at the hub. The fare structure for each of these scenarios is compared and the overall social impact of the two types of inter-carrier agreement estimated. Finally, economic welfare measures are computed for changes in hub gate allocations, keeping all other scenario conditions constant. This allows some general conclusions to be drawn about the importance of gate access in the process of competition in this industry.

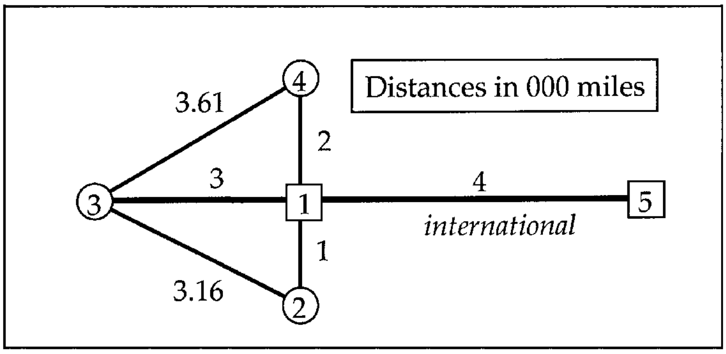

Figure 1. Airports and routes.

While the scope of this model is in the spirit of the analytic work of Hendricks et al. (1997), the basic framework most closely resembles the work of Brueckner et al. (1991, 1994), where numerical simulations of competition were used to study the effects of hubbing on fares in both hub and non-hub markets. The latter (1994) paper also simulated a merger between two hub dominant airlines. Their findings with respect to economic welfare surplus appear similar to those in the present work, but are interpreted in a different context. This study expands this line of research by adding the element of airport access into the model, so that no one airline completely dominates at any airport. Furthermore, while the Brueckner et al. model of "hub competition" may be used to study the behavior of airlines within a single country, when analyzing the effects of airline mergers in an international context, the assumption of multiple firms operating at a hub airport is a necessary addition to approximate reality.

5. Simulation environment and assumptions

The network consists of a single hub serving three spokes. This market is connected to a gateway airport (to the east) via a direct link, as shown in Figure 1. Aircraft may operate between spoke-ends as well as to the hub, but gateway service is provided via the hub only. A carrier may offer direct flights from Airport 4 to Airports 1, 2 and 3 but not to Airport 5 (the gateway).

Assume only two carriers operate in the system. The first is an international carrier (IC) with large aircraft that can serve all routes. The second is a regional carrier (RC), assumed to be operating smaller aircraft than the international carrier and precluded from operating on the hub-gateway link (1 to 5). Furthermore, capacity at the hub is limited and divided transparently between each carrier, which then has exclusive rights to its portion of the gates and runway slots. For realism and tractability, assume that there are no free or open gates in the system available for other carriers.

5A. *Time of travel*

The day is divided into four periods (on a 24-hour clock) as shown in Table 1.

Table 1. Time period definitions.

Time period, t	Hours
1. Peak	07:00–09:00
2. Off-peak	09:00–17:00
3. Peak	17:00–19:00
4. Off-peak	19:00–24:00

The two 2-hour slots beginning at 7:00 and 17:00 represent peak demand. Off-peak demand is captured by the mid-day period (9:00–17:00), and in the evening from 19:00 to midnight. Long flights departing late in the day can generate arrivals in the morning peak period. To avoid explicit modeling of crew and equipment repositioning, and to keep demand for return flights as tractable as possible, the schedule is constrained to be flight and route symmetric.[2] A flight from spoke i to spoke j leaving in time t generates a symmetric (and simultaneous) departure from spoke j to spoke i by the same carrier. Symbolically,

$$q(i, j, k, t) = q(j, i, k, t) \qquad \text{for all} \quad i, j, k, t$$

where q is the number of flights from Airport i to Airport j by carrier k leaving in time period t. If i is the hub airport (1), $q(1, j, k, t)$ is constrained by carrier k's limited space at time t, and by the need for space for the incoming flight from j in a subsequent time period.

5B. *Demand considerations*

Demand is assumed to be for travel between two airports, regardless of whether these airports are directly linked or not. For example, in Figure 1, passengers demand travel between Airports 4 and 5, supplied by flights from 4 to 1 and from 1 to 5 (and return). Passenger demand is divided between relatively inelastic peak demand and a more elastic off-peak demand. These types correspond loosely to business and recreational travel, respectively. To abstract from route specific parameters, we assume that demand for air travel in each market is linear, of the form

$$Q = a - (bP/d)$$

where a and b are standard linear demand parameters, but we include d as a spatial demand factor (representing the distance within a flight segment). This parameter implies that for each demand type, airfare (price) is proportional to the route distance between originating and destination airports, whether domestic or foreign.[3] In addition, non-hub routes are most likely to represent travel between smaller cities. Therefore, demand between the spoke-ends is reduced by a factor of one-half relative to demand at the hub. Demand for indirect travel, such as between Airports 4 and 5, is used to derive demand for the component flights. These assumptions imply that both carriers charge the same fare for the same service. The peak/off-peak distinction is an imprecise one since off-peak regional legs may feed peak international flights and conversely. However, we assume that demand is shaped predominantly as described, with the following exceptions:

a) There is no demand for departure after 19:00 (period 4).
b) Travel from Airport 3 to Airport 4 starting during the evening peak (period 3) is assumed to be a "red-eye" flight which arrives the following morning (period 1). Therefore this flight satisfies off-peak rather than peak demand.
c) Since the gateway airport (5) is assumed to be in a significantly earlier time zone, return flights leaving during hub period 1 would involve departures in the very early hours of the morning. Hence, to preserve demand symmetry, international departures are limited to periods 2 and 3 (from 9:00 to 19:00).

5C. *Supply considerations*

Firm supply is modeled on the assumption of positive profits on a route-by-route basis: the incremental revenues minus costs from operating an aircraft over a specified route must be positive. For revenue generation, load factors are assumed constant and each carrier has a single type of aircraft in sufficient quantity to operate chosen flights. Incremental cost is expressed as a linear function of distance and passenger load for each aircraft type. Typical aircraft data are shown in Table 2. Cost and passenger capacity data are drawn from available sources (Transport Canada). The average load factor, assumed constant at 0.69, is from Velocci (1997).

Since one purpose of the simulation model is to examine the impact of

Table 2. Aircraft load and cost data.

Aircraft type	Pax capacity	Average load	Cost/mile C$
747-400	398	274.62	18.13508
DC9–10	72	49.68	4.824147

very limited competition between the two carriers, the model is solved initially with the firms acting independently. For tractability, this paper employs the assumption that the firms behave as Cournot competitors; Cournot behavior implies each carrier maximizes its own profits on the assumption that its rival's market or schedule is unaffected by its decisions. Modeling competition in this fashion builds upon previous research describing the nature of airline competition (Brueckner et al. 1991; Park and Zhang 1998). The first order conditions of the two-firm Cournot problem used to solve for equilibrium firm profits using linear demand schedules are well known [see Dutta (1999) for a good description of the basic Cournot competition model]. The subsequent modeling scenarios simulate increasing firm interaction and gradually remove competition between the air carriers.

6. Market and competition scenarios

The simulation model assumes all hub capacity constraints are tight, without non-negativity constraints on the number of flights on each route. The model is solved as follows: from the initial demand, supply and competition assumptions, compute the equilibrium revenues for each firm on each flight segment. Using aircraft capacities (weighted by the average load factor for each aircraft) as a measure of quantity and considering the peak vs. off-peak structure of demand, compute revenue per individual flight according to the following (Cournot) formula:

$$\text{Revenue per flight} = \#\text{ of connecting nodes} \times \text{distance} \times \frac{\text{total passengers}}{b \times \text{hub factor}}$$

where b is the demand parameter and the "hub factor" is 1 for a flight using the hub airport and 2 otherwise. Revenue per individual flight is inverted and multiplied by total profits per flight segment (consisting of flights by both carriers) to simultaneously compute the optimal number of flights by each carrier in the network. Once total flights are computed, the corresponding airfare for a particular flight segment is calculated. Additional simulations confirm that the basic results on fares and flights described below under Scenarios A, B and C are robust and not overly dependent on these particular parameter values.[4] The following are general descriptions of each scenario.

Scenario A – Non-cooperation (competition)

In the base scenario each carrier operates independently, subject to its own gate constraints and common fares for the same services. Passengers from spoke-ends (2, 3, 4) to the gateway (5) are assumed to attach a high premium to interlining; therefore the demand for the domestic portion of their travel is applied to the international carrier only. This means hub flights by the regional carrier are restricted to terminating passengers.

Scenario B – Code-sharing

Under this scenario each carrier continues to use its own gates exclusively, but the regional carrier is now able to supply feeder service to the international link. Access to this market is an approximation to "complementary" code sharing between the carriers, as defined by Oum, Park and Zhang (1996).

Scenario C – Gate alliance

To model a full alliance, assume the regional carrier is able to provide feeder service as in scenario B. However, under this scenario, both carriers are allowed to pool their gate access at the hub; either carrier can potentially use every gate. The next section provides an analysis of the results of each simulation and discusses the implications of these simulations within a larger policy context.

Demand parameters were adjusted to calibrate the model (under Scenario A) in order to obtain a plausible set of fares throughout the network. To ensure that feasible solutions for the number of flights in equilibrium, integer values on $q(i, j, k, t)$ are not imposed. Strictly, partial flights at the hub cannot be interpreted as partial loads since an aircraft uses virtually the same hub space (capacity) regardless of passenger numbers. Since the network is intended to characterize a much larger, more complex system, partial flights may be interpreted as a representative "sampling" of a larger system.

7. Simulation results

The simulations began by restricting the regional carrier (RC) in Scenarios A and B to 10 of 35 total hourly slots on each of two runways (approximately 29% of the hub capacity), to mimic market size differences between local vs. international markets. Therefore the following discussion of fare effects focuses on results computed subject to this slot restriction. This constraint is later relaxed in order to further examine the welfare effects of gate allocations.

7A. *Scenario A*

The flight network configuration and associated constraints yield 42 equations to be solved simultaneously in each scenario. The first 38 equations, one for each flight by each carrier, are used to solve for equilibrium revenue per flight in the network. The last four equations (one for each time period in the day) track flights flown by the carriers which are destined for the hub airport, bearing in mind the assumptions about demand for hub vs. off-hub flights discussed in Section 5B. For instance in Scenario A with spoke competition between the carriers, the regional carrier is restricted to terminal traffic from the spokes to the hub, whereas the international airline only carries connecting traffic to the hub. However, in Scenario C where competition is relaxed, both carriers generate either connecting or terminal traffic on flights to the hub.

Fares for direct flights under Scenario A are compiled in Table 3. Flights requiring more than one segment (known as a connecting or compound flight) have highly variable fares depending upon which segments take-off in a particular direction during a peak period or off-peak period. It is this connecting traffic demand that produces the reversal of relative fares between peak and off-peak on flights between the hub and Airports 2 and 4.

Table 3. Return fares under Scenerio A (non cooperation) Regional carrier hub capacity 10 of 35 slots.

Route	1-2		1-3		1-4	
Demand	Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
Fare $	125.83	281.45	621.92	381.19	205.95	212.16
Route	1-5		2-3		2-4	
Demand	Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
Fare $	472.79	386.67	506.24	395.46	506.31	375.16
Route	3-4					
Demand	Peak	Off-peak				
Fare $	1442.37	225.74				

7B. *Scenario B*

The more even spreading of feeder demand resulting from the assumptions of Scenario B contributes to a general lowering of fares for hub traffic compared to the base simulations (see Table 4). The most impacted fares are on those for peak travel on routes 1–2 and 1–4. These airports are close enough to the hub to provide more connections than the more distant Airport 3, so Airports 2 and 4 gain from the increased throughput efficiency under code sharing.

Table 4. Return fares under Scenerio B (code-sharing) Regional carrier hub capacity 10 of 35 slots.

Route	1-2		1-3		1-4	
Demand	Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
Fare $	88.01	269.61	607.09	381.98	133.68	212.49
Route	1-5		2-3		2-4	
Demand	Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
Fare $	470.06	386.67	506.24	395.46	506.31	375.16
Route	3-4					
Demand	Peak	Off-peak				
Fare $	1442.37	225.74				

7C. *Scenario C*

The fares listed in Table 5 suggest that flight volumes do not change significantly on the non-hub routes from those in Scenario B. The changes that occur are concentrated on the feeder routes, as expected. Scenario C shows a smaller general fare between Airports 2 and 4 but a more marked change for the route from Airport 1 to 3. This substantial fare decrease (from $607.09 in Scenario B to $172.34 in Scenario C) indicates that an important aspect of airline alliances from the passenger's perspective is access to hub airport space (found in Scenario C) rather than simply to a connecting passenger pool (as in Scenario B). The magnitude of this change at peak compared to the other connecting flights in Scenario C implies that this effect is more important when the connecting flight is further away from the hub. In fact, compared with Scenario B, some volume is displaced from the short route 1-4 to the longer 1-3 as reflected in the increase in the short haul peak fare.

Table 5. Return fares under Scenerio C (gate alliance).

Route	1-2		1-3		1-4	
Demand	Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
Fare $	80.86	250.20	172.34	380.36	172.18	202.87
Route	**1-5**		**2-3**		**2-4**	
Demand	Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
Fare $	485.94	389.19	506.24	395.46	506.31	375.16
Route	**3-4**					
Demand	Peak	Off-peak				
Fare $	1442.37	225.74				

Table 6 illustrates changes in flight volumes under the present parameter assumptions.

7D. *Welfare effects of changes in gate allocation at the hub*

Changes in social welfare across each scenario under varying assumptions of regional carrier gate allocations at the hub airport are readily extracted due to the simplicity of the demand and supply structure in the simulation. Table 7 shows the overall welfare effects of scenarios A, B and C on both passengers and carriers under varying hub gate allocations. Consumer welfare is measured by consumer surplus (CS). Changes in producer surplus are reflected by the contribution (revenue minus incremental cost) for each carrier (PSI and PSR for the international and regional carriers respectively). Since Scenario C implies open access to gates at the hub the results are the same regardless of the initial gate restrictions. However, it should be recalled that Carrier I maintains its monopoly on the international route (1-5) throughout.

Taking the open gates scenario (C) as a basis, the move to dedicated slots permits both carriers to earn monopoly rent on their allocations at the hub. This has most impact on the carrier with the largest share of the gates. Comparing the extreme cases, the regional carrier is able to extract no gain from a 14% share of the hub, but gains significantly at the expense of the international carrier when it controls 85% of the gates.

As might be expected, the international carrier gains from monopoly over feeder traffic as long as it has reasonable hub access. If it is restricted to very few of the hub gates (5 of 35), there is a loss of producer surplus from having to use slots to provide feeder service at the expense of the more profitable international link.

Table 6. Percentage change in number of flights on some regional "spokes".

Route	1-2			
Demand	Peak		Off-peak	
Carrier	IC	RC	IC	RC
Scenario A to Scenario B	12	0	4	11
Scenario B to Scenario C	3	–20	–18	285
Scenario A to Scenario C	15	–21	–15	328
Route	**1-3**			
Demand	Peak		Off-peak	
Carrier	IC	RC	IC	RC
Scenario A to Scenario B	1	33	1	–2
Scenario B to Scenario C	–1	–4	–4	7
Scenario A to Scenario C	0	28	–3	5
Route	**1-4**			
Demand	Peak		Off-peak	
Carrier	IC	RC	IC	RC
Scenario A to Scenario B	2	33	0	0
Scenario B to Scenario C	–2	–12	6	0
Scenario A to Scenario C	0	18	6	0

For all but the highest level of its hub gate allocation, the regional carrier makes profits at the expense of the international carrier in each Scenario C when hub access is further improved via alliance. For an alliance to be stable, a clearly defined revenue sharing mechanism may be necessary in order to ensure that one partner does not gain excessively at the expense of the other. Recent evidence suggests that revenue sharing among alliance partners has evolved in a variety of ways, and some agreements appear to favor one carrier over another (Park & Zhang 1998). One possible explanation for the existence of what appear to be "biased" alliance agreements arises. In real markets, a transfer of surplus resulting from improved hub access for a carrier (the regional carrier in this case) could form the basis for negotiated revenue sharing or other side payments in an alliance agreement.

However, from Table 7 it is clear that neither code sharing (B) nor open gates (C) adds anything to total producer surplus since the carriers are

Table 7. Economic welfare and changes in hub gate allocation.

Hub capacity of Regional Carrier (RC)	Economic welfare (in thousands of $)					
	Scenario	CS	PSI	PSR	PSI+PSR	Total surplus
30 of 35 slots (85%)	A	64	133	65	198	262
	B	67	136	62	198	264
	C	94	145	49	194	287
20 of 35 slots (57%)	A	74	153	57	210	284
	B	77	153	57	210	288
	C	94	145	49	194	287
10 of 35 slots (29%) (base assumption)	A	88	164	50	214	302
	B	95	161	52	213	308
	C	94	145	49	194	287
5 of 35 slots (14%)	A	98	166	46	212	310
	B	106	161	49	210	316
	C	94	145	49	194	287

relinquishing monopoly rents. Chen and Ross (2000) have suggested that limited alliances may be used in the airline industry as a way of preventing or pre-empting more significant competition. Comparison of individual producer surpluses for Scenarios B and C lends some support to this conclusion. In all cases, Scenario B is considerably more attractive to Carrier I than Scenario C.

If the regional carrier has access to a significant proportion of the gates, then consumer surplus increases from Scenarios A through B to C as restrictions are lifted. However, in plausible situations where regional carrier access is highly constrained, the code sharing option may appear to be the most attractive from the standpoint of consumers and of society as a whole. This stems from the influence of Carrier I's monopoly on the long, and hence highly profitable, international route. As noted above, reserving a small part of the hub for the higher cost regional carrier increases volume across the domestic network, particularly the spokes which serve domestic and international demand. If the regional hub allocation is larger, this advantage is offset by Carrier R's higher cost. The latter effect may depend critically on the absence of competition on the international link. Clougherty (2000) suggests that international carriers may use a domestic market advantage to improve their competitive position on international routes.

Park and Zhang's (2000) empirical work is directed towards the overall effects of alliances with international and national components. As such it captures a variety of effects and alliance structures over the 1990–94 test period. However, they conclude that complementary alliances such as the one modelled here, tend to increase output and consumer surplus as the current model suggests. Moreover, the average increase in consumer surplus as the result of an alliance in their estimation is about 12%. This falls within the range of the present simulation results when the regional carrier has a small share of hub slots (between five and ten out of 35).

The simulation results highlight a major reason why airlines are increasingly turning to alliances as part of corporate strategy (Goold 1998), and it has to do with the need for carriers to obtain the right to access airport gates. While overlooked in the move to de-regulation in the US, market or gate access is now seen as crucial to carrier viability (Viscusi et al. 1996). In most countries, airlines can only rarely obtain gate space in established markets and major airports without resorting to an alliance (ICAO 1994). This fact, combined with the evidence presented here, leads to the postulate that the primary strategic purpose of alliances is in terms of gate access both directly and possibly for the consolidation of barriers to further entry.

The results only hint at the potential for market power stemming from the current "grandfathered" gate allocation process common around the globe. This problem is not new to airline regulatory policy, although very little formal research has been done to date (Saunders & Shepard 1993). Clearly, further research along the lines presented here is needed to assess the impact of the gate allocation process on the evolution of airline competition.

8. Conclusions

As noted in the introduction, airline alliances are neither new nor are their effects on society easy to evaluate. The network competition model presented here attempts to characterize network alliances in the simplest possible way while maintaining some degree of realism in the simulations.

It appears that, in the absence of sever capacity constraints, better access to airline markets by additional firms benefits the air traveling public. However considering the virtually ubiquitous non-market airport gate allocation process, alliances are most likely to be the result of airlines desire to enhance market power worldwide. To the extent that cross-subsidisation of international routes by exploiting limited competition in the domestic market as suggested by Clougherty (2000) is undesirable, the unimpeded domestic access in Scenario C may provide a significant counterbalance.

While this study captures some interesting nuances of the airline alliance issue, it will be of interest to examine whether or not these basic results hold true in a more complex network with more competitors. Of particular interest is the situation in which competition along international routes is linked with the domestic markets at both ends. This will be the subject of future research.

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Notes

1. Given the emphasis on safety in today's airline markets, it is reasonable to expect that safety standards will converge to higher, not lower, standards within an alliance.
2. These assumptions simplify the solution process considerably, while allowing the simulations to contain and approximate certain aspects of logistical reality for airlines. For example, symmetric return flights mean that the model does not have to accommodate concerns about positioning an aircraft at a gate for a particular departure.
3. This assumption implies that prices on each link are proportional to cost which is not always the case on any given link in a large network (Mitchell & Vogelsang 1998). However, in our stylized network, travelers moving longer distances are assumed to have relatively less elastic demands due to the lack of modal substitutes. Conversely travelers over shorter distances are assumed to have more elastic demands (and thus pay proportionately less) due to the availability of other modes of travel.
4. In particular, changing the distance the international carrier has to travel to Airport 5 did not strongly impact consumers surplus under any scenario. A sample of the sensitivity results is available from the corresponding author.

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