

# Price and Frequency Choice under Monopoly and Competition in Aviation Markets

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## Abstract

Using data on 172 city-pair markets in eight European countries, we investigate the effect of the market structure on airlines choices of frequency and prices. Applying an address model, we show that equilibrium prices depend on passengers value of time, marginal flight costs and the aggregate number of flights. Furthermore, we show that under monopoly the equilibrium price is higher and the aggregate frequency is lower than under competition. The estimations show that market structure does not have any effect on Economy class ticket prices. However, market structure does have an effect on Business class ticket prices. The effects are in the expected direction: increased market concentration and decreased number of airlines results in increased ticket prices. Further, we find that applying the Herfindahl index as a measure of market concentration is restrictive and that the index instead should be decomposed. However, comparing the equilibrium price between monopoly and competitive routes we can reject the hypothesis of differences in equilibrium price. Regarding frequency choice, market structure again has a significant impact on the equilibrium prices, and the effects are as expected: decreased market concentration and an increased number of airlines results in increased aggregate frequencies. In the case of frequency we can reject the hypothesis that the aggregate frequency is the same under monopoly as it is under competition; the aggregate frequency under monopoly is found to be much lower.

**Key words:** *Aviation, competition, frequency choice, address model.*

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## **1. Introduction**

The European airline markets have undergone many changes over the last 15 years. There has been an extensive deregulation - removing barriers to entry and allowing airlines to set their prices freely - starting with the renegotiation of intra-European bilateral agreements in the mid and late 1980's. In 1987 the first European Community deregulation package was introduced, followed by the second package in 1990 and a third in 1993 (Marin, 1995). The experiences from the deregulations of the US and European markets are mixed, although most studies seem to conclude that the overall welfare effects of the deregulation have been positive.<sup>1</sup> Deregulation is of course no guarantee for competition. In Europe many small routes are still operated by only one airline although on most large routes at least two airlines operate. In this paper we are not primarily concerned with the effects of the deregulation. We investigate the differences between monopoly and competitive routes, as well as the effects of market concentration, on the competitive routes, on airlines choices of prices and frequency. Price and frequency are two main characteristics of an airline's product of air transport. They are also, of course, not only important for the consumer welfare, but also from an environmental perspective, since the number of flights is an important determinant of the environmental impact of aviation. We begin with presenting a simple address model of frequency and price choice. Then, using data on 172 city-pair markets in eight European countries, we investigate what effects market structure has on airlines choices of frequency and prices.

## **2. Price and Frequency Choice in an Address Model**

In order to illustrate the airlines choices of price and frequency, we apply a so-called address (or spatial) model (see Greenhut et al., 1987, for an overview). In particular we apply the circular market model developed by Salop (1979). Address models have been applied to airline markets in several papers (Greenhut et al., 1991, Norman and Strandenes, 1994; Panzar, 1970; Schipper et al., 1998). The model outlined here is essentially the model presented in Schipper (2001). We do not address the important question of scheduling, i.e. the timing of the departures.<sup>2</sup> We assume that the

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<sup>1</sup> See e.g. Borenstein (1990, 1992), Marin (1995), Morrison and Winston (1986), Schipper et al. (2002).

<sup>2</sup> See for example Brander and Eaton (1984) and Martinez-Giralt and Neven (1988) for an analysis of location choice in address models, i.e. the timing of departures. In particular, Martinez-Giralt and Neven

equilibrium is characterized by equal spacing of departures, and symmetric prices and frequencies, i.e. the airlines set the same prices in equilibrium and have the same number of departures.

### 2.1 Demand

Suppose that a potential traveler can choose between a number of departures. These departures are spaced over a circular time interval with length  $L$ ; for simplicity the length is set to  $L=1$ . A traveler faces the following net utility from flight  $i$  with departure time  $t_i$

$$v_i = \bar{v} - p_i - \theta|t_i - z|, \quad (1)$$

where  $\bar{v}$  is the gross utility associated with the flight,  $p_i$  is the money cost of the flight,  $z$  is the preferred departure time and  $\theta$  is the traveler's opportunity cost of time. A traveler is indifferent between flight  $i$  and another flight  $i+1$ , with departure time  $t_{i+1} > t_i$ , if

$$v_i = \bar{v} - p_i - \theta|t_i - z| = \bar{v} - p_{i+1} - \theta|t_{i+1} - z| = v_{i+1}. \quad (2)$$

Similarly an earlier flight exists, with departure time  $t_{i-1}$ , for which a traveler is indifferent under a similar condition. For both of these competing flights we can define the addresses for indifference, denoted  $t_+$  and  $t_-$ , where  $v_i = v_{i+1}$  and  $v_i = v_{i-1}$  respectively. Denote the distance, in time, between two flights by  $H$ . In a symmetric equilibrium,  $H$  is also symmetric. Substituting this into the conditions for indifference and rearranging we have

$$t_+ = \frac{p_{i+1} - p_i + \theta H}{2\theta} + t_i \text{ and } t_- = -\frac{p_{i-1} - p_i + \theta H}{2\theta} + t_i. \quad (3)$$

Customers are assumed to be distributed uniformly with respect to preferred departure time with density  $D$ . Let  $s(t)$  be the share of passengers with preferred departure time  $t$ . Thus, the aggregate demand for flight  $i$  is

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show that market segmentation, under certain assumptions, does not occur in this type of model. Instead, firms will only choose one location in order to avoid price competition.

$$q_i = D \int_{t_-}^{t_+} s(x) dx. \quad (4)$$

Assuming homogeneity in gross utility,  $\bar{v}$ , we then have

$$q_i = D \int_{t_-}^{t_+} s(x) dx = D \int_{t_-}^{t_+} 1 dx = D \left( \frac{p_{i+1} - p_i + \theta H}{2\theta} + \frac{p_{i-1} - p_i + \theta H}{2\theta} \right). \quad (5)$$

## 2.2. Competition

Assuming that an airline sets the same price for each flight on a given route, an airline  $j$  maximizes the following profit function with respect to price and number of flights:

$$\max_{p_j, n_j} \pi_j = (p_j - c)q_j n_j - n_j \beta - F, \quad (6)$$

where  $n_j$  is number of flights during for example one day,  $c$  is marginal passenger costs,  $\beta$  is marginal flight costs and  $F$  is fixed route costs. We restrict the analysis to a symmetric equilibrium, both in prices and flights; this implies that the equilibrium is characterized by equal spacing between flights. Second, we assume homogeneity in gross utility,  $\bar{v}$ . Given equal prices, any flight faces competition from at most two flights. We assume that both of these flights are competitors flights; the equilibrium is interlaced. The demand for flight  $i$  is then given by (5).

We can distinguish between a one-stage game where prices and frequencies are determined simultaneously, and a two-stage game where the decision on the number of flights is made before the price decision. In the two-stage game each airline acts strategically in the sense that it considers the effect of its frequency decision on the equilibrium price. The type of game that applies depends on whether or not the frequency decision is less flexible than the price decision. A number of factors suggest that the frequency decision is less flexible than the price decisions. For example, increasing the number of departures could require additional aircrafts, which of course makes the decision much more complex. Further, an airline can through yield management have a very flexible price setting, even if the list prices are not changed. The equilibrium solutions are not that different between the one- and two-stage games,

and we therefore only present the two-stage game. The game is solved by backward induction. Beginning with the price decision, first order conditions are

$$q_j n_j + n_j (p_j - c) \frac{\partial q_j}{\partial p_j} = 0. \quad (7)$$

Therefore, the equilibrium price is

$$p_j^c = c + \frac{\theta}{fn_j}, \quad (8)$$

where  $f$  is the number of airlines. The equilibrium price increases with marginal passenger cost and the opportunity cost of time, and decreases with the number of flights and the number of firms. This is a standard result in the address models. Note in particular that in this symmetric model, the effect of the number of flights on the equilibrium price is independent of airline.<sup>3</sup> The first order condition for the number of flights is

$$q_j (p_j^c - c) + n_j (p_j^c - c) \frac{\partial q_j}{\partial n_j} + \frac{\partial p_j^c}{\partial n_j} n_j q_j - \beta = 0. \quad (9)$$

The equilibrium number of flights for an airline and the aggregate number of flights are therefore

$$n_j^c = \sqrt{\frac{\theta D f^{-2} - 2\theta f^{-3} D}{\beta}} \quad \text{and} \quad f n_j^c = \sqrt{\frac{\theta D (f - 2)}{\beta}}. \quad (10)$$

Consequently, an equilibrium only exists if the number of airlines,  $f$ , is larger than or equal to three.<sup>4</sup> The equilibrium number of flights for a given airline decreases with the cost per flight and the number of airlines, and increases with the opportunity cost of time. The aggregate number of flights, on the other hand, increases with the number of airlines. The equilibrium number of airlines, and hence the aggregate frequency, can

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<sup>3</sup> If airlines could price discriminate, they would do so based on the opportunity cost of time, so that passengers with a higher opportunity cost of time would face a higher price.

<sup>4</sup> The one-stage game does not have this restriction on the number of airlines. When there are only two airlines in the two-stage game, both airlines profit functions decrease in their own number of departures; if an airline increases its own number of flights, it has a negative effect on the demand for its existing flights, and with only two airlines, this effect will dominate the positive effects on profits.

also be endogenous to the model. Assuming that airlines will enter as long as profits can be made, the equilibrium number of airlines is given by a zero profit condition.

### 2.3 Monopoly

A monopolist can, for a given flight, charge a price without considering competition. The demand for a given flight is therefore derived by solving  $v_i = 0$  for the addresses of indifference (so the marginal passenger is indifferent between buying and not buying a ticket):

$$t_+ = \frac{\bar{v} - p_i}{\theta} + t_i \text{ and } t_- = -\frac{\bar{v} - p_i}{\theta} + t_i. \quad (11)$$

Given homogeneity in gross valuations, the demand for flight  $i$  is

$$q_i = D \int_{t_-}^{t_+} s(x) dx = 2D \frac{\bar{v} - p_i}{\theta}. \quad (12)$$

The monopolist maximizes profit with respect to prices,  $p_j$ . Using the first order condition, the equilibrium price is

$$p_j^m = c + \frac{\theta}{2n_j}. \quad (13)$$

Again, this is a standard result; the equilibrium price increases with marginal passenger cost and the opportunity cost of time, and decreases with the number of flights. The number of flights is not exogenous. Given that the profit for flight  $i$  is non-negative, the monopolist can increase its profit by supplying an additional flight outside the headway for flight  $i$ . Note that the headway for a symmetric equilibrium with no gaps is  $H = D^{-1} q_i^m$ , where the equilibrium number of passengers is  $q_i^m = D \frac{\bar{v} - c}{\theta}$ .

Consequently the equilibrium number of flights is

$$n_j^m = \frac{1}{H} = \frac{\theta}{\bar{v} - c}. \quad (14)$$

Finally, the equilibrium price can therefore be written

$$p_j^m = \frac{\bar{v} + c}{2}. \quad (15)$$

We are now ready to compare the equilibrium solutions under monopoly and competition.

#### 2.4 Comparison

Following Schipper (2001) we can, using the fact that profits are maximized under monopoly, show that the equilibrium frequency is higher under monopoly than under competition. Here we derive a sufficient condition, slightly different from the condition in Schipper (2001). The reason is that this will also provide information on the price differences. Inserting the equilibrium price,  $p_j^c = c + \frac{\theta}{fn_j^c}$ , and demand,  $q_j^c = \frac{D}{fn_j^c}$ , we can write the aggregate profit function under competition as

$$\Pi^c = fn_j^c p_j^c = \frac{\theta D}{fn_j^c} - fn_j^c \beta - fF. \quad (16)$$

Inserting the equilibrium price,  $p^m = c + \frac{\theta}{2n^m}$ , and demand,  $q_i^m = D \frac{\bar{v} - c}{\theta}$ , and using the fact that  $n^m = \frac{\theta}{\bar{v} - c}$ , we can write the profit function for a monopolist as

$$\Pi^m = \frac{\theta D}{2n^m} - n^m \beta - F. \quad (17)$$

Taking the difference between profits, and rearranging, we have the following condition

$$\Pi^m - \Pi^c > 0 \Rightarrow D\theta \left( \frac{1}{2n^m} - \frac{1}{fn_j^c} \right) + \beta (fn_j^c - n^m) + F(f - 1) > 0. \quad (18)$$

Hence, the sufficient conditions for the difference in profit to be non-negative are that  $fn_j^c > n^m$  and  $fn_j^c > 2n^m$ . This implies that the aggregate frequency is higher under competition than under monopoly; actually, the aggregate frequency is at least twice the

monopoly frequency. Furthermore, since  $fn_j^c > 2n^m$  it follows from (8) and (13) that the equilibrium price is lower under competition than under monopoly.

### 3. Data and model specification

The data consists of price and flight information for a number of city pairs at eight European hub airports in eight countries. The countries included are Finland, France, Germany, Italy, Norway, Spain, Sweden and the United Kingdom. For all countries except Germany, the hub airport is the capital city; in the case of Germany, Frankfurt is the hub airport. The data was collected in 2001 by the Swedish Civil Aviation Administration (see Luftfartsverket 2001). Two types of price categories were collected, Business and Economy, and all prices are expressed in PPP-adjusted Swedish kronor. The table below reports the descriptive statistics for the sample used in the estimations. In total there are 172 city-pair markets, of which 122 are monopoly markets. On the city-pair markets with competition, i.e. with more than one airline, the average number of airlines is 2.6. Consequently, the total number of airline routes is 252.<sup>5</sup> The average number of airlines on a given route, including monopoly routes, is 1.47.

#### [Table 1]

We are interested in the determinants of ticket price and frequency for different routes. We specify airlines  $i$ 's ticket price,  $P_{ij}$ , and frequency,  $Freq_{ij}$ , to be functions of a number of characteristics:

$$Price_{ij} = f(\alpha_h, Dist_j, SeatFlight_{ij}, Pop_j, Monop_j, Freq_j, Herf_j, Time_j) + \varepsilon_{ij} \quad (19)$$

$$Freq_{ij} = g(\alpha_h, Pop_j, Monop_j, Freq_j, Herf_j, Time_j) + \varepsilon_{ij} \quad (20)$$

where  $\alpha_h$  is a dummy variable for hub airport  $h$  and country  $h$ , since only one hub airport from each country is included. Seats per flight are a measure of the airplane size, and it is assumed that the cost per seat kilometer decreases with aircraft size. The

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<sup>5</sup> Luftfartsverket (2001) collected data on 292 airline routes. Some routes were excluded due to governmental subsidies and others because the distance between the city-pairs was much larger than the distance between the other city-pairs. The latter routes mainly concerned traffic between Madrid and a number of Spanish islands. In our analysis connections with less than 7,000 inhabitants in the non-hub city were also excluded. In addition, on three of the competitive routes, one airline had only one departure per week. These airlines were excluded in the analysis.



distance also affects the cost per seat kilometer, and it is assumed that the cost per seat kilometer decreases with distance (Doganis, 1991). Population in the connecting cities is a measure of the demand. We also include travel time difference, between air and rail, as an explanatory variable. This variable is supposed to capture the degree of competition between the air and rail modes.<sup>6</sup> There are also a number of city-pair markets that do not have a railway connection. The Herfindahl index is a concentration index equal to the sum of squared market shares. In this case we define the market share as the airline's share of the aggregate number of seats. Note that in the estimations, the value of the index is set to zero for routes with no competition. Instead the impact of a monopolist compared to a non-monopolist is indicated with a separate dummy variable for routes with only one airline. The Herfindahl index can be decomposed into two parts (Adelman, 1969):

$$Herf_j = \sum_{i=1}^f \left( \frac{Seat_{ij}}{\sum_{k=1}^f Seat_{kj}} \right)^2 = \frac{cv_j^2}{f_j} + \frac{1}{f_j}, \quad (21)$$

where  $cv$  is the coefficient of variation for the market shares. Note that in a symmetric equilibrium, where all firms have the same market share, the value of the Herfindahl index is  $f_j^{-1}$ . Using the Herfindahl index, and not the decomposition, we would implicitly assume that the impacts of the two terms are identical. The first part of the decomposition reflects the impact of market share inequality for a given number of firms. It may well be the case that the impact of this part is different than the effect of the number of firms; see Barla (2000) for an extended discussion on different measures of firm size inequality and market power. We therefore apply the decomposed version of the Herfindahl index in our estimations, in order to test the restrictiveness of using the Herfindahl index as a concentration measure. Again the two parts of the index are set to zero for monopolist routes.

Whether or not there is competition in a particular city-pair market is likely to be affected by factors such as population size and the country dummy variables. We

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<sup>6</sup> The travel time data was collected from various travel databases at the Internet. In all cases the shortest available travel time was chosen.

therefore estimate a so-called treatment effects model (see Maddala, 1983); this is done both for the price and the frequency models. The treatment effect model is specified as follows:

$$\begin{aligned}
 Monop_{ij}^* &= \theta' z_{ij} + v_{ij} & (22) \\
 Monop_{ij} &= 1 \text{ if } Monop_{ij}^* > 0 \text{ and } Monop_{ij} = 0 \text{ if } Monop_{ij}^* \leq 0 \\
 Y_{ij} &= \beta' x_{ij} + \delta Monop_{ij} + \varepsilon_{ij}
 \end{aligned}$$

Since the monopoly variable is a binary variable, the first stage model is estimated with a Probit model. The overall model is estimated with a two-stage procedure, where the inverse Mills ratio from the first stage Probit model is included as an independent variable in the second-stage regression. The coefficient for the inverse Mills ratio is denoted  $\lambda_{ij}$ . The treatment effects model is a restricted version of a selection model with separate price/frequency regressions for the two regimes monopoly and competition (cnf. Lanfranchi et al. 2002). However, using an F-test the pooling of the model, i.e. a treatment effects model, could not be rejected in any of the estimated models. We therefore only report the results of the treatment effects model.

In addition to the price and frequency regressions, we also estimate a model with the aggregate frequency for route  $j$ ,  $Freq_j$ , as dependent variable:

$$Freq_j = h(\alpha_h, Pop_j, Time_j, Monop_j, Herf_j) + \varepsilon_{ij} \quad (23)$$

The reason is mainly that we want to be able to compare the frequency between a monopolist and the aggregate frequency under competition. This model is also estimated as a treatment effects model.

#### 4. Results

The dependent variables, price per km and frequency, are in log form. Furthermore, the variables distance, seats per flight and number of departures are also in log form. In a PE-test (Greene, 2000) a linear model was rejected in favor of the log-linear model.

Table 2 presents the results of the first-stage Probit model, where the dependent variable is set to 1 if the airline is a monopolist on the city-pair market.

**[Table 2]**

From Table 2 we see that it is less likely that an airline is a monopolist on city-pair markets with a large population and on city-pair markets with no competition with the railway. This means that it is more likely to be competition between airlines if there is no competition with the railway. Furthermore, it is more likely that a monopoly airline is a flag-carrier.

Table 3 presents the ticket price results for Business and Economy class passengers and the individual airline frequency choice. The inverse mills ratio from the first-stage probit model is included among the independent variables.

**[Table 3]**

In the two models with the ticket list price for Economy class passengers as dependent variable, only the two cost variables - distance between cities and number of seats per flight – and the time difference variable are significant. Consequently, there does not seem to be a significant influence of market conditions on the ticket price for this type of passenger. One interpretation is that this type of passenger has a low opportunity cost of time. This implies that the effect of, for example, number of flights will not affect the equilibrium price to a large extent. Furthermore, this segment is likely to be more sensitive to prices and, presumably, the competition with other modes of transport is stronger.

Regarding ticket list price for Business class passengers, the results are somewhat different. The two variables relating to costs are significant and are of the expected signs. In addition, the number of own flights have a significant effect on the ticket price, although competitors flights does not have a significant impact on the ticket price. The standard symmetric address model predicts no difference between airlines in the effect on ticket price. The Herfindahl index has a significant effect on the ticket price. As expected, the coefficient is positive, indicating that an increase in the concentration increases the ticket price. If we decompose the Herfindahl index, allowing the coefficients for these two variables to be different, both coefficients are still significant and positive. Consequently, for a given number of airlines, an increase in market share inequality results in an increased price. Further an increase in the number of airlines, for

a given market share inequality, decreases the price. However, the coefficients are significantly different, indicating that using the Herfindahl index is restrictive. This result is in line with the results in Barla (2000), examining the US airline market, where it was also found that using the Herfindahl index was restrictive.

As a way to compare price per km between a monopoly airline and an airline at a competitive market we calculate the predicted difference in price per km. This is done in a simple fashion where mean values for the Herfindahl index and departure frequencies are calculated for the two sub samples monopoly airlines and airlines under competition, and all other variables are calculated at sample means. We find that there is no significant difference between a monopoly airline and an airline facing competition, and the predicted differences are very small. Consequently, we cannot reject the hypothesis of equality of prices.

Turning to the results for the number of airline departures, for a given route, the coefficient for the Herfindahl index is significant. An increase in the concentration index reduces the number of flights. For the decomposed parts of the Herfindahl index, only the coefficient for the market share inequality is significant. Consequently, an increase in market share inequality reduces the number of flights, but an increase in the number of airlines does not have a significant effect on the number of flights. Again, the coefficients are significantly different from each other. Consequently, as is also the case of ticket price, the use of the Herfindahl index is restrictive. An increase in the number of competitor departures reduces an airline's own number of departures, although the coefficient is insignificant. As expected, the larger the population, the larger the number of flights.

Two similar models with the aggregate frequency on the routes are also estimated, mainly because we want to compare the frequency between a monopolist and the aggregate frequency under competition. The results are reported in Table 4.

**[Table 4]**

The first stage Probit model reveals that city-pairs with large populations are less likely to have monopoly routes. Furthermore, the routes are less likely to be monopoly routes

if there is no possibility of traveling by rail between the two cities. In the second-stage model, all the variables describing the market conditions are still significant, and the coefficients have the expected sign. Again, using the Herfindahl index seems to be restrictive. The aggregate frequency is, as expected, decreases with market share inequality. The difference in predicted aggregate frequency is calculated in a similar fashion as before, i.e. the mean values for the Herfindahl index, or the decomposed parts, are calculated for the sub sample airlines under competition, and mean values for the population variables and fixed effects are calculated at sample means. We find that there is a significant difference in aggregate frequency; the aggregate frequency is higher under competition compared to monopoly. The predicted differences are however very large compared with the average number of flights.

## **5. Conclusions**

Using data on a number of city-pair markets in eight European countries, we have investigated the effect of market conditions on airlines choices of frequency and prices. Applying an address model we show that equilibrium prices depend on passengers value of time, marginal flight costs and the aggregate number of flights. In addition, we show that under monopoly, prices are higher and the aggregate frequency is lower than under competition. The estimations show that for Economy class ticket price, the market conditions do not seem to have any effect on the equilibrium price. One interpretation of this is that the value of time is so low that the marginal impact of, for example, number of flights is negligible. Further, this segment of passengers is presumably more price sensitive. Regarding Business class ticket prices, market conditions do have an impact on ticket price. The effects are in the expected direction - increased market concentration and decreased number of airlines result in increased ticket prices. Furthermore, we find that applying the Herfindahl index is restrictive and that the index instead should be decomposed. Comparing the equilibrium price between a monopoly and a competitive route (calculated at sample mean), we can reject the hypothesis of differences in the equilibrium ticket price per km. Regarding frequency choice, market structure again has a significant impact on the equilibrium prices, and the effects are as expected: decreased market concentration and an increased number of airlines result in increased aggregate frequencies. Here we can reject the hypothesis that the frequency for a monopolist is the same as the aggregate frequency under competition.

Consequently, our results show that market structure has an impact on airlines behavior, and that increased competition increases aggregate frequency but has no effect on the equilibrium price.

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Table 1. Descriptive statistics variables included in the estimations.

Name	Variable	Mean	Stdv
$PriceB_{ij}$	Business class price, kronor per kilometer, airline $i$ route $j$	9.50	4.10
$PriceP_{ij}$	Economy class price in kronor per kilometer, airline $i$ route $j$	4.31	2.41
$Freq_{ij}$	Departures, airline $i$ route $j$	41.19	36.33
$Freq_{cj}$	Departures, competitor(s) to airline $i$ on route $j$	90.84	84.53
$Freq_j$	Departures, route $j$	59.73	65.52
$Seat_{ij}$	Seats, airline $i$ route $j$	4918.10	5585.98
$Seat_j$	Seats, route $j$	7205.58	9391.80
$SeatFlight_{ij}$	Seats per flight airline $i$ route $j$	102.73	47.89
$Monop_j$	Dummy variable = 1 if a monopoly airline on route $j$	0.71	0.46
$f_j$	Number of airlines on route $j$	1.47	0.91
	Number of airlines on route $j$ (only for non-monopolist routes)	2.60	1.01
$Herf_j$	Herfindahl index (in seat capacity) for route $j$ (only for non-monopolist routes)	0.57	0.16
$Dist_j$	Distance between airports route $j$	407.51	153.37
$Time_j$	Difference between travel time by air and by rail, route $j$ (minutes)	207.49	189.75
$NoRail_j$	Dummy variable = 1 if no rail traffic on route $j$	0.12	0.32
$Pop_j$	Product of the populations of the two cities (10,000)	83.91	114.06
$FlagC_{ij}$	Dummy variable = 1 if airline $i$ on route $j$ is a flag carrier	0.56	0.50

Table 2. Estimated probit model, dependent variable:  $Monop_{ij}$ , P-values in parentheses. Country dummy variables not reported.

	Coeff
$\ln(Dist_j)$	-0.011 (0.89)
$Pop_j$	-0.004 (0.00)
$FlagC_{ij}$	0.771 (0.00)
$Time_j$	-0.001 (0.19)
$NoRail_j$	-0.935 (0.02)
Log-likelihood	106
Restricted log-likelihood	175



Table 3. Estimated models, price per km, business and economy class. Dependent variable:  $\ln(\text{Price}_{ij})$ . P-values in parentheses. Country dummy variables not reported.

	Ticket price per km				Frequency	
	Economy class		Business class			
	<i>Coeff</i>	<i>Coeff</i>	<i>Coeff</i>	<i>Coeff</i>	<i>Coeff</i>	<i>Coeff</i>
$\ln(\text{Dist}_j)$	-0.811 (0.00)	-0.813 (0.00)	-0.817 (0.00)	-0.816 (0.00)		
$\ln(\text{SeatFlight}_{ij})$	-0.173 (0.00)	-0.172 (0.00)	-0.138 (0.00)	-0.139 (0.00)		
$\text{Herf}_j$	0.058 (0.79)		0.413 (0.01)		-3.003 (0.00)	
$f_j^{-1} cv_j^2$		0.099 (0.67)		0.364 (0.03)		-3.574 (0.00)
$f_j^{-1}$		-0.069 (0.83)		0.570 (0.02)		-0.582 (0.53)
$\text{Monop}_j$	0.025 (0.93)	-0.054 (0.87)	0.244 (0.24)	0.341 (0.15)	-0.966 (0.24)	0.508 (0.58)
$\ln(\text{Freq}_{ij})$	0.023 (0.37)	0.026 (0.33)	0.075 (0.00)	0.072 (0.00)		
$\ln(\text{Freq}_{ej})$	-0.017 (0.62)	-0.022 (0.54)	-0.014 (0.58)	-0.007 (0.78)	-0.128 (0.19)	-0.023 (0.82)
$\text{Pop}_j$	-0.00002 (0.93)	-0.00007 (0.81)	0.0001 (0.57)	0.0002 (0.42)	0.003 (0.00)	0.004 (0.00)
$\text{Time}_j$	0.0003 (0.06)	0.0003 (0.06)	0.0004 (0.00)	0.0004 (0.00)	-0.0003 (0.28)	-0.0003 (0.37)
$\text{NoRail}_j$	0.023 (0.77)	0.015 (0.85)	0.129 (0.02)	0.138 (0.02)	-0.009 (0.97)	0.126 (0.55)
$\lambda_{ij}$	-0.040 (0.65)	-0.034 (0.70)	-0.010 (0.88)	-0.017 (0.79)	-0.954 (0.00)	-1.014 (0.00)
Adjusted R <sup>2</sup>	0.69	0.69	0.78	0.78	0.26	0.29
Number of cases						252
Pred. Price(Monop) - P(Comp)	0.136 (0.82)	0.082 (0.89)	-0.099 (0.92)	-0.25 (0.81)		

Table 4. Estimated models, aggregate number of departures. Dependent variable:  $Monop_j$  in the first-stage Probit model and  $\ln(Freq_j)$  in the second-stage. P-values in parentheses. Country dummy variables not reported.

	First-stage	Second-stage	
	<i>Coeff</i>	<i>Coeff</i>	<i>Coeff</i>
$\ln(Dist_j)$	-0.390 (0.42)		
$FlagC_j$	-0.200 (0.52)		
$Pop_j$	-0.004 (0.02)	0.001 (0.32)	0.001 (0.33)
$Time_j$	0.0005 (0.64)	-0.001 (0.01)	-0.001 (0.02)
$NoRail_j$	-0.916 (0.07)	-0.711 (0.03)	-0.703 (0.04)
$Herf_j$		-2.785 (0.00)	
$f_j^{-1}cv_j^2$			-2.449 (0.00)
$f_j^{-1}$			-3.552 (0.00)
$Monop_j$		-4.224 (0.00)	-4.391 (0.00)
$\lambda_{ij}$		0.768 (0.12)	0.697 (0.17)
Adjusted R <sup>2</sup>		0.51	0.15
Number of cases	172	172	172
Pred. Freq(Monop) - Freq(Comp)		-205 (0.09)	-189 (0.10)