

# **Code-sharing, price discrimination and welfare losses**

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## Abstract

Airlines frequently use code-share agreements allowing each other to market seats on flights operated by partner airlines. Regulation may allow code-share agreements with antitrust immunity (cooperative price setting), or without antitrust immunity, or not at all. I compare relative welfare effects of these regulation regimes for complementary airline networks. A crucial point is that such agreements are used to identify and price discriminate interline passengers. I find that interline passengers always benefit from code-share agreements while non-interline passengers are worse off. Furthermore, I show that the second effect questions the overall usefulness of code-share agreements from a welfare perspective.

*JEL Classification:* D01, L13, L41, L51, L93.

*Keywords:* Airlines, alliances, code-share agreements, antitrust immunity, price discrimination.

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# 1 Introduction

During the last decades the airline industry experienced major changes. Liberalization significantly increased competition between airlines which affected the development and structure of the market. For instance, incumbent carriers began to use hub-and-spoke systems where passengers are concentrated at a (hub) airport in order to realize economies of scope and economies of density. In contrast to the incumbent hub-and-spoke carriers, low-cost carriers appeared that exclusively offer point-to-point flights normally for a low fare.

Another phenomenon that has appeared during the time of deregulation is airline alliances. At present three major global airline alliances exist: Oneworld, The Star Alliance, and SkyTeam (Doganis 2006). Moreover, during the last years domestic alliances appeared (Bamberger, Carlton, and Neumann 2004), (Ito and Lee 2005). Alliances in general can fall between full integration of the parties and simple market mediated exchanges between them (Chen and Ross 2003). A variable degree of cooperation between strategic alliances has been explicitly analyzed by Zhang and Zhang (Zhang and Zhang 2006).

In the air transport industry alliances constitute a framework for cooperation between airlines, e.g., sharing of sales offices and maintenance facilities, coordinating schedules and aligning airport facilities. Frequently used forms of cooperation between alliance partners and even non-allied airlines include code-share agreements. They allow airlines to market seats on directions operated by partner airlines. An important consequence is that interline passengers can buy only one ticket for their flights although they are in fact served by two different airlines. The total price for this ticket is composed of the sub-fares each airline charges for its part of the connection. In

most instances code-share agreements are provided with antitrust immunity which allows partner airlines to set sub-fares for interline passengers cooperatively. However, in the case of American Airlines and British airways antitrust immunity was denied, i.e. airlines were not allowed to set sub-fares cooperatively.

Current studies consistently argue that in the case of complementary networks code-share agreements generate positive welfare effects (Oum, Park, and Zhang 1996), (Park 1997), (Brueckner and Whalen 2000), (Park and Zhang 2000), (Brueckner 2001), (Hassin and Shy 2004), (Bilotkach 2005). For instance, one reason is that interline fares are reduced because airlines avoid double marginalization of interline fares. Only with overlapping networks negative welfare effects of code-share agreements with antitrust immunity are supposed to occur. This is because they are expected to lead to collusion and higher fares on city-pair connections served by partner airlines in parallel. In this case interline passengers still benefit from code-share agreements but other passengers can be worse off.

However, it has been widely ignored that even in the case of complementary networks non-interline passengers can be negatively affected by code-share agreements (with or without antitrust immunity). The reason is that without code-share agreements airlines lose their ability to price discriminate and, as a consequence, set only one fare for all passengers on each city-pair connection served entirely by their own (Bilotkach 2005). In this context, price discrimination means that the sub-fares airlines charge to interline passengers are different from the fares other passengers have to pay for the same trip. This is a third degree price discrimination. Why are code-share agreements essential for price discrimination? Suppose that airlines are not allowed to use code-share agreements. Then, on a city-pair connection that

is not entirely served by only one airline but by a combination of different airlines, passengers need to buy tickets from different airlines to make their trip. Observe that in this situation it is difficult for airlines to identify interline passengers. Consequently, price discrimination cannot be used and interline passengers are charged like other passengers. On the other hand, if airlines make use of code-share agreements they market interline trips as one product which allows for price discrimination of interline passengers.

Now, without code-share agreements fares for each connection depend on the aggregate demand by interline and non-interline passengers and airlines might decide to reduce fares in order to attract additional demand from interline passengers. Then non-interline passengers clearly benefit from the existence of interline passengers, if price discrimination cannot be applied, even in the case of complementary networks. The implementation of code-share agreements, therefore, has two effects. First, it can reduce fares for interline passengers and, second, it can increase fares for non-interline passengers. The second effect has been ignored so far. However, both effects have to be taken into account to evaluate the total welfare effect of code-share agreements.

In this paper I consider a model with two airlines using perfectly complementary networks which implies that airlines do not compete. One airline uses one hub airport and a number of spoke airports. The other airline serves only one single connection that is between the other airline's hub and a spoke airport, but not served by the hub airline. I analyze three different regulation regimes:<sup>1</sup>

1. airlines are not allowed to cooperate using code-share agreements,
2. airlines use code-share agreements with antitrust immunity, and

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<sup>1</sup>These three regulation regimes have also been analyzed by Bilotkach (Bilotkach 2005).

### 3. airlines use code-share agreements but antitrust immunity is denied

I show that the detrimental welfare effects of price discrimination with regard to non-interline passengers depends on the number of spoke airports and can compensate the positive welfare effects on interline passengers. This holds for the case of code-share agreements with antitrust immunity, but even more so for the case of code-share agreements without antitrust immunity. Taking into account the negative effects which code-share agreements can have on competition in the case of overlapping networks, my results question their overall usefulness from a welfare perspective.

The effects of alliances and in particular code-share agreements on airline fares and welfare has been the subject of intensive theoretical and empirical investigation. The theoretical approach used by Park indicates that the welfare effect of alliances using code-share agreements will depend on whether the partner airlines' networks are parallel or complementary in nature, i.e. whether partner airlines serve connections in parallel or not (Park 1997). He derives positive welfare effects for complementary networks and negative welfare effects for parallel networks. Positive effects arise because in the complementary case partner airlines jointly enter into markets they did not serve before and, as a consequence, increase competition there. On the other hand, with parallel networks code-share agreements are a means of collusion and lead to welfare losses.

Brueckner (Brueckner 2001) demonstrates that the welfare effects of international alliances using code-share agreements with antitrust immunity in comparison to code-share agreements without antitrust immunity are detrimental on interhub markets because of collusion. In contrast, markets where each partner airline serves only a part of a city-pair connection are likely to benefit from antitrust immunity. The latter is because cooperative pricing

puts downward pressure on interline fares. The results presented by Brueckner are consistent with the theoretical results from Brueckner and Whalen (Brueckner 2001), (Brueckner and Whalen 2000). However, the theoretical model developed by Brueckner and Whalen accounts for competition between airline alliances. Zhang and Zhang analyze competition between complementary alliances without explicitly modeling the effects of code-share agreements (Zhang and Zhang 2006).

The studies mentioned above consider Cournot behavior on city-pair connections that are served in parallel by competing airlines. In contrast, Bilotkach applies a Bertrand competition approach (Bilotkach 2005). He points out that code-share agreements are crucial for airlines in order to price discriminate interline passengers. Furthermore, he concludes that antitrust immunity is not crucial to eliminate a double-mark up for interline fares because inter-alliance competition can reduce interline fares. In contrast to this paper, Bilotkach does not consider city-pair connections that are only served by a single monopolistic airline. Moreover, he considers a fixed number (eight) of airports.

Hassin and Shy concluded that no passengers become worse off but some passengers are strictly better off with code-share agreements using a line of reasoning that is different from the ones presented so far (Hassin and Shy 2004). Applying a Hotelling model they assume that passengers' preferences for airlines are heterogenous. Then, their basic argument is that code-share agreements generate an additional travel opportunity to passengers which enhances welfare. Namely, passengers who are heavily oriented towards an airline that does not serve a connection entirely by itself can benefit from code-sharing because they get the opportunity to use a flight that is entirely marketed by the preferred airline.

The power of code-share agreements to reduce interline fares has been evidenced by empirical studies. Oum, Park, and Zhang showed that code-share agreements lead to fare reductions and increasing passenger numbers of the market leader (Oum, Park, and Zhang 1996). Brueckner and Whalen found that allied airlines' interline fares are 25 percent below those charged by non-allied airlines (Brueckner and Whalen 2000). Park and Zhang found that international alliances lead to a reduction of fares and an increase of passenger numbers in the case of complementary airline networks (Park and Zhang 2000). In the other case of parallel networks they conclude that fares are likely to increase while passenger numbers fall. Similar results are provided by Bamberger, Carlton, and Neumann for domestic airline alliances in the U.S. (Bamberger, Carlton, and Neumann 2004). A positive welfare effect of domestic code-share practices in the U.S. has also been confirmed by Ito and Lee (Ito and Lee 2005). Regarding the impact of code-share alliances on airline cost structure Goh and Yong found statistically significant but little cost savings (Goh and Yong 2006).

The paper is organized as follows. In section 2 the model is presented. In section 3 airline behavior under code-share agreements provided with antitrust immunity and airline behavior using any form of code-share agreements is analyzed. In section 4 airlines using code-share agreements without antitrust immunity are considered. Section 5 presents the conclusions.

## 2 The model

I consider an airline market with a fixed network structure including  $n$  spoke airports,  $n \in \mathbb{N}_+$  and  $n \geq 2$ , as well as one hub airport. The number of city-pair connections between hub and spoke airports, which I call *direct*



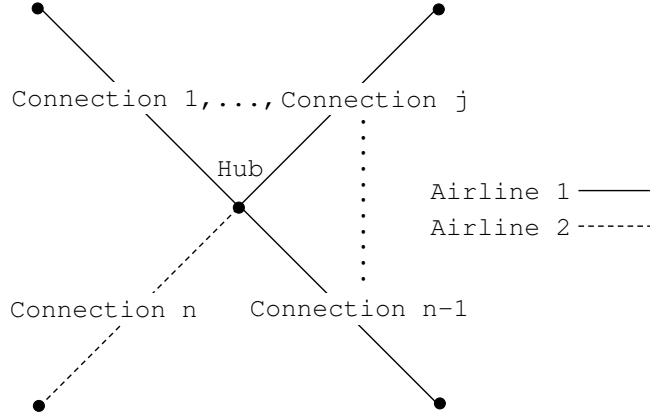


Figure 1: Airlines' networks including  $n$  direct connections between one hub and  $n$  spoke airports.

*connections* because they contain a non-stop service, is also determined by  $n$ . A city-pair connection between two spoke airports, using a pair of direct connections to form an indirect route will be called *indirect connection*. There are  $\binom{n}{2}$  indirect connections. Thus the total number of connections is

$$\bar{n} := n + \binom{n}{2} = \frac{n(n+1)}{2}. \quad (1)$$

There are two airlines. Assume that direct connections  $i \in \{1, \dots, n-1\}$  are served by airline 1 and the direct connection  $n$  is served by airline 2. Notice that airlines 1 and 2 are not competing for passengers because networks are fully complementary.

The number of (round trip) passengers on each connection is denoted by  $q_i \geq 0$  with  $i \in \{1, \dots, n, \dots, \bar{n}\}$  where connections  $i \in \{1, \dots, n\}$  are direct and connections  $i \in \{n+1, \dots, \bar{n}\}$  are indirect. Figure 1 illustrates this case.

Indirect connections can be of two types. First, they can be composed of a pair of direct connections entirely served by airline 1 or, second, of a pair of direct connections where one part is served by airline 1 and the other part by airline 2 which I call *interline connections*. There are  $n - 1$  interline connections. Assume that interline connection  $n + 1$  includes direct connections 1 and  $n$ , interline connection  $n + 2$  includes direct connections 2 and  $n$ , until  $n - 1$  and  $n$ . Thus, connections  $i \in \{n + 1, \dots, 2n - 1\}$  are interline connections. Indirect connections  $i \in \{2n, \dots, \bar{n}\}$  are entirely served by airline 1.

Assume that passengers appreciate direct connections, i.e. passenger demand might be lower at a given price if a connection is served indirectly including transfers at the hub airport. In particular business passengers usually have a preference for direct connections. Let the reservation price for a direct connection be 1 and that for an indirect connection  $a \in (0, 1]$ .

For connections entirely served by only one airline it holds: airline fares are  $p_i \geq 0$  for  $i \in \{1, \dots, n; 2n, \dots, \bar{n}\}$  and demand

$$D_i(p_i) = \begin{cases} \max\{0, 1 - p_i\} & \text{for } i \in \{1, \dots, n\} \\ \max\{0, a - p_i\} & \text{for } i \in \{2n, \dots, \bar{n}\}. \end{cases} \quad (2)$$

Interline connections are indirect connections served by two airlines. Each airline charges a sub-fare for its part of the interline connection denoted by  $p_{i,j} \geq 0$  with  $i \in \{n + 1, \dots, 2n - 1\}$  and  $j \in \{1, 2\}$  where  $j$  denotes the airline. Hence, interline passengers are charged twice and demand is

$$D_i(p_{i1} + p_{i2}) = \max\{0, a - p_{i1} - p_{i2}\} \quad (3)$$

Notice that the above demand specifications for indirect connections including interline connections require that fare-arbitrage conditions are satisfied: total fares for indirect connections are not greater than the sum of fares for the relevant direct connections.

The way sub-fares are set depends on the regulation regime. Without code-share agreements airlines are not able to price discriminate between interline and other passengers. Remember that interline connection  $i \in \{n + 1, \dots, 2n - 1\}$  is composed of direct connections  $i - n$  and  $n$  by assumption. Therefore, without code-share agreements, it holds  $p_{i1} = p_{i-n}$  and  $p_{i2} = p_n$  for all  $i \in \{n + 1, \dots, 2n - 1\}$ . Under code-share agreements with or without antitrust immunity price discrimination is possible. However, with antitrust immunity sub-fares are set cooperatively by the two airlines, such that the joint profit of airlines 1 and 2 is maximized. In contrast, without antitrust immunity sub-fares are set independently.

I consider the airlines' networks including the choice of aircraft as given and, therefore, fixed airline costs are not relevant for my analysis. Furthermore, assume that airlines do not face capacity constraints. Finally, I assume that variable airline costs are zero. Notice that according to the literature in my case with fully complementary networks code-share agreements should be increasing social welfare.

### **3 Code-share agreements with antitrust immunity versus no code-share agreements**

Most code-share agreements are provided with antitrust immunity so that airlines are allowed to coordinate fares. In this case partner airlines set total interline fares in order to maximize joint profits and then share the revenues by splitting the fare into airline specific sub-fares (Brueckner 2001). This case will be referred by index  $I$ .

Setting aside the fare arbitrage conditions, the airlines' behavior in terms of fares on non-interline connections is determined by

$$p_i^I := \arg \max_{p_i} p_i D_i(p_i) = \begin{cases} \frac{1}{2} & \text{for all } i \in \{1, 2, \dots, n\} \\ \frac{a}{2} & \text{for all } i \in \{2n - 1, \dots, \bar{n}\}. \end{cases} \quad (4)$$

Assume that under code-share agreements with antitrust immunity the sub-fares of airlines are equal, i.e. each airline charges exactly one half of the total fare they agreed upon. Since airlines jointly maximize revenues on interline connections this leads to

$$p_{i,j}^I := \frac{1}{2} \cdot \arg \max_{p_{i,1} + p_{i,2}} (p_{i,1} + p_{i,2}) \cdot D_i(p_{i,1} + p_{i,2}) = \frac{a}{4} \quad (5)$$

for all  $i \in \{n + 1, \dots, 2n - 1\}$  and  $j \in \{1, 2\}$ .<sup>2</sup> Notice that airlines actually make use of their possibility to price discriminate; the sub-fares for interline passengers are  $a/4$  which is strictly lower than the fares for direct connections that are  $1/2$ . Furthermore, since  $\frac{a}{2} < 1$ , the fare arbitrage conditions are indeed strictly satisfied.

Now I consider the case that code-share agreements are banned. Indirect connections composed of direct connections exclusively served by airline 1 are not affected by code-share agreements. In contrast, code-share agreements change the picture on interline and direct connections. Without code-share agreements interline passengers buy two tickets and pay the same fare as passengers on direct connections pay. Thus,  $p_{i,1} = p_{i-n}$  and  $p_{i,2} = p_n$  for all  $i \in \{n + 1, \dots, 2n - 1\}$ . If code-share agreements are not used, the total demand  $\hat{D}_i$  for direct connections  $i \in \{1, \dots, n - 1\}$ , offered by airline 1, is determined by the demand for direct connection  $i$  and interline connection  $i + n$ :

$$\hat{D}_i(p_i, p_n) := D_i(p_i) + D_{i+n}(p_i + p_n). \quad (6)$$

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<sup>2</sup>One can check that each airline is better off under code-share agreements with antitrust immunity.

The total demand  $\hat{D}_n$  for direct connection  $n$ , offered by airline 2 includes the demand from passengers on this direct connection and the demands from all interline passengers:

$$\hat{D}_n(p_1, \dots, p_n) := D_n(p_n) + \sum_{i=1}^{n-1} D_{i+n}(p_i + p_n). \quad (7)$$

How do airlines' behave in this situation? Denote critical levels for  $a$  by

$$\bar{a} := \frac{1}{2} + \frac{1}{1 + \sqrt{n}} \quad \text{and} \quad (8)$$

$$\tilde{a} := \max \left\{ \frac{9\sqrt{n} + 2n - 1}{6(\sqrt{n} + n)}, \frac{4 + (1 + 7n)\sqrt{2} - 8n}{4 + 4n} \right\}. \quad (9)$$

Regarding  $\tilde{a}$ , observe that for  $n < 34$  the first term in brackets is relevant and for  $n \geq 34$  the second. Moreover, it always holds  $\tilde{a} < \bar{a} < 1$ . Then denote price vectors

$$(p_1^{N1}, \dots, p_n^{N1}) := (p_1^I, \dots, p_n^I) \quad (10)$$

and  $(p_1^{N2}, \dots, p_n^{N2})$  with

$$p_i^{N2} := \frac{a - 1 + n(2 + a)}{1 + 7n} \quad (11)$$

for all  $i \in \{1, \dots, n - 1\}$  and

$$p_n^{N2} := \frac{5 - n + 3a(n - 1)}{1 + 7n}. \quad (12)$$

**Proposition 1** *Without code-share agreements the following holds:*

*If  $a < \tilde{a}$ ,  $(p_1^{N1}, \dots, p_n^{N1})$  is the unique Nash equilibrium.*

*If  $a > \bar{a}$ ,  $(p_1^{N2}, \dots, p_n^{N2})$  is the unique Nash equilibrium.*

*If  $a \in [\tilde{a}, \bar{a}]$ , there are exactly two Nash equilibria,  $(p_1^{N1}, \dots, p_n^{N1})$  and  $(p_1^{N2}, \dots, p_n^{N2})$ , of which  $(p_1^{N2}, \dots, p_n^{N2})$  is the Pareto-dominant one.*

**Proof** See appendix A.1. ■

For illustration, assume  $n = 4$ . In this situation  $\tilde{a} = 25/36 < \bar{a} = 5/6$ . Under  $N1$  airline 1's profit is  $3/4$ , airline 2's profit is  $1/4$  and the mass of interline passengers is 0, since the sum of fares for two direct connections is  $1 \geq a$ . Under  $N2$  airline 1's fare on direct connections is  $(7 + 5a)/29$  leading to profits  $6(7 + 5a)^2/841$ , airline 2's fare on its direct connection is  $(1 + 9a)/29$  leading to profits  $4(1 + 9a)^2/841$ . Furthermore, under  $N2$  the number of interline passengers is positive, since the sum of fares on direct connections used by interline passengers is  $(8 + 14a)/29 < a$  for all  $a \geq \tilde{a}$ . Notice that  $a \geq \tilde{a}$  implies  $6(7 + 5a)^2/841 > 3/4$  and  $4(1 + 9a)^2/841 > 1/4$ . Hence, airlines are strictly better off under  $N2$  than under  $N1$ .

Since  $(p_1^{N2}, \dots, p_n^{N2})$  exists and is Pareto-dominant from the airlines' point of view if  $a \in [\tilde{a}, \bar{a}]$  holds, I consider it to be a focal point in the following. The welfare implications of Proposition 1 are mixed. First, have a look at passengers' point of view:<sup>3</sup>

**Proposition 2** *Comparing code-share agreements under antitrust immunity and no code-share agreements at all, the following holds. Passengers on interline connections are better off with code-share agreements. Passengers on direct connections are better off with code-share agreements if and only if  $a \geq \tilde{a}$ .*

**Proof** Under code-share agreements with antitrust immunity interline fares are always lower than in a situation without code-share agreements. This is so because  $a/2 < p_i^{N1} + p_n^{N1}$  holds for all  $a \leq \bar{a}$  and all  $i \in \{1, \dots, n-1\}$ , and  $a/2 < p_i^{N2} + p_n^{N2}$  holds for all  $a \geq \tilde{a}$  and all  $i \in \{1, \dots, n-1\}$ . Furthermore, observe that in a situation without code-share agreements the number of interline passengers is 0 if  $(p_1^{N1}, \dots, p_n^{N1})$  realizes. In contrast, under code-share

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<sup>3</sup>Notice that passengers on indirect connections entirely served by airline 1 are not affected by code-share agreements.

agreements with antitrust immunity the number of interline passengers is always positive. For  $a \geq \tilde{a}$  it follows  $p_i^{N2} < p_i^I$  for all  $i \in \{1, \dots, n\}$ . Hence, passengers on direct connections can benefit if there are no code-share agreements with antitrust immunity.  $\blacksquare$

What about the effect of code-share agreements with antitrust immunity on total welfare compared to a situation without code-share agreements? Observe that only direct and interline connections, i.e. connections  $i \in \{1, \dots, 2n - 1\}$ , are affected by code-share agreements. Consumer surplus on direct connections  $i \in \{1, \dots, n\}$  is  $\int_{p_i}^1 D_i(y) dy$  and consumer surplus on interline connections  $i \in \{n + 1, \dots, 2n - 1\}$  is  $\int_{p_{i,1} + p_{i,2}}^a D_i(y) dy$ . Airline profits on direct connections  $i \in \{1, \dots, n\}$  are  $p_i D_i(p_i)$  and total airline profits on interline connections  $i \in \{n + 1, \dots, 2n - 1\}$  are  $(p_{i,1} + p_{i,2}) \cdot D_i(p_{i,1} + p_{i,2})$ . To measure the total welfare effect of code-share agreements I will focus on the average welfare  $\bar{W}$  on these  $2n - 1$  connections which is

$$\bar{W}(p_1, \dots, p_n; (p_{n+1,1}, p_{n+1,2}), \dots, (p_{2n-1,1}, p_{2n-1,2})) := \quad (13)$$

$$\frac{1}{2n - 1} \cdot \left( \sum_{i=1}^n \left( \int_{p_i}^1 D_i(y) dy + p_i D_i(p_i) \right) + \quad (14)$$

$$\sum_{i=n+1}^{2n-1} \left( \int_{p_{i,1} + p_{i,2}}^a D_i(y) dy + (p_{i,1} + p_{i,2}) \cdot D_i(p_{i,1} + p_{i,2}) \right) \right). \quad (15)$$

Denote the average welfare reached on direct and interline connections under code-share agreements with antitrust immunity by

$$\bar{W}^I := \bar{W}(p_1^I, \dots, p_n^I; (p_{n+1,1}^I, p_{n+1,2}^I), \dots, (p_{2n-1,1}^I, p_{2n-1,2}^I)) \quad (16)$$

and without code-share agreements at all by

$$\bar{W}^{Nj} := \bar{W}(p_1^{Nj}, \dots, p_n^{Nj}; (p_{n+1,1}^{Nj}, p_{n+1,2}^{Nj}), \dots, (p_{2n-1,1}^{Nj}, p_{2n-1,2}^{Nj})) \quad (17)$$

for  $j \in \{1, 2\}$ . Denote another critical level for  $a$  by

$$\tilde{\tilde{a}} := \frac{24(1+n)^2 - (1+7n)\sqrt{32+37n+23n^2}}{17+34n-19n^2} \quad (18)$$

and note that  $\tilde{\tilde{a}} > \tilde{a}$  if and only if  $n \geq 32$  (and  $0 < \tilde{\tilde{a}} < 1$  for all  $n$ ).

**Proposition 3**  $\bar{W}^I > \bar{W}^{N1}$  holds when N1 exists (i.e. for all  $a \leq \bar{a}$ ).

If  $n < 32$ ,  $\bar{W}^I > \bar{W}^{N2}$  holds when N2 exists (i.e. for all  $a \geq \tilde{a}$ ).

If  $n \geq 32$ ,  $\bar{W}^I \geq \bar{W}^{N2}$  for  $a \geq \tilde{\tilde{a}}$  and  $\bar{W}^I < \bar{W}^{N2}$  for  $a \in [\tilde{a}, \tilde{\tilde{a}})$ .

**Proof** See appendix A.2. ■

Notice that there is a strong dependence between the number of direct and interline connections: the ratio of interline and direct connections  $(n-1)/n$  is increasing in  $n$ . Hence, with an increasing number of direct connections the relative importance of interline connections is increasing, too.

Proposition 3 states an important result: It may happen that welfare is higher without code-share agreements than with code-share agreements under antitrust immunity ( $n \geq 32$  and  $a \in [\tilde{a}, \tilde{\tilde{a}}) \Rightarrow \bar{W}^I < \bar{W}^{N2}$ ). Without code-share agreements airlines lose their ability of effective price discrimination. Now, without price discrimination airlines might decide to reduce fares for direct connections in order to attract additional demand from interline passengers. Hence, passengers on direct connections can benefit from the existence of interline passengers if price discrimination is not possible. Furthermore, this might compensate the loss of positive welfare effects code-share agreements have on interline passengers. Notice that this effect of code-share agreements and price discrimination on welfare has been ignored so far. So far code-share agreements were considered to generate only positive welfare effects in the case of complementary airline networks (Park 1997), (Brueckner 2001), (Bilotkach 2005).



To understand the impact of  $a$  on welfare, consider the passengers on direct connections when code-share agreements are not allowed. On the one hand, a critical level  $\tilde{a}$  must be reached such that airlines will reduce fares on direct connections in order to attract additional demand from interline passengers. On the other hand, the reduction in fares shrinks with further increases in  $a$ . The positive welfare effects arising from the fact that airlines do not price discriminate between passengers on direct connections and interline passengers is, therefore, declining after  $\tilde{a}$  is reached. As a consequence, another critical level  $\tilde{\tilde{a}}$  exists such that, for  $a > \tilde{\tilde{a}}$ , code-share agreements with antitrust immunity lead to higher welfare compared to a situation without code-share agreements. Observe that, first,  $\tilde{\tilde{a}} < 1$  holds and, second,  $\tilde{\tilde{a}} < \tilde{a}$  holds for  $n < 32$ . Hence, if  $a$  is close enough to 1 then code-share agreements with antitrust immunity will always lead to better welfare results compared to a situation without code-share agreements. Furthermore, for  $n < 32$  code-share agreements with antitrust immunity always lead to higher welfare results compared to a situation without code-share agreements. A positive welfare effect of a ban on code-share agreements can only occur for a high number of connections, i.e.  $n \geq 32$ , and an intermediate value of  $a \in [\tilde{\tilde{a}}, \tilde{a})$ .

In reality, the number of relevant interline passengers, in particular at major airports, is potentially very high. Consider an airport with 80 air traffic movements per hour (e.g., Frankfurt airport in Germany). Suppose that passengers accept up to four hours of transfer time and the minimum transfer time is one hour. Then, since on average the number of departing flights will be the half of total air traffic movements, the number of potential interline connections reaches approximately 120. This illustrates that the condition  $n > 32$  is likely to be satisfied on medium size and large airports.

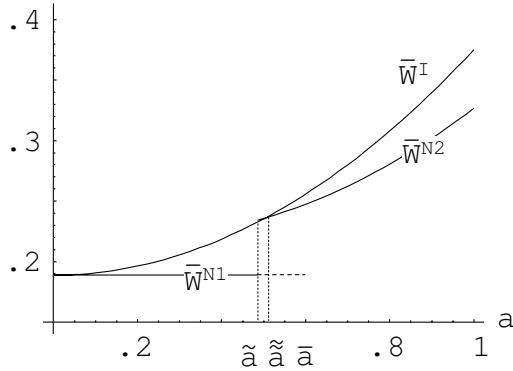


Figure 2: Welfare under code-share agreements with antitrust immunity,  $\bar{W}^I$ , and welfare without code-share agreements,  $\bar{W}^{Nj}$  with  $j \in \{1, 2\}$  ( $n = 80$ ).

Figure 2 shows the average welfare with code-share agreements under antitrust immunity and without code-share agreements as a function of  $a$  for  $n = 80$ . For the cases with two Nash equilibria it depicts the focal point equilibrium  $N2$  as a solid curve. The figure indicates that the range on which a ban of code-share agreements leads to higher welfare levels is rather small, i.e. the difference  $\tilde{a} - \tilde{a}$  is rather small for reasonable numbers of interline connections. However, the positive effect on the passengers for direct flights is always present at equilibrium  $N2$ , implying that the difference between  $\bar{W}^I$  and  $\bar{W}^{N2}$  is rather small for *all*  $a \geq \tilde{a}$  (compared to the much larger difference between  $\bar{W}^I$  and  $\bar{W}^{N1}$ ).

Recall that in my case airline networks are fully complementary. Considering overlapping networks puts more question marks on the usefulness of code-share agreements from a welfare perspective. With overlapping networks, airlines compete on connections served in parallel. In this case code-

share agreements with antitrust immunity have two effects. First, they lead to collusion and higher fares on connections served in parallel. Second, they can lead to increasing fares for passengers on direct connections. The first effect has already been shown in (Park 1997), (Brueckner 2001), while the second effect has not been investigated so far. Both effects in conjunction give a strong argument against code-share agreements with antitrust immunity in the case of overlapping airline networks.

## 4 Code-share agreements without antitrust immunity

In some instances, e.g. in the case of American Airlines and British Airways, code-share agreements are not forbidden but at the same time antitrust immunity is denied. Airlines then have to set fares for interline passengers independently (Brueckner 2001). I now consider the effect of code-share agreements *without* antitrust immunity on airline fares and welfare. Notice that code-share agreements allow for price discrimination between passengers on direct connections and interline passengers even if antitrust immunity is denied (Bilotkach 2005).

Under code-share agreements without antitrust immunity airlines independently choose their part of the interline fare. Denoting this case by  $C$ , a Nash equilibrium  $((p_{n+1,1}^C, p_{n+1,2}^C), \dots, (p_{2n-1,1}^C, p_{2n-1,2}^C))$  is then determined by

$$p_{i,j}^C = \arg \max_{p_{i,j}} p_{i,j} (a - p_{i,j} - p_{i,k}^C) = \frac{a - p_{i,k}^C}{2} \Rightarrow p_{i,j}^C = \frac{a}{3} \quad (19)$$

for all  $j \in \{1, 2\}$ ,  $j \neq k$ ,  $i \in \{n + 1, \dots, 2n - 1\}$  and  $j \in \{1, 2\}$ . It is straightforward to check that the fare arbitrage conditions are satisfied in this case.

I now analyze the welfare effects of code-share agreements without antitrust immunity on interline passengers.

**Proposition 4** *Interline passengers are better off if code-share agreements are provided with antitrust immunity compared to code-share agreements without antitrust immunity. Even if antitrust immunity is denied, interline passengers are better off with code-share agreements compared to a situation without code-share agreements.*

**Proof** If code-share agreements are provided with antitrust immunity interline passengers pay a fare equal to  $a/2$ . If code-share agreements are not provided with antitrust immunity interline passengers pay a fare equal to  $2p_{ij}^C = 2a/3$ . Thus, interline passengers are better off when antitrust immunity is provided. Furthermore, since  $p_i^{N1} + p_n^{N1} > 2a/3$  holds for all  $a \leq \bar{a}$  and  $p_i^{N2} + p_n^{N2} > 2a/3$  holds for all  $a \geq \tilde{a}$ , interline passengers are better off with than without code-share agreements even if antitrust immunity is denied. ■

For the analysis of total welfare effects of code-share agreements without antitrust immunity denote

$$\bar{W}^C := \bar{W}(p_1^C, \dots, p_n^C; (p_{n+1,1}^C, p_{n+1,2}^C), \dots, (p_{2n-1,1}^C, p_{2n-1,2}^C)). \quad (20)$$

Comparing welfare effects of code-share agreements with and without antitrust immunity leads to:

**Corollary 1**  $\bar{W}^C < \bar{W}^I$  always holds.

**Proof** By Proposition 4 antitrust immunity (strictly) reduces interline fares (at positive demand). Fares for passengers on direct connections and on indirect connections entirely served by airline 1 are not affected by antitrust immunity as long as code-share agreements are used. ■

Corollary 1 reproduces the standard result for complementary airline networks found by Brueckner (Brueckner 2001): code-share agreements with antitrust immunity reduce interline fares and increase welfare compared to code-share agreements without antitrust immunity. The reason is that an independent choice of sub-fares creates a double mark-up, since airlines do not take into account the negative effects of their own sub-fares on the other airline's revenues.

However, suppose airlines had overlapping networks such that they could compete on parallel connections. In this case code-share agreements with antitrust immunity would lead to collusion and higher fares on parallel connections. The overall welfare effect of antitrust immunity, therefore, depends on the share of interline and parallel connections. This has also been pointed out by Brueckner (Brueckner 2001). It might therefore be preferable, with a view to overlapping networks, to deny antitrust immunity. This leads to the question whether code-share agreements should be allowed without antitrust immunity or not at all.

Proposition 1 indicates that a situation without code-share agreements is more likely to generate better welfare results than airlines using code-share agreements if antitrust immunity is denied. Denote another critical level for  $a$  by

$$\hat{a} := \frac{3(32 + n(43 + 29n))}{80 + 202n + 86n^2}. \quad (21)$$

It holds  $\hat{a} > \tilde{a}$ , and  $\hat{a} < 1$  if and only if  $n < 73$ .

**Proposition 5**  $\bar{W}^C > \bar{W}^{N1}$  holds when  $N1$  exists (i.e. for all  $a \leq \bar{a}$ ).

If  $n < 73$ ,  $\bar{W}^C < \bar{W}^{N2}$  holds for all  $a \in [\tilde{a}, \hat{a})$  and  $\bar{W}^C \geq \bar{W}^{N2}$  holds for all  $a \geq \hat{a}$ .

If  $n \geq 73$ ,  $\bar{W}^C < \bar{W}^{N2}$  holds when  $N2$  exists (i.e. for all  $a \geq \tilde{a}$ ).

**Proof** See appendix A.3. ■

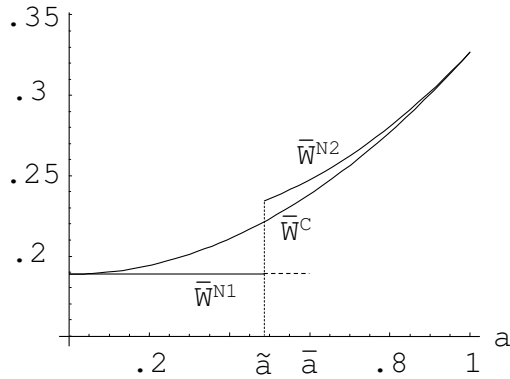


Figure 3: Welfare under code-share agreements without antitrust immunity,  $\bar{W}^C$ , and welfare without code-share agreements,  $\bar{W}^{Nj}$  with  $j \in \{1, 2\}$  ( $n = 80$ ).

Proposition 5 indeed implies that code-share agreements lose value compared to the case of non-cooperating airlines if antitrust immunity is denied ( $n < 73$  and  $a \in [\tilde{a}, \hat{a})$  or  $n \geq 73 \Rightarrow \bar{W}^C < \bar{W}^{N2}$ ). Recall that airlines that do not make use of code-share agreements will reduce fares to attract additional demand from interline passengers if and only if  $a \geq \tilde{a}$  is satisfied. However, as  $a$  increases the reduction in fares shrinks. Therefore, code-share agreements without antitrust immunity lead to better welfare results if and only if  $a$  exceeds another critical level  $\hat{a}$ .

Figure 3 demonstrates that there is a high probability that a ban on code-share agreements leads to better welfare results compared to code-share agreements without antitrust immunity. Assuming that  $n = 80$  holds it shows  $\bar{W}^{N1}$  for  $a < \tilde{a}$  (dashed line for  $\tilde{a} < a < \bar{a}$ ),  $\bar{W}^{N2}$  for  $a \geq \tilde{a}$ , and  $\bar{W}^C$ . Since  $n > 73$ ,  $\bar{W}^{N2} > \bar{W}^C$  holds for all  $a \geq \tilde{a}$ , implying that non-cooperating airlines lead to higher welfare compared to airlines using code-

share agreements without antitrust immunity. On the other hand, for  $a < \tilde{a}$ ,  $\bar{W}^C > \bar{W}^{N1}$  holds because the number of interline passengers would be zero without code-share agreements.

## 5 Conclusions

Airline alliances are a common phenomenon in the airline industry. A basic element of alliances are code-share agreements that allow airlines to offer connections they could not offer as one product by their own. Code-share agreements are normally provided with antitrust immunity allowing airlines to cooperatively set fares such that joint profits are maximized.

My analysis of code-share agreements with and without antitrust immunity is based on (perfectly) complementary airline networks. I demonstrate that the welfare effects of code-share agreements are not straightforward in this situation. This is in contrast to the current literature arguing that in the case of complementary airline networks code-share agreements improve welfare.

A crucial point is that code-share agreements are necessary to identify interline passengers which is the basis for price discrimination. I demonstrate that interline passengers are always better off if code-share agreements are used and price discrimination takes place. This result is consistent with the existing literature on alliances and code-share agreements.

On the other hand, I also demonstrate that price discrimination makes non-interline passengers worse off (or may leave them unaffected). Without price discrimination airlines set only one fare for all passengers on connections served entirely by their own. Thus fares depend on the aggregate demand of non-interline and interline passengers. It is then possible that airlines reduce

fares for all passengers in order to attract additional demand from interline passengers. This in turn benefits non-interline passengers. Notice that the positive welfare effects that interline passengers can have on non-interline passengers have been ignored so far.

The probability that fares are reduced after a ban of code-share agreements and without price discrimination depends on, first, the level of demand for special interline connections and, second, the number of interline connections. If both values are high, the probability is high that fares are reduced.

More importantly, I find that a ban of code-share agreements that prevents price discrimination can enhance total welfare, i.e. the positive welfare effects of code-share agreements on interline passengers are smaller than the negative effects on non-interline passengers. The probability for this to happen is, however, low if code-share agreements are provided *with* antitrust immunity. In contrast, there is a high probability that a ban of code-share agreements outperforms the use of code-share agreements *without* antitrust immunity.

It is well known that the case against code-share agreements with antitrust immunity becomes stronger after taking into account that, in practice, airline networks are overlapping. Hence, without antitrust immunity airlines are supposed to compete on some connections served in parallel by partner airlines. The provision of code-share agreements with antitrust immunity leads to collusion and higher fares on these connections and, therefore, generates additional welfare losses. Altogether, the results of my analysis question the usefulness of code-share agreements with or without antitrust immunity from a welfare perspective and, hence, from a policy point of view. Notice, however, that other forms of cooperation between airlines or alliance partners



are not affected by these results as long as they can not be used for price discrimination which is at the core of code-share agreements.

## A Proofs

### A.1 Proof of Proposition 1

Reaction functions of airline 1 on directions  $i \in \{1, \dots, n-1\}$  are

$$\begin{aligned} p_i^r(p_n) &:= \arg \max_{p_i} p_i \hat{D}_i(p_i, p_n) \\ &= \begin{cases} \frac{1}{2} & \text{for } p_n \geq 1 - \sqrt{2} + a \\ \frac{1}{4} (1 + a - p_n) & \text{for } p_n \leq 1 - \sqrt{2} + a. \end{cases} \end{aligned} \quad (22)$$

On directions  $i \in \{1, \dots, n-1\}$  demand conditions are symmetric for airline 1. Reaction functions (22) demonstrate that it might be useful for airline 1 to charge fares that are below  $p_i^I = 1/2$  in order to exploit demand from interline passengers. Notice, if this strategy is useful on any direction  $i \in \{1, \dots, n-1\}$  then it will be useful on *all* those directions (due to symmetry). For that reason it is sufficient to depict reaction functions of airline 2 for symmetric fares  $p := p_1 = \dots = p_{n-1}$  of airline 1 to identify the existing set of Nash equilibria. Noting that

$$\hat{D}_n(\underbrace{p, \dots, p}_{n-1}, p_n) = \max\{0, 1 - p_n\} + (n-1) \max\{0, a - p - p_n\} \quad (23)$$

it holds

$$\begin{aligned} p_n^r(p) &:= \arg \max_{p_n} p_n \hat{D}_n(p, \dots, p_{n-1}, p_n) \\ &= \begin{cases} \frac{1}{2} & \text{for } p \geq a - \frac{1}{1 + \sqrt{n}} \\ \frac{1}{2n} (1 + (a - p)(n-1)) & \text{for } p \leq a - \frac{1}{1 + \sqrt{n}}. \end{cases} \end{aligned} \quad (24)$$

Note that the reaction functions (22) and (24) are discontinuous (at the point of discontinuity, they are actually correspondences instead of functions). An intersection of the upper parts of the reaction functions,  $p_i^r(p_n) = 1/2 \geq a - 1/(1 + \sqrt{n})$  and  $p_n^r(p) = 1/2 \geq 1 - \sqrt{2} + a$  exists if and only if  $a \leq \hat{a}$  and implies equilibrium  $(p_1^{N1}, \dots, p_n^{N1})$ . An intersection of the lower parts of the reaction functions,  $p_i^r(p_n) = (1 + a - p_n)/4 \leq a - 1/(1 + \sqrt{n})$  and  $p_n^r(p) = (1 + (a - p)(n - 1))/(2n) \leq 1 - \sqrt{2} + a$ , exists if and only if  $a \geq \tilde{a}$  and implies equilibrium  $(p_1^{N2}, \dots, p_n^{N2})$ . Finally,  $p_i^r(p_n) = 1/2 \geq a - 1/(1 + \sqrt{n})$  and  $p_n^r(1/2) = (1 + (a - 1/2)(n - 1))^2/(4n) \leq 1 - \sqrt{2} + a$  is a contradiction, as well as  $p_i^r(1/2) = (1 + a - 1/2)/4 \leq a - 1/(1 + \sqrt{n})$  and  $p_n^r(p) = 1/2 \geq 1 - \sqrt{2} + a$ .

The Nash equilibrium  $(p_1^{N2}, \dots, p_n^{N2})$  is Pareto-dominant for  $a \in [\tilde{a}, \bar{a}]$  if and only if both airlines strictly prefer this equilibrium over  $(p_1^{N1}, \dots, p_n^{N1})$ . Now, recall that the number of interline passengers is 0 in equilibrium  $N1$ . Thus, starting from equilibrium  $N2$  each airline can unilaterally realize profits as high as under equilibrium  $N1$  by charging fares equal to  $1/2$ . However,  $N2$  is a Nash-equilibrium where both airlines have a unique best response. Thus, both airlines are strictly better off in equilibrium  $N2$  than in  $N1$ .

## A.2 Proof of Proposition 3

Consider equilibrium  $N1$  (which exists for  $a \leq \bar{a}$  and is the unique equilibrium for  $a < \tilde{a}$ ). Without code-share agreements interlining does not take place. Furthermore, fares on direct connections are equal to fares under code-share agreements with antitrust immunity.  $\bar{W}^I > \bar{W}^{N1}$  follows.

Notice that, due to symmetry, in any equilibrium prices are identical for  $i = 1, \dots, n-1$ . Letting  $p_i =: p$ ,  $p_{i1} =: p_{.1}$ , and  $p_{i2} =: p_{.2}$  for  $i = 1, \dots, n-1$ , then for  $p \leq 1$  and  $p_{.1} + p_{.2} \leq a$  the expression for  $\bar{W}$  simplifies to

$$\bar{W} = \frac{1}{2n-1} \cdot \left( (n-1) \left( \int_p^1 (1-y) dy + p(1-p) \right) \right) \quad (25)$$

$$+ \int_{p_n}^1 (1-y) dy + p_n(1-p_n) \quad (26)$$

$$+ (n-1) \left( \int_{p_{.1}+p_{.2}}^a (a-y) dy + (p_{.1} + p_{.2})(1-p_{.1}-p_{.2}) \right). \quad (27)$$

Consider equilibrium  $N2$  (which exists and is the relevant one for  $a \geq \tilde{a}$ ).

Using (25) one obtains:

$$\bar{W}^I = \frac{3(a^2(n-1) + n)}{16n-8} \text{ and } \bar{W}^{N2} = \quad (28)$$

$$\frac{2n^2(7+22n) + a^2(n-1)(5+n(19+32n)) - 12a(n-1)(1+n)^2 - 2(4+n)}{2(2n-1)(1+7n)^2}. \quad (29)$$

It is straightforward to show that  $\bar{W}^{N2} > \bar{W}^I$  holds if and only if  $a < \tilde{\tilde{a}}$  is satisfied. Moreover,  $\tilde{a} < \tilde{\tilde{a}}$  holds if and only if  $n \geq 32$ . Therefore, if  $n < 32$  or  $n \geq 32$  and  $a \geq \tilde{\tilde{a}}$  it follows  $\bar{W}^I \geq \bar{W}^{N2}$ .

### A.3 Proof of Proposition 5

Consider equilibrium  $N1$  (which exists for  $a \leq \bar{a}$  and is the unique equilibrium for  $a < \tilde{a}$ ). Without code-share agreements interlining does not take place. Furthermore, fares on direct connections are equal to fares under code-share agreements without antitrust immunity.  $\bar{W}^C > \bar{W}^{N1}$  for all  $a \leq \bar{a}$  follows.

Consider equilibrium  $N2$  (which exists and is the relevant one for  $a \geq \tilde{a}$ ).

Equation (25) leads to

$$\bar{W}^C = \frac{20a^2(n-1) + 27n}{72(2n-1)}. \quad (30)$$

$\bar{W}^{N2}$  is given in the proof of Proposition 3.

It is straightforward to show that  $\bar{W}^{N2} > \bar{W}^C$  holds if and only if  $a < \hat{a}$  is satisfied. One also checks that  $\hat{a} > \tilde{a}$  always holds, and that  $\hat{a} \leq 1 \Leftrightarrow n < 73$ . Hence, the proposition follows.

## References

- Bamberger, G. E., D. W. Carlton, and L. R. Neumann (2004). An empirical investigation of the competitive effects of domestic airline alliances. *Journal of Law and Economics* 47(1), 195–222.
- Bilotkach, V. (2005). Price competition between international airline alliances. *Journal of Transport Economics and Policy* 39(2), 167–189.
- Brueckner, J. and W. T. Whalen (2000). The price effect of international airline alliances. *Journal of Law and Economics* 43(2), 503–545.
- Brueckner, J. K. (2001). The economics of international codesharing: an analysis of airline alliances. *International Journal of Industrial Organization* 19, 1475–1498.
- Chen, Z. and T. W. Ross (2003). Cooperating upstream while competing downstream: a theory of input joint ventures. *International Journal of Industrial Organization* 21(3), 381–397.
- Doganis, R. (2006). *The Airline Business* (2nd ed.).
- Goh, M. and J. Yong (2006). Impacts of code-share alliances on airline cost structure: A truncated third-order translog estimation. *International Journal of Industrial Organization* 24(4), 835–866.

- Hassin, O. and O. Shy (2004). Code sharing agreements and interconnections in markets for international flights. *Review of International Economics* 12(3), 337–352.
- Ito, H. and D. Lee (2005). Domestic codesharing practices in the US airline industry. *Journal of Air Transport Management* 11(2), 89–97.
- Oum, T. H., J.-H. Park, and A. Zhang (1996). The effects of airline codesharing agreements on firm conduct and international air fares. *Journal of Transport Economics and Policy* 30, 187–202.
- Park, J.-H. (1997). The effects of airline alliances on markets and economic welfare. *Transportation Research E* 33(3), 198–195.
- Park, J.-H. and A. Zhang (2000). An empirical analysis of global airline alliances: cases in North Atlantic markets. *Review of Industrial Organization* 16, 367–383.
- Zhang, A. and Y. Zhang (2006). Rivalry between strategic alliances. *International Journal of Industrial Organization* 24(2), 287–301.