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Competitive impact of the air ticket levy on the European airline market

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ABSTRACT

In tribute to Jules Dupuit, this study analyzes how the innovative financing tax for development has influenced the competition among airline companies and to what extent it affected their sales. To do so, we specify an econometric model where the representative consumer chooses the utility maximizing alternative among the differentiated products offered by the airlines which compete in terms of prices. It is a fairly reasonable and well accepted representation of the competition in the airline industry, assuming that the structure of their networks is given in the short run. The present solidarity tax has increased the average price for the European airlines by only 0.08% and could increase average prices by 1% if it were applied to all European airlines. Implemented by all countries it would lead to a 0.17% increase in Air France prices while the price increase would be 1.05% for the other airlines in our sample. These numbers compared to the growth rate of the air traffic show that the impact of the solidarity tax would be very small. Overall the air ticket levy applied by all European airlines would not affect significantly the degree of competition among airlines.

1. Introduction

Air transport is one of industries that benefits most from globalization. In 2013, the air traffic shows a 5.2% increase in passenger demand, in line with the annual growth rate of the past 30 years. The International Air Transport Association (IATA) has recently forecasted a 4.1% average annual growth in demand for air connectivity until 2034 that will result in more than a doubling of the 3.3 billion passengers expected to travel in 2014.

An actual case of global governance concerning this industry is the air-ticket solidarity levy initiated by France in July 2006. The idea is to impose a tax on those who benefit from globalization and redistribute revenue to those who benefit the least from globalization by charging a 10–40 euros and 1–4 euros tax on business and economy class passenger fares, respectively. The revenue serves for improving access of the poor to treatment of diseases such as HIV, malaria and tuberculosis through its governing mechanism, UNITAID.

Consider the following events

On June 24, 2015, Korean Air Lines Co. and Asiana Airlines Inc. cancelled 230 flights to and from Japan due to the ongoing spread of the Middle East Respiratory Syndrome (MERS) coronavirus through South...
Korea. Korean Air suspended a total of 122 flights connecting Japanese airports of Okayama, Akita, Komatsu, Aomori, and Kagoshima with Incheon Airport in Seoul from June 24. The length of the suspensions varied depending on the route. The Okayama-Incheon route remained closed until August 10, making it the longest suspension.

Asiana Airlines canceled 108 flights to Narita, Haneda, Chubu, Hiroshima, Toyama, and Matsuyma airports between June 30 and July 30. Excluding With Narita, Haneda and Chubu, none of the remaining eight Japanese airports had flights operated by other airlines that fly to South Korea.

The MERS outbreak had also a significant toll on South Korea's tourism industry such that tourist arrivals in the June 2015 have fallen by 25% compared to June 2014. (See WTTC, 2015.)

Ebola has cost billions dollars to Ginea, Liberia and Sierra Leone. In World Bank (2014), they estimate the medium-term impact of Ebola on output for West Africa as a whole. Under Low Ebola, the loss in Gross Domestic Product (GDP) is estimated to be 2.2 billion dollars in 2014 and 1.6 billion dollars in 2015. Under High Ebola, the estimates are even higher as 7.4 billion dollars in 2014 and 25.2 billion dollars in 2015.

These facts – and many others can be reported—are evidence that the air transport is one of the first industries impacted by the development of epidemics, which then affects the activities of other industries like tourism and trade.

It is therefore in the interest of the airline industry to experience lower risk of epidemic. In this perspective, investing in the improvement of health infrastructure and programs in developing countries is crucial.

To finance these investments, one possible economic tool is to raise a tax. The economic rationale is classical: As nobody is ready to pay for the negative externality that epidemics impose on the world social welfare, public economics advocates the use of taxes to solve this market failure.

This could be a rationale behind the air ticket levy. However, it is legitimate to doubt that such a tax is innocuous on the working of the airline industry and in particular on its competitive conditions.

It is precisely the objective of this study to analyze how the innovative financing tax for development has influenced the competition among airline companies and to what extent it affected their sales.

To study the effect of the solidarity tax, we specify an econometric model where the representative consumer chooses the utility maximizing alternative among the differentiated products offered by the airlines which compete in terms of prices. It is a fairly reasonable and well accepted representation of the competition in the airline industry, assuming that the structure of their networks is given in the short run.

This report is structured as follows. Section 2 describes the data and provides descriptive analysis. In Section 3 we discuss the simulation results. Section 4 we provide an evaluation of these results. Section 5 explains the passengers’ and airlines’ behavior and introduces the models with estimation results.

2. Data

Four main sources are used for the construction of the database for this study: The International Civil Aviation Organization (ICAO) Data plus, the French Civil Aviation Authority (DGAC) annual statistics bulletins, the National School of Civil Aviation (ENAC) Air Transport Data and the Association of European Airlines (AEA) data. The ICAO Data plus provides information on air carrier traffic, traffic, flight size and number of personnel, and international traffic by stage. The passenger traffic from France by air carrier is collected from DGAC annual statistics bulletins. In addition to ICAO Data plus, we use the ENAC Air Transport Data to complete the data on air carrier finance and traffic, and carrier characteristics such as number of destinations and flight size. The share of business and economy classes in each network is provided by the AEA data. The demographic data are collected from Eurostat and the World Bank.

While the data are aggregated at the firm level, we are able to obtain an average per passenger solidarity tax by combining the origin-destination data of DGAC, ICAO and AEA as explained below. The sample includes annual observations of 17 European airlines for the period 2000–2013 (See Table 1A in the Appendix.).

Table 1 reports the summary statistics of the main variables of the econometric model. The average number of passengers is 22.8 million in the sample data. The air ticket fares are calculated as a ratio of the total passenger revenues to the number of passengers for each airline and the overall average ticket fare is $238.8. Note that it is a proxy since the ticket price data are not available in Europe. The average solidarity tax per passenger is $0.21. We include a network measure in the empirical model which is the total number of kilometers flown by an airline per year. We measure the market size as the total population of Europe and Central Asia since most of the air traffic of airlines in our sample is within this region. The model comprises demographic variables: Income and population of the country where airlines’ headquarters is located. We measure income as the real GDP per capita (measured in 2011 $) of the country.

Computation of the average solidarity tax

The basic rules governing the solidarity tax is that it is collected at the origin, it is not collected when the passenger is in transfer, and it differs depending on the destination and the type of fare class. In July 2006, France began collecting an “international solidarity contribution” of €1 on all European economy class flights (€10 in business class) and €4 on international economy flights (€40 in business class) departing from its territory. The tax rates have been increased with effect from 2015. Now the levels of the solidarity tax in France are provided in Table 2.

Almost all Air France flights are originated from French airports, and therefore any ticket provided by Air France includes the tax. For Lufthansa, for instance, only the flights originated form French airports are affected by the solidarity tax. This structure necessitates origin destination data in order to study the impact of solidarity tax. From AEA data, we obtain the number of passengers for business and economy classes within Europe and in the international markets for the airlines which are members of AEA. Note that the solidarity tax is charged per ticket depending on the destination and the fare class, and the AEA data provides the number of passengers for each class and network but not the ticket prices. The main drawback of European data is that ticket price data are not available. For that reason, we use data aggregated at firm level and compute a firm level average solidarity tax by taking the weighted average of tax, as follows:

\[ \text{Average Tax per Ticket} = \sum_{i} \left( \frac{\text{Ticket Price}_i \times \text{Passengers}_i}{\text{Passengers}_i} \right) \]

Note the prices can fall on a very large range of values (See Table 1). This is probably due the strategy of yield management implemented by the airlines. We account for part of this heterogeneity through airline specific effects, time effects and effects of observable characteristic. The other effects are related at unobservable characteristics or at random effects that are included in our model, but probably not in the right structural way. Indeed we abstract from the dynamic aspects raised by the yield revenue management systems. How this affects measure of market power and degree of competition is an open question. We believe that in terms of the comparison among airlines, the average price is a correct and meaningful measure of the competitive positioning of each airline in the market.
### Table 2
The levels of the solidarity tax.

| Final Destination                                      | Class         | Level  |
|--------------------------------------------------------|---------------|--------|
| France, EU, Switzerland, French territories.           | First or business | €11.27 |
| Others                                                 | Others        | €1.13  |
| Others                                                 | First or business | €45.07 |
| Others                                                 | Others        | €4.51  |

### Table 3
Impact of the solidarity tax on average (all carriers).

| Variable                  | Current | Tax implemented on all countries | Without Solidarity tax |
|---------------------------|---------|---------------------------------|------------------------|
| Price ($ per passenger)   | 238.80  | 241.16                          | 238.61                 |
| % change                  | +0.99   | +0.99                           | +0.99                  |
| Marginal Cost ($ per passenger) | 144.28 | 146.66                          | 144.09                 |
| % change                  | +1.65   | +1.65                           | +1.65                  |
| Own price elasticity      | −3.54   | −3.58                           | −3.54                  |
| % change                  | +0.95   | +0.95                           | +0.95                  |
| Traffic (million passengers) | 22.84  | 22.55                           | 22.88                  |
| % change                  | −1.27   | −1.27                           | +0.18                  |
| Market Share (%)          | 2.60    | 2.57                            | 2.61                   |
| % change                  | −1.28   | +0.21                           | +0.21                  |
| Profit (billion €)        | 2.09    | 2.07                            | 2.09                   |
| % change                  | −0.99   | +0.14                           | +0.14                  |
| Consumer Surplus (billion €) | 266.99 | 261.89                          | 267.91                 |
| % change                  | −1.91   | +0.35                           | +0.35                  |

**Weighted Tax**

\[
\text{Weighted Tax} = \frac{\mathcal{E}^{40^*B_i + 4^*E_i + 10^*B_c + 1^*E_c}}{\text{TotalPassenger}}
\] (1)

where \(B\) is the number of business is class passengers and \(E\) is the number of Economy class passengers, the index \(i\) refers to international flights and the index \(e\) to European flights, and \(r\) is the euro-dollar exchange rate of the respective year. The weighted solidarity tax is equal to €4.97 per passenger for Air France and, on average, to €0.12 per passenger for other airlines. That is to say, the solidarity tax adds on average approximately €4.50 to each Air France ticket.

### 3. Simulation results

Using our model of oligopolistic competition with differentiated products among airlines presented in details in a technical appendix below, we compute the equilibrium prices for each airline and the implied passenger demand under different situations. After obtaining these equilibrium values, we can compute marginal costs, own price elasticities, market shares, profits and consumer surpluses for each airline. Table 3 presents these values for the current situation and under two scenarios: i) The equilibrium where all European airlines are charged by the tax; ii) the equilibrium where the solidarity tax is absent. In the first case all countries implement the solidarity tax; hence all airlines are charged for their whole network. In the second case, there is no solidarity tax at all.

The solidarity tax has increased the average price for the European airlines by 0.08% and could increase average prices by almost 1% if it is applied to all European airlines. We find that the marginal cost of airlines has increased by 0.13% in average due to the current solidarity tax. If all European countries implement the tax then it could result in a 1.65% rise in marginal cost. If France removes the solidarity tax, the passenger traffic would increase by 0.18% which would lead to a 0.21% increase in the market share of the airlines. In other words, airlines would attract passengers who are using other modes of transportation or not travelling. In the absence of the solidarity tax, there would be a 0.14% increase in airlines’ profits and a 0.35% increase in consumer surplus. Hence, the ticket price elasticity would increase by 0.95%; therefore, the passengers becomes more price sensitive if all countries implement the solidarity tax, which is coherent with economic theory.

The impact on Air France and all other carriers in our dataset is presented in Table 4. A solidarity tax implemented by all countries would lead to a 0.17% increase in Air France prices while the price increase would be 1.05% for the other airlines in our sample. If France removes the solidarity tax, the passenger traffic would increase by 1.7% while for other airlines, this would lead to a decrease of 0.03%. The removal of tax would lead to a fall in the average price both for Air France (0.39%) and for other carriers (0.05%). The market shares for Air France would increase while for other airlines the market share would almost not change in average. Hence, one can conclude that there would be more people using air transportation. Finally, these numbers compared to the growth rate of the air traffic show that the impact of the solidarity tax would be very small.

### Table 4
Comparison of air France and the average European carrier.

| Variable                  | Air France | Current | Tax implemented on all countries | Without solidity tax | All other carriers (on average) | Current | Tax implemented on all countries | Without solidity tax |
|---------------------------|------------|---------|---------------------------------|---------------------|--------------------------------|---------|---------------------------------|---------------------|
| Price ($ per passenger)   | 289.84     | 290.32  | 288.70                          | −0.39               | 235.61                         | 238.09  | 235.48                          | −0.05               |
| % change                  | +0.17      | +0.17   | +0.17                           | +0.17               | +0.17                          | +0.17   | +0.17                           | +0.17               |
| Marginal Cost ($ per passenger) | 225.88  | 226.35  | 224.68                          | −5.32               | 139.18                         | 141.68  | 139.06                          | −0.09               |
| % change                  | +0.21      | +0.21   | +0.21                           | +0.21               | +0.21                          | +0.21   | +0.21                           | +0.21               |
| Own price elasticity      | −4.53      | −4.54   | −4.51                           | −3.48               | 23.43                          | 23.39   | 23.43                           | +0.00               |
| % change                  | +0.15      | +0.15   | +0.15                           | +0.15               | +0.15                          | +0.15   | +0.15                           | +0.15               |
| Traffic (million passengers) | 47.00   | 47.10   | 47.80                           | +1.70               | 21.33                          | 21.02   | 21.33                           | −0.03               |
| % change                  | +0.21      | +0.21   | +0.21                           | +0.21               | +0.21                          | +0.21   | +0.21                           | +0.21               |
| Market Share (%)          | 5.35       | 5.36    | 5.44                            | 2.43                | 2.43                           | 2.43    | 2.43                            | 2.43                |
| % change                  | +0.22      | +0.22   | +0.22                           | +1.73               | +1.73                          | +1.73   | +1.73                           | +1.73               |
| Profit (billion €)        | 3.00       | 3.01    | 3.06                            | 2.03                | 2.03                           | 2.03    | 2.03                            | 2.03                |
| % change                  | +0.33      | +0.33   | +0.33                           | +0.20               | +0.20                          | +0.20   | +0.20                           | +0.20               |
| Consumer Surplus (billion €) | 481.00  | 474.00  | 489.00                          | −1.11               | 253.61                         | 248.64  | 254.09                          | +0.19               |
| % change                  | −1.46      | −1.46   | −1.46                           | −1.46               | −1.46                          | −1.46   | −1.46                           | −1.46               |

### 4. Evaluation

These results are obtained under the assumption that the airlines consider the solidarity tax as a cost that they have to bear. It means that the solidarity tax is not fully added to the ticket price but it is added to the
marginal cost of the airline. In these conditions, the solidarity tax should impact more the airlines than the customers. As a matter of fact, since the cost increases, even if the demand for air ticket is elastic, the airlines are able to pass a part of the cost increase to their clients. This is why eventually the fares increase.

We estimate cost pass-through under the actual situation where only France implements and the case where all countries implement the solidarity tax. According to Table 6, empirical results indicate that the pass-through rates for the European carriers fall between 94% and 103%. We find that the cost pass-through rate is 94.8% for Air France and 100.35% for all other carriers when the solidarity tax is charged only in France. Hence, Air France could not fully pass through the cost rising from the solidarity tax. According to Table 6, empirical results indicate that the pass-through rate is 94.8% for Air France and 100.35% for all other carriers when the solidarity tax is charged only in France. Hence, Air France could not fully pass through the cost rising from the solidarity tax in the actual situation while the pass through rates for other carriers is around 100%. As a part of other carriers’ network affected from the solidarity tax, they are able to pass the effect of cost changes on prices. However, Air France has to take up a part of cost in order to compete with other carriers. In the second case, the solidarity tax is implemented by all countries hence all airlines are charged for their whole network. Then, the pass-through rate increases for Air France and decreases for other carriers.

However, even for Air France the pass-through rate is very high. It results that the competitive position of Air France vis-à-vis its main competitors is quasi unchanged. As it can be read on Table 7, the margin of Air France only decreased by 0.11%

Going a step further, we have not rejected the hypothesis that the changes in margins due to the implementation of the solidarity tax by all airlines are equal to zero (using a procedure detailed in the technical appendix). Precisely the associated test statistics is $F = 406.841$ for the hypothesis and the critical value from the F distribution is 708.8105 at 5%. In other words, we statistically do not reject the assumption that the solidarity tax has no effect on the degree of competition. Implementing the air ticket levy on all European airlines would not affect significantly the degree of competition among airlines.

It is not surprising then that the expected gains from the solidarity tax are significant but relatively small. The total revenue from this levy when it is implemented by all countries would approach $1.6 billion per year which is 1.73% of the total income of the European Industry, as shown in Table 8.

5. Concluding remarks

The numbers show that the impact of the solidarity tax would be very small. Overall the air ticket levy applied by all European airlines would not affect significantly the degree of competition among airlines.

What it is missing here is a full cost-benefit analysis of the solidarity tax. Since the latter should not affect the airline industry, the question would be to evaluate the amount of welfare it could create. We are back to the Dupuit’s concern for maximizing the surplus of consumers.

6. Technical appendix

**Theoretical model**

The main purpose of this study is to measure the impact of solidarity tax on the airlines and passengers. To do so, we consider a model where airlines offer a set of differentiated products on which they compete in terms of price given the structure of the network assuming product characteristics and network structure are fixed in the short run. The demand model is a simple logit model following Berry (1994).

A passenger $i$, $i = 1, \ldots, I$, has to choose an airline $j$ among the set of available airlines $j = 1, \ldots, J$ to travel with and $j = 0$ corresponds to the outside good. To represent the behavior of passengers, we adopt a logit model. The indirect utility level achieved by passenger $i$ from choosing airline $j$ is:
\[ U_{ij} = V_j + \varepsilon_{ij} \]  

where \( V_j \) is the mean utility level of using airline \( j \) and \( \varepsilon_{ij} \) is a consumer specific unobservable effect which follows the extreme value distribution. The mean utility, \( V_j \), is specified as:

\[ V_j = X_j \beta - ap_j + \xi_j \]  

where \( X_j \) is the observed product characteristics, \( p_j \) is the ticket price of airline \( j \), and \( \xi_j \) is an error term capturing product unobservable characteristics such as departure time, frequency and destination. Let \( s_j \) be the market share of airline \( j \) and the mean utility of the outside option be normalized to 0, i.e., \( V_0 = 0 \). Then, the share of the passengers using airline \( j \), \( s_j \), is given by:

\[ s_j = \frac{\exp(V_j)}{1 + \sum_{i=1}^{J} \exp(V_i)} \]  

which leads to the following demand equation:

\[ \ln s_j - \ln s_0 = X_j \beta - ap_j + \xi_j \]  

expressed in terms of market shares measured as:

\[ s_j = \frac{q_j}{M} s_0 = \frac{1 - \sum_{i=1}^{J} s_i}{M} \]  

where \( q_j \) is the total number of passengers travelling by airline \( j \) and \( M \) is the total market size.

We consider a competition model with differentiated products in which each airline \( j \) sets its price, \( p_j \), maximizing its profit \( \pi_j \). The profit maximization problem of airline \( j \) is written as:

\[ \max_{p_j} \pi_j = (p_j - \tau_j - c_j)q_j - F_j \]  

subject to \( x_j \geq 0 \).

\[ \text{where } \tau_j \text{ is the average solidarity tax per passenger paid by the airline } j, c_j \text{ is the marginal cost per passenger of airline } j \text{ and } F_j \text{ is the airline } j \text{'s fixed cost. Since we do not observe this marginal cost, we posit that} \]

\[ c_j = Z \lambda + u_j \]  

where \( Z \) is a vector of cost shifters and \( u_j \) is an error term. Then, the optimal level of price derived from Equation (6) is given by the pricing equation:

\[ p_j = \tau_j + c_j + \frac{1}{a(1 - s_j)} \]  

Note that the solidarity tax is considered to be a cost paid by airline \( j \) and the price is equal to the sum of the average solidarity tax paid by airline \( j \), marginal cost of airline \( j \) and a mark-up term. The market equilibrium is obtained by solving the systems of Equations (5) and (9).

**Model specification**

The empirical implementation of the model requires simultaneous estimation of passenger demand equation (5) and pricing equation (9). The demand is affected by the following attributes: Ticket fare, total kilometre flown, squared of total kilometre flown, population of the country where carrier's headquarter is located, dummy for alliance membership taking value 1 if an airline is a member of any alliance, 2008–2009 crisis dummy indicating the economic crisis in the period 2008–2009, and airline dummies. The list of airlines in our sample is presented in Table 1A.

In Equation (5) the marginal utility of income, \( \alpha \), is assumed to vary across countries of the airline. As in Foncel and Ivaldi (2005), it is a function of the income (GDP per capita) of the country where the headquarter of airline is located:

\[ \alpha = \alpha_0 + \alpha_1 \text{INCOME}_j \]  

where \( \alpha_0 \) and \( \alpha_1 \) are parameters to be estimated. With this specification we attempt to capture a wealth effect. Assuming that income is a proxy for wealth, we expect \( \alpha_1 \) to be negative and \( \alpha_0 \) to be positive. However, the overall effect \( \alpha \) should be positive, that is, demand decreases with price.

The marginal cost defined by Equation (8), which enters the optimal price equation of each airline, \( V_j \), contains total kilometre flown, squared total kilometre flown, number of passengers, and airline dummies.

We estimate the system of Equations (5) and (9) simultaneously by means of the Generalized Method of Moments. (See Hansen, 1982.) In Equation (5), the market share of airline \( j \) which is measured as the number of passengers travelling with airline \( j, q_j \), divided by the market size. We choose to fix the total market size, \( M \), as the total population of Europe and Central Asia, a rough measure of potential passengers while still allowing the total number of air passengers, i.e., \( \sum_{j=1}^{J} q_j \), to change. With this setting, as the number of passengers changes, the market share of the outside good, \( s_0 \), also changes. Following Nevo (2000a), we check the sensitivity of the demand model estimation to the market size measurement which is exogenous to the model. We observe that the parameter estimates of the demand model do not change for different market size measures.²

In the model passenger demand \( q_j \), price \( p_j \) and weighted solidarity tax \( \tau_j \) are endogenous. The classical solution is to estimate the econometric model by instruments which are orthogonal to the unobservable variables of demand and pricing equations. In addition to exogenous variables in each equation, we build four variables as instruments following Berry et al. (1995): 1) the average number of passengers; 2) the average number of flights of rival carriers; 3) the product of first two instruments; 4) first instrument multiplied by full service carrier dummy. We believe that these four variables reflect the cost structure and size of airlines.

Following Gaudry (1980), Wills (1982), Oum (1989) and Mandel et al. (1997), we perform a model specification test by using the Box-Cox transformation in order to determine whether the utility function of the logit model is linear in price variable. The functional form of the mean utility, \( V_j \), is transformed as:

\[ V_j = \frac{X \beta - \frac{a p_j}{\lambda} - 1 + \xi_j}{\lambda} \]

where \( \lambda \) is the transformation parameter. If \( \lambda \) equals to 1 then the variable is entered in its linear form to the equation. The test results are presented in Table 2A.

The Box-Cox function enables us to identify the most appropriate functional form for the demand equation. This model rejects the multiplicative inverse and log specifications strongly at the 1% significance level. However, we cannot reject the hypothesis that the model is linear, that is, the Box-Cox parameter estimate of \( \lambda \) is not significantly different from 1. These results favour simple logit demand specification where the utility is linear in price.

### Estimation results

The parameters estimated from the passenger demand and airline pricing equations are presented in Table 3A. In the upper panel, we

² Nevo (2000b) controls whether demand estimation is influenced by market definition. We explore the sensitivity of results to the market size measures by regressing the model with different market definitions and results are found to be robust. Results of this test are available upon request.
report the parameters of demand and cost equations, and in the lower panel we report Hansen J-test of over-identifying restrictions.

All parameters have the expected sign. To begin with, the price coefficient, \( \alpha \), is positive hence the effect of price on passenger demand is always negative. In other words, any increase in ticket fare leads to a decrease in passenger demand. Moreover, \( \alpha \) is assumed to vary across airline main location (See Equation (10)). By specifying the price coefficient as in Equation (10), we introduce origin country dependent effects of price on passenger demand. As expected, \( \alpha \) is estimated to be negative and significant. Thus, passengers flying by an airline located in a richer country are expected to be less sensitive to ticket fare. Regarding the network related variable (total kilometre flown), a carrier with larger network size is likely to have higher demand. Overall, the airline dummies are consistent with what is expected.

We estimate the demand and pricing equations of airlines, and then we use estimated parameters to back out estimates of their marginal costs. We then change the solidarity tax levels and solve the model to obtain new equilibrium prices. The results are presented in the simulation results section.

**Test**

Let \( D_i = \text{Margin}_{i uçak} - \text{Margin}_{i current} \) for airline \( i \) where \( i = 1, 2, \ldots, k \). Consider the hypotheses:

\[
H_0 : D_1 = D_2 = \ldots = D_k = 0
\]

\[
H_1 : \text{Atleastoneisnotequal}
\]

To test the null hypothesis, the F-statistics is given by:

\[
F = \frac{\text{Var}_{\text{within}}}{\text{Var}_{\text{between}}}
\]

\[
\text{Var}_{\text{within}} = \frac{\sum_{i=1}^{k} \sum_{j=1}^{n_i} (D_{ij} - \bar{D}_i)^2}{n - k}
\]

\[
\text{Var}_{\text{between}} = \frac{\sum_{i=1}^{k} n_i (\bar{D}_i - \bar{D})^2}{k - 1}
\]

where \( n_i \) is the number of observations for airline \( i \) and \( n = \sum_{i=1}^{k} n_i \). \( \bar{D}_i \) is the sample mean for airline \( i \) and \( \bar{D} \) is the sample mean.

In the hypothesis that there is no effect of the tax on the degree of competition, it means that the sample mean of difference between two margins is zero. In other words, we must plug in zero instead of \( \bar{D} \) in the numerator of the above statistic. Table 1A

### Airlines

| Air Carrier         | No. Observations | Traffic (million passengers) | Ticket Price ($) |
|---------------------|------------------|-----------------------------|-----------------|
| Air France          | 14               | 47.00                       | 289.84          |
| Finnair             | 14               | 6.27                        | 299.80          |
| Alitalia            | 14               | 23.17                       | 163.77          |
| British Airways     | 14               | 33.60                       | 386.20          |
| Flybe               | 14               | 5.15                        | 116.56          |
| Icelandair         | 14               | 1.54                        | 226.14          |
| Ryanair             | 14               | 45.02                       | 55.75           |
| Iberia              | 14               | 22.43                       | 203.65          |
| KLM                 | 14               | 23.74                       | 317.12          |
| Lufthansa           | 14               | 55.00                       | 264.30          |
| Swiss               | 14               | 12.65                       | 259.73          |
| International       |                  |                             |                 |
| Austrian Airlines   | 14               | 9.00                        | 226.11          |
| SAS                 | 14               | 23.31                       | 168.77          |
| Turkish Airlines    | 14               | 20.94                       | 156.26          |
| TAP Air Portugal    | 14               | 7.55                        | 233.90          |
| Easy Jet            | 14               | 31.2                        | 102.45          |

(continued on next page)

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### Table 1A (continued)

| Air Carrier         | Observations | Traffic (million passengers) | Ticket Price ($) |
|---------------------|--------------|------------------------------|-----------------|
| Virgin Atlantic     | 14           | 4.90                         | 512.13          |

Total 238 22.84 238.8

### Table 2A

#### Model Specification: Functional form and log-likelihood values

| Functional form | \( \lambda \) | Restricted Log-likelihood | LR statistic | P-value |
|-----------------|--------------|---------------------------|--------------|---------|
| Constant        |              | -12.0182***               | 80.5357***   |
| Number of passengers (million) |          | 4.7161***                  |              |
| Origin Pop (million) |          | 0.1808***                  |              |
| Km Flown (billion) |          | 4.3777***                  | 499.2604***  |
| (Km Flown)² |          | -0.2662                    | 101.7497     |
| Alliance Member Dummy |          | 0.4273*                    |              |
| 2008-2009 Crises Dummy |          | 0.0564                     |              |
| Fare ($) |          | 0.0464***                   |              |
| Fare*GDP per Cap (thousand $) |          | -0.0008***                 |              |
| Airline Dummies |              |                            |              |
| Air France       | -0.7806*     | -85.6065**                 |              |
| Alitalia         | -0.4904      | -13.2589                   |              |
| British Airways  | 1.5162***    | 18.2837                    |              |
| Flybe            | -1.9105***   | -21.4178*                  |              |
| Ryanair          | 7.7353***    | -99.9731***                |              |
| Iberia           | 2.6327**     | 1.6208                     |              |
| KLM              | 7.1238***    | 26.4902                    |              |
| Lufthansa        | -5.2632***   | -134.7440***               |              |
| Swiss            | 6.7039***    | -194.3920**                |              |
| SAS              | 5.1279***    | -79.8537***                |              |
| EasyJet          | -1.5667**    | -39.9445***                |              |
| Virgin Atlantic  | 4.6507***    | 335.9769***                |              |
| Others           | 9.4345***    | 70.5692***                 |              |

N 238 Objective 0.0717 Test DF Statistics P-value

Hansen J (Over Identification) 12 17.07 0.1471

Notes: Others Dummy includes (Finnair, Icelandair, Austrian Airlines, TAP Portugal), default dummy is Turkish Airlines.

*Significant at the 1 percent level.

**Significant at the 5 percent level.

***Significant at the 10 percent level.
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