

# Endogenous Costs and Price-Cost Margins

## An application to the European Airline industry<sup>1</sup>

by

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### **Abstract**

This paper allows for endogenous costs in the estimation of price cost margins. In particular, we estimate price-cost margins when firms bargain over wages. We extend the standard two-equation set-up (demand and first-order condition in the product market) to include a third equation, which is derived from bargaining over wages. In this way, price-cost margins are determined by wages and vice versa. We implement the model using data for eight European airlines from 1976-1994, and show that the treatment of endogenous costs has important implications for the measurement of price-cost margins and the assessment of market power. Our main result is that observed prices in Europe are virtually identical to monopoly prices, even though observed margins are consistent with Nash behavior. Apparently, costs had been inflated to the point that the European consumers were faced with a *de facto* monopoly prices.

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## 1. *Introduction*

Empirical work on price-cost margins often treats costs as exogenous. The standard approach specifies demand and a first-order condition, which characterize competition in the product market (see for instance Bresnahan (1989) or Berry, Levinsohn, and Pakes 1995). The simultaneity between product market competition and costs are generally not taken into account. To the extent that the simultaneity between costs, demand and product market competition are significant, treating costs as exogenous introduces a simultaneity bias when estimating price-cost margins.

Allowing for endogenous costs when estimating price-cost margins is the topic of this paper. There are a number of ways in which cost can be affected by firms' behavior in the output market. In this paper, we explore one potential channel, namely the possibility that input prices (wages) are affected by the presence of market power<sup>2</sup>. Methodologically, the endogenous cost model we propose leads to an additional equation that allows for the simultaneity in price setting between the product and the input market. In other words, the usual two-equation empirical set-up (demand and first-order condition in the product market) is generalized to include a third equation, which endogenizes costs. This equation is based on an explicit model of the input market concerned. The primary goal is to investigate the implications of treating costs, and in particular input prices, endogenously for the measurement of market power.

In this paper, we focus on one input market, namely labor, and consider the settlement of wages in the presence of market power. We endogenize costs through a model of rent sharing between management and unions. Our empirical implementation uses data from the European airline industry for the period 1976-1994. The European airline industry is an ideal testing ground for our purposes. Reduced form evidence that costs and productivity change according to the structure of the product market indeed suggest that an endogenous treatment of costs may be appropriate in this industry<sup>3</sup>. Moreover, a mechanism such as rent-sharing is plausible in the context of the airline industry. Personnel working for carriers with substantial market power is a priori in a more favorable position to bargain for wage increases<sup>4</sup> and share the rents with management and the owners of the firms. Given that most airlines at the time of our sample were still (at least partly)

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<sup>2</sup> Other mechanisms have been highlighted in the literature. For instance, market power could affect the terms of the contract between owners and managers and might lead to x-inefficiency (see for example Hart (1983), Hermalin (1992) and Schmidt (1997).

<sup>3</sup> See for example Encaoua (1991), Good, et.al. (1993a), or Marin (1998) for productive efficiency estimates in the airline industry.

<sup>4</sup> Evidence in favor of this hypothesis has been provided by McGowan and Seabright (1989), who compare wages and labor productivity of European carriers to those found among US carriers. They find that European airlines pay a significant mark up over US rates for all categories of personnel.

owned by governments, management did not face hard budget constraints and governments were presumably inclined to let airlines negotiate with unions because of wider concerns (such as social peace). Overall, the European airline industry at the time appears to be an ideal testing ground for a framework where endogenous cost emerge through rent-sharing.

Formally, we model airlines decisions as a two stage game, in which wage settlement occurs in the first stage and airlines set prices in the second stage. Wage settlement at the first stage is modeled as a bargaining game between management and a representative union. We solve for a subgame perfect equilibrium of this model. The theoretical model yields three equations to be estimated: demand, the first-order condition at stage two (product market equation), and the first-order condition of the bargaining stage (endogenous costs). We implement the model empirically using data on European airlines for the period 1976-1994.

Our results suggests that the endogenous treatment of costs matters empirically. In particular, margins effect costs and vice versa. Our main empirical finding is that observed prices in Europe are virtually identical to monopoly prices, even though observed margins are consistent with Nash behavior. The reason for this is that rent sharing inflates costs to the point that the European consumers were faced with a *de facto* monopoly prices. Note that the price-cost margins are consistent with Nash behavior, *given* the level of costs. Only when costs are treated as endogenous, do we uncover the fact that prices are in line with monopoly pricing.

There have been a large number of empirical studies that address the issue of product market competition in the airline industry. Empirical work in the measurement of price-costs margins has focused on a number of factors, such as non-cooperative behavior (Brander and Zhang (1990, 1993),) the effect of entry (Hurdle et al. (1989), Whinston and Collins (1992)), hub dominance (Berry (1990, 1992), Borenstein (1989, 1990)), price dispersion (Borenstein and Rose (1994)), network effects (Brueckner, Dyer, and Spiller (1992)), and multimarket contact (Evans and Kessides (1994)). Generally, these studies do find significant market power in the product market. There has also been a number of studies using European data (see for instance Good, Röller, and Sickles (1993b), Marin (1995) SØrgard et. al. (1997)), which all find significant evidence of market power in the product market. In fact, conduct consistent with monopoly is found in Röller and Sickles (2000) within a simple one-stage set-up, even though a model of capacity competition followed by price competition results in lower levels of market power.

Besides the above papers there are a number of studies that consider the impact of input markets on airlines performance. Amongst those contribution mostly related to our work are Hirsch and

Macpherson (2000) who analyze relative earnings in the U.S. airline industry using data from 1973-1997. They find that labor rents are "attributable largely to union bargaining power, which in turn is constrained by the financial health of carriers." In contrast to their approach, our approach explicitly models the interdependence between product market competition, union power, and wages. Ng and Seabright (1999) estimate the effect of competition on productive efficiency. They estimate that "the European airline industry is currently operating at cost levels some 25% higher than they would be if the industry had the same ownership and competitive structure as the US industry." Unlike our approach, Ng and Seabright estimate a cost function together with a second equation that explains the rent to labor, in some reduced form. Considering a cross section of industries, Nickel and Nicolitsas (1999) investigate the impact of financial pressures (as measured by the ratio of interest payments to cash flow) on employment, wages, and productivity<sup>5</sup>. They find that financial pressure negatively affect both employment and wages, while having a positive impact on productivity. By contrast, our approach uses more structure within the product market. However, we do not endogenize productivity.

An advantage of our set-up is that the interdependence between product market competition, union power, and wages is made explicit. However, there are also disadvantages to this approach (see Genesove and Mullin 1998). In particular, the results may be rather sensitive to the precise specifications of demand and cost conditions.

The present paper proceeds as follows. Section 2 introduces the theoretical model of rent sharing. Section 3 develops the empirical implementation, discusses the results, and interprets the findings. Section 4 concludes.

## ***2. A Model of Rent Sharing***

In this section we specify a two-stage game in which a representative union bargains with management over the wage rate in the first stage, and in which firms selling differentiated product set prices in stage two<sup>6</sup>. In this approach, unions and management take the product market game into account when bargaining takes place in stage one. In particular, the more profitable the product market game in stage two, the higher the equilibrium wage which unions are able to extract from management (holding bargaining power constant). Higher wages, in turn, will affect

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<sup>5</sup> See also Nickel et al. (1994).

<sup>6</sup> The model has originally been sketched in Neven and Röller (1996).

prices and profits in stage two and this will reduce union's ability to obtain higher wages. In equilibrium, this feedback effect is fully internalized. In this sense, the product market outcome and the cost function are simultaneously determined.

Demand for airline  $i$  is given by,

$$q_i(p_i, p_j, Z_i), \quad (1)$$

where  $q_i$  is the demand for airline  $i$ ,  $p_i$  is the price of airline  $i$ , and  $p_j$  is a price index of the competitors. We maintain the usual assumption on the price effect of demand,  $-\frac{\partial q_i}{\partial p_i} > \frac{\partial q_i}{\partial p_j} > 0$ , i.e. the own-price effect is larger in absolute value than the cross-price effect.  $Z_i$  is a vector of country-specific, exogenous factors affecting demand.

The implicit duopoly assumption in (1) can be justified by the existence of *bilateral agreements*. While the European carriers were engaged in moderate competition in transatlantic travel, the domestic scheduled market remained heavily regulated through bilateral agreements. The resulting duopolistic market structures created by the bilateral agreements prevented new entry in the intra-European market.<sup>7</sup>

Firm-level cost functions are,

$$C(q_i, \mathbf{w}_i, R_i) \quad (2)$$

That is, total costs depend on quantity ( $q_i$ ), the wage rate ( $\mathbf{w}_i$ ), and a vector of exogenous cost characteristics  $R_i$ .

At stage 2 firms compete in the product market via Bertrand-Nash by choosing prices to maximize profits, i.e. firms solve the following problem,

$$\max_{p_i} \mathbf{p}_i = q_i(\cdot) p_i - C(q_i(\cdot) | \mathbf{w}_i, R_i)$$

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<sup>7</sup> The existence of entry restrictions and other competition reducing regulations (such as the bilaterals) can be interpreted as evidence of regulatory rents. For more evidence that regulatory rents can be transferred to labor see the studies by Hendricks (1977) and Rose (1987).

where  $q_i(\cdot)$  is given in (1). Note that the wage rate is assumed to be exogenous at this stage. The corresponding first-order conditions for the product market game are given by

$$q_i + (p_i - MC) \cdot \frac{\partial q_i}{\partial p_i} = 0 \quad (3)$$

where  $MC(\cdot) = \frac{\mathcal{J}C(\cdot)}{\mathcal{J}q_i}$  is the marginal cost function. We denote the equilibrium prices defined by (3) as  $p_i(\mathbf{w}_i, \mathbf{w}_j)$ .

At stage 1 firms bargain with their respective unions over wages. We assume that the solution is characterized by an asymmetric Nash bargaining outcome given by the following program:

$$\max_{w_i} \left\{ (w_i - w_i^c)^d p_i(w_i)^{(1-d)} \right\},$$

where  $d$  is the degree of union bargaining power and  $(1-d)$  is the firms' bargaining power. Whenever  $d$  is one, unions have all the bargaining power. Conversely, as  $d$  gets closer to zero, management has almost all the bargaining power. Finally, the threat point is denoted by  $w_i^c$ , which is the outside wage rate obtained when bargaining breaks down. The above Nash solution thus assumes that management maximize  $p_i$ , whereas unions maximize wages.

There are a number of qualifications with the above set-up that are important to mention at this point. First, we assume that unions bargain only over wages and do not include employment in the negotiation (in our model, employment is determined by the airline at the second stage taking wage as given). This assumption helps in keeping the model tractable, yet it is consistent with the prominent insider-outsider model of bargaining in which unions are only concerned about the fate of insiders. If employment is not expected to fall, bargaining would then take place only over wages. An increase in demand faced by the airline during the period under investigation is likely to have been sufficient to compensate for the fall in employment that higher wages might imply. It is only with the recent pressures from deregulation that unions and management begun to explicitly reduce their wage demands in exchange for employment security. Overall, it appears that

restricting bargaining to wages only is supported by the institutional environment of the European airline industry at the time.<sup>8</sup>

Second, we model the situation as a single union bargaining with management. As similarly skilled workers segregate into many smaller unions (pilots, mechanics, flight attendants), one could think of a more complicated bargaining set-up. Modeling several unions bargaining independently over several factors - possibly simultaneously - with management is well beyond the scope of this paper. Essentially, our set-up assumes that labor interests are defended by a representative union (or by a collusive set of unions) and that the primary factor of conflict are wages.

The final caveat is that we need to account for the subsidies, which airlines receive from their respective governments. Subsidies should be included in the rent which management and unions bargain over. Unfortunately, reliable data on subsidies to European airlines are not available. We therefore assume that airlines are subsidized to the extent that the government ensures that firms will at least break even. In particular, we assume that the government decides on a subsidy *prior* to the wage bargaining process. Since the subsidy is given *ex ante*, its effect on the bargaining can be introduced by imposing a non-negativity constraint on  $p_i$ .

The first-order conditions for stage 1 is then given by,

$$\frac{\mathbb{1}p_i}{\mathbb{1}w_i} + \left( \frac{d}{1-d} \right) \frac{p_i}{(w_i - w_i^c)} = 0 \quad (4)$$

Differentiating the profit function  $p_i$  with respect to  $w_i$ , using (3), yields,

$$(p_i - MC) \frac{\partial q_i}{\partial p_j} \frac{\partial p_j}{\partial w_i} - \frac{\partial C}{\partial w_i} + \frac{d}{1-d} \frac{p_i}{w_i - w_i^c} = 0. \quad (5)$$

The effect of the stage 1 variable (wages) on stage two variables (prices),  $\mathbb{1}p_i / \mathbb{1}w_i$  and  $\mathbb{1}p_j / \mathbb{1}w_i$ , are obtained by implicit differentiating (3),

$$\frac{\mathbb{1}p_i}{\mathbb{1}w_i} = \frac{A\Delta_i}{H^p} \frac{\mathbb{1}MC}{\mathbb{1}w_i} \quad \text{and} \quad \frac{\partial p_j}{\partial w_i} = - \frac{B\Delta_i}{H^p} \frac{\partial MC}{\partial w_i}, \quad (6)$$

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<sup>8</sup> We do not consider other types of work rule negotiations and benefits (such as working hours, vacations, social benefits, etc.). Even though these other benefits may have played some role in negotiation, they are difficult to observe, verify and especially measure. To the extent that these other factors are not correlated with wages (and enter the objective functions of management or the unions differently) our results would need to be qualified.

where  $A = \frac{\partial^2 p_i}{\partial p_i^2}$ ,  $B = \frac{\partial^2 p_i}{\partial p_i \partial p_j}$ ,  $H^p = A^2 - B^2$ , and  $\Delta_i = \frac{\partial q_i}{\partial p_i}$  and  $\Delta_j = \frac{\partial q_i}{\partial p_j}$  are the own and cross demand derivatives.

When wages and prices are chosen simultaneously,  $\frac{\partial p_i}{\partial w_i}$  and  $\frac{\partial p_j}{\partial w_i}$  must be zero. Note from (6) that  $\frac{\partial MC}{\partial w_i} = 0$  implies that  $\frac{\partial p_i}{\partial w_i}$  and  $\frac{\partial p_j}{\partial w_i}$  are zero, i.e. there is no strategic link between the two periods. Therefore, a specification test for the sequential set-up is given by whether wages affect marginal costs, i.e. whether  $\frac{\partial MC}{\partial w_i} = 0$ .

### 3. Empirical Implementation

The empirical implementation of the above model involves simultaneously estimating the demand equation (1), the two first-order condition (3) and (5) subject to (6). The corresponding endogenous variables are prices, quantities, and wages. The demand equation corresponding to (1) is specified as follows,

$$q_i = a_0 + a_1 p_i + a_2 p_j + a_3 \text{GASOLINE}_i + a_4 \text{GDP}_i + a_5 \text{GCONS}_i + a_6 \text{RAIL}_i + a_7 \text{NETWORK}_i + e_{1i} \quad (7)$$

where  $e_{1i}$  denotes the error term. The variables influencing demand are as follows.  $p_i$  is a price index for airline  $i$  and  $p_j$  is an index of the price of all other airlines.  $\text{GASOLINE}$  is an index of the price of gasoline and represents the price of a substitute transportation form,  $\text{GDP}$  is the gross domestic product and a measure of country size,  $\text{GCONS}$  is private consumption growth and a measure of economic activity,  $\text{RAIL}$  is an index for the price of rail transportation and is computed by the ratio of passenger revenue to passenger tone-kilometers, and  $\text{NETWORK}$  is a measure of the size of the carriers' network and is based on the total number of route kilometers. The data and their construction are described in more detail in Appendix A. Summary statistics of the data are given in Table 1.



Note that  $p_j$  in (7) is endogenous, such that instruments are necessary to obtain consistent estimates. As instruments we use the set of exogenous demand and cost shifters given in (7) and in (8)<sup>9</sup>.

Regarding the cost function, we must specify the derivatives of (2), since they enter into the first-order conditions. The marginal cost equation ( $\mathcal{J}C / \mathcal{J}q_i$ ) defined implicitly in (2) is assumed to be linear in wage ( $w$ ), the price indexes for capital and materials ( $PK$  and  $PM$ ), as well as a variety of cost and quality characteristics such as the percentage of wide-bodied planes in the fleet ( $PWIDEB$ ), the percentage of turboprop planes ( $PTURBO$ ), the load factor ( $LOADF$ ), the stage length ( $STAGE$ ), and a measure of network size ( $NETWORK$ ). That is,

$$MC = b_0 + b_1 w_i + b_2 PK_i + b_3 PM_i + b_4 LOADF_i + b_5 STAGE_i + b_6 PWIDEB_i + b_7 PTURBO_i + b_8 NETWORK_i \quad (8)$$

Using these functional specifications, the first-order condition for the product market (3) is,

$$p_i = MC - \frac{q_i}{a_1} + e_{2i} \quad (9)$$

where  $e_{2i}$  is an error term, where  $e_{2i}$  can be interpreted as either an error in marginal cost (8) or an error in the optimization problem that firms face in stage 2.

Substituting this into (5), making use of (6) and  $e_{2i}$  and  $B = a_2$ , as well as making use of Shephard's lemma such that  $\frac{\mathcal{J}C}{\mathcal{J}w_i} = L_i$ , we obtain the first-order condition for wages<sup>10</sup>,

$$-(p_i - MC) \frac{b_1 a_1 a_2^2}{4a_1^2 - a_2^2} - L_i + \frac{d}{1-d} \frac{p_i}{(w_i - w_i^c)} + e_{3i} = 0 \quad (10)$$

where  $MC$  is again given by (8) and  $e_{3i}$  is an error term. The interpretation of  $e_{3i}$  may again stem from an error in the marginal costs (8), or there could be an error in the bargaining solution itself. To the extent that both error terms in (9) and (10) are partially stemming from the same error in

<sup>9</sup> We have checked robustness with respect to using different subsets of our demand and cost shifters. The results below are essentially unaffected by this.

<sup>10</sup> Note that by using Shephard's lemma in the first-order condition for wages, we assume that firms take the impact of wages on labor input into account whenever they bargain over wages.

marginal cost (8), they will be correlated. Our estimation procedure will involve non-linear three stage least squares of (7), (9) and (10), which indeed allows the error terms to be correlated.

Note that the estimation of (10) involves information on  $w_i^c$ , which is the outside option when bargaining breaks down. We use OECD data on PPP adjusted business-sector wages in the relevant country as our measure of  $w_i^c$ .

In sum, we estimate the above system of three equations (7), (9), and (10), where the endogenous variables are given by wages, prices and output<sup>11</sup>. The set of instruments is given by the exogenous variables listed in equations (7) and (8). The estimation is done by non-linear three stage least squares as given by the Proc Model routine in SAS. The objective function is  $r'(S_{N2SLS}^{-1} \otimes Z(Z'Z)^{-1} Z')r / n$ , where  $n$  is the number of observations (i.e. 141 on our data set),  $r$  is a  $gn \times 1$  stacked vector of residuals (where  $g=3$  is the number of equations),  $S$  is the  $3 \times 3$  covariance matrix across equations, and  $Z$  is the matrix of instruments as given in (7) and (8). The estimates and their significance are reported in Table 2.

The above specification does not allow for any correlation in the errors within a single airline. As pointed out by Mouton (1990), it might be reasonable to expect that unobservable characteristics of airlines will result in such correlations. One method to handle this is clustering. Assuming a single-equation set-up, we have recalculated the standard errors by clustering on the airlines. The resulting adjusted standard errors are smaller than before. In particular, the t-stats are larger by a factor of 2.698 for the demand equation (7), by a factor of 1.372 for equation (9), and a factor of 2.643 for equation (10). Given that this is done within the context of single equations, we do not report these results explicitly.

### 3.1 Two Specification Tests

Before interpreting the results in Table 2 in more detail, we perform two specification tests. Given that we have imposed a certain amount of structure, there are some conditions that can serve as a specification test. The purpose of this subsection is to investigate whether the "data reject the model".

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<sup>11</sup> Note that the above specification assumes that the degree of union power parameter is time and firm invariant. As a result, our estimates are to be interpreted as averages (over firms and over time).

The first type of specification test refers to the maintained assumption about demand. Recall that we have assumed that the own price effect is negative and larger in absolute value than the (positive) cross-price effect. Note that these conditions ensure that the model is well-specified in the sense that the both second-order conditions and the stability condition in stage 1 are met by the empirical estimates. This is shown in Appendix B, which derives the second order conditions for both stages of the game as well as the stability condition.

As can be seen in Table 2, both the own-price effect (-1.687) and the cross-price effect (0.610) have the expected signs and are significant. Also, our maintained assumption that the own-price effect is larger in absolute value than the cross-price effect is confirmed by the data. We thus find that the necessary conditions for the model to be well behaved are supported by the data.

A second specification test can be done by testing whether the two-stage set-up is appropriate. An important assumption of the theoretical model has been that wages are determined in stage one, while product market competition is assumed to be taking place in stage two. As mentioned above, the effect of wage on marginal costs,  $\partial MC / \partial w_i$ , determines whether the two-stage model can be reduced to a one-stage model. The estimates in Table 2 imply that wages increase marginal costs. Since this effect is significant (t-stat of 3.34), we reject a one-stage model in favor of our two-stage specification<sup>12</sup>.

In sum, both specification tests support the theoretical model developed above.

### 3.2 Interpretation

We now turn to the interpretation of our results in Table 2. The price elasticity of demand is estimated at -1.687, while the cross-price elasticity is estimated at 0.610, which indicates that the services provided by airlines are substitutes. Many of the remaining parameters have the expected signs. For the demand equation, GDP and consumption growth have positive and significant effects. The price of railroad transportation also has a positive impact on airline

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<sup>12</sup> Note that the elasticity of marginal cost with respect to wages is equal to 38%. When marginal cost is independent of output, the elasticity of marginal cost with respect to wage will be equal to the elasticity of total cost with respect to wages (as long as there are no fixed cost), which in turn is equal to the share of labor cost in total costs. The share of labor cost in total revenues in our sample is equal to 33%. Overall, we feel that this is close enough to the estimated elasticity (note that we do not assume zero fixed cost) and does provide support regarding the quality and consistency of our estimates.

demand, which suggests that air travel and rail travel are significant substitutes. By contrast, the price of gasoline has a negative and significant effect on airline demand, indicating that automobiles and air travel are complements. However, the reader should note that the materials costs in the pricing equation includes gasoline costs, which might explain the above correlation. The cost parameters have the expected signs as well. The price of capital and the price of materials are positively related to marginal costs. An increase in both wide-bodied and turboprop planes lowers marginal costs, while stage length and load factor have no significant impact on marginal costs. Finally, the larger the network of an airline is, the lower are its marginal costs.

Turning to the bargaining power, we find significant evidence suggesting that unions do have considerable bargaining power. Our estimate of the union bargaining power parameter  $d$  is 0.896 with a t-statistic of 17.38. This implies that unions have a positive and significant impact on wages and that price-cost margins are affected by the presence of unions (see below). This finding suggests that accounting for endogenous costs matters significantly.<sup>13</sup>

In order to assess the importance of this finding on prices and wages we use our estimates and perform several simulation exercises which are reported in Table 3. We consider four alternatives depending on whether the labor market is unionized ( $d = 0.896$ , i.e. the estimated degree of union power) or not ( $d = 0$ ), as well as whether the output market is monopolized (i.e. joint profit maximization) or Nash. The simulation of these four scenarios involves solving three simultaneous equations (7), (9)<sup>14</sup>, and (10) for the endogenous variables (wages, prices and quantities), while setting all exogenous variables at their sample means. Table 3 presents the simulation results of input and/or output market imperfections on prices and price-cost margins using the estimates in Table 2.

Focusing on the left column of Table 3, where the output market is Bertrand-Nash, we find that the impact of unions on prices and margins are economically very significant. Product market prices

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13 We have also considered a semi-log specification for demand, which changes the specification of the first-order condition. We have then re-estimated our model. Many of the resulting parameter estimates do not change significantly, however some lose precision (especially the marginal cost estimates).  $d$  is now estimated at 0.746 (with a t-stat of 10.08). We therefore continue to find that delta is significant, but less than 1. The effect of wages on marginal costs does not change much and is now estimated at 0.016 (before it was 0.015), yet the new estimate is only significant at the 15% level. Overall, many of the parameters have the same sign and significance. We have also considered the possibility that the load factor may be endogenous and have considered the lag of the load factor as an instrument. Here again, results are not changed in any important way.

14 Equation (9) has to be adjusted appropriately for monopolization, i.e.  $p_i = MC - Q / (a_1 + a_2)$ , where Q is the industry output.

increase from 1.213 to 1.351 (some 11%), while price-cost margins decrease from 47% to 32%. In other words, rent sharing matters significantly.

To understand the magnitude of this impact, it is instructive to compare the relative impact of higher costs (through rent-sharing) with the impact of product market power (in our case perfect monopolization of the product market). As can be seen Table 3 predicted observed price (1.351) is almost identical to the price under monopolization, assuming no rent sharing (1.340). In other words, if current prices were related “deflated” marginal cost, margins would equal to monopoly margins. This leads us to our main finding which is that observed prices in Europe are virtually identical to monopoly prices, even though observed margins are consistent with Nash behavior. Note that the price-cost margins are consistent with Nash behavior, *given* the level of costs. Only when costs are treated as endogenous, do we uncover the fact that prices are in line with monopoly pricing.

Moreover, Table 3 also shows that the impact (on prices and margins) of input market imperfections (through rent sharing) is larger than the impact of output market imperfections. For example, prices through monopolization are increased from 1.213 to 1.340 (some 10 %) for  $d = 0$  and from 1.351 to 1.446 (some 7 %) for  $d = 0.896$ , while rent sharing increases prices by 11% or 8%, respectively (see Table 3). Similarly, price-cost margins increase through monopolization only by some 5 basis points, while rent sharing decreases margins by some 15 basis points. Overall, we find that input market imperfections has a more pronounced effect on prices and especially price-cost margins as compared to output market monopolization.

#### **4. Conclusion**

In this paper we specify and estimate an oligopoly model with endogenous cost through rent sharing and test the implications of this approach for the estimation of market power. Methodologically, this approach leads to an additional equation that allows for the simultaneity between the product market and the input market (wages in our case). In other words, the usual two-equation empirical set-up is generalized by including a third equation, which endogenizes costs. We apply this approach to data from the European airline industry for the period 1976-1994. Our results suggest that the endogenous treatment of costs does matter empirically. We find that input market power appears to be considerable and that observed prices in Europe are virtually

identical to monopoly prices, even though observed margins are consistent with Nash behavior. Moreover, input market imperfections actually have a somewhat stronger effect on prices and price-cost margins in our estimates than a hypothetical move to monopoly.

More generally, observed price cost margins are misleading indicators of the distortions in the market when costs are endogenous. In the context of our estimates, if margins were calculated with respect to the cost that would obtain in the absence of rent sharing, they would be roughly equal to monopoly margins. Hence, a substantial part of the distortion is hidden in the excessive level of cost.

These results emphasize the importance of competition enforcement and structural reforms in input markets. In the context of the airline industry, the exercise of market power in the labor market is at least as serious for final consumers as the impact of product market monopolization.

## ***Appendix A: Data Description, Sources and Construction***

This study uses a panel of the eight largest European carriers - Air France, Alitalia, British Airways, Iberia, KLM, Lufthansa, SABENA and SAS with annual data from 1976 through 1994. There are therefore in principle 152 observations. Since some variables for SABENA and KLM are missing for the years 1991-1994, as well as for Air France, LH, and Alitalia for 1994, we are left with a total of 141 observations. Summary statistics are given in Table 1.

In general, the data can be organized into three broad categories: factor prices, output, output prices, airline characteristics, and demand data.

### *Factor Prices*

The primary source for the production data is the *Digest of Statistics* from the International Civil Aviation Organization (ICAO). Good, Röller, and Sickles [1993] constructed a set of three airline input prices: (i) Labor, (ii) Materials and (iii) Capital.

(i) Labor (variable  $w$ ): The labor input is an aggregate of five separate categories of employment used in the production of air travel. Included in these categories are all cockpit crew, mechanics, ticketing, passenger handlers and other employees. Information on annual expenditures and the number of employees in each of the above categories were obtained from the International Civil Aviation Organization (ICAO) *Fleet and Personnel Series*. These indices are aggregates of a number of sub components using a Divisia multilateral index number procedure [Caves, Christensen and Diewert, 1982]. The numbers in Table 1 can be interpreted as annual wages in thousand U.S. dollars.

(ii) Materials (variable  $PM$ ): Expenditures on supplies, services, ground-based capital equipment, and landing fees are combined into a single input aggregate called materials. It is not necessarily true that the purchasing power of a dollar or its market exchange rate equivalent is the same in all countries. Consequently we use the purchasing power parity exchange rates constructed from

Heston and Summers [1988]. These are adjusted by allowing for changes in market exchange rates and changes in price levels. Use of airport runways is constructed by using landing fee expenses and using aircraft departures as the quantity deflator. The service price for owned ground based equipment is constructed by using the original purchase price, 7 % depreciation and the carrier's interest rate on long term debt. Fuel expenses are given for each carrier in ICAO's Financial Data Series. Unfortunately, there are no quantity or price figures given in that source. There are two possible solutions. The first is to estimate fuel consumption for each aircraft type in the fleet, given the consumption of U.S. carriers on similar equipment for the specific number of miles flown and adjusting for stage length. Alternatively, fuel prices for international traffic in several different regions is available through ICAO's Regional Differences in Fares and Costs. The airline's fuel price is then estimated as a weighted average of the domestic fuel price (weighted by domestic available ton-kilometers), and regional prices (weighted by international available ton-miles in the relevant region). This method explicitly recognizes that for international carriers not all fuel is purchased in the airline's home country. As with the labor input, these sub components are aggregated using a multilateral index number procedure and are termed materials.

(iii) Capital (variable  $PK$ ): A very detailed description is available for aircraft fleets. These data include the total number of aircraft, aircraft size, aircraft age, aircraft speed, and utilization rates. This information is available over the course of a year from ICAO and a calendar year's end inventory is available from IATA's *World Air Transport Statistics*. Asset values for each of these aircraft types in half-time condition is obtained from Avmark, one of the world's leading aircraft appraisers. This data source provides a more reasonable measure of the value of the fleet since it varies with changing market conditions. Jorgenson-Hall user prices for the fleet are constructed by using straight line depreciation with a total asset life of 20 years and the relevant long term interest rates.

### *Output*

Output (variable  $q_i$ ) is obtained from ICAO's *Commercial Airline Traffic Series*. ICAO disaggregate airline output along physical dimensions (classification into passenger output and cargo), along utilization dimensions, along functional dimensions (classification into scheduled and non-scheduled output), and finally on geographic dimensions (classification into domestic and international output). We utilize the classification based on physical dimensions and on services



provided. Total airline output is gotten by aggregating quantities of passenger and cargo tonne kilometers of service, and incidental services where weights are based on revenue shares in total output.

### *Output Prices*

The output price (variable  $p_i$ ) is calculated as a ratio of the carrier's passenger revenues to passenger ton-kilometer miles performed. The revenues for the carriers are obtained from the - *Digest of Statistics (Financial Data - Commercial Air Carriers)* from the International Civil Aviation Organization (ICAO). The price of the "other" airlines (variable  $p_j$ ) in the duopoly model is computed by weighting all the individual prices by their respective revenue shares in the market.

### *Airline Characteristics*

Three characteristics of airline output and two characteristics of the capital stock are calculated. These included load factor (*LOADF*), stage length (*STAGE*), the percent of the fleet which is wide bodied (*PWIDE*), and the percent of the fleet which uses turboprop propulsion (*PTURBO*).

The primary source for the network data is the *World Air Transport Statistics* publication of the International Air Transport Association (IATA). Load factor provides a measure of service quality and is used as a proxy for service competition. Stage length provides a measure of the length of individual route segments in the carrier's network. Both the percent of the fleet which is wide bodied and the percent using turboprop propulsion provide measures of the potential productivity of capital. The percent wide bodied provides a measure of average equipment size. As more wide bodied aircraft are used, resources for flight crews, passenger and aircraft handlers, landing slots, etc. do not increase proportionately. The percent turboprops provide a measure of aircraft speed. This type of aircraft flies at approximately one-third of the speed of jet equipment. Consequently, providing service in these types of equipment requires proportionately more flight crew resources than with jets.

## *Demand Data*

Demand data was collected for the respective countries - France, Italy, Great Britain, Spain, Netherlands, Germany, Belgium and the three Scandinavian countries, Denmark, Sweden, Norway. The different data series for Denmark, Sweden and Norway are weighted by their respective GDP's in order to create single representative indices for the Scandinavian countries, which share the majority of the equity in SAS.

A measure of network size (*NETWORK*) is constructed by the total number of route kilometers (in thousands) an airline operates on. Gross Domestic Product (*GDP*) was obtained from the *Main Economic Indicators* publication of the Economics and Statistics Department of the Organization for Economic Cooperation and Development (OECD). It is reported for the above countries, in billions of dollars. The growth in private consumption (*GCONS*) is defined as an implicit price index with year to year percentage changes as reported by the OECD Economic Outlook publication, *Historical Statistics*. *Jane's World Railway* is the source of the rail data. Rail traffic is reported in four categories: passenger journeys, passenger tone-kilometers, freight net tone-kilometers and freight tones. The three revenue categories are passengers and baggage, freight, parcels and mail, and other income. To be consistent with the price of air travel, the rail price (*RAIL*) was calculated as the ratio of passenger revenue to passenger tone-kilometers. We thank S. Perelman for making available to us some of the more recent rail data which were not available in *Jane's World Railway*. Finally, the retail gasoline price (*GASOLINE*) were obtained from the OECD, International Energy Agency's publication, *Energy Prices and Taxes*.

## Appendix B

### Second-order conditions

In this appendix we derive the second order conditions for stage 1 and 2. We start with stage 2 by rewriting its first order condition (3) as,  $\frac{\partial p_i}{\partial p_i} = q_i + (p_i - MC) \cdot \frac{\partial q_i}{\partial p_i} = 0$ . For a linear demand function and constant marginal cost, the second order conditions and its Hessian are,

$$\frac{\partial^2 p_i}{\partial p_i^2} = 2 \frac{\partial q_i}{\partial p_i}, \quad \frac{\partial^2 p_i}{\partial p_i \partial p_j} = \frac{\partial q_i}{\partial p_j}, \quad \text{and } H^p = \begin{bmatrix} 2 \frac{\partial q_i}{\partial p_i} & \\ & \frac{\partial q_i}{\partial p_j} \end{bmatrix}.$$

The assumption on price effects of demand  $-\frac{\mathbb{1}q_i}{\mathbb{1}p_i} > \frac{\mathbb{1}q_i}{\mathbb{1}p_j} > 0$  guarantees the existence and stability condition in stage 2, i.e.  $\frac{\partial^2 p_i}{\partial p_i^2} < 0$  and  $H^p > 0$ .

For stage 1, denote  $U_i = (w_i - w_i^c)^d p_i^{(1-d)}$ . For linear demand and constant marginal cost, the second order condition is given by,

$$D = \frac{\partial^2 U_i}{\partial w_i^c} = (w_i - w_i^c)^{d-1} p_i^{-d} \left[ \frac{\partial p_i}{\partial w_i} + (1-d) w_i \frac{\partial^2 p_i}{\partial w_i^2} \right],$$

Note that  $\frac{\partial p_i}{\partial w_i} = -\frac{d}{1-d} \frac{p_i}{w_i - w_i^c}$ . Furthermore  $\frac{\partial^2 p_i}{\partial w_i^c} = \left[ \frac{\partial p_i}{\partial w_i} - \frac{\partial MC_i}{\partial w_i} \right] \frac{\partial q_i}{\partial p_j} \frac{\partial p_j}{\partial w_i} < 0$ , since

$$\frac{\mathbb{1}p_i}{\mathbb{1}w_i} - \frac{\mathbb{1}MC_i}{\mathbb{1}w_i} = -2 \left[ \frac{\mathbb{1}q_i}{\mathbb{1}p_i} \right]^2 + \left[ \frac{\mathbb{1}q_i}{\mathbb{1}p_j} \right]^2 < 0 \quad \text{and} \quad \frac{\mathbb{1}p_j}{\mathbb{1}w_i} > 0. \quad \text{Therefore, } D < 0.$$

**Table 1**  
**Summary Statistics**

<b>Variable</b>	<b>Number of Observations</b>	<b>Mean</b>	<b>Minimum</b>	<b>Maximum</b>
$p_i$	141	1.123	0.626	2.021
$q_i$	141	2304691.910	69085.130	8839172.470
$w_I$	141	32.019	8.677	88.392
$w^c_i$	141	14.233	6.104	25.776
$p_j$	141	1.119	0.745	1.647
$PK$	141	1900.780	533.980	5800.890
$PM$	141	138.883	79.740	225.663
$L_i$	141	26809.890	6277.000	54919.000
$K_i$	141	98.594	23.500	233.000
$M_i$	141	12924.570	2148.400	53386.780
$GASOLINE$	141	0.691	0.311	1.270
$GDP$	141	679.375	147.900	1737.400
$GCONS$	141	7.313	-0.900	23.700
$RAIL$	141	0.052	0.014	0.136
$NETWORK$	141	445.878	188.787	1072.390
$LOADF$	141	0.639	0.535	0.727
$STAGE$	141	1.202	0.689	3.660
$PWIDEB$	141	0.234	0.080	0.529
$PTURBO$	141	0.029	0.000	0.195

For variable definitions see Appendix A.

**Table 2**  
**European Airlines – Endogenous Cost Model**  
**(Non-Linear Three-Stage Least Squares Estimates)**

Variable	Estimate	t-statistic
<i>Demand Equation</i>		
INTERCEPT	-3695509	-4.47
$p_i$	-1.687	-7.70
$p_j$	0.610	7.28
<i>GASOLINE</i>	-1.350	-4.59
<i>GDP</i>	0.505	5.94
<i>GCONS</i>	0.147	2.18
<i>RAIL</i>	0.702	6.88
<i>NETWORK</i>	0.012	0.09
<i>Marginal Cost (<math>\partial c/\partial q_i</math>)</i>		
INTERCEPT	1.478	1.33
$w_l$	0.015	3.34
<i>PK</i>	0.0004	2.38
<i>PM</i>	0.009	3.31
<i>LOADF</i>	-2.151	-1.17
<i>STAGE</i>	0.080	0.48
<i>PWIDEB</i>	-5.322	-2.88
<i>PTURBO</i>	-6.491	-2.61
<i>NETWORK</i>	-9.25E-7	-2.35
<i>Union Power</i>		
$\delta$	0.896	17.38

The estimates reported in the demand equation are converted into elasticities evaluated at their sample means. Number of observations is equal to 141.

**Table 3**  
**Prices and Price-Cost Margins under alternative Input and Output Market Imperfections**

		<b>Product Market</b>	
		Bertrand-Nash	Monopolization (joint profit maximization)
<b>Labor Market</b>	$d = 0.896$ (estimated degree of union power)	$p_i = 1.351$  $\frac{p_i - MC_i}{p_i} = 32\%$	$p_i = 1.446$  $\frac{p_i - MC_i}{p_i} = 37\%$
	$d = 0$ (no unions)	$p_i = 1.213$  $\frac{p_i - MC_i}{p_i} = 47\%$	$p_i = 1.340$  $\frac{p_i - MC_i}{p_i} = 52\%$

## References

- Berry, S., 1990, "Airport presence as product differentiation", *American Economic Review* (Paper and Proceedings) 80, 394-399.
- Berry, S., 1992, "Estimation of a model of entry in the airline industry", *Econometrica*, 60, 889-917.
- Berry, S. T., J. Levinsohn and A. Pakes, 1995, "Automobile Prices in Market Equilibrium," *Econometrica*.
- Borenstein, S., 1989, "Hubs and High Fares: Dominance and Market Power in the U.S. Airline Industry," *Rand Journal of Economics*, Vol. 20, 344-365.
- Borenstein, S., 1990, "Airline Mergers, Airport Dominance and Market Power," *American Economic Review*, 80, 400-404.
- Borenstein, S., and N. L. Rose, 1994, "Competition and Price Dispersion in the U.S. Airline Industry," *Journal of Political Economy*, 102, 653-683.
- Brander, J. A. and A. Zhang, 1990, "Market Conduct in the Airline Industry: An Empirical Investigation", *Rand Journal of Economics*, Vol. 21, 567-583.
- Brander, J. A. and A. Zhang, 1993, "Dynamic Oligopoly Behavior in the Airline Industry", *International Journal of Industrial Organization*, Vol. 11, 407-436.
- Bresnahan, T. F., 1989, "Empirical Studies in Industries with Market Power," in Handbook of Industrial Organization, Vol. II, 1011-1058.
- Brueckner, J.K., N.J. Dyer, and P.T. Spiller, 1992, "Fare Determination in Airline Hub-and-Spoke Networks", *Rand Journal of Economics*, Vol. 23, 309-333.
- Caves, D.W., L.R. Christensen, and W.E. Diewert, 1982, "The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity", *Econometrica*, 50, 1393-1413.
- Encaoua, D., 1991, "Liberalizing European Airlines: Cost and Factor Productivity Evidence", *International Journal of Industrial Organization*, Vol. 9, 109-124.
- Evans, W. N. and I. Kessides, 1994, "Living by the "Golden Rule": Multimarket Contact in the U.S. Airline Industry," *Quarterly Journal of Economics*, CIX, 2, 341-366.
- Genesove, D. and W.P. Mullin, 1998, "Testing static oligopoly models: conduct and cost in the sugar industry, 1890-1914," *Rand Journal of Economics*, Vol. 29, No. 2, 355-377.
- Good, D., M.I. Nadiri, L-H. Röller, and R. C. Sickles, 1993a, "Efficiency and Productivity Growth Comparisons of European and U.S. Air Carriers: A First Look at the Data," *Journal of Productivity Analysis*. Vol. 4, 115-125.
- Good, D., L-H. Röller, and R.C. Sickles, 1993b, "U.S. Airline Deregulation: Implications for European Transport", *Economic Journal*, 103, 1028-1041.
- Hart, O., 1983, "The market mechanism as an incentive scheme", *Bell Journal of Economics*, 14, 366-382
- Hendricks, Wallace, 1977, "Regulation and Labor Earnings", *Bell Journal of Economics*, vol. 8, issue 2, pages 483-496

- Hermalin, B., 1992, The effect of competition on executive behavior, *Rand Journal of Economics*, 23, 350-365
- Hirsch, B., T. and D.A. Macpherson, 2000, "Earnings, Rents, and Competition in the Airline Labor Market", *Journal of Labor Economics*, forthcoming.
- Hurdle, G.J., R.L. Johnson, A.S. Joskow, G.J. Werden and M.A. Williams, 1989, "Concentration, potential entry, and performance in the airline industry", *Journal of Industrial Economics* 38, 119-139.
- Heston, A. and R. Summers, 1988, "Comparison of Price and Gross Domestic Product for Several Countries", *Review of Income and Wealth*, 34, 1-28.
- Marin, P., 1995, "Competition in European Aviation: Pricing Policy and market Structure", *Journal of Industrial Economics*, XLIII (2): 141-160.
- Marin, P., 1998, "Productivity Differences in the Airline Industry: Partial Deregulation versus Short Run Protection", *International Journal of Industrial Organization*, Vol 16, Issue 4, 395-414.
- McGowan, F, and P. Seabright, 1989, "Deregulating European Airlines, " *Economic Policy*, 9, 284-344.
- Moulton, B. R., 1990, "An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Units", *The Review of Economics and Statistics*, Vol. 72, No. 2 (May), 334-338.
- Neven, D. J. and L.-H. Röller, 1996, "Rent Sharing in the European Airline Industry", *European Economic Review*, 40, 933-940.
- Neven, D. J. and L.-H. Röller, 1999, "An Aggregate Structural Model of Competition in the European Banking Industry", *International Journal of Industrial Organization*, Vol. 17, No. 7.
- Ng, C.K. and P. Seabright, 1999, "Competition, Privatization, and Productive Efficiency: Evidence from the Airline Industry", *The Economic Journal*, forthcoming.
- Nickel, S., J. Vainomaki, S. Wadhvani, 1994, "Wages and Product Market Power", *Economica*, 61, 457-474.
- Nickel, S. and D. Nicolitsas, 1999, "How Does Financial Pressure Affect Firms?" *European Economic Review*, 43, 1435-146.
- Rose, N., 1987, "Labor Rent-Sharing and Regulation: Evidence form the Trucking Industry", *Journal of Political Economy*, 45, 1146-1178, December.
- Sørgard, L., K. Salvanes and F. Steen, 1997, "Hotelling in the Air? Flight Departures in Norway", mimeo.
- Röller, L.-H. and R.C. Sickles, 2000, "Capacity and Product Market Competition: Measuring Market Power in a 'Puppy-Dog' Industry", *International Journal of Industrial Organization*, 18, 845-865.
- Schmidt, Klaus M., 1997, "Managerial Incentives and Product Market Competition", *The Review of Economic Studies*, Vol. 64 (2), 191-213.
- Whinston, M.D. and S.C. Collins, 1992, "Entry, contestability, and deregulated markets: An event study analysis of People Express", *Rand Journal of Economics*, 23, 445-462.