Airline Partnerships and Schedule Coordination

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Abstract

Scheduling coordination is considered both a reason for and a consequence of airline consolidation. We formally model this dimension of airline partnerships, with complementary alliance where stop-over delays affect passengers' utility. We compare partnership where carriers are only allowed to coordinate scheduling to the one, where airlines can jointly set prices and schedules. Coordination in fares and schedules yields lower fares and better scheduling coordination. Coordination in only the price results in lower consumer welfare than under no coordination. We suggest an example of a complementary airline alliance hurting interline passengers.

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1.0 Introduction

Airline partnerships have by now become an integral part of the airline industry. Carriers cooperate in a variety of ways, from shared use of airport facilities to complex agreements uniting entire partner airlines' networks. Doganis (2001) recorded over 500 various airline partnerships in 1998, and this number has undoubtedly increased since then. Since airline cooperation started in international markets, it was initially suggested that the main reason for such partnerships was to avoid the entry barriers on those heavily regulated routes. This assertion is now not so obvious, as US carriers have also formed a number of partnerships in the deregulated US domestic market. Another line of thought has suggested that establishing airline partnerships was a way to make the partner airlines' product more attractive to passengers by introducing 'seamless travel', a service which includes checking in both passenger and luggage through to the final destination for trips requiring change of the operating carrier, as well as coordination in scheduling. Even though this 'service quality' dimension of the airline cooperation has been regarded as important, formal analysis has not paid attention to it. This paper starts filling this gap in the literature by offering the first simple formal model of scheduling coordination between partner airlines.

In our modeling exercise we examine pricing and scheduling decisions made by the partner airlines on a market where no single-airline service is possible (thus, airline alliance members provide complementary services), and consumers' preferences depend on price and stop-over delay, defined as duration of the stop en route. Given the positive re-scheduling costs, we compare the scenario where airlines coordinate their schedules while setting prices in a non-coordinated fashion to the one where the carriers jointly set both schedules and price. These two scenarios can be thought of as analogous to airline partnerships with and without antitrust immunity (the right given to international airline partners to coordinate price setting for interline trips). It is believed that given antitrust immunity with complementary networks the partner airlines can better get rid of the problem of double marginalization, leading to lower fares for the interline trips. In this paper we address the question of whether we can expect any differences in the service quality (as measured by the stop-over delay in our case) between the cases of allowing and prohibiting explicit price coordination. In a recent application for the antitrust immunity, a group of carriers including Northwest Airlines, Delta Air Lines, KLM Royal Dutch Airlines and Air France (Joint Application, 2004) claimed that the antitrust immunity fosters cooperation in other dimensions, including the schedule coordination of interline trips.[1]

Partnership with the antitrust immunity yields both better scheduling coordination and lower fares as compared to that where only scheduling coordination is permitted. As compared to the no coordination scenario, scheduling coordination yields higher fares, shorter stop-over delays, and lower consumer welfare. Thus, the airline partnership with carriers cooperating only on the quality dimension ends up offering a higher quality service at an overly high price. Our model is, therefore, the first one suggesting a way in which a complementary airline alliance hurts interline passengers.

[1] Northwest Airlines has had a long-lasting partnership with KLM Royal Dutch Airlines, backed by the antitrust immunity; while Air France's major partner on the other side of the Atlantic has been Delta Air Lines (this partnership is also protected by the antitrust immunity). Following the merger of the two European carriers, the decision was made to unite the two alliances. In December 2005 the US Department of Transportation made a tentative decision to deny antitrust immunity to Northwest-Air France and Delta-KLM pairs.

The literature on airline partnerships is growing, and has thus far mostly dealt with the price effects of airline consolidation. Theoretical models of airline consolidation include works by Park (1997), Brueckner (2001), Brueckner and Whalen (2000), Bilotkach (2005, 2007), Flores-Fillol and Moner-Colonques (2005), Barla and Constantatos (2006), Heimer and Shy (2006).

Park assumes quantity competition and looks at two types of code-sharing agreements: complementary and parallel. He finds that, while the complementary alliance increases welfare (by removing double marginalization), the parallel one tends to be welfare-decreasing, reducing competition on overlapping parts of the network. Brueckner models formation of a single alliance with antitrust immunity on a simple overlapping hub-and-spoke network. He finds that alliance with the antitrust immunity will benefit interline passengers, but fares for travel between partner airlines' hubs will increase. On the whole, the general effects on consumer welfare provoked by such an alliance are positive and more so with higher economies of traffic density. Brueckner and Whalen confirm lower interline fares for their setup. Again, their model implicitly assumes cooperating airlines have antitrust immunity. Heimer and Shy's model assumes partner airlines coordinate their choice of frequency in an overlapping partnership. They conclude that alliances will increase total welfare, while making consumers unambiguously worse off. Bilotkach (2005) models price competition between two airline alliances and finds gains for interline passengers and higher fares on routes between hubs of the alliance partners. He further suggests that code-sharing with and without the antitrust immunity will lead to an equal decrease in the interline fares. Bilotkach (2007a) compares price and welfare effects of complementary and semi-complementary (those involving partially overlapping networks) airline partnerships under economies of traffic density. Flores-Fillol and Moner-Colonques determine that partners sharing the same hub have an incentive to form a complementary alliance only if the product differentiation is sufficiently high. Barla and Constantatos suggest that among three airlines, two of which deciding to cooperate, a strategic alliance will give the partners higher profit as compared to a full merger.

Empirical analysis of the effects of international airline partnerships has been offered by Oum et al. (1996), Park and Zhang (2000), Brueckner and Whalen (2000), Brueckner (2003), Whalen (2005), and Bilotkach (2007b). All of these papers confirm that airline alliances benefit interline passengers by offering lower fares. Park and Zhang also find evidence for increasing market power of the alliance members at their hubs, even though they suggest that this effect is offset by cost savings that an alliance brings about. While finding that alliances decrease interline fares, Brueckner and Whalen fail to observe a statistically significant increase in fares due to airline consolidation, where this appears to decrease the number of competitors. Brueckner's empirical research shows that antitrust immunity decreases fares for interline trips to a greater extent than code-sharing without such immunity. Whalen confirms these findings in a time-series analysis of the effects of international airline partnerships. Bilotkach finds the price effect of airline consolidation similar in magnitude as reported in other studies; yet, he suggests joining of partner airlines' networks through the code-sharing agreements as the primary source of gains to the interline passengers (antitrust immunity is not found to contribute to lower interline fares).

There is also growing literature examining the competitive effects of the domestic U.S. airline partnerships. Here there is no clear consensus as to the kind we observe in studies of international markets. Bamberger et al. (2004) and Ito and Lee (2007) suggest consumers did benefit from such consolidation. However, Armantier and Richard (2005) suggest ambiguous effects.

The rest of the paper is organized in a straightforward way. Section 2 describes the model, Section 3 provides formal analysis, and Section 4 offers discussion of results and presents conclusions.

2.0 Model Setup

Consider market for travel between cities A and B, where no non-stop service is offered, and therefore all passengers must travel via point H. Further, travel from city A to city H is only possible with airline 1, while airline 2 is the only carrier serving the HB market, as depicted on Figure 1. Therefore, a passenger traveling from A to B will face a stop en route, and the duration of that stop will affect the passenger's utility. Consequently, airlines should be able to charge a higher price for this interline trip if they space their flights at H closer together. The question is then whether better scheduling coordination can be achieved if airlines are allowed to jointly decide not only on the schedule but also on the price to be charged for this interline trip.

Formally, we will simplify the analysis by dropping markets AH and HB from the model and considering *directional* AB market only. That is, we assume that all passengers travel from A to B one-way. A passenger's indirect utility of travel depends on the total fare and duration of the stop at the airport H, as follows:

$$U = \theta - P_{AB} - \delta(t_2 - t_1) \qquad (1)$$

Where θ is consumer's reservation utility; δ is the disutility of delay, P_{AB} is the airfare, and $(t_2 - t_1)$ is the duration of stop en route. Further, t_1 and t_2 are times of airline 1's flight arrival to and airline 2's departure from the airport H, respectively ($0 \le t_1 \le t_2 \le 1$). The passengers are differentiated with respect to the reservation utility in a very simple way: θ is distributed uniformly over the interval $[0,1]$. With indirect utility of the outside alternative (which can be interpreted as either not traveling or using an alternative mode of transport) set to zero, the demand for travel will be given by:

$$q_{AB} = \Pr(\theta \ge P_{AB} + \delta(t_2 - t_1)) = \int_{P_{AB}+\delta(t_2-t_1)}^{1} d\theta = 1 - P_{AB} - \delta(t_2 - t_1) \qquad (2)$$

On the cost side, we will have two things: the cost of transporting passengers and the cost of schedule adjustment. We assume a constant transportation cost, equal to *c* per segment. Thus, the total cost of transporting a passenger from A to B is *2c*. The schedule adjustment part of cost is set up as follows. First, we assume that initially $t_1^0 = 0$ and $t_2^0 = 1$ (exogenously given), such that both airlines start off with their flights spaced as far apart as possible. Second, the cost of changing time of the flight is given by $c_t(t_i - t_i^0)^2$. In fact, assuming non-decreasing returns to schedule adjustment does not give any interesting results, as it will lead to airlines spacing their flights as close to each other as possible. Further, it is easy to show that allowing coordination on prices will lead to a lower price than otherwise (due to removal of double marginalization). Therefore, it is obvious that with a non-convex cost of re-scheduling allowing price coordination leads to lower price, and duration of stop en route will be the same (zero, technically) no matter whether the airlines are allowed to coordinate only scheduling or both scheduling and pricing decisions.

The assumption of convex cost of re-scheduling can be further justified if we consider the segments of our market as part of the airlines' networks outside of our analysis. In this case, re-scheduling a flight introduces disruptions throughout the network and more so the further from the original time you choose to move the flight. Thus, the airlines' total cost functions will be given by:

$$\begin{aligned} TC_1 &= cq_{AB} + c_t(t_1)^2 \\ TC_2 &= cq_{AB} + c_t(1-t_2)^2 \end{aligned} \tag{3}$$

To finish description of the model, we will introduce the following parameter restrictions. First, we will assume $\frac{2\delta(1-c)}{3} \leq c_t$, which will ensure that in equilibrium $0 \leq t_1 \leq t_2 \leq 1$. This means that the passengers' disutility of stop-over delay relative to the cost of rescheduling a flight is sufficient for an airline to move the flight closer to that of its partner, but not high enough for flights to be spaced equally in equilibrium. Since we assume directional market, we require that airline 1's flight arrive to airport H before airline 2's flight be scheduled to depart from there. Second, we suppose $\frac{\delta^2}{c_t} < \frac{3}{2}$; this condition ensures positive equilibrium prices. Finally, to ensure positive equilibrium quantity, we need $2c + \delta < 1$.

3.0 Model Analysis

The purpose of our analysis is to compare airlines' pricing and scheduling choices under different degrees of coordination, assuming the pricing-scheduling game is played once.

First, we consider the case where the two carriers set both prices and schedules non-cooperatively. Then, airlines will be allowed to coordinate their scheduling decisions, but each player will set the sub-fare for its portion of the interline trip independently, taking the other carrier's choice as given. In the last case, carriers will determine both the total price of the trip and their scheduling choices jointly.

3.1 Non-Cooperative Pricing and Scheduling

In the first scenario, each airline will choose the sub-fare for its portion of the interline trip and the arrival/departure time to maximize its profit, taking the competitor's choice as given. The airlines' profit functions will be:

$$
\begin{aligned}
\pi_1^{NC} &= (p_1 - c)(1 - p_1 - p_2 - \delta(t_2 - t_1)) - c_t (t_1)^2 \\
\pi_2^{NC} &= (p_2 - c)(1 - p_1 - p_2 - \delta(t_2 - t_1)) - c_t (1 - t_2)^2
\end{aligned} \tag{4}
$$

The superscript *NC* stands for the "no cooperation" scenario. The first-order conditions are found simply as:

$$
\begin{aligned}
\frac{\partial \pi_1^{NC}}{\partial p_1} &= 1 - 2p_1 - p_2 - \delta(t_2 - t_1) + c = 0 \\
\frac{\partial \pi_1^{NC}}{\partial t_1} &= \delta(p_1 - c) - 2c_t t_1 = 0 \\
\frac{\partial \pi_2^{NC}}{\partial p_2} &= 1 - 2p_2 - p_1 - \delta(t_2 - t_1) + c = 0 \\
\frac{\partial \pi_2^{NC}}{\partial t_2} &= -\delta(p_2 - c) + 2c_t (1 - t_2) = 0
\end{aligned} \tag{5}
$$

From (5) we can obtain the following conditions for the equilibrium prices and scheduling choices:

$$t_2^{NC} - t_1^{NC} = 1 - \frac{\delta}{2c_t}\left(p_1^{NC} + p_2^{NC} - 2c\right)$$
$$p_1^{NC} = p_2^{NC} = \frac{1}{3}\left(1 + c - \delta\left(t_2^{NC} - t_1^{NC}\right)\right) \tag{6}$$

Eventually, the system (6) can be solved to yield the following expressions for the equilibrium price and stop-over delay:

$$p^{NC} = p_1^{NC} + p_2^{NC} = \frac{2\left(1 - \delta + c\left(1 - \frac{\delta^2}{c_t}\right)\right)}{3 - \frac{\delta^2}{c_t}} \tag{7}$$

$$t_2^{NC} - t_1^{NC} = 1 - \frac{\delta(1 - 2c - \delta)}{3c_t - \delta^2} \tag{8}$$

We will stop here to return to the above expressions when comparing the results across scenarios.

3.2 Coordination in Scheduling

It is reasonable to model this scenario as the two-stage game, in which partner airlines first choose the departure times in a cooperative fashion, later setting sub-fares for each portion of the interline trip in a non-cooperative way in the second stage. At the first stage of this game the partners will choose t_1 and t_2 to maximize the following joint profit function:

$$\pi^{SC} = \left(p_1 + p_2 - 2c\right)\left(1 - p_1 - p_2 - \delta(t_2 - t_1)\right) - c_t\left((t_1)^2 + (1 - t_2)^2\right) \tag{9}$$

Where the superscript SC stands for “schedule coordination”. The game is solved by backward induction. The first order conditions with respect to sub-fares at the second stage of the game will be the same as in (5), and the solution to this system of equations will be:

$$p_1^{SC} = p_2^{SC} = \frac{1}{3}\left(1 + c - \delta\left(t_2^{SC} - t_1^{SC}\right)\right) \tag{10}$$

The first-stage joint profit function will then become (after some algebra):

$$\pi^{SC}\left(p_1^*, p_2^*\right) = \tfrac{2}{9}\left[1 - 2c - \delta\left(t_2^{SC} - t_1^{SC}\right)\right]^2 - c_t\left(\left(t_1^{SC}\right)^2 + \left(1 - t_2^{SC}\right)^2\right) \tag{11}$$

The optimal scheduling choices and prices that obtain from (10) and (11) are:

$$t_2^{SC} - t_1^{SC} = 1 - \frac{4\delta(1 - 2c - \delta)}{9c_t - 4\delta^2} \tag{12}$$

$$p^{SC} = \frac{2\left(3(1-\delta) + c\left(3 - \frac{4\delta^2}{c_t}\right)\right)}{9 - \frac{4\delta^2}{c_t}} \tag{13}$$

3.3 Coordination in Prices and Scheduling (Antitrust Immunity)

In the final scenario to be considered, carriers will jointly determine the total price for the interline trip, as well as the timing of their flights. Such an arrangement is very similar to the case of airline partnerships with antitrust immunity, so we will use the term ‘antitrust immunity’ as the shorter name for this scenario. Formally, the airlines will maximize the following joint profit function:

$$\pi^{AI} = (p - 2c)(1 - p - \delta(t_2 - t_1)) - c_t\left((t_1)^2 + (1 - t_2)^2\right) \tag{14}$$

The first-order conditions will be:

$$\frac{\partial \pi^{AI}}{\partial p} = 1 - 2p - \delta(t_2 - t_1) + 2c = 0$$

$$\frac{\partial \pi^{AI}}{\partial t_1} = \delta(p - 2c) - 2c_t t_1 = 0 \tag{15}$$

$$\frac{\partial \pi^{AI}}{\partial t_2} = -\delta(p - 2c) + 2c_t(1 - t_2) = 0$$

Which will give:

$$p^{AI} = \frac{1}{2}\left(1 + 2c - \delta\left(t_2^{AI} - t_1^{AI}\right)\right) \tag{16}$$

$$t_2^{AI} - t_1^{AI} = 1 - \frac{\delta}{c_t}(p - 2c) \tag{17}$$

And the equilibrium price and stop-over delay obtain from (16) and (17) as:

$$p^{AI} = \frac{1 - \delta + 2c\left(1 - \frac{\delta^2}{c_t}\right)}{2 - \frac{\delta^2}{c_t}} \tag{18}$$

$$t_2^{AI} - t_1^{AI} = 1 - \frac{\delta(1 - 2c - \delta)}{2c_t - \delta^2} \tag{19}$$

3.4 Comparison of Equilibrium Prices and Stop-over delays

Once we have written down expressions for the equilibrium prices and schedule choices in all three scenarios, comparing them is a straightforward task. Namely, it can be easily shown that the case of antitrust immunity leads to the lowest price for an interline trip, as expected. Surprisingly, the case of scheduling coordination yields the highest interline trip price of all the scenarios considered. When no coordination is allowed, passengers face the longest stop en route as compared to other scenarios. Formally, these results are summarized in the Proposition below.

Proposition: if $\frac{2\delta(1-c)}{3} \leq c_t$, $\frac{\delta^2}{c_t} < \frac{3}{2}$, and $2c + \delta \leq 1$, then equilibrium prices and scheduling choices across the three scenarios considered above compare as follows: $p^{AI} < p^{NC} < p^{SC}$ and $t_2^{AI} - t_1^{AI} < t_2^{SC} - t_1^{SC} < t_2^{NC} - t_1^{NC}$

Proof: The relevant derivations are straightforward. In fact, since without antitrust immunity the first-order conditions with respect to prices are the same whether or not scheduling coordination is allowed, comparison of stop-over delays will immediately give us a relevant comparison of prices. After some algebra, we obtain:

$$\left(t_2^{SC} - t_1^{SC}\right) - \left(t_2^{NC} - t_1^{NC}\right) = \frac{-3c_t\delta(1-2c-\delta)}{\left(3c_t - \delta^2\right)\left(9c_t - 4\delta^2\right)} < 0 \tag{20}$$

Result (20) immediately tells us that $p^{NC} < p^{SC}$.

Next, it is straightforward to show that:

$$p^{NC} - p^{AI} = \frac{\left(1 - \frac{\delta^2}{c_t}\right)(1 - \delta - 2c)}{\left(2 - \frac{\delta^2}{c_t}\right)\left(3 - \frac{\delta^2}{c_t}\right)} > 0 \tag{21}$$

This completes comparisons of prices across all the scenarios.

Next, comparing (12) and (19), we obtain:

$$\left(t_2^{SC} - t_1^{SC}\right) - \left(t_2^{AI} - t_1^{AI}\right) = \frac{c_t\delta(1-2c-\delta)}{\left(2c_t - \delta^2\right)\left(9c_t - 4\delta^2\right)} > 0 \tag{22}$$

or $t_2^{AI} - t_1^{AI} < t_2^{SC} - t_1^{SC}$. ■

Thus, allowing only schedule coordination leads to a higher total price on the AB market as compared to the case of both pricing and scheduling coordination. An interesting conclusion of our analysis is that no coordination in scheduling yields a lower price as compared to the case where airline partners are allowed to coordinate their scheduling but not pricing choices.

Thus, consumers do get a higher quality product with firms coordinating in the quality dimension, but passengers will also face higher prices if coordination in the pricing dimension is not allowed. One should therefore wonder whether consumers are at all better off with only scheduling coordination between partner airlines than with no coordination whatsoever. Passenger's utility has two components in our model – price and stop-over delay, and lack of cooperation between the airlines produces lower prices and longer stop-over delays as compared to cooperation in scheduling but not in prices. The consumer surplus in our model is calculated in general as:

$$\begin{aligned} CS &= \int_{p^* + \delta(t_2^* - t_1^*)}^{1} \left(\theta - p^* - \delta\left(t_2^* - t_1^*\right)\right) d\theta \\ &= \tfrac{1}{2}\left[1 - \left(p^* + \delta\left(t_2^* - t_1^*\right)\right)^2\right] - \left[p^* + \delta\left(t_2^* - t_1^*\right)\right]\left[1 - \left(p^* + \delta\left(t_2^* - t_1^*\right)\right)\right] \\ &= \tfrac{1}{2}\left[1 - \left(p^* + \delta\left(t_2^* - t_1^*\right)\right)\right]^2 \end{aligned} \tag{23}$$

Further, for any of the scenarios we considered:

$$1 - \left(p^* + \delta\left(t_2^* - t_1^*\right)\right) = \frac{1 - \delta - 2c}{A} \tag{24}$$

where A is the denominator in expression for the equilibrium price under the respective scenario. Therefore, since $2 - \frac{\delta^2}{c_t} < 3 - \frac{\delta^2}{c_t} < 9 - \frac{4\delta^2}{c_t}$, we can establish the following comparison of consumer surpluses across the cases considered in this paper:

$$CS^{AI} > CS^{NC} > CS^{SC} \tag{25}$$

Thus, an airline alliance with antitrust immunity results in the highest consumer welfare among those we have considered. This is consistent with the double marginalization story. What is interesting is the comparison of consumer welfare with no cooperation and only scheduling coordination, which shows that coordination in only the scheduling dimension leaves consumers worse off than in the no coordination scenario. Thus, if airlines are allowed to coordinate only in quality, the price consumers have to pay for the increased convenience is too high.

4.0 Discussion and Conclusions

Our analysis has shown that allowing coordination in both pricing and scheduling (equivalent to granting antitrust immunity to the partner airlines) produces lower prices and a higher quality product as compared to the case of only scheduling coordination. The equilibrium price with coordination in scheduling but not in pricing is higher than that under no coordination; yet, coordination in scheduling also results in shorter stop-over delay as compared to the no coordination case. Consumers gain the most if carriers are allowed to coordinate both pricing and scheduling decisions; coordination in only scheduling leaves passengers worse off than with no coordination at all. In this way, our model is the first one suggesting a way in which a complementary airline alliance can hurt interline passengers, if airlines are not allowed to cooperate in all dimensions of service.

Obviously, decreasing returns due to re-scheduling is the main assumption behind our main result. Without this, airlines will choose to schedule their flights as close to each other as possible, with antitrust immunity case leading to lower price as compared to the schedule coordination scenario. Moreover, any difference between results for the schedule coordination and no coordination cases that we have here will disappear. The actual structure of re-scheduling costs is a rather open question, but we believe that our assumption of decreasing returns to re-scheduling a flight is justified for a network carrier shifting around one of its flights; such a move introduces disruptions throughout the entire network. More generally, applicability of our results to other demand and cost specifications within our framework seems an open question; yet, the simplest structures (while requiring imposition of certain artificial parameter restrictions to ensure interior solution) give rather interesting results.

Also, we assumed that the game was played only once. In fact, if we were to extend our analysis to the second time period assuming scheduling choices made in the first time period were again made according to airlines' initial positions, we would see that in that case carriers would have strong incentives to move their flights closer together. In the limit, if the game as described in the previous section were repeated infinitely many times with adjustment in initial scheduling choices to those made in the previous period, the airlines would reach a zero stop-over delay. Such a scenario, however, is plausible either where carriers do not perform any services outside of our model's network or if changes to other parts of carriers' networks are made following rescheduling of AH and HB flights. Obviously, such re-organization becomes more likely the higher the share of alliance passengers in the airline's total traffic. Yet, a more complex analysis is needed to address this issue.

In conclusion, we have introduced the dimension of schedule coordination into the modeling of airline partnerships. It has long been suggested that one of the reasons for and benefits from airline consolidation is partners' ability to offer a higher quality product, including better schedule coordination; yet, the literature has not paid attention to this quality dimension of airline partnerships. Our analysis confirms that when allowed to coordinate schedules in a setup where consumers value shorter trips, partner airlines will place connecting flights closer together as compared to carriers not allowed to coordinate their actions. We also determine that when airlines are allowed to jointly make only scheduling but not pricing choices, the end result can be lower consumer welfare as compared to the no coordination case. Thus, we provide a model in which a complementary airline alliance can actually hurt the interline passengers, as they end up paying too much for higher quality.

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Figure 1

The Market