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Network competition in the open aviation area

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ABSTRACT

In 2008 the 'joint open aviation area' between the US and EU will become reality. It is expected that competition will increase. The reaction of the airlines depends on the possibility to make profits in 'new' markets (markets that can now be entered). This, in turn, depends on network characteristics. In this paper we find that full liberalization of international markets by means of a bilateral agreement results in higher welfare than the formation of an alliance. Carriers, however, will also in fully deregulated aviation markets most likely opt for an alliance. This is a result of a built-in competitive effect of hub–spoke networks. Only in markets where the reservation price is very high (e.g. to London Heathrow), hub–spoke airlines may enter a competitive game. Low-cost airlines, which do not operate extensive hub–spoke networks, may find it profitable to enter new markets.

1. Introduction

In 2008 the 'joint open aviation area' between the US and EU will become reality. The agreement between the US and EU that created this open aviation area was endorsed by EU transport ministers on March 22, 2007. This draft US–EU open skies agreement deregulates the largest aviation market in the world. According to US Transportation Secretary Mary Peters, this agreement will benefit both passengers and airlines: "Tearing down regulatory barriers allows us to foster more affordable and convenient air travel and gives our airline industry more opportunities to compete, innovate and thrive". In the media, there were already claims that enhanced competition would lower transatlantic fares with hundreds of Euros. The main competitive threat would come from low-cost carriers, as the removal of regulatory barriers opens up transatlantic markets for low-cost carriers. The market from London to the US accounts for about 1/3 of all flights from Europe to the US, so one could expect that entry will take place especially in this lucrative market.

It is not the first time that hopes were high when the deregulation of aviation markets was announced. When the US aviation market was deregulated in 1978, the number of airlines increased rapidly. But it decreased just as rapidly. Although fares decreased in real terms, airlines also succeeded in creating fortress hubs, protecting them from competition from other conventional airlines, and allowing them to charge hub-premiums. Following the deregulation of the EU and US markets, increased competition usually came from low-cost carriers on short-haul markets and from other conventional airlines offering indirect tickets on long-haul markets. Competition between airlines on direct links between major hubs on the transatlantic market was usually limited to competition between US and European airlines. More often than not, US and European airlines entered alliance agreements, to exploit network complementarities, and to reduce competition. Although such alliances created clear benefits for passengers in terms of network connectivity, competition on routes between major hubs decreased.

The expectations from the joint aviation area resemble the expectations from the deregulation of the US and EU aviation markets: increased competition, and lower fares. But the experience of the deregulation shows that we should be careful making strong statements about an increase in the number of competitors. What will be the effects on airline networks of the new 'joint open aviation area'? In this paper we discuss the network changes that may occur as a result of the joint open aviation area. Specifically, we discuss the changes in the sector following the deregulation of the EU and US markets, and then see how this carries over to the transatlantic market. The effects of the deregulation of the US and EU markets are discussed in a literature review in Section 2. Section 3 discusses a model of network competition in the Open Aviation Area, and Section 4 presents the theoretical results. Section 5 concludes.

2. Effects of deregulation of aviation markets in the US and EU

Prior to the deregulation in the US, Civil Aeronautics Authority, later renamed as the Civil Aeronautics Board (CAB), determined

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routes and regulated fares in the US to protect the carriers from "destructive" competition and protect consumers, while allowing airlines to obtain a reasonable return on ticket sales. The CAB allowed fare increases to compensate for the higher airline operating costs following the oil crisis in the 1970s, but it became more and more clear that government regulations were too restrictive for the airline industry. In 1975 the CAB concluded that the airline industry is naturally competitive and not monopolistic, and in 1978 the Airline Deregulation Act was passed. All restrictions on (domestic) routes, fares and schedules were to be removed. Increased airline operating efficiency and competition were expected to benefit both airlines and passengers.

Following deregulation of the US aviation market, there was a large-scale entry of new carriers, followed by the rapid departure of almost all of them. Immediately after the deregulation, there were about 40 major carriers, while some 15 years later there were six or seven. It thus appears that competition did not increase following the deregulation, albeit that fares decreased in real terms since the deregulation. The decline in fares from 1976 to 1985 represented savings of $11 billion US to passengers in 1986 (Kahn, 1988). The disciplining effect of competition was, however, geographically unevenly distributed. Airlines were free to operate their most efficient networks, and most airlines decided to operate the hub-and-spoke network, which allows for the exploitation of density economies. The number of competitors may have actually decreased on routes starting or terminating at a hub. On routes between hubs and on long haul, connecting flights, there may, however, be fierce competition. Hub airlines offer their local passengers direct flights, with greater frequency, better airport facilities, and more destinations than its competitors. Because of this service quality, airlines are able to charge a hub premium to its local passengers. The empirical evidence has widely varying estimates of the hub premium, but 15% is probably a reasonable point estimate.

But also the exploitation of market power can lead to higher fares; a lack of competition allows airlines to create so-called fortress hubs and raise fares without the threat of entry. Zhang (1996) shows that airlines using hub–spoke networks may not have an incentive to invade each other's network, because this may lower profits in the 'original' network. Zhang uses the network depicted in Fig. 1 to make this point, where airline 1 uses H as a hub, serves AH and BH directly, and AB indirectly, while airline 2 uses K as a hub, serves AK and BK directly, and serves AB indirectly. This network is not realistic since the market between hubs is missing, but similar results are obtained when this market is included.

When airline 1 invades markets AK and BK, the price decreases because of increased competition. Airline 2 can behave by behaving aggressively in the AB-market: increased output in AB market lowers average costs on the AK and BK links because of density economies. Because airline 2 behaves aggressively in AB-market, airline 1 looses output in AB market (airline 2 captures part of the AB market of airline 1). As a result, marginal costs on the AH and BH links increase. Average costs thus increase. Because

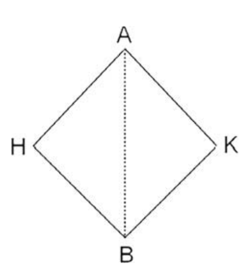

Fig. 1. Network configuration.

average cost increase on AH and AB links, the number of passengers in the AH and BH markets decreases (flights are more expensive). Because output is decreased in the original network (HAB), the additional profits of the new AK and BK markets have to be balanced against losses in the other markets. When density economies are strong (effects mentioned above are strong) and willingness-to-pay is high, attacking the network of airline 2 decreases profits for airline 1. If airline 2 also responds by invading the AH and BH markets, the effects resemble effects of invasion of AK and BK markets by airline 1. Therefore, entry in competitor's network may lead to lower overall profits. Instead, more often than not airlines choose to enter alliance agreements rather than to enter a competitive game. The concentration on the US aviation market resulted from a number of bankruptcies and various forms of cooperation between carriers (varying from "loose agreements" to full mergers). Alliances (national or intercontinental) allow airlines to reduce competition (in the case of parallel alliances), but also to add destinations to the network without 'invading' new markets, so that density economies can be exploited (in the case of complementary alliances). The process of alliance formation therefore can be seen as a continuation of the network formation process that started with the formation of hub–spoke networks.

The policy implications of the above mentioned findings are interesting. In deregulated aviation networks, where airlines can enter and leave markets at their own discretion, airlines using hub–spoke networks, most likely do not have an incentive to enter each other's networks. Instead, they opt for the formation of 'fortress hubs', where one airline (the major hubbing airline at the airport) dominates the airport in the number of flights, and the formation of alliances. Low-cost carriers, which do not operate hub–spoke networks and therefore do not face the network effects resulting from indirect passengers, do not 'suffer' from the network effects described above when they enter new markets. In a deregulated environment, low-cost carriers are therefore likely to enter new markets as soon as they see potential profits, while cooperation with other airlines may be difficult due to large differences in operating procedures.

The deregulation of the EU aviation market was far more gradual compared to the US case. But the outcomes are, to a certain extent, similar. Many European airlines were state companies with radial networks. In the deregulated environment, more and more airlines will be privatized, while the shift of the radial network to the hub–spoke network related to the timing of the flights, to allow for more convenient transfers. Airlines with hub–spoke airlines did not invade each other's networks, and also in the EU there was concentration: some airlines went bankrupt (Swissair, Sabena), while other airlines entered alliance agreements (the Air France-KLM merger being the most far reaching). Low-cost airlines appeared also in Europe after the deregulation of the EU aviation markets. Low-cost airlines opened new markets (e.g. Ryanair London–Carcassonne), but also entered local markets of established hub-carriers (e.g. easyJet on Paris–Toulouse).

Another important implication of deregulation and bilateral agreements between the US and European countries is that US airlines and European airlines can form alliances, thus expanding the number of intercontinental destinations (and benefit from economies of density) without extending the network size.

To summarize, the deregulation of aviation markets led to the adoption of hub–spoke networks by full-service carriers. Such networks allow full-service airlines to form fortress hubs, and prevent full-service airlines from entering each other's local markets. Low-cost airlines are not 'limited' by the network effects, and can enter markets whenever they see profits. In the next sections, we see how these findings carry over to transatlantic markets.

3. Model setup

In the past decade, international airline alliances rapidly gained importance. Bilateral agreements between the US government and European countries gave US airlines access to airports within the European country in question, and vice versa. The Open Aviation Area extends the bilateral agreements between two individual countries to an agreement between the US and EU. For reasons explained above, it seems likely that the process of alliance formation and concentration will continue. The hub–spoke networks used by full-service carriers rely on transfer passengers to keep the cost per seat low. As a result, small airliners are relatively expensive to operate, so that consolidation leads to lower operating costs.

In this section we present a theoretical analysis of international airline alliances, for example on the transatlantic market. The analysis concerns three scenarios. The first scenario is the "base scenario". In this scenario the airlines (or alliances) are only allowed to operate a service to one foreign destination ("gateway"), and no cooperation between airlines or alliances is allowed. Following the deregulation of the aviation market, airlines or alliances are allowed to operate flights to other foreign destinations. There are two options. In scenario II, the airlines (or alliances) invade the competitor's network; airlines choose not to cooperate. In scenario III, the airlines or alliances decide to cooperate. The networks are depicted in Fig. 2.

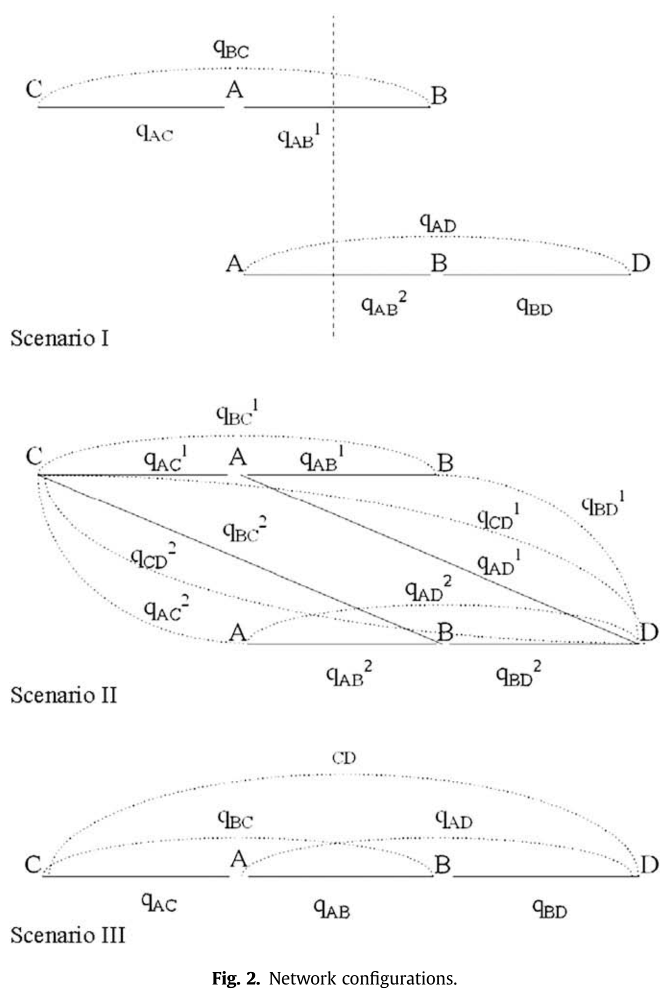

Fig. 2. Network configurations.

Assume that we have two airlines which operate networks as in Fig. 2. In the 'base scenario', which we will call scenario I, airline *a* operates a hub-and-spoke network with A as the hub. One of the destinations in *a*'s network, B, lies in a foreign country. Airline *b* also operates a hub-and-spoke network and has B as its hub. A is airline *b*'s foreign destination. In this network, there is only (direct) competition on link AB. We assume the cost per link is a quadratic function of the number of passengers using the link: $C = Q + (\theta/2)Q^2 + f$, where Q is demand and f is the fixed cost per link. The inverse demand function in all markets is $P = \alpha - Q/2$, where Q is demand in the market under consideration[1], so that we have for example in market AB: $P_{AB} = \alpha - (Q^a_{AB} + Q^b_{AB})/2$, where the superscript denotes the airline and the subscript denotes the market. In this setting airline *a*'s profits are:

$$\pi^a_{I} = P_{AB}\cdot Q^a_{AB} + P_{AC}\cdot Q_{AC} + P_{BC}\cdot Q_{BC} + P_{CD}\cdot Q_{CD} - \left\{\left(Q^a_{AB} + Q_{BC} + \frac{1}{2}\cdot Q_{CD}\right) - \frac{\theta}{2}\cdot\left(Q^a_{AB} + Q_{BC} + \frac{1}{2}\cdot Q_{CD}\right)^2\right\} - \left\{\left(Q_{AC} + Q_{BC} + \frac{1}{2}\cdot Q_{CD}\right) - \frac{\theta}{2}\cdot\left(Q_{AC} + Q_{BC} + \frac{1}{2}\cdot Q_{CD}\right)^2\right\} - 2\cdot f$$

As a result of, for example, an open skies agreement between the two regions, the two carriers are allowed to serve the other foreign destination from their own hub.[2] If the airlines decide to do so noncooperatively, they are in effect invading each other's markets; this is scenario II. For example, airline *b* operates an indirect route between A and C and competes with airline *a*, which operates a direct route. Both airlines also operate two new indirect markets next to the new direct market. Corresponding profits are:

$$\pi^a_{II} = P^a_{AB}\cdot Q^a_{AB} + P^a_{AC}\cdot Q^a_{AC} + P^a_{AD}\cdot Q^a_{AD} + P^a_{BC}\cdot Q^a_{BC} + P^a_{BD}\cdot Q^a_{BD} + P^a_{CD}\cdot Q^a_{CD} - \left\{(Q^a_{AB} + Q^a_{BC} + Q^a_{BD}) - \frac{\theta}{2}\cdot(Q^a_{AB} + Q^a_{BC} + Q^a_{BD})^2\right\} - \left\{(Q^a_{AC} + Q^a_{BC} + Q^a_{CD}) - \frac{\theta}{2}\cdot(Q^a_{AC} + Q^a_{BC} + Q^a_{CD})^2\right\} - \left\{(Q^a_{AD} + Q^a_{BD} + Q^a_{CD}) - \frac{\theta}{2}\cdot(Q^a_{AD} + Q^a_{BD} + Q^a_{CD})^2\right\} - 3\cdot f$$

Rather than invading each other's markets, the airlines can also choose to cooperate; this is scenario III. The carriers jointly operate the AB-route. Passengers traveling on the BC- and AD-routes use one or both of the cooperating carriers (depending on which airline offers the service on the AB-route), passengers traveling on the CD-route use both carriers. Following Brueckner (1997) we make the following assumptions concerning the alliance. Revenues from the markets where passengers may have to travel on both airlines are shared evenly between the carriers. The fixed costs of operating the AB-route are also shared evenly between the carriers. Carrier *a*'s profit function in this scenario is:

[1] This specification is quite common in the aviation economics literature; see e.g. Brueckner (1997), Brueckner and Spiller (1991), Park (1997) and Zhang (1996).

[2] In effect the airlines are restricted to operate a hub-and-spoke network, while a link between, for example, B and D is also an (theoretical) option. Optimality of the hub-and-spoke network is studied by Pels (2000). Here we assume the airline chooses to operate a hub-and-spoke network; we return to this later.

$$\pi^a_{III} = \frac{P_{AB}\cdot Q_{AB}}{2} + P_{AC}\cdot Q_{AC} + P_{BC}\cdot Q_{BC} + \frac{P_{CD}\cdot Q_{CD}}{2} - \left\{\left(\frac{Q_{AB}}{2} + Q_{BC} + \frac{Q_{CD}}{2}\right) - \frac{\theta}{2}\cdot\left(\frac{Q_{AB}}{2} + Q_{BC} + \frac{Q_{CD}}{2}\right)^2\right\} - \left\{\left(Q_{AC} + Q_{BC} + \frac{Q_{CD}}{2}\right) - \frac{\theta}{2}\cdot\left(Q_{AC} + Q_{BC} + \frac{Q_{CD}}{2}\right)^2\right\} - \frac{3}{2}\cdot f$$

In scenarios I and II airline a maximizes its own profits with respect to q_i, where subscript i denotes the markets served by a. In scenario III the carriers maximize their joint profits in the AB and CD markets. In the other markets the carriers maximize their own profits.[3]

4. Network competition in the open aviation area: a theoretical perspective

In this section we compare the three different scenarios. The purpose of the analysis is to see if and how airline a (and b due to symmetry) will change its strategy compared to the base scenario (I) if it is allowed to enter the BD market (and through that market the indirect AD and CD markets). We do this by comparing the maximum profits in the different scenarios. The parameter space in which we can compare profits is bounded by the second order for profit maximization and the requirements of nonnegative quantities and marginal costs, see e.g. Pels (2000) for details. From the optimal prices and quantities reported in Appendix A, it is clear that analytical comparison of profits in the three scenarios is for all practical purposes meaningless. Instead we make a graphical comparison of scenarios by plotting $\pi^a_x - \pi^a_y = 0$, where x and y represent different scenarios.[4]

4.1. Airline strategies

In Fig. 3 we compare scenarios I and II for $f = 0$.[5] We see that airline a will not invade airline b's markets if both α and θ are relatively high; in that case profits in scenario I are always higher. If f increases, the area in which scenario I is more profitable increases; see Appendix B, Fig. B1. In scenario II, airline a operates one extra direct link. Revenues have to be high to compensate: Q and/or P must be relatively high. When θ is low, marginal costs ($MC = 1-\theta Q$), and with it marginal revenues, are relatively high. But when θ is high marginal costs and prices are low: airline a may not generate sufficient revenues under scenario II, and scenario I will be preferred. Even though it extracts revenues from three extra markets (AD, BD and CD), the high value of θ combined with the downward pressure of competition[6] on prices leaves airline a with a loss.

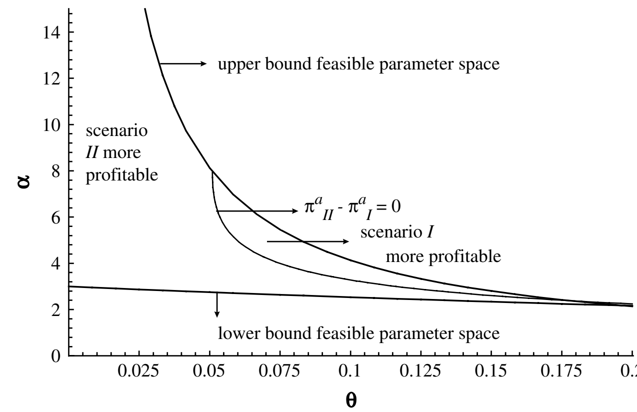

Fig. 3. Comparison of profits in scenarios I and II, $f = 0$.

This result is similar to the result obtained by Zhang (1996), who finds that an invading airline's profits may decrease as result of invasion of the competitor's local markets.

It is always more profitable for airline a to enter an alliance. This is no surprise, as competition is eliminated from the AB market. Moreover, under this scenario, airline a is able to sell tickets in the AC and CD markets, and shares the fixed costs of the AB-route with airline b. Finally, network effects allow airline a to obtain higher profits due to economies of density.

In Fig. 4 we compare profits in scenario II and III, again for $f = 0$. We see that only if α and θ are low, the fully competitive scenario (II) will be preferred by the airline. In scenario III there is no competition, and as a result prices are higher and, ceteris paribus, demand will be lower compared to scenario II. In scenario III, less direct links are operated, allowing the airlines to profit from economies of density. But when α and θ are low and demand is low, costs are relatively high because there is little opportunity to exploit density effects. In that case, the positive effect of higher prices on profits may not balance the negative effects of relatively high costs and lower demand in scenario III. However, if f is sufficiently high it is always optimal to enter an alliance agreement (under which fixed costs are lower); see Appendix B, Fig. B2, where the indifference curve lies outside (below) the feasible parameter space. Above the curve, scenario III is more profitable. Hence inside the feasible parameter space, it is always more profitable to enter an alliance agreement.

From the analysis in this section we conclude that an airline will "expand its horizon" if it gets the opportunity to enter new

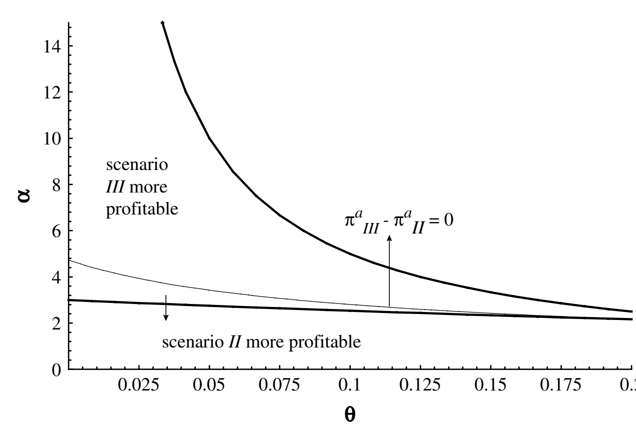

Fig. 4. Comparison of profits in scenarios II and III, $f = 0$.

[3] Carrier a may use carrier b's capacity in the BC market. Likewise, carrier b can use a's capacity in the AD market.

[4] These curves also exist outside the feasible parameter space, and are backward bending (the curves used to compare consumer surplus in the following section are also exist outside the feasible area and are also backward bending). Only those parts of the curves that are of economic interest (i.e. are located inside or partly inside the parameter space) are plotted.

[5] The assumption $f = 0$ is common in the literature. Pels (2000) shows that a fully connected network is most likely the optimal network rather than a hub-and-spoke network for $f = 0$. The assumption $f = 0$ may thus may lead to a situation where optimal strategies in a sub-optimal networks are analyzed. If we assume that due to legal or other constraints airline a can only serve destination D from its hub in scenario II, we can make this assumption. Moreover, if f increases, a hub-and-spoke is likely to become more profitable (Pels, 2000), and the point we try to make in this paper does not change (see Appendix B).

[6] Remember that in scenario II all markets are competitive.

(foreign) markets. Assuming that the parameters f, α and θ are sufficiently large, the airlines will enter an alliance agreement. The literature shows that density economies are strong in the aviation industry (see e.g. Caves et al., 1984), while conventional airlines have relatively high costs compared to low-cost airlines. Low-cost airlines are able to operate with relatively low fixed costs due to extensive outsourcing.

We see that conventional US airlines will not "invade" European networks if the level of demand and economies of density are relatively high. The US airlines operate more links, so fixed costs are higher and revenues have to be higher to compensate. But when density economies are high, marginal costs and marginal revenues are low. We also see that joining an alliance agreement with a European carrier is in most cases more profitable than invading the European carrier's network. Only when the level of demand and density economies are low, there are not enough opportunities to exploit density economies. It is then always more profitable to enter an agreement compared to the "base scenario".

4.2. Consumer effects

We now compare consumer surplus in the different scenarios. Consumer surplus in scenario II is always higher than consumer surplus in scenario I inside the feasible parameter space. This is straightforward, because prices are likely to be lower under scenario II because of increased competition and density effects. To compare scenarios I and III and II and III, respectively, we plot $CS_x - CS_y = 0$ inside the feasible parameter space, where CS stands for consumer surplus and x and y are different strategies.

In Fig. 5 we see that at low levels of α and θ, consumer surplus is lower under scenario III than it is under scenario I. Elsewhere inside the feasible parameter space, consumers prefer scenario III (i.e. an alliance). In scenario III, competition is reduced compared to scenario I (which leads to higher prices). On the other hand, by linking the networks, new markets are opened, and there are opportunities to exploit economies of density, which can lead to lower prices. The latter effect only outweighs the former if α (maximum reservation price) and θ are sufficiently high.

Brueckner (1997) finds that codesharing increases welfare for most parameter combinations, but the networks analyzed are different form the networks analyzed here. Brueckner compares scenarios I and III for the case where both airlines operate hub-and-spoke networks with three spoke markets, one of which is the intercontinental market on which both airlines compete. In our model, we have one less spoke market but by entering an alliance

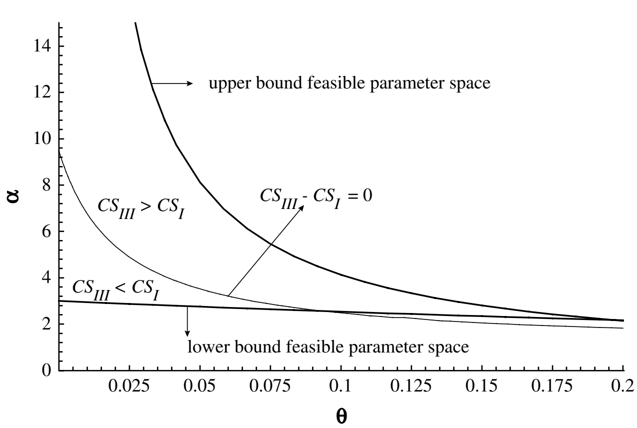

Fig. 5. Comparison of consumer surplus I and III, $f = 0$.

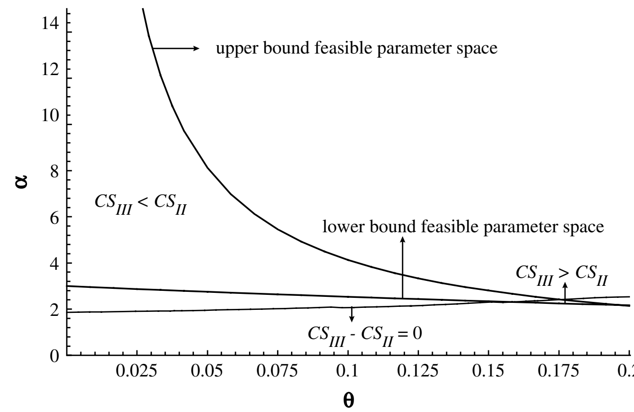

Fig. 6. Comparison of profits in scenarios II and III, $f = 0$.

agreement, an airline can open up new markets. This is not possible in Brueckner's model.

In Fig. 6 we see that consumer surplus in scenario II is higher for almost all parameter combinations. Only if θ is close to its maximum value, there is a (small) region in which consumers would prefer scenario III. Although airline a (and also airline b) will opt for an alliance if f is sufficiently high, consumers prefer the "fully competitive" scenario II. Comparing scenarios II and III, there are two countervailing effects. First, in scenario II all markets are competitive. In scenario III there is no competition; airlines collude or have local monopolies. Therefore prices can be expected to be higher in scenario III. On the other hand, in scenario III airline a operates one less direct link (AD). Passengers in the AD and CD markets therefore have to travel one extra link. This increases the number of passengers on the AB, AC and BD links, and lowers the prices in all markets in which these links are used. It turns out the latter effect is not strong enough to balance the former effect unless θ is very high. Thus passengers are most likely better of in scenario II.

The authorities may have the intention to protect consumers in either the AB market or, in a naive approach following the conjecture that alliances are always harmful because they eliminate competition, in all markets. If they do so by simply not allowing airlines to enter alliances, to encourage the airlines to adopt the fully competitive strategy, we see that at high levels of α and θ the airlines do not choose to invade their competitor's network; i.e. the airlines stick to the strategy of scenario I. However, at these levels of α and θ it is likely that consumers will prefer the codesharing scenario over the base scenario. Although the authorities have the intention to protect consumers, in this case the consumers would actually be better off if the authorities would not intervene. Whether or not the government should intervene (i.e. forbid an alliance) then depends on the parameter values. If levels of demand and density economies are high the government should not intervene.

To conclude, it is most likely a dominant strategy for an airline to enter an alliance. Consumer surplus is then most likely lower than under scenario II. Authorities may forbid alliance in favor of scenario II, in which consumer surplus is higher than in I. But then it may be a dominant strategy for airlines to keep their old network.

5. Conclusion

In this paper we argue that the effects of the Open Atlantic Aviation Area may resemble the effects of the earlier deregulation of the US and EU markets. Following the deregulation of these markets, airlines rearranged their networks in a process of hub-and-spoke network formation and consolidation. Rather than to compete, the airlines using hub–spoke networks stick to their fortress hubs, and enter alliance agreements. The lack of competition on low-density routes may be intrinsic to the aviation sector; demand may be too low to allow more than just a few (or even one) carrier to obtain a profitable market share. This is a result of network characteristics. Routes between hubs and e.g. transatlantic routes (i.e. routes with a relatively high reservation price α, such as routes to London Heathrow) are more competitive. In the latter case, the number of direct competitors may be low, but there are a number of indirect alternatives available. The theoretical analysis in Sections 3 and 4 confirms that when density effects are important, airline consolidation will be the most dominant strategy. When the authorities intervene by forbidding cooperation to stimulate competition, airlines will stick to their original networks. Two remarks are in order. First, the authorities may decide to protect consumers in the AB market. This may then happen at the expense of the consumers in the other markets; the remarks above about the undesired policy effects are based on consumer surplus. Second, in this paper, consumers are better off if the prices are lower. Network effects have influence (due to economies of density), but frequency plays no part. Aggregate frequencies may be higher if airlines enter an alliance agreement, to the benefit of passengers. Scenario III might become more attractive to passengers if frequency is also considered. Including frequency in the analysis is therefore an important point on the research agenda.

Low-cost carriers will markets whenever they see profits. Although low-cost carriers will operate in 'thin' markets between secondary airports, they only do so if they are able to make money. In the US, and in the EU, low-cost carriers engage in cherry-picking: select only the most profitable markets. At this moment low-cost carriers are not allowed to fly on transatlantic routes. But as soon as these markets are opened up for low-cost carriers, they will also follow the cherry-picking strategy in the Open Atlantic Aviation Area. This means that they will fly on 'thick routes' offering competition to full-service carriers. Also in the Open Atlantic Aviation Area it is to be expected that competition will come mainly from low-cost carriers. The important question then is whether low-cost airlines will enter such markets. In such markets, they may not be able to achieve the quick turn-around times that are so important for their strategies. Also, they may not be able to generate enough revenues on long-haul flights if they stick to the singe class aircraft configuration. But the most important barrier to entry may be the availability of slots at the airports on routes that have enough potential demand to be interesting for low-cost airlines. Slot-allocation therefore should also be high on the agenda of policy makers.

Appendix A. Optimal prices and quantities

Scenario I

$$Q^a_{AB} = 2\frac{(\theta-1)[(\theta-1)\alpha+1]}{(7\theta-11)\theta+3} \qquad P^a_{AB} = \frac{[(5\theta-7)\theta+1]\alpha-2(\theta+1)}{(7\theta-11)\theta+3}$$

$$Q_{AC} = \frac{(2\theta-3)[(\theta-1)\alpha+1]}{(7\theta-11)\theta+3} \qquad P_{AC} = \frac{1}{2}\frac{[(12\theta-17)\theta+3]\alpha+3-2\theta}{(7\theta-11)\theta+3}$$

$$Q_{BC} = -\frac{\left(2\theta^2-3\right)\alpha+6-5\theta}{(7\theta-11)\theta+3} \qquad P_{BC} = \frac{1}{2}\frac{[(8\theta-11)2\theta+3]\alpha+6-5\theta}{(7\theta-11)\theta+3}$$

Scenario II

$$Q^a_{AB} = \frac{2}{9}\frac{[(4\theta-3)4\theta+3]\alpha-3+4\theta}{(4\theta-1)(2\theta-1)} \qquad P^a_{AB} = \frac{1}{9}\frac{[(4\theta-3)10\theta+3]\alpha-8\theta+6}{(4\theta-1)(2\theta-1)}$$

$$Q^a_{AC} = \frac{2}{9}\frac{[(8\theta-9)2\theta+3]\alpha+4\theta}{(4\theta-1)(2\theta-1)} \qquad P^a_{AC} = \frac{1}{9}\frac{[(16\theta-9)4\theta+3]\alpha-20\theta+9}{(4\theta-1)(2\theta-1)}$$

$$Q^a_{AD} = \frac{2}{9}\frac{[(8\theta-9)2\theta+3]\alpha+4\theta}{(4\theta-1)(2\theta-1)} \qquad P^a_{AD} = \frac{1}{9}\frac{[(16\theta-9)4\theta+3]\alpha-20\theta+9}{(4\theta-1)(2\theta-1)}$$

$$Q^a_{BC} = -\frac{2}{9}\frac{\left(8\theta^2-3\right)\alpha-16\theta+9}{(4\theta-1)(2\theta-1)} \qquad P^a_{BC} = \frac{1}{9}\frac{[(16\theta-9)4\theta+3]\alpha-20\theta+9}{(4\theta-1)(2\theta-1)}$$

$$Q^a_{BD} = -\frac{2}{9}\frac{\left(8\theta^2-3\right)\alpha-16\theta+9}{(4\theta-1)(2\theta-1)} \qquad P^a_{BD} = \frac{1}{9}\frac{[(16\theta-9)4\theta+3]\alpha-20\theta+9}{(4\theta-1)(2\theta-1)}$$

$$Q^a_{CD} = -\frac{2}{9}\frac{\left[\left(4\theta^2+3\right)2\theta-3\right]\alpha-16\theta+6}{(4\theta-1)(2\theta-1)} \qquad P^a_{CD} = \frac{1}{9}\frac{[(44\theta-21)2\theta+3]\alpha-32\theta+12}{(4\theta-1)(2\theta-1)}$$

Scenario III

$$Q^a_{AB} = 2\frac{[(3\theta-5)\theta+2]\alpha+2(\theta-1)}{(11\theta-18)\theta+4} \qquad P^a_{AB} = \frac{[(8\theta-13)\theta+2]\alpha-2\theta+2}{(11\theta-18)\theta+4}$$

$$Q^a_{AC} = \frac{[(3\theta-8)\theta+4]\alpha+2\theta-4}{(11\theta-18)\theta+4} \qquad P^a_{AC} = \frac{1}{2}\frac{[(19\theta-28)\theta+4]\alpha-2\theta+4}{(11\theta-18)\theta+4}$$

$$Q^a_{AD} = -2\frac{\left(\theta^2-2\right)\alpha+4-3\theta}{(11\theta-18)\theta+4} \qquad P^a_{AD} = \frac{[(12\theta-18)\theta+2]\alpha-4\theta+3}{(11\theta-18)\theta+4}$$

$$Q^a_{BC} = -2\frac{\left(\theta^2-2\right)\alpha+4-3\theta}{(11\theta-18)\theta+4} \qquad P^a_{BC} = \frac{[(12\theta-18)\theta+2]\alpha-4\theta+3}{(11\theta-18)\theta+4}$$

$$Q^a_{CD} = -2\frac{\left(\theta^2-2\right)\alpha+4-3\theta}{(11\theta-18)\theta+4} \qquad P^a_{CD} = \frac{[(12\theta-18)\theta+2]\alpha-4\theta+3}{(11\theta-18)\theta+4}$$

Appendix B. The effect of increased fixed costs

In Fig. B1, where $f=1$, we see that the area in which profits in scenario I exceed profits in scenario II is larger compared to Fig. 3, where $f=0$. This is not surprising, because in scenario II one more link is operated. If the fixed costs of this additional link are (very) high, the extra revenues resulting from need to be high to compensate. These revenues are, however, independent of the level of the fixed costs. Therefore, if f increases, scenario II becomes more and more unattractive to the airline. In Fig. B2 we see that, for similar reasons, scenario II is no longer an alternative for scenario III if f increases; if f is too high, the indifference curve falls outside the feasible area and scenario III is always preferred. Hence, if f is high, the authorities need to be extra careful implementing a "naive" policy of simply not allowing an alliance to protect consumers; airlines are more likely to stick to scenario I.

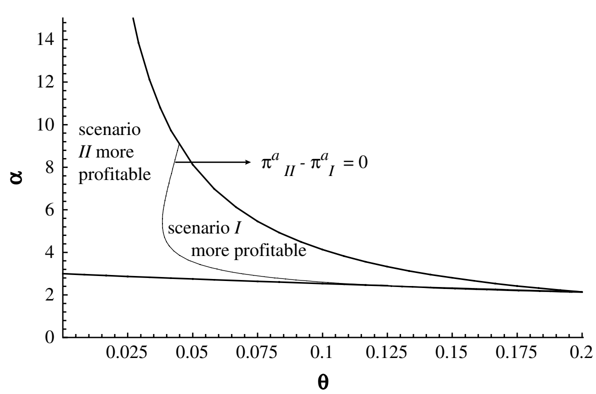

Fig. B1. Comparison of consumer surplus I and III, $f=1$.

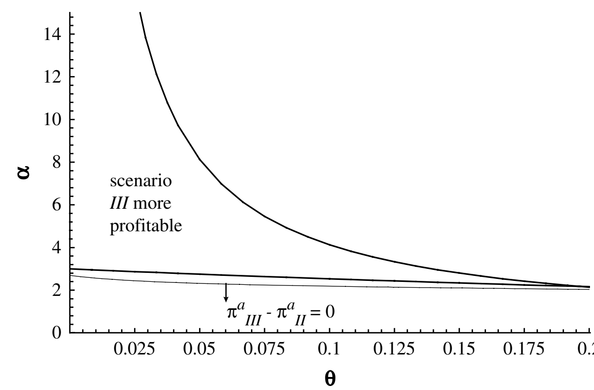

Fig. B2. Comparison of profits in scenarios II and III, $f=1$.

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