EUROPEAN AIRLINE MERGERS, ALLIANCE CONSOLIDATION, AND CONSUMER WELFARE

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Abstract

This paper explores the effects of a European airline merger followed by a consolidation of two competing international alliances. The exercise has been inspired by the Air France-KLM merger, which is expected to spur consolidation of the Northwest-KLM and SkyTeam alliances into a single mega-alliance. The results of the analysis show that, although the airlines benefit through higher profits, the merger and alliance consolidation harm consumers while reducing overall social surplus. The reason for this negative outcome is that, as modeled, all the effects of the merger and alliance consolidation are anticompetitive.

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1. Introduction

Observers of the European airline industry have long believed that the flag-carrier system, though affirming national pride, has created too many airlines and led to inefficient excess capacity. The suggested remedy is consolidation of the European industry via cross-border mergers, an avenue that is now open as a result of EU deregulation. The first major consolidation event is currently unfolding, with the proposed Air France-KLM merger recently approved by EU regulators.

Because most major international carriers belong to one of the global alliances, European airline mergers can upset the alliance structure, leading to further realignments that extend beyond the localized effects of the merger itself. With Air France and KLM belonging to different global alliances, their merger is expected generate exactly this kind of secondary impact. In particular, KLM's current alliance partner, Northwest, is expected to join the SkyTeam alliance, whose major partners are Air France and Delta, with Continental (Northwest's long-time domestic alliance partner) joining as well. In effect, the Air France-KLM merger will lead to consolidation of the Northwest-KLM alliance and the SkyTeam alliance, creating a mega-alliance containing four of the world's largest airlines.

The present paper offers an economic analysis of the impacts of this kind of merger, and the related alliance consolidation, using a stylized model of airline networks. The analysis is prompted by the concern that such a merger of carriers and alliances will generate effects that are mostly anticompetitive, leading to a likely negative impact on consumer welfare. In particular, the European merger itself will reduce competition in intra-European city-pair markets and in transatlantic markets where the merger partners compete. In addition, the alliance consolidation will reduce interalliance competition for passengers traveling between smaller US and European endpoints, who rely on interline service jointly provided by two alliance partners. While such passengers currently benefit from competition between different alliances, such competition will be reduced when these separate pairings collapse into one mega-alliance.

The analysis, which makes use of an airline network model like that introduced by Brueckner and Spiller (1991), confirms the suspicion that the merger and alliance consolidation are harmful to passengers and to society in general. Although the setup of the model, which omits some possible efficiency gains, may lead to an overstatement of the harmful effects of the merger in intra-European markets, the negative verdict on the impact of alliance consolidation seems unequivocal. The paper thus suggests that regulators should not accede to a full integration of the Northwest-KLM and SkyTeam alliances even though the Air France-KLM merger has been approved.

Although the overall negative conclusions of the analysis come as no surprise given the anticompetitive nature of the merger and the associated alliance consolidation, the results do offer some unexpected insights. In particular, even though anticompetitive effects are directly felt in only a few city-pair markets in the model, fares rise and traffic falls in almost every market served by the carriers. This outcome reflects the existence of negative spillovers across markets, which are transmitted by economies of traffic density.[1] With economies of density, greater operating efficiencies reduce cost per passenger on a route as traffic volume on the route rises. In the model, when anticompetitive effects reduce traffic in a given city-pair market, traffic density falls on the route(s) used to serve that market, raising cost per passenger on these routes. However, in a network setting, passengers traveling in city-pair markets where competition is unchanged will in some cases flow across these same higher-cost routes, paying higher fares as a result (with a consequent reduction in traffic volumes). Through such cost impacts, localized anticompetitive effects can be transmitted across airline networks, and the analysis illustrates in graphic fashion how such spillovers can occur.

In previous work, Brueckner (2001, 2003a) and Brueckner and Whalen (2000) emphasized the benefits of alliances, and it is important to understand the difference between this view and the negative conclusions of the present paper. This previous research drew a contrast between interline service provide by alliance partners and service provided by nonallied carriers. The papers showed theoretically that alliance partners should charge a lower fare for interline trips than carriers with no alliance relationship, and empirical work strongly confirmed the existence in the data of this alliance fare discount. The research thus established that alliances are good for interline passengers, with lower fares reinforcing any convenience gains the passengers may enjoy.[2] In the present analysis, however, these alliance benefits are already exhausted because all interline passengers are assumed in the model to make alliance trips. The only effect of creation of the mega-alliance is thus to remove interalliance competition, without creating any new alliance travel. The appropriateness of this setup, which rules out any benefits from alliance consolidation, is discussed in paper's concluding section.

The plan of the paper is as follows. Section 2 presents the network structure of the model and explains how competition is affected by the merger and alliance consolidation, using two different scenarios. Section 3 develops revenue and cost expressions for the carriers, making use of the setup from section 2. This section is technical and can be skipped by uninterested readers without loss of continuity. Section 4 imposes specific functional forms on demand and cost and presents general results regarding the effect of the merger and alliance consolidation, which hold for all feasible parameter values. Section 5 offers a specific numerical example based on representative parameter values. Extensive discussion of this example provides intuitive insight into the results generated by the model. Section 6 offers conclusions.

2. The Setup

The model has two US airlines, denoted 1 and 2, and two European airlines, denoted 3 and 4. Airlines 1 and 3 are alliance partners, while 2 and 4 are matched in a separate alliance. The carriers operate the networks shown in Figure 1, where A, B and E denote US cities and C, D and F denote European cities. Carrier 1 uses city A as its hub and operates routes from this hub to cities B, C, D and E (the routes are indicated by the heavy solid lines in the Figure). Carrier 2 uses city B as its hub and operates routes to A, C, D and E (indicated by the lighter solid lines). Carrier 3 uses city C as its hub and operates routes to A, B, D and F (indicated by the heavy dotted lines). Finally, carrier 4 uses D as its hub and operates routes to A, B, C and F (indicated by the lighter dotted lines). Note that for simplicity, Europe and the US are portrayed as having only one non-hub endpoint each (E and F). A more realistic model with many such endpoints would yield results similar to those derived below.

The collection of cities shown in Figure 1 generates 15 city-pair markets, which are listed in the first column of Table 1. City-pair markets are non-directional, with travel in the market consisting of round-trip travel originating at either endpoint city (endpoints are thus listed in alphabetical order).

2.1. The base case

The base case represents the premerger situation, where airlines 3 and 4 operate independently. The following discussion explains the patterns of service and competition in the 15 city-pair markets for this case. The discussion, which also introduces a number of assumptions underlying the analysis, is summarized in the second and third columns of Table 1.

Market AB, which connects the hubs of carriers 1 and 2, is served by both of these carriers, who behave as competitors. Similarly, market CD, which connects the hubs of airlines 3 and 4, is served by both carriers, who also compete for passengers. AE is a monopoly market served by carrier 1, while BE is a monopoly market served by carrier 2. In parallel fashion, CF and DF are monopoly markets served by airlines 3 and 4, respectively. Market AD is a transatlantic market connecting the hubs of carriers 1 and 4, and it is served competitively by both carriers. Similarly, airlines 2 and 3 compete in the transatlantic interhub market BC.

Market CE, which connects the European hub C to the interior US endpoint E, is served by airline 1 through its hub A and by airline 2 through its hub B. Similarly, market DE is served by carriers 1 and 2 through their respective hubs. Note that passengers must change planes at one of the hubs when traveling in these markets. In parallel fashion, market BF is served by airlines 3 and 4 through hubs C and D, respectively, with market AF served in the same fashion. It should be noted that these service patterns reflect a key underlying assumption designed to make the analysis tractable. In particular, *interline service is assumed not to occur in a market where online service is available.* Thus, even though a passenger traveling in market CE could in principle take an interline trip on carriers 1 and 3 (traveling between A and E on 1 and between A and C on 3), the passenger is assumed to shun such service in favor of more-convenient, single-carrier service on airlines 1 or 2. In the same fashion, interline service in markets DE, AF and BF does not occur. This constraint on service patterns, though restrictive, appears to be fairly realistic.

The remaining markets are affected by the alliances between the US and European carriers, which pair airlines 1 and 3 and airlines 2 and 4. Travel in market EF, which connects the interior US and European endpoints, requires interline travel, and it is assumed that passengers stay within one alliance in carrying out such trips. In other words, EF passengers fly either on airlines 1 and 3 via hubs A and C, or on airlines 2 and 4 via hubs B and D. Nonalliance interline trips combining carriers 1 and 4 or 2 and 3 are assumed not to occur. Note that the interline traffic of carriers 1 and 3 flows across the interhub route between A and C. The airlines are assumed to divide this traffic equally, with half of the 1–3 interline passengers on the AC route carried by 1 and half by 3. A parallel assumption applies to the 2–4 interline traffic flowing across the interhub route BD. Finally, with the EF market served by both the 1–3 and 2–4 alliances, it is assumed that the interline EF fare is determined by interalliance competition. More detail on EF fare determination is presented below.

Finally, consider market AC, which is served in nonstop fashion by the alliance partners 1 and 3, as well as market BD, which is served by the partner airlines 2 and 4. To characterize competition in these markets, note that regulatory rulings, which allow alliance partners to collaborate in setting interline fares, typically impose a "carve-out" in interhub markets such as AC and BD. In other words, the usual grant of antitrust immunity does not permit cooperative pricing in the interhub markets, on the grounds that the presence of overlapping service in these markets makes such behavior anticompetitive (see Brueckner (2001) and Brueckner and Whalen (2000)). However, despite the presence of such restrictions, some observers doubt that carve-out provisions are actually effective, wondering how alliance partners can collaborate extensively while still competing in the markets connecting their hubs. Given this view, the present analysis assumes that alliance partners collude in setting fares in their interhub markets, implicitly viewing carve-out provisions (if they exist) as ineffective. This collusion is noted in the "behavior" column of Table 1 for the base case, which indicates collusion in markets AC and BD while also showing airline behavior in the remaining markets.

One final implicit assumption underlying Table 1 should be noted. In particular, it is assumed that *connecting (change-of-plane) service is never used when nonstop service is available*. For example, although connecting service in market AE is feasible on airline 2 via hub B, passengers are assumed to shun such service in favor of nonstop service on airline 1. Similarly, BD passengers are assumed to shun connecting service on airline 1 via A and connecting service on airline 3 via C in favor of nonstop service on either airline. Without this assumption, which applies as well in several additional markets, the analysis would be much more complex.

2.2. Scenarios I and II

Two different merger scenarios are considered in the analysis. Each scenario involves a merger of airlines 3 and 4 along with consolidation of the 1–3 and 2–4 alliances into a four-carrier mega-alliance. Scenario II differs from scenario I in the degree of cooperation within the mega-alliance, which is greater under scenario II. To facilitate the discussion of the two scenarios, the merged airlines 3 and 4 are still labeled separately even though they behave like a single firm following the merger. While convenient, this approach is also realistic in the case of the Air France-KLM merger, where the airlines will maintain separate identities for an extended period despite their common ownership.

Following the merger, airlines 3 and 4 cease to compete in the interhub market CD, setting fares collusively so as to maximize their joint profit. In addition, the two carriers collude in markets AF and BF, where they previously competed. These changes are shown in the fourth column of Table 1.

The merger of airlines 3 and 4 spurs consolidation of the 1–3 and 2–4 alliances into one mega-alliance, mirroring the likely consolidation of the Northwest-KLM and SkyTeam alliances as a result of the Air France-KLM merger. In this case, airline 1 would represent Northwest and airline 2 would be Delta, with airlines 3 and 4 representing KLM and Air France respectively.

The main effect of this alliance consolidation is that the interline fare in market EF is no longer determined by competition between the 1–3 and 2–4 alliances. Instead, the fare is set collusively by all four mega-alliance carriers so as to maximize their combined profit.

The additional details of the alliance consolidation differ between scenarios I and II. Under scenario I, the interline pairings in the EF market remain as in the base case, with passengers traveling either on the 1–3 carrier pair or on the 2–4 pair. Thus, even though competition between the 1–3 and 2–4 alliances disappears, interline traffic patterns remain unchanged. By contrast, under scenario II, all four possible interline pairings are observed. In other words, in addition to 1–3 and 2–4 interline trips, passengers travel on the 1–4 carrier pair and on the 2–3 pair. As a result, the AD and BC routes, which carry no EF interline traffic under the base case and scenario I, each get one-quarter of the total interline traffic under scenario II. Concretely, scenario I assumes that interline passengers continue to use either Northwest-KLM or Delta-Air France despite creation of the mega-alliance, while scenario II allows Northwest-Air France and Delta-KLM interline trips to occur as well.

Consistent with a deeper alliance consolidation, scenario II also allows collusion in city-pair markets AD and BC, which were previously competitive. This outcome is plausible given that the mega-alliance will require new grants of antitrust immunity to the carrier pairs 1–4 and 2–3 (e.g., Northwest and Air France will gain immunity, as will Delta and KLM). While such immunity will allow all four carriers to collude in setting the EF fare, the previous argument against the efficacy of carve-outs suggests that immunity will foster collusion by carriers 1 and 4 in interhub market AD and by carriers 2 and 3 in interhub market BC.

These differences between scenarios I and II can be reviewed by comparing the last four columns of Table 1. Looking more generally at the Table as a whole, it is clear that the progression from the base case to scenario I and then to scenario II involves successive eliminations of competition. In going from the base case to scenario I, competition is lost in markets AF, BF, CD and EF. Further movement to scenario II involves an additional loss of competition in markets AD and BC, coupled with a change in the split of interline EF traffic. Given these reductions in competition, one would expect that the 3–4 merger and the associated alliance consolidation is bad for consumers and good for the airlines. The remainder of the analysis is devoted to evaluating this conjecture.

3. Revenues and Costs

The first step in this evaluation is to derive revenue and cost expressions for the airlines under the base case and the two scenarios, relying on several simplifying assumptions.[3] The first assumption is that the demand for air travel is the same in all city-pair markets, with the fare p in a market given by a common inverse demand function $d(Q)$, where Q is total traffic in the market. As suggested above, Q gives the total number of round-trip passengers traveling in either direction in the market. Relaxing the assumption of a common demand function would introduce inessential complexity without affecting the main conclusions derived below.

3.1. The base case

Using this demand function, consider airline 1's revenue in the base case, which can be written as

$$\begin{aligned} Rev^1_{base} \;=\;& Q^1_{AB}\, d(Q^1_{AB}+Q^2_{AB}) \;+\; (Q^{1,3}_{AC}/2)\, d(Q^{1,3}_{AC}) \;+\; Q^1_{AD}\, d(Q^1_{AD}+Q^4_{AD}) \\ &+\; Q^1_{AE}\, d(Q^1_{AE}) \;+\; Q^1_{CE}\, d(Q^1_{CE}+Q^2_{CE}) \;+\; Q^1_{DE}\, d(Q^1_{DE}+Q^2_{DE}) \\ &+\; (Q^{1,3}_{EF}/2)\, d(Q^{1,3}_{EF}+Q^{2,4}_{EF}). \end{aligned} \tag{1}$$

In (1), the Q subscripts denote the individual city-pair markets in self-explanatory fashion, and the numerical superscripts denote the carriers. If a carrier chooses its traffic level in a market in a noncollusive fashion, then only its single superscript is attached to the Q variable. If carriers collude, then the superscript contains the identities of the carriers engaged in the collusion.

Using these conventions, interpretation of (1) is straightforward. The first term gives airline 1's revenue in market AB, where it competes with carrier 2. Note that price in the market, given by $d(\cdot)$, depends on the sum of the carriers' traffic levels, $Q^1_{AB}+Q^2_{AB}$. Similar observations apply to third, fifth and sixth terms in (1), which give revenue in the competitive markets AD, CE and DE. The fourth term represents carrier 1's revenue in its monopoly market, AE. In market AC, represented by the second revenue term, carriers 1 and 3 collude in setting a total quantity in the market (hence the 1,3 superscript), with both getting equal traffic shares. The last term in (1) represents interline revenue from market EF, with $Q^{1,3}_{EF}$ giving the interline traffic carried by airlines 1 and 3. Here, collusion consists of agreeing on a common 1–3 interline traffic level, recognizing that the fare in the EF market also depends on the traffic choice of the 2–4 alliance partners, $Q_{EF}^{2,4}$. Note that carrier 1 gets half of the 1–3 alliance's EF revenue.

To develop the airline 1's cost expression, let the cost of operating a route be given by $c(V)$, where V is the total traffic on the route. The function $c(\cdot)$ reflects economies of traffic density, with $c' > 0$ and $c'' < 0$ holding. With economies of density, cost per passenger falls as traffic volume on a route rises, reflecting the lower operating cost per seat of larger aircraft, as well as other efficiency gains from higher densities (see Caves, Christensen and Tretheway (1984) and Brueckner and Spiller (1994) for evidence).

With each airline operating four routes, total cost is just the sum of four separate $c(\cdot)$ functions evaluated at the appropriate traffic levels. Any fixed costs that a carrier incurs in operating its hub can be ignored without affecting the analysis. Using the traffic levels from (1), airline 1's cost in the base case can be written

$$\begin{aligned} Cost_{base}^{1} \;&=\; c(Q_{AB}^{1}) \;+\; c(Q_{AC}^{1,3}/2 + Q_{CE}^{1} + Q_{EF}^{1,3}/2) \;+\; c(Q_{AD}^{1} + Q_{DE}^{1}) \\ &\quad+\; c(Q_{AE}^{1} + Q_{CE}^{1} + Q_{DE}^{1} + Q_{EF}^{1,3}). \qquad (2) \end{aligned}$$

The first term in (2) gives the cost of operating the AB route, which carries traffic only in the AB city-pair market. The second term gives the cost of operating the AC route, which carries half of the traffic in market AC (the rest is carried by airline 3), airline 1's portion of CE traffic, and half of the EF interline traffic of the 1–3 alliance. The third term gives the cost of operating the AD route, which carries airline 1's portion of traffic in the AD and DE markets. Finally, the fourth term gives the cost of operating the AE route, which carries all AE traffic, carrier 1's portion of CE and DE traffic, and all of the 1–3 alliance's EF interline traffic.[4]

While the other airlines have analogous cost and revenue expressions, it is useful to present the expressions for airline 3, as they are needed for future comparisons. The relevant expressions for the base case, which can be interpreted in a parallel fashion to (1) and (2), are given by

$$Rev_{base}^{3} \;=\; Q_{CD}^{3}\; d(Q_{CD}^{3} + Q_{CD}^{4}) \;+\; (Q_{AC}^{1,3}/2)\; d(Q_{AC}^{1,3}) \;+\; Q_{BC}^{3}\; d(Q_{BC}^{2} + Q_{BC}^{3})$$

$$+ \quad Q^3_{CF}\ d(Q^3_{CF}) \quad + \quad Q^3_{AF}\ d(Q^3_{AF} + Q^4_{AF}) \quad + \quad Q^3_{BF}\ d(Q^3_{BF} + Q^4_{BF})$$

$$+ \quad (Q^{1,3}_{EF}/2)\ d(Q^{1,3}_{EF} + Q^{2,4}_{EF}). \tag{3}$$

$$Cost^3_{base} \quad = \quad c(Q^3_{CD}) \quad + \quad c(Q^{1,3}_{AC}/2 + Q^3_{AF} + Q^{1,3}_{EF}/2) \quad + \quad c(Q^3_{BC} + Q^3_{BF})$$

$$+ \quad c(Q^3_{CF} + Q^3_{AF} + Q^3_{BF} + Q^{1,3}_{EF}). \tag{4}$$

Profit for each airline is given by revenue minus cost, and the airlines choose their traffic levels in the various markets to maximize either individual profit or the appropriate sum of profits. For example, airline 1 chooses Q^1_{AB}, Q^1_{AD}, Q^1_{AE}, Q^1_{CE}, and Q^1_{DE} to maximize its own profit, treating Q^2_{AB}, Q^4_{AD}, Q^2_{CE}, and Q^2_{DE} in (1) as parametric in Cournot fashion. The traffic levels $Q^{1,3}_{AC}$ and $Q^{1,3}_{EF}$, which are treated as parametric in choosing the previous variables, are themselves chosen to maximize the sum of profits for carriers 1 and 3, with $Q^{2,4}_{EF}$ again treated as parametric in Cournot fashion. This procedure generates seven first-order conditions, which equate the relevant marginal revenues and marginal costs, and the analogous procedure for the three additional carriers generates additional conditions. However, the equilibrium values, which are symmetric across carriers given the symmetry of the base case, can be determined from a single set of first-order conditions.[5]

3.2. Scenarios I and II

The revenue and cost expressions change under scenario I. For airline 1, revenue under this scenario is given by

$$Rev^1_{scnI} \quad = \quad \text{first six terms of (1)} \quad + \quad \underbrace{(Q^{1,2,3,4}_{EF}/4)\ d(Q^{1,2,3,4}_{EF})}_{new}. \tag{5}$$

The only difference relative to (1) is in the last term, where the Q superscript indicates that EF traffic is now chosen collusively by all four airlines, with airline 1 getting one-quarter of total EF revenue.

Airline 1's cost under scenario I is given by

$$\begin{aligned} Cost^1_{scnI} \;&=\; \text{first term of (2)} \;+\; c(Q^{1,3}_{AC}/2 + Q^1_{CE} + \underbrace{Q^{1,2,3,4}_{EF}/4)}_{new} \;+\; \text{third term} \\ &\quad + \; c(Q^1_{AE} + Q^1_{CE} + Q^1_{DE} + \underbrace{Q^{1,2,3,4}_{EF}/2)}_{new}, \end{aligned} \tag{6}$$

and the only differences relative to (2) are again related to the EF market. Focusing on the last term, the AE route carries half of total EF traffic, and airline 1's AC route (second term) carries one-quarter of the total.[6]

Airline 3's revenue under scenario I is given by

$$\begin{aligned} Rev^3_{scnI} \;&=\; \underbrace{(Q^{3,4}_{CD}/2)\; d(Q^{3,4}_{CD})}_{new} \;+\; \text{next three terms of (3)} \;+\; \underbrace{(Q^{3,4}_{AF}/2)\; d(Q^{3,4}_{AF})}_{new} \\ &\quad + \; \underbrace{Q^{3,4}_{BF}\; d(Q^{3,4}_{BF})}_{new} \;+\; \underbrace{(Q^{1,2,3,4}_{EF}/4)\; d(Q^{1,2,3,4}_{EF})}_{new}. \end{aligned} \tag{7}$$

The difference relative to (3) is that traffic levels in markets CD, AF and BF are now chosen collusively with airline 4. The last term in (7) matches airline 1's corresponding EF term in (5).

Cost for airline 3 under scenario I is given by

$$\begin{aligned} Cost^3_{scnI} \;&=\; \text{first term of (4)} \;+\; c(Q^{1,3}_{AC}/2 + \underbrace{Q^{3,4}_{AF}/2 + Q^{1,2,3,4}_{EF}/4)}_{new} \;+\; c(Q^3_{BC} + \underbrace{Q^{3,4}_{BF}/2)}_{new} \\ &\quad + \; c(Q^3_{CF} + \underbrace{Q^{3,4}_{AF}/2 + Q^{3,4}_{BF}/2 + Q^{1,2,3,4}_{EF}/2)}_{new}, \end{aligned} \tag{8}$$

where the changes reflect the differences just discussed.[7]

The revenue and cost expressions under scenario II are not shown in detail, but the further changes are easily described. First, carrier 1 now colludes with 4 in market AD, so that the third term in (1) is replaced by $(Q^{1,4}_{AD}/2)\; d(Q^{1,4}_{AD})$. In addition, because of the four-way interline split, carrier 1 loses half of its interline traffic on route AC, causing $Q_{EF}^{1,2,3,4}/4$ in the second term of (6) to be replaced by $Q_{EF}^{1,2,3,4}/8$. Parallel changes occur for carrier 3, with the third term in (3) replaced by $(Q_{BC}^{2,3}/2)\ d(Q_{BC}^{2,3})$ and $Q_{EF}^{1,2,3,4}/4$ in the second term of (8) replaced by $Q_{EF}^{1,2,3,4}/8$.[8]

For both scenarios, parallel changes in the cost expressions apply for carriers 2 and 4. Once again, traffic levels are chosen to maximize the appropriate profit expression, equal to own-profit or the relevant sum of profits for the colluding carriers. For example, $Q_{EF}^{1,2,3,4}$ is chosen to maximize the sum of profits for all four airlines. Since the full symmetry of the base case is disrupted under both scenarios, a larger collection of first-order conditions is needed to determine the solution. However, since carriers 1 and 2 remain symmetric, as do 3 and 4, only two sets of first-order conditions are required.

4. The Impacts of the Merger and Alliance Consolidation

4.1. Solving for the equilibrium

In order to generate results, more structure must be imposed on the model by assuming specific functional forms for demand and cost. Following Brueckner and Spiller (1991) and Pels, Nijkamp and Rietveld (2000), the demand function $d(\cdot)$ is assumed to be linear, and the cost function is assumed to be quadratic, generating a linear marginal-cost function. Specifically, demand is given by $d(Q) \equiv \alpha - .5Q$ while cost is given by $c(V) \equiv V - .5\theta V^2$, implying that the marginal-revenue function is $\alpha - Q$ and that marginal cost is $1 - \theta V$. Note that two normalizations are imposed, with the marginal-cost intercept and marginal-revenue slope both normalized to one (the first normalization can be imposed arbitrarily and the other justified by choice of quantity units). The parameter α thus measures the strength of demand, while θ measures the strength of economies of density (i.e., the rate at which marginal and average costs fall as traffic volume on a route rises).[9]

Using these functional forms, the first-order conditions described above can be derived and solved for the equilibrium traffic levels under any given scenario. The analytical solutions, which are computed using the Maple software package, show that the various Q's are complicated ratios of polynomials involving α and θ. Since these solutions are not of interest in and of themselves, they are not reported.

The goal of the analysis is to compare the base-case equilibrium to the equilibrium outcomes under each of two scenarios. This task requires comparison of the complicated Q solutions just described, contrasting the base-case solution to the solution under a given scenario. But since the outcome of each comparison depends on the magnitudes of α and θ, which affect the Q solutions, a necessary first step is to characterize the feasible parameter region, which contains the admissible α and θ values.

Three admissibility requirements must be satisfied in generating the feasible parameter region. First, all of the equilibrium traffic levels must be positive. Second, the marginal cost of an extra passenger on each route must be positive, a condition that in turn implies (via the first-order conditions) positivity of marginal revenue and hence the fare. Third, the second-order conditions for the carrier maximization problems must be satisfied.

Consider the comparison of the base-case equilibrium to the equilibrium under scenario I. Extensive analysis shows that if two particular admissibility conditions hold, then all of the remaining admissibility requirements are automatically satisfied under both the base case and scenario I. The first of these conditions is the nonnegativity requirement on $Q_{EF}^{1,2,3,4}$, which says that EF interline traffic under scenario I is nonnegative. The second condition is the nonnegativity requirement for marginal cost on the AE route in the base case.[10] When α and θ take values such that these two conditions hold, then analysis shows that all the other admissibility conditions are automatically satisfied.

Figure 2 shows the resulting feasible parameter region. The lower boundary of the feasible region is the locus of (θ, α) combinations where $Q_{EF}^{1,2,3,4} = 0$, and the upper boundary is the locus of parameter combinations where the AE route's marginal cost in the base case equals zero. Any parameter combination between the upper and lower boundaries is admissible. For earlier analyses that generate similar feasible regions, see Pels et al. (2000) and Brueckner (2001).

4.2. Comparing equilibria

To compare the equilibrium outcomes at the market level between the base case and scenario I, the following graphical procedure is used. First, focusing on the total traffic level in a particular market, the difference between the base-case and scenario-I equilibrium values is computed. For example, in the AD market, this difference equals $(Q^1_{AD} + Q^4_{AD}) - Q^{1,4}_{AD}$, and it is denoted ΔQ_{AD}. This expression, which depends on α and θ via the Q solutions, is set equal to zero to produce an "equality" locus in (θ, α) space, along which $\Delta Q_{AD} = 0$. Computations show that ΔQ_{AD} is positive above the AD equality locus and negative below it.

Next, the AD equality locus is plotted along with the feasible region, and their relative positions are compared. The resulting graph, shown in Figure 3, reveals that the equality locus lies entirely below the feasible region. As a result, for all parameter combinations in the feasible region, ΔQ_{AD} is positive, indicating that base-case traffic in the AD market exceeds scenario-I traffic $(Q^1_{AD} + Q^4_{AD} > Q^{1,4}_{AD})$. Since fares and traffic are inversely related via the demand curve, this conclusion also implies that that the AD fare is lower in the base case than under scenario I.

Figure 3 also shows the equality locii for markets AC, AE, and AF, all of which similarly lie below the feasible region. As a result, the previous conclusion applies for these markets as well: total traffic is higher and the fare lower in the base case than under scenario I. Analogous graphs for the remaining city-pair markets are contained in the appendix, and they show the same pattern, with all the equality locii lying below the feasible region.[11] The following conclusion is therefore established:

> **Proposition 1.** *Relative to the base case, a merger of the two European carriers along with consolidation of the two transatlantic alliances leads, under scenario I, to lower traffic and higher fares in all city-pair markets except for AB, which is unaffected. As a result, consumer welfare, as measured by consumer surplus, falls. Total profit earned by the four airlines rises as a result of the merger and alliance consolidation, but social surplus, as measured by the sum of profit and consumer surplus, falls.*

Although the reduction in consumer surplus is an immediate consequence of lower traffic and higher fares, the results for profit and social surplus are based on computations showing that these measures are higher and lower, respectively, under scenario I throughout the feasible region. Given the loss of competition in moving from the base case to scenario I, the increase in carrier profit comes as no surprise. However, the decline in social surplus shows that these higher profits are not sufficient to offset the reduction in consumer welfare.

Exactly the same exercise can be carried out in comparing the equilibria under the base case and scenario II.[12] While details are not presented, the conclusions are the same as those in Proposition 1:

> **Proposition 2.** *Relative to the base case, merger scenario II leads to lower traffic and higher fares in all city-pair markets except for AB, lower consumer surplus, higher carrier profits, and lower social surplus.*

Thus, the analysis confirms the conjecture stated at the end of section 2: the European airline merger and the associated alliance consolidation are bad for consumers and for society as a whole, but good for the airlines, regardless of whether scenario I or II is considered.

With comparisons to the base case covered by Propositions 1 and 2, a third exercise is to compare the two merger outcomes themselves by contrasting the equilibria that emerge under scenarios I and II. Using the same graphical methodology as before, the following conclusion can be established:[13]

> **Proposition 3.** *While fares and traffic levels in markets AB and CD are the same under scenarios I and II, fares are typically higher and traffic levels typically lower in other markets under scenario II than under scenario I. The only exception to this rule occurs in markets AC and BD, where scenario-II fares are lower and traffic levels higher over a small portion of the feasible region. Relative to scenario I, consumer surplus is lower, carriers profits are higher, and social surplus is lower under scenario II.*

Thus, while usually amplifying scenario I's effects on fares and traffic, scenario II is also worse from the point of view of consumers and society as a whole.

In order gain a better understanding of the results summarized in Propositions 1, 2, and 3, it is helpful to consider a numerical example based on representative values for the parameters α and θ. Such an example is presented in the next section.

5. A Representative Numerical Example

Consider the parameter combination given by $\alpha = 2.89$ and $\theta = 0.11$, which corresponds to a point lying roughly in middle of the feasible region in Figure 2. Table 2 shows the resulting equilibrium Q values and fares for the three cases, while Table 3 shows the welfare measures.

Note that, while the Q values are shown at the airline level within each market, the market-level Q's (which are the focus of Propositions) are easily inferred. Although the absolute magnitudes of the solution values are not particularly meaningful, insight can be gained by comparing these magnitudes across the three cases, as well as within each case.

5.1. Understanding the base case

Before comparing the results across cases, it is useful to consider the patterns of fares and traffic levels in the base case. These patterns, which are shown in the first panel of Table 2, highlight two separate factors that interact in determining the fare in a particular market. The first factor is the extent of competition in the market, with greater competition naturally leading to a lower fare, other things equal. The second factor is economies of traffic density, with higher densities on the route(s) carrying passengers in a market leading to lower cost per passenger and hence a lower fare, other things equal.

Focusing intially on the domestic markets in the base case, note that the domestic interhub markets AB and CD have identical fares and Q's, as do the domestic monopoly markets AE, BE, CF, DF. The absence of competition in the latter markets puts upward pressure on the fare, but since the routes to endpoints E and F carry traffic in additional city-pair markets, densities are higher than on the AB and CD routes. As a result, the absence of competition in AE and the other similar markets is partially offset by lower costs per passenger, leading to fares that are not much higher than the domestic interhub fares (1.62 vs. 1.53).

Similarly, even though markets AD and BC are competitive like AB and CD, fares are lower, and traffic is higher, in these markets. The reason is that the AD and BC routes carry traffic in the DE and BF markets, respectively, along with traffic in the AD and BC markets themselves. As a result, densities are higher than on the AB and CD routes, yielding lower costs per passenger and lower fares for AD and BC passengers.

Another notable feature of the solutions is the traffic asymmetry between airlines 1 and 2 in markets CE. One reason for this asymmetry is the absence of any interline EF traffic on route BC, which tends to reduce BC density relative to that on route AC. Another contributing factor is that both markets that use route BC are competitive (markets BC and CE) while one market that uses route AC is not (the AC market itself), a difference that tends to raise BC density relative to that on route AC. Under the given parameter values, the net effect of these differences is to reduce traffic density on route BC relative to that on route AC. This density asymmetry, in turn, gives airline 1 a cost advantage over carrier 2 in competing for CE traffic, which is reflected in a higher traffic level for 1. The positions of airlines 1 and 2 are reversed in market DE, giving 2 the higher traffic level. All of these asymmetries are repeated markets AF and BF, yielding different traffic levels for airlines 3 and 4.

Next, observe that, while markets AC and BD are similar to monopoly markets like AE in their lack of competition, the former markets have higher fares and lower traffic levels. One reason for this outcome is that, relative to routes AC and BD, a route like AE carries traffic in four rather than three city pair markets and thus has a higher density (such a route also carries all of its alliance's interline traffic rather than half; see (2)). In addition, rather than being concentrated on a single monopoly airline, traffic in a market like AC is split between two colluding carriers, limiting exploitation of economies of density and thus raising costs. For both reasons, the fare is higher, and traffic lower, in markets AC and BD than in the pure monopoly markets.

Finally, market EF has the highest fare and the lowest total traffic of any city-pair market. Although this market benefits from interalliance competition, cost per passenger is the highest of any market given the need to travel across three routes in making an EF trip. Note, however, that despite these higher costs, the EF interline fare is only slightly higher than the fares for other, shorter international trips. This pricing outcome appears to be realistic and is a typical property of models like the present one (see Brueckner (2001)).

5.2. Scenario I

With this background, consider the effects on the equilibrium levels of traffic and fares of moving from the base case to scenario I. The second panel of Table 2 shows that fares rise and total traffic levels fall in all city-pair markets except AB, as stated in Proposition 1.[14] To understand these changes, consider first the European interhub market CD, where carriers 3 and 4 now collude rather than compete. The fare in this market rises dramatically and traffic falls. Similarly, in markets AF and BF, where airlines 3 and 4 now collude, fares again rise and traffic levels decline. Note that AF and BF traffic is now symmetric across carriers 3 and 4 as a result of the assumption that, in colluding, they evenly split passengers in these markets. In market EF, where interalliance competition disappears, the fare again rises while traffic falls.

Although competition is unchanged in all other city-pair markets, the downward pressure on traffic in markets AF, BF, and EF generates negative spillovers that raise fares and reduce traffic everywhere except in market AB. To understand these effects, note first that the traffic losses in markets EF and AF reduce densities on route AC for carrier 1 and on routes AC and CF for carrier 3. By raising cost per passenger, these changes tend to raise fares and reduce traffic in markets AC and CF even though competition is unchanged. Similarly, the traffic losses in markets EF and BF reduce densities on route BD for carrier 2 and on routes BD and DF for carrier 4, changes that tend to raise fares and reduce traffic in markets BD and DF. The resulting density losses on the AC, CF, BD, and DF routes compound those already caused by lower AF, BF and EF traffic.

Higher fares in markets AF and BF also reduce the traffic that flows along routes AD and BC on carriers 4 and 3, cutting densities. The resulting increase in cost per passenger for these two carriers tends to raise fares and reduce total traffic in markets AD and BC, compounding the carriers' density losses on these routes. However, because airlines 1 and 2 lack a source of upward pressure on cost per passenger on routes AD and BC (i.e., no externally-caused loss of densities), their traffic levels in markets AD and BC rise in response to the increase in fares, as can be seen from Table 2.

While these higher traffic levels tend to increase AD and BC densities for carriers 1 and 2, the drop in EF traffic tends to reduce their densities on routes AE and BE. These lower densities in turn tend to increase AE and BE fares while reducing traffic in these markets. In addition, the density losses on routes AE and BE are large enough relative to the gains on AD and BC to raise the overall costs of serving passengers in markets CE and DE, so that fares in these markets rise and traffic levels fall. While all of these density and traffic changes have been described sequentially across routes for heuristic reasons, it is important to recognize that they are mutually reinforcing and simultaneous, being determined by the model's equilibrium conditions.

Although spillovers from lost competition in markets EF, AF and BF thus raise fares and reduce traffic elsewhere, the one market that is insulated from these effects is AB, where the fare and traffic remain the same as in the base case. The reason for this outcome is that, since the AB route carries traffic only in the AB city-pair market, its density level is unaffected by traffic changes in other markets.[15]

Finally, Table 3 shows the welfare effects of moving from the base case to scenario I. With fares rising and traffic falling in each market except for AB, consumer surplus declines. Profit levels for the individual airlines rise, with carriers 3 and 4 reaping the largest increases as a result of their individual collusion. Because the decline in consumer surplus is larger than the increase in total profit, social surplus declines under scenario I.

5.3. Scenario II

The third panel of Table 2 shows the equilibrium traffic levels and fares under scenario II, where collusion is introduced in markets AD and BC, and where EF interline traffic is split four ways. As can be seen from the Table, movement to scenario II amplifies the changes already seen in moving to scenario I, with fares increasing further in the affected markets and traffic showing additional declines. As a result, relative to the base case, fares are higher and market-level traffic is lower in all city-pair markets except for AB under scenario II, as stated in Proposition 2.[16]

Because markets AB and CD are insulated from the effects of the scenario II changes, their fares and traffic levels remain the same as in scenario I. To understand the effects in other markets, observe from Table 2 that collusion in markets AD and BC dramatically raises fares and lowers traffic levels in these markets, changes that reduce densities on the AD and BC routes. These density reductions in turn tend to raise fares and reduce total traffic levels in the other markets that use the AD and BC routes (CE, DE, AF, BF).

However, as discussed above, higher fares in these markets tend to elicit a higher (not lower) traffic level from the carrier not experiencing an externally-caused density loss, despite the overall drop in market traffic. For example, since carrier 1's densities and hence costs are not directly affected by collusion between airlines 2 and 4 in market BC, the higher CE fare described above tends to spur an increase in 1's traffic level in the CE market. Such an increase in turn tends to raise carrier 1's density on the AC route, tending to reduce fares and raise traffic in the AC market. Parallel observations apply to the BD market.[17]

A countervailing force, however, is the AC density loss caused by shifting EF interline traffic to routes AD and BC. If EF traffic is large, then this traffic loss is sufficient to nullify the gain in 1's AC density described above, so that the fare rises and traffic falls in both markets AC and CE. The CE traffic loss, in turn, reduces density on route AE, tending to raise the fare and reduce traffic in market AE. With parallel negative density effects felt on routes BD, BE, CF and DF, fares rise and traffic falls in all remaining city-pair markets aside from AB and CD.

While this type of outcome is the one shown in Table 2, different parameter values can generate an outcome where AC and BD traffic are higher under scenario II than under scenario I (recall Proposition 3). Such an outcome occurs for (θ, α) combinations near the bottom edge of the relevant feasible region, where EF interline traffic is near zero and the loss of a portion of that traffic from routes AC and BD is inconsequential. However, the set of parameter values leading to such an outcome represents a very small portion of the feasible region, so that the outcome in Table 2 can be viewed as representative.

Finally, Table 3 shows that consumer surplus falls further under scenario II, while airline profit rises above the scenario-I level. Since the additional surplus decline is larger than the profit increase, social surplus is lower than in scenario I.

6. Conclusion

This paper has explored the effects of a European airline merger followed by a consolidation of two competing international alliances. The exercise has been inspired by the Air France-KLM merger, which is expected to spur consolidation of the Northwest-KLM and SkyTeam alliances into a single mega-alliance. The results of the analysis show that, although the airlines benefit through higher profits, the merger and alliance consolidation harm consumers while reducing overall social surplus. The reason for this negative outcome is that, as modeled, all the effects of the merger and alliance consolidation are anticompetitive. First, the European merger reduces domestic competition as well as competition in markets that connect interior European endpoints to US hubs, markets that are served in the model solely by European carriers. Second, alliance consolidation reduces competition in the market connecting interior US to interior European endpoints, a market that relies on interline service provided by US and European alliance partners. In the model, creation of a mega-alliance eliminates the previous interalliance competition for passengers in such markets, leading to higher interline fares and lower welfare for these passengers. Creation of a mega-alliance also leads to new collusion on transatlantic interhub routes that were previously served by competing US and European carriers from different alliances.

In appraising these results, it is important to ask whether key sources of benefits have been omitted from the analysis. In the interest of realism in depicting the Air France-KLM case, one possible source of benefits is indeed absent from the model. In particular, following the merger, the European interhub market (CD in the model) is served by two separate airlines who collude in setting fares but sacrifice economies of density by splitting the market. While this depiction accurately represents the initial stages of the Air France-KLM merger, where both airlines are expected to preserve their identities, the carriers will eventually be blended into a single entity. By allowing better exploitation of economies of density, this change will enhance efficiency and thus offset some of the negative effects of lost competition.[18] However, since such efficiency gains are unlikely to fully reverse the merger's anticompetitive effect, the negative verdict of the present analysis would be softened but not overturned. However, other cost-reducing synergies not captured by the simple model developed in the paper may be present, further softening and perhaps reversing the negative view of the merger's domestic impact.

Another omitted potential source of gains relates to interline passengers. In the model, all interline traffic is carried by alliances in the premerger situation. However, in reality, it is possible that some passengers who currently make nonalliance interline trips would have access to alliance service following creation of the mega-alliance. As explained in the introduction, such passengers would benefit from lower fares as well as greater travel convenience. In particular, residents of a US endpoint served by Northwest may need to travel to a European (or perhaps African, Middle Eastern, or Indian) endpoint served by Air France but not by KLM. Under the current situation, such a passenger would need to make a nonalliance trip on Northwest and Air France, whereas alliance travel would be possible following creation of the mega-alliance. The same gain would accrue to a resident of a US city served by Delta and not by Northwest who needs to travel to an endpoint served by KLM but not by Air France. However, given the extensive domestic service provided by each US carrier, as well as the fair degree of overlap in the European and international route systems of Air France and KLM, the number of passengers fitting the above criteria is no doubt small. As a result, the gains from this source are not likely to be large.[19]

Thus, while efficiency gains may partly soften the domestic anticompetitive effects of a merger like the one involving Air France and KLM, justifying this movement toward European airline consolidation, the paper's negative verdict on creation of a mega-alliance appears to be more robust. In particular, it is difficult to identify any signficant positive effect from such an alliance consolidation. As a result, while arguments can be made in support of the recent regulatory approval of the Air France-KLM merger, similar approval of a mega-alliance that blends the Northwest-KLM and SkyTeam alliances when KLM continues to exist as a separate entity would be hard to justify. Thus, while regulators might be unable to block a superficial marketing arrangement involving this large group of carriers, it may be unwise to grant antitrust immunity to Northwest and Air France and to Delta and KLM. Doing so would unleash the some of the anticompetitive forces highlighted in the present analysis.

Table 1

Market Structures

	Base Case		Scenario I		Scenario II	
market	*airlines*	*behavior*	*airlines*	*behavior*	*airlines*	*behavior*
AB	1,2	*compete*	1,2	*compete*	1,2	*compete*
AC	1,3	**collude**	1,3	**collude**	1,3	**collude**
AD	1,4	*compete*	1,4	*compete*	1,4	**collude**
AE	1	*monopoly*	1	*monopoly*	1	*monopoly*
AF	3,4	*compete*	3,4	**collude**	3,4	**collude**
BC	2,3	*compete*	2,3	*compete*	2,3	**collude**
BD	2,4	**collude**	2,4	**collude**	2,4	**collude**
BE	2	*monopoly*	2	*monopoly*	2	*monopoly*
BF	3,4	*compete*	3,4	**collude**	3,4	**collude**
CD	3,4	*compete*	3,4	**collude**	3,4	**collude**
CE	1,2	*compete*	1,2	*compete*	1,2	*compete*
CF	3	*monopoly*	3	*monopoly*	3	*monopoly*
DE	1,2	*compete*	1,2	*compete*	1,2	*compete*
DF	4	*monopoly*	4	*monopoly*	4	*monopoly*
EF*	1+3, 2+4	*compete*	1+3, 2+4	**collude**	1+3, 2+4, 1+4, 2+3	**collude**

*In market EF, '+' indicates that two airlines are joint providers of interline service. Competition in the base case occurs between the two sets of interline partners.

Table 2

Equilibrium Traffic Levels and Fares

($\theta = 0.11,\ \alpha = 2.89$)

Base Case

	AB	AC	AD	AE	AF	BC	BD	BE	BF	CD	CE	CF	DE	DF	EF
Traffic:															
airline 1	1.36	1.10	1.45	2.54	-	-	-	-	-	-	1.24	-	1.20	-	0.50
airline 2	1.36	-	-	-	-	1.45	1.10	2.54	-	-	1.20	-	1.24	-	0.50
airline 3	-	1.10	-	-	1.24	1.45	-	-	1.20	1.36	-	2.54	-	-	0.50
airline 4	-	-	1.45	-	1.20	-	1.10	-	1.24	1.36	-	-	-	2.54	0.50
Fares:															
all	1.53	1.79	1.44	1.62	1.67	1.44	1.79	1.62	1.67	1.53	1.67	1.62	1.67	1.62	1.90

Scenario I

	AB	AC	AD	AE	AF	BC	BD	BE	BF	CD	CE	CF	DE	DF	EF
Traffic:															
airline 1	1.36	1.07	1.49	2.48	-	-	-	-	-	-	1.16	-	1.19	-	0.31
airline 2	1.36	-	-	-	-	1.49	1.07	2.48	-	-	1.19	-	1.16	-	0.31
airline 3	-	1.07	-	-	0.82	1.38	-	-	0.82	1.00	-	2.39	-	-	0.31
airline 4	-	-	1.38	-	0.82	-	1.07	-	0.82	1.00	-	-	-	2.39	0.31
Fares:															
all	1.53	1.82	1.45	1.65	2.07	1.45	1.82	1.65	2.07	1.89	1.72	1.69	1.72	1.69	2.27

Scenario II

	AB	AC	AD	AE	AF	BC	BD	BE	BF	CD	CE	CF	DE	DF	EF
Traffic:															
airline 1	1.36	1.06	1.06	2.47	-	-	-	-	-	-	1.15	-	1.15	-	0.30
airline 2	1.36	-	-	-	-	1.06	1.06	2.47	-	-	1.15	-	1.15	-	0.30
airline 3	-	1.06	-	-	0.80	1.06	-	-	0.80	1.00	-	2.39	-	-	0.30
airline 4	-	-	1.06	-	0.80	-	1.06	-	0.80	1.00	-	-	-	2.39	0.30
Fares:															
all	1.53	1.83	1.83	1.65	2.09	1.83	1.83	1.65	2.09	1.89	1.74	1.70	1.74	1.70	2.29

Table 3

Welfare Measures

$(\theta = 0.11,\ \alpha = 2.89)$

	Base Case	Scenario I	Scenario II
consumer surplus	84.83	77.73	74.84
profit 1	5.30	5.44	5.55
profit 2	5.30	5.44	5.55
profit 3	5.30	5.70	5.88
profit 4	5.30	5.70	5.88
social surplus	106.01	100.00	97.70

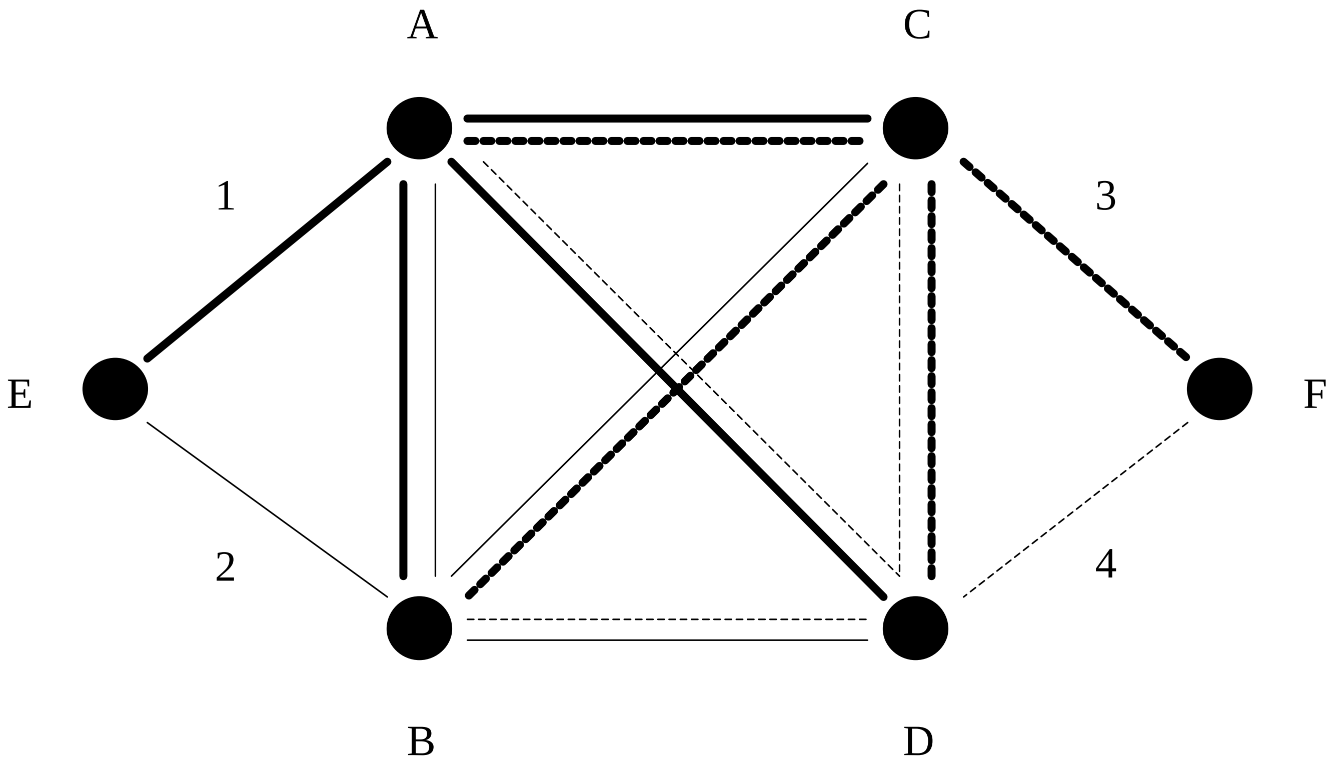

Figure 1: Network Structure

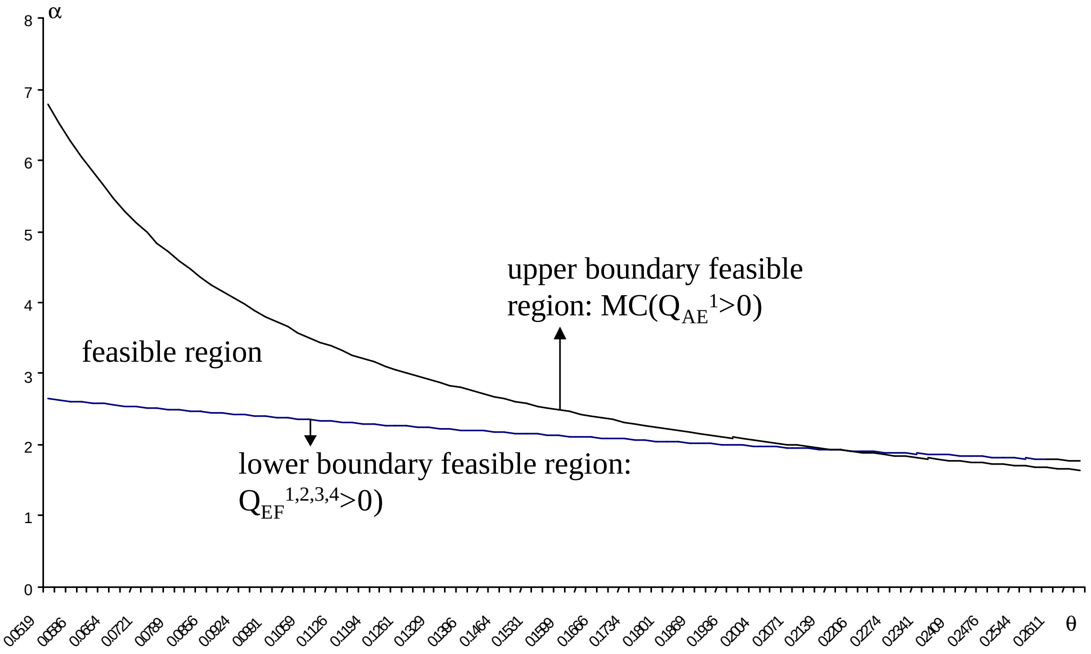

Figure 2. Feasible parameter region

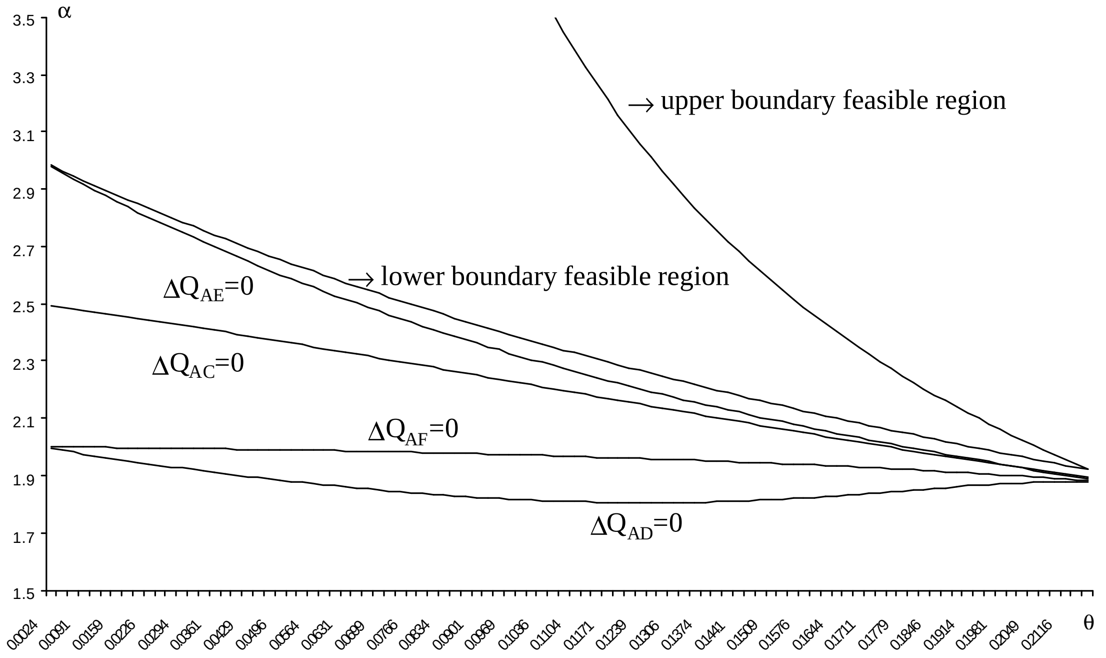

Figure 3. Comparison of traffic levels in two scenarios

Appendix

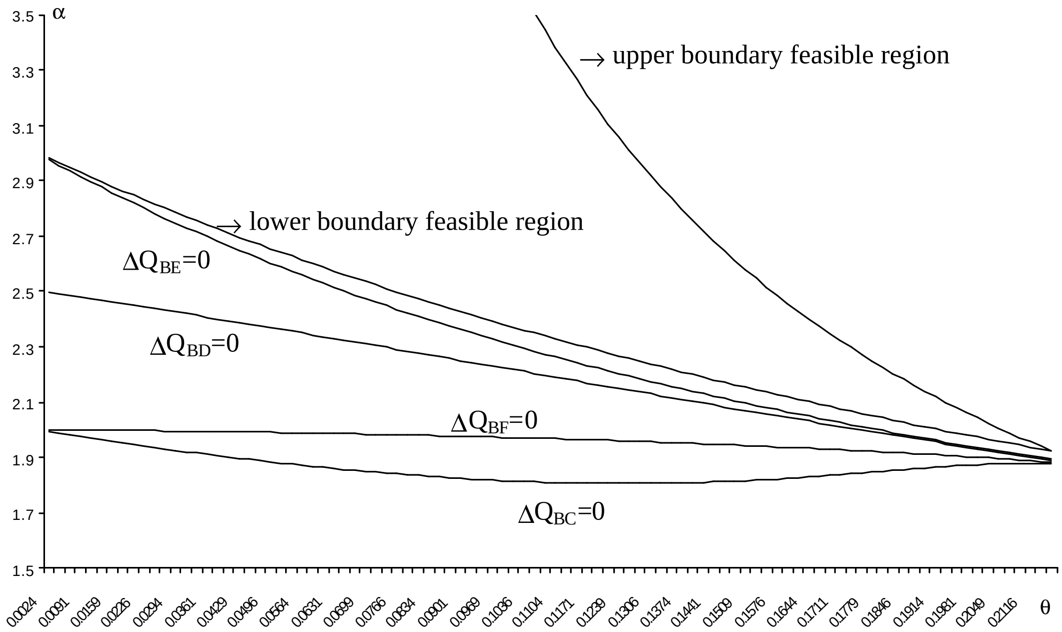

Figure A1 Comparison of traffic levels in two scenarios

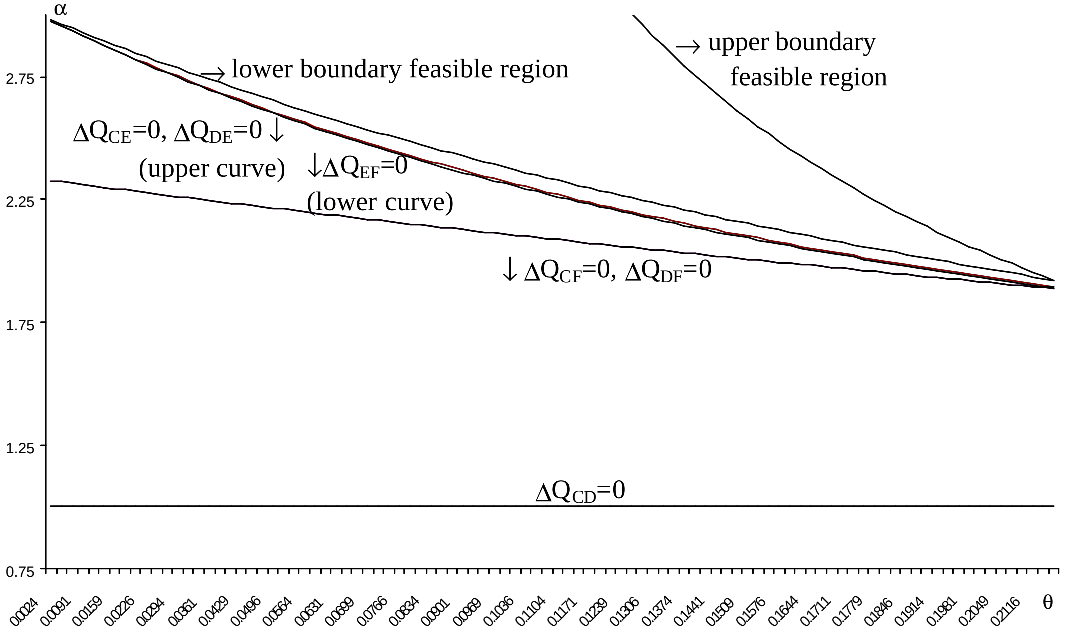

Figure A2 Comparison of traffic levels in two scenarios

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Footnotes

[*] We thank Tom Whalen for comments. Any errors or shortcomings in the paper, however, are our responsibility.

[1] Similar spillovers are present in the analysis of Brueckner and Spiller (1991).

[2] For a nontechnical overview of this research, see Brueckner (2003b). For other research on alliances, see the book by Oum, Park and Zhang (2000), which summarizes research from a large number of journal articles on this subject written by the authors (citations can be found in the book). For other accessible overview pieces see Oum and Park (1997) and Pels (2001). For research on alliances outside the economics literature, see Youssef and Hansen (1994), Bissessur and Alamdari (1998), and Dennis (2000).

[3] A reader not interested in technical details can skip this section as well as subsection 4.1 without loss of continuity.

[4] It should be noted the equal division of AC and EF interline traffic between carriers 1 and 3 on route AC in (2) does not maximize their combined profit. Given economies of traffic density, the proper traffic allocation would concentrate on a single carrier all AC traffic and all EF interline traffic on the AC route. However, given that carriers 1 and 3 remain separate despite their alliance partnership, this kind of extreme traffic allocation is untenable. The equal-split rule is imposed as realistic constraint on the operation of their alliance.

[5] Note that, to avoid redundancy, the first-order conditions for $Q_{AC}^{1,3}$ and $Q_{EF}^{1,3}$ are not be repeated in listing carrier 3's optimality conditions. As a result, carriers 1 and 3 contribute a total of 12 conditions to the complete set (carriers 2 and 4 also contribute 12 conditions).

[6] By fully exploiting economies of density, the interline traffic allocation that would maximize the combined profit of the four carriers would concentrate all of the traffic on three routes (for example, AE, AC (using either 1 or 3 but not both), and CF). Again, this allocation is unrealistic.

[7] Note that AF traffic is equally allocated to routes AC and AD in (8), while BF traffic is equally allocated to BC and BD. Again, this allocation will not maximize the combined profit of carriers 3 and 4 but seems realistic given the maintenance of separate identities for the carriers.

[8] As observed previously, while EF interline traffic should be concentrated on one set of routes

to maximize combined carrier profit, a four-way split is more realistic.

[9] It should be noted that any fixed costs of operating a route are suppressed in this formulation, without loss of generality. While route fixed costs should be considered in analyzing an airline's choice of network structure, where the number of routes is endogenous, the route number is fixed at four for each airline in the present model. As a result, the magnitude of fixed costs is inconsequential, generating a constant that is subtracted from profit in each case. Thus, fixed costs can be conveniently set at zero. To see how the level of fixed costs can affect network structure, see Pels, Nijkamp and Rietveld (2001).

[10] Referring to (2), this condition is written $1 - \theta(Q^1_{AE} + Q^1_{CE} + Q^1_{DE} + Q^{1,3}_{EF}) \geq 0$.

[11] Since the ΔQ_{CE} and ΔQ_{EF} locii nearly coincide, they appear to be one curve in Figure A2 even though they are distinct (the ΔQ_{CE} and ΔQ_{DE} locii are identical).

[12] The relevant feasible region is the set of parameter values generating admissible solutions under both the base case and scenario II.

[13] The relevant feasible region is the set of parameter values generating admissible solutions under both the base case and scenarios I and II.

[14] Note that BC traffic on carrier 2 and AD traffic on carrier 1 is higher under scenario I than in the base case. Total traffic in each of these markets is lower, however, under scenario I, as stated in Proposition 1.

[15] One additional difference relative to the base case is that CE traffic is now higher on airline 2 than on airline 1. This outcome reflects a different net effect of the forces discussed above, which leads to higher rather than lower traffic density on route BC than on AC, giving airline 2 a cost advantage in competing for CE traffic. Parallel comments apply to market DE.

[16] Note that, because of a round-off convention, fares or traffic appear to be same between the scenarios in a few cases. However, either the fare or traffic value differs in every case, showing that the other variable would differ as well if expanded to include more significant digits.

[17] Analogous forces generated by collusion in the AD market tend to raise carrier 2's density on the BD route, tending to reduce fares and increase traffic in the BD market.

[18] These countervailing effects of airline mergers are analyzed by Brueckner and Spiller (1991,

1994). For additional discussion of mergers, see Han and Singal (1993) and Morrison and Winston (1995).

[19] The analysis misses another potential benefit of a mega-alliance. In particular, in contrast to the assumptions of the model, Air France does not currently provide service to Detroit, while KLM does not serve Atlanta. As a result, the European carriers do not provide service on the AD and BC routes in the model, and formation of the mega-alliance would probably lead to beneficial introduction of such service.

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