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Abstract

In this paper, we ask how antitrust immunity subject to a carve-out affects collusion incentives in international airline alliances. We show that the gains from economies of density due to higher interline traffic under the alliance strengthen the incentive to collude on the interhub segment, while the accompanying revenue gain heightens the incentive to defect from collusive behavior. These two effects exactly cancel in the case of linear demands and linear economies of density. Under this approximation, the incentives for interhub collusion are no different before and after the emergence of an airline alliance subject to a carve-out.

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1 Introduction

Airline alliances that have received antitrust immunity from regulatory authorities gain full license to cooperate in setting fares. The theoretical literature on immunized alliances has shown that such cooperation can have both positive and negative effects.[1] On the one hand, cooperation in fare setting confers benefits on "interline" passengers, who must travel across the networks of both alliance partners to make their trips. Since an interline trip is a joint product provided by two carriers, the fare is lower when it is set cooperatively than when it is determined by "arm's length" interaction between the carriers. Cooperation eliminates double marginalization, reducing the interline fare.

However, alliances affect a separate group of passengers, those starting and ending their trips at the hub airports of the alliance partners. In the case of transatlantic travel, one hub would be in the US and the other in the EU, so that the interhub market might be New York-London. In contrast to an interline passenger, whose typical trip between smaller interior US and EU cities cannot be carried out on a single carrier, passengers in a hub-to-hub market can make their trip using one alliance partner or the other, given that both fly between the hubs. With such overlapping service, cooperation in fare setting may lead to anticompetitive collusion, with the result that fares in the interhub market rise. Thus, interhub passengers may be harmed by cooperative pricing.

One remedy for this potential downside to immunized alliances is known as a "carve-out." Under a carve-out, the alliance partners are allowed to cooperate in setting fares in the interline markets, but are prohibited from discussing interhub fares. The expectation is that a carve-out will prevent loss of competition in the interhub market while still reaping the benefits of cooperation for other passengers. See Brueckner and Proost (2010) for an analysis of carve-outs.

A carve-out is thus expected to maintain the pre-alliance competitive situation in the interhub market, laying to rest anticompetitive concerns regarding this market. However, a factor overlooked in the previous analyses of airline alliances suggests that this conclusion may be premature. The difficulty is that prior work has ignored the possibility of tacit collusion on routes like the interhub market where carriers provide overlapping service. Any appraisal of the competitive state of such a market should include some gauge of the sustainability of collusion in the market. If tacit collusion is sustainable under a wide range of conditions, with competitors having little incentive to defect from a collusive arrangement, then expectations for a competitive outcome are reduced.

The rationale justifying a carve-out assumes that it preserves the nominal competitive state of the interhub market. However, the prealliance competitive situation might not be preserved if the

[1] See Brueckner (2001, 2003) and Brueckner and Whalen (2000). A large additional literature on alliances exists. See Bamberger, Carlton and Neumann (2004), Bilotkach (2005), Chen and Gayle (2007), Flores-Fillol and Moner-Colonques (2007), Gayle (2007, 2008), Hassin and Shy (2004), Park (1997), Park, Park and Zhang (2003), Park and Zhang (1998), Park, Zhang and Zhang (2001), and Whalen (2007).

existence of the alliance increases the sustainability of collusion in that market. Instead, the alliance could strenghten the incentive for tacit collusion so that the interhub market could become less competitive despite the imposition of a carve-out. The alliance could exert such an effect through its impact on interline passengers, who make more trips in response to a cooperative reduction in the interline fare. This larger interline traffic volume raises traffic density on the interhub route, reducing the marginal cost of carrying a passenger on this route. The crucial observation is that this cost reduction could affect the incentives for collusion by the alliance partners in the interhub market, strengtening them relative to the prealliance situation.

Using the standard approach to analyzing deviations from collusive behavior, the analysis explores the effect of interline cooperation on the incentives for interhub collusion. These incentives are measured by the critical value of the discount factor beyond which collusion is sustainable. We show that, as the alliance boosts interline passenger traffic, the resulting cost reduction from economies of density on the interhub segment raises the incentive to collude in the interhub market, validating the previous concern. However, the density-generated interhub cost reduction leads to an expansion of traffic in the interhub market itself, which raises the revenue gain from defection in this market relative to the losses incurred during the retaliation period. Hence, an increase in interline traffic leads to an *ambiguous net effect* on collusion incentives. However, these two effects exactly cancel under functional forms that are widely used in theoretical work on airlines: linear demand and linear, decreasing marginal cost (corresponding to a quadratic cost function). As a result, the incentives for collusion in the interhub market are no different between the pre-alliance situation and an alliance subject to a carve-out.

Viewing the linear specification as a reasonable approximation to more general functional forms, our result provides encouraging news for airline regulators. In particular, regulators can be confident that a carve-out, which maintains the nominal state of competition in the interhub market, does not worsen actual competitive conditions by increasing the incentive for collusion in that market. The analysis in remainder of the paper establishes this result.

2 Model

In the spirit of Brueckner and Proost (2010), we assume two national airlines A and B belonging respectively to countries A and B. Each airline operates a hub in its own country, which also serves as an international gateway. Airline A's hub is denoted h and B's hub is denoted j, and both airlines provide service on the interhub route between h and j. The airlines also provide exclusive service to interior cities in their home countries, a and b respectively. Airline A provides service between a and its hub h, while airline B provides service between b and j. For simplicity, we follow Brueckner and Proost (2010) by assuming that passenger demands exist only for round-trip air travel between the cities a and b and between the hubs h and j. Airlines carry passengers between the hubs on direct flights, whereas they carry passengers between a and b using connections at the two hubs h and j, trips that require use of both airlines.

We denote the trip demand originating from the city h for a return journey to city j by $D_h(p_h)$, while the opposite trip demand is $D_j(p_j)$. The trip demand originating in city a for a return journey to b is given by $D_a(p_a)$, while the opposite trip demand is $D_b(p_b)$. For simplicity we assume that $D_a(p) = D_b(p)$. Airlines incur symmetric costs that depend on the distance and number of passengers carried on a route segment. For simplicity, we assume that distances are identical for the ah, hj and jb routes. Costs are characterized by economies of density as larger passenger flows imply larger aircraft seat capacities and smaller average costs per passenger. As a result, a carrier's cost for Q return trips on each segment is given by $C(Q)$, where $C' > 0 \geq C''$.

In the interhub market between h and j, we assume that airlines compete by setting their seat capacities Q_h and Q_j. The aggregate demand for travel between h and j is given by $D(p) = D_h(p) + D_j(p)$ and the inverse demand by $P(Q)$. The firms therefore play a Cournot capacity game, where the market clears at the price $P(Q_h + Q_j)$.

In the interline market between a and b, the airline A has monopoly power over the passengers originating from city a, supplies the two trip legs from a to h and from h to j, but needs a third leg from j and b using a seat on airline B to complete the trip. Let s_a be the seat (access) price paid to airline B, so that airline A gets revenue per passenger of only $p_a - s_a$. The symmetric situation applies for airline B. As in Brueckner and Proost (2010), we assume that passengers flowing between a and b are equally split on the hj segment between airlines A and B. So, the total number of passengers flying from h to j on airline A is equal to $Q_h + \frac{1}{2}\left[D_a(p_a) + D_b(p_b)\right]$.

The firms simultaneously set their seat capacities (Q_h, Q_j) at the same time as they set their trip and access prices (p_a,s_b) and (p_b,s_a), which determine their seat capacities on the ah and jb segments. The profit of airline A is given by

$$\begin{aligned}\pi_A = {} & P(Q_h + Q_j)Q_h - C\left\{Q_h + \frac{1}{2}\left[D_a(p_a) + D_b(p_b)\right]\right\} \\ & + (p_a - s_a)\, D_a(p_a) + s_b D_b(p_b) - C\left[D_a(p_a) + D_b(p_b)\right]\end{aligned}$$

A symmetric expression holds for airline B.

Finally, we assume that airlines interact in an infinitely repeated game where they set their prices and capacities in each period. There is no commitment between time periods. Airlines A and B have the same discount factor δ, and they maximize their intertemporal profits, given by

$$\Pi^A = \sum_{t=0}^{\infty} (\delta)^t \, \pi_A^t \text{ and } \Pi^B = \sum_{t=0}^{\infty} (\delta)^t \, \pi_B^t$$

where the subscript t denotes the profit in time period t.

3 Airline alliance structure and collusion

Our focus is on the sustainability of collusion in the hub city-pair market hj. In the analysis, we do not explicitly consider the determination of prices (p_a, p_b, s_a, s_b) in the interline market ab. Given symmetry of the model, we assume that symmetric prices $p \equiv p_a = p_b$ and $s \equiv s_a = s_b$ emerge in equilibrium. Moreover, we assume that p is lower when the carriers cooperate in setting the interline fare than when (p_a, p_b, s_a, s_b) are chosen in noncooperative fashion. While Brueckner and Proost (2010) and earlier papers show that this outcome is not guaranteed in general, it emerges for most parameter values in numerical examples. The case of an alliance subject to a carve-out, where cooperation in the ab market occurs, thus corresponds to a low value of p, with p being higher in the pre-alliance case, where cooperation is absent.

For the sake of conciseness, let $D_A \equiv [D_a(p) + D_b(p)]/2$ be the demand by ab passengers using airline A and let $v_A \equiv (p_a - s_a) D_a(p_a) + s_b D_b(p_b) - C[D_a(p_a) + D_b(p_b)]$, which equals ab revenue minus the cost of operating the ah segment and is independent of the traffic between h and j. The profit of airline A is then given by

$$\pi_A = P(Q_h + Q_j)Q_h - C(Q_h + D_A) + v_A$$

In this Cournot-Nash game, each firm maximizes its individual profit taking the other airline's output as given. At the Cournot-Nash equilibrium, airline A chooses a seat capacity that satisfies the first-order condition

$$P(Q_h^* + Q_j^*) + P'(Q_h^* + Q_j^*)Q_h^* - C'(Q_h^* + D_A) = 0, \tag{1}$$

while airline B's choice is determined by a symmetric condition. Because of cost symmetry, these conditions yield the competitive seat capacities $Q_h^* = Q_j^* \equiv Q^*$, with airline A's profit given by

$$\pi_A^* \equiv P(2Q^*)Q^* - C(Q^* + D_A) + v_A$$

and airline B's by the symmetric expression. Coordination in the interline market affects the price p and therefore profit π_A^* through the effect on D_A and v_A. Differentiating the profit function, we get

$$\frac{d\pi_A^*}{dp} = v_A' - C'(Q^* + D_A) D_A' + [P(2Q^*) + P'(2Q^*) 2Q^* - C'(Q^* + D_A)] \frac{dQ^*}{dD_A} D_A'$$

where $D_A' = dD_A/dp < 0$ and $v_A' = dv_A/dp$. Using (1), we have

$$\frac{d\pi_A^*}{dp} = v_A' - C'(Q^* + D_A) D_A' + [P(2Q^*) - C'(Q^* + D_A)] \frac{dQ^*}{dD_A} D_A' \tag{2}$$

Hence, a fall in p induces an increase in interline traffic and in profits in the interline market (first two terms). It also generates economies of density that allow airlines to reduce their interhub fares and to earn a positive markup on additional passengers (last term).

When firms collude, they jointly set the seat capacity $Q_h + Q_j$ so as to maximize their joint profits $\pi_A + \pi_B$. The first-order condition for Q_h is given by

$$P(Q_h^o + Q_j^o) + P'(Q_h^o + Q_j^o)(Q_h^o + Q_j^o) - C'\left(Q_h^o + D_A\right) \tag{3}$$

The symmetric condition holds for Q_j. Because of symmetry, we have that $Q_h^o = Q_j^o \equiv Q^o$. It is straightforward to show that $Q^o < Q^*$. Airline A's profit is given by

$$\pi_A^o \equiv P(2Q^o)Q^o - C\left(Q^o + D_A\right) + v_A$$

and can be shown to be larger than π_A^*. Coordination in the interline segment affects the profit π_A^o through the effect on D_A and v_A. Differentiating the profit function gives

$$\frac{d\pi_A^o}{dp} = v_A' - C'\left(Q^o + D_A\right)D_A' + \left[P\left(2Q^o\right) + P'\left(2Q^o\right)2Q^o - C'\left(Q^o + D_A\right)\right]\frac{dQ^o}{dD_A}D_A'$$

However, by (3), the last term vanishes. Changes in interline traffic bring no first-order changes in the profits of the interhub segment because the cooperating airlines have set the seat capacities that yield zero marginal profit. So, the above expression simplifies to

$$\frac{d\pi_A^o}{dp} = v_A' - C'\left(Q^o + D_A\right)D_A' \tag{4}$$

Since interhub traffic has already been optimized, a fall in p only affects profit in the interline market itself. So, despite the existence of economies density, cooperation in the interline market therefore brings no gains in the interhub market.

When airline A deviates from the collusive outcome, it chooses its seat capacity $Q_h^d \equiv Q^d$ to maximize profit taking as given $Q_j = Q^o$. The first-order condition is

$$P(Q^d + Q^o) + P'(Q^d + Q^o)Q^d - C'\left(Q^d + D_A\right) = 0 \tag{5}$$

It can be shown that $Q^d > Q^* > Q^o$. Airline A's profit is given by

$$\pi_A^d \equiv P(Q^d + Q^o)Q^d - C\left(Q^d + D_A\right) + v_A$$

which can be shown to be higher than π_A^o. Differentiating the profit function with respect to p and using (5) gives

$$\frac{d\pi_A^d}{dp} = v_A' - C'\left(Q^d + D_A\right)D_A' + \left[P(Q^d + Q^o) - C'\left(Q^d + D_A\right)\right]\frac{dQ^o}{dD_A}D_A' \tag{6}$$

As in the case of the Nash equilibrium, a fall in the interline fare p increases interline traffic and brings additional traffic and profit to the interhub segment (second term).

Collusion incentives are determined as follows. We assume that a deviation is followed by a reversion to the Cournot-Nash equilibrium forever. This assumption can be relaxed with little effect on the analysis. Collusion is then sustainable if and only if the long-run gain from collusion outweighs the short-run gain from deviating. In time period 0, this condition is satisfied if

$$\sum_{t=0}^{\infty} (\delta)^t \pi_A^o \geq \pi_A^d + \sum_{t=1}^{\infty} (\delta)^t \pi_A^*$$

An analogous condition applies for any other time period and for airline B. The above inequality implies that collusion is sustainable if and only if

$$\delta \geq \overline{\delta} \equiv \frac{\pi_A^d - \pi_A^o}{\pi_A^d - \pi_A^*}$$

where the numerator is the *deviation gain* and the denominator is *punishment cost.*

We are now in a position to discuss how the fare p for interline trips between a and b affects airline collusion in the interhub market hj. Lower fares increase the demand D_A and augment airline profits under collusion, deviation and competition provided that the price p lies above the sum of marginal costs on the three route segments, which we assume in the sequel. Collusion is more easily sustained if the *deviation gain* $\pi^d - \pi^o$ decreases faster than *punishment cost* $\pi^d - \pi^o$ when p falls. In other words,

$$\begin{aligned} \frac{d\overline{\delta}}{dp} \geq 0 \iff & \frac{d}{dp} \ln\left(\pi^d - \pi^o\right) \geq \frac{d}{dp} \ln\left(\pi^d - \pi^*\right) \\ \iff & \frac{d}{dp}\left(\pi^d - \pi^o\right) \geq \overline{\delta}\, \frac{d}{dp}\left(\pi^d - \pi^*\right) \end{aligned} \tag{7}$$

Using (2), (4) and (6), the change in the deviation gain is given by

$$\frac{d}{dp}\left(\pi^d - \pi^o\right) = |D_A'| \left[\begin{array}{c} C'\left(Q^d + D_A\right) - C'\left(Q^o + D_A\right) \\ + \left[P(Q^d + Q^o) - C'\left(Q^d + D_A\right)\right] \frac{dQ^o}{dD_A} \end{array} \right] \tag{8}$$

while the change in the punishment cost is

$$\frac{d}{dp}\left(\pi^d - \pi^*\right) = |D_A'| \left[\begin{array}{c} C'\left(Q^d + D_A\right) - C'\left(Q^* + D_A\right) \\ + \left[P(Q^d + Q^o) - C'\left(Q^d + D_A\right)\right] \frac{dQ^o}{dD_A} - \left[P\left(2Q^*\right) - C'\left(Q^* + D_A\right)\right] \frac{dQ^*}{dD_A} \end{array} \right] \tag{9}$$

where $|D_A'| = -dD_A/dp > 0$.

It is instructive to first discuss the case where economies of density are absent, with C' equal to a constant c. In this case, the traffic D_A does not appear in the above first-order conditions (1) to (5), so that seat capacity decisions (Q^o, Q^*, Q^d) in the hj market are unaffected by passenger traffic D_A between a and b. Therefore, the profits under collusion, deviation and competition are each increased by the same exogenous profit that is earned from interline passengers. For airline A, this profit is equal to net revenue from interline passengers, $(p_a - s_a) D_a(p_a) + s_b D_b(p_b)$, minus the cost of carrying them from/to the airport a, $c[D_a(p_a) + D_b(p_b)]$, and the cost of carrying them between hubs h and j, $c[D_a(p_a) + D_b(p_b)]/2$. This profit is actually equal to $v_A - cD_A$. As a result, a larger demand D_A increases the profits π^o, π^* and π^d by the same amount and therefore does not change the profit differences $\pi^o - \pi^*$ and $\pi^d - \pi^*$ in expressions (8) and (9). So, *without economies of density, the fare level in the interline market ab has no impact on collusion incentives in market hj*.

The impact of p on collusion therefore stems from the economies of density generated by the resulting change in ab traffic on the hj segment. Accordingly, suppose now that $C'' < 0$. The impact of ab traffic then includes a direct and an indirect effect. The direct effect is presented in the first lines of the bracketed terms in expressions (8) and (9) and stems from economies of density, as higher traffic between a and b reduces marginal costs on the hj segment. Because $Q^* > Q^o$ and $C'' < 0$, we get

$$C'\left(Q^d + D_A\right) - C'\left(Q^o + D_A\right) < C'\left(Q^d + D_A\right) - C'\left(Q^* + D_A\right) < 0$$

So, with economies of density, an increase in D_A tends to decrease the deviation gain more than the punishment cost. Therefore, from a cost perspective, collusion is more likely to be sustained with an increase in ab traffic.

The indirect effect stems from the revenue effects of an increase in traffic D_A and is presented in the second lines of the bracketed terms in expressions (8) and (9). This effect results from the price decline in the interhub market hj that follows from the drop in marginal costs due to the density effect. The price decline emerges because the lower marginal costs on the interhub segment increases hj traffic ($dQ^o/dD_A > 0$ and $dQ^*/dD_A > 0$). Given these increases, it is easily seen that

$$\begin{aligned}&\left[P(Q^d + Q^o) - C'\left(Q^d + D_A\right)\right] \frac{dQ^o}{dD_A} > \\ &\qquad\qquad \left[P(Q^d + Q^o) - C'\left(Q^d + D_A\right)\right] \frac{dQ^o}{dD_A} - \left[P\left(2Q^*\right) - C'\left(Q^* + D_A\right)\right] \frac{dQ^*}{dD_A}\end{aligned}$$

Therefore, referring to (5) and (6), the indirect effect of the additional ab traffic increases the deviation gain by more than the punishment cost. So from a revenue perspective, collusion is less likely to be sustained with additional ab traffic. Hence, an increase in ab traffic leads to direct and indirect effects on deviation gains and punishment costs that have opposite signs, making the net effect on collusion incentives ambiguous. These effects, however, exactly cancel under functional forms that are widely used in theoretical models of the airline industry and are likely to represent a close approximation to actual demand and cost functions.

In particular, suppose that demands are linear and symmetric between markets and that cost is quadratic. Normalizing the units of output and specifying the numeraire, we can assume $P = 1-Q$ while cost is given by $C(Q) = cQ - dQ^2/2$, where $c, d \in (0,1)$. We successively get

$$\begin{aligned}
Q^* &= \frac{2}{3-2d}\,(1-c+d\,D_A) \\
Q^o &= \frac{1}{2-d}\,(1-c+d\,D_A) \\
Q^d &= \frac{(3-2d)}{2\,(1-d)\,(2-d)}\,(1-c+d\,D_A)
\end{aligned}$$

The profit differentials become

$$\begin{aligned}
\pi^d - \pi^o &= \frac{1}{8\,(1-d)\,(2-d)^2}\,(1-c+d\,D_A)^2 \\
\pi^d - \pi^* &= \frac{17-24d+8d^2}{8\,(1-d)\,(3-2d)^2\,(2-d)^2}\,(1-c+d\,D_A)^2
\end{aligned}$$

The profit differentials thus have the common factor $(1-c+d\,D_A)^2$. As a result, critical value $\overline{\delta}$ of the discount factor, above which collusion is sustainable, is invariant to traffic in the ab market. It can be computed as

$$\overline{\delta} = \frac{(3-2d)^2}{17-8\,(3-d)\,d}$$

which increases in d. This result generalizes to a setup where demand is linear but asymmetric across markets, although it does not generalize to the case of quadratic costs that are asymmetric across route segments. We summarize the above results as follows:

Proposition 1 *The incentives for collusion in the hj market are independent of the level of traffic ab market and thus independent of the price p in that market (i) under linear costs and (ii) under linear demand and symmetric quadratic costs.*

Thus, the nature of pricing in the ab market has no impact on the incentives for collusion on the interhub hj market. The reason is the resulting change in ab traffic has effects on costs and revenues in the hj market that effectively balance out.

4 Conclusion

Proposition 1 provides welcome news for airline regulators. Its implication is that the incentives for collusion in an alliance's interhub market under a carve-out are the same as in the prealliance situation, where the ab price is higher. Thus, the carve-out's nominal preservation of competition in the interhub market is not undermined by a worsening of actual competitive conditions, as measured by the incentives for collusion. If regulators believe that a carve-out is worth imposing, their decision will not be undone by a greater incentive for tacit collusion between the alliance partners.

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