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Endogenous Costs and Price-Costs
Margins

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Endogenous Costs and Price-Cost Margins[1]

by

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Abstract

Empirical work on price-cost margins often treats costs as exogenous. Allowing for endogenous costs when estimating price-cost margins is the topic of this paper. Methodologically, the endogenous cost model we propose leads to an additional equation that allows for the simultaneity in price setting in the product and the input market (labor in our case). In other words, the usual two-equation set-up (demand and first-order condition in the product market) is generalized to include a third equation, which endogenizes costs. 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.

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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 and hence can be endogenous.   In this paper, we explore one potential channel, namely the possibility that input prices may be affected by the presence of market power[2]. 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 generalised to include a third equation, which endogenizes costs.   Ideally, this equation should be structural, i.e. be based on an explicit model of the input market concerned. The primary goal of the paper 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 of costs and productivity changes due to changes in the product market suggest that an endogenous treatment of costs is appropriate in this industry[3]. Moreover, a mechanism such as rent-sharing is plausible: one may expect that personnel working for carriers with substantial market power will be in a favorable position to bargain for wage increases[4] and share the rents with management and the owners of the firms.

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[2] Other mechanims 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 instance, Hart (1983), Hermalin (1992) and Schmidt (1997).

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

[4] 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.

Given that most airlines were still (at least partly) owned by governments in our sample period, airlines did not face hard budget constraints and governments were presumably inclined to negotiate with unions because of wider concerns (like social peace). Overall, the European airline industry thus appears to be an ideal testing ground for a model in which endogenous cost come about through rent-sharing (at least for the period covered by our sample).

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 leads to 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.

The main contribution of our approach is thus to endogenize costs by explicitly taking into account the link between product market competition and costs through a model of rent-sharing. We show that the endogenous treatment of costs does matter empirically: it affects the estimation of market power in the product market. More specifically, we find evidence of extensive rent sharing and conclude that output market imperfections are lower when the endogeneity of costs is properly accounted for.

Building on these findings, we then perform several simulations that allow us to compare the impacts of input vs. output market imperfections. We find that the input market imperfection has rather little impact on prices and margins relative to output market imperfection, namely the potential exercise of market power that would arise if the market was monopolised. This arises because the effect of rent sharing on marginal cost is quantitatively small. Rent sharing thus appears to be moslty about redistribution. These findings have important competition policy implications, which are discussed below.

Our findings also shed light on the common claim that the margins of airlines are "*hidden*" in their excessive level of cost. According to this claim, if one were to reduce marginal costs to those levels that would prevail under competitive input markets, then observed margins would be indicative of extensive market power. We find that margins would indeed by higher under competitive conditions in the input market. However, given that the effect of rent sharing on marginal cost is estimated to be rather small, the extent to which true margins are hidden should not be exaggerated.

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 in the airline industry 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 and Spiller (1991), 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 and derives three simultaneous equations. 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 quation 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[5]. 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.

Compared to some of the other contributions in this literature, our approach is more "structural". An advantage of this approach is that the interdependence between product market competition, union power, and wages are explicitly accounted for. However, there are also disadvantages

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[5] See also Nickel et al. (1994).

(see Genesove and Mullin 1998). For once, the results may be rather sensitive to the precise specifications of demand and cost conditions. Our framework is also static and this will introduce a bias in estimating the conduct parameter, especially when conduct is correlated with demand and cost variables (see Corts 1999). A third problem might occur when "average conduct" estimates are imposed, even though the industry is asymmetric, which introduces an aggregation bias (see Neven and Röller 1999).

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[6]. 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 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.

We begin by modeling demand for airline i in the following fashion,

$$q_i(p_i, p_j, Z_i), \tag{1}$$

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. 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

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[6] The model has originally been sketched in Neven and Röller (1996).

resulting duopolistic market structures created by the bilateral agreements also prevented new entry in the intra-European market.

Moreover, we maintain the usual assumption on price elasticity of demand: $-\frac{\partial q_i}{\partial p_i} > \frac{\partial q_i}{\partial p_j} > 0$. That is, the own-price effect is larger in absolute value than the cross-price effect.

Next, we specify the firm-level cost function as follows,

$$C(q_i, \omega_i, R_i) \tag{2}$$

That is, total costs depend on quantity (q_i), the wage rate (ω_i), and a vector of exogenous cost characteristics R_i.

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

$$\max_{p_i} \pi_i = q_i(.)p_i - C(q_i(.) \mid \omega_i, R_i)$$

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

$$q_i + (p_i - MC) \cdot \left(\frac{\partial q_i}{\partial p_i} + \theta \frac{\partial q_i}{\partial p_j} \right) = 0 \tag{3}$$

where $\theta \equiv dp_j / dp_i$ is firm i's conjectural variation and $MC(.) = \frac{\partial C(.)}{\partial q_i}$ is the marginal cost function. We denote the equilibrium prices defined by (3) as $p_i(\omega_i, \omega_j)$.

The firms' behavior parameter θ can be interpreted in terms of firms' behavior. In particular, when $\theta = 0$, firms behavior is consistent with Bertrand-Nash. In this case (3) reduces to the well-known case in which firms price according to their own elasticities. Monopoly (or cartel) pricing is associated with a $\theta = 1$. Finally, as $\theta \rightarrow -\infty$, price approaches marginal costs and the market outcome can be categorized as perfectly competitive.

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:

$$\max_{\omega_i}\left\{(\omega_i - \omega_i^c)^\delta \pi_i^{(1-\delta)}\right\},$$

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

There are a number of further qualifications with the above set-up that are important to mention at this point. First, we assume that unions take employment as given and bargain only over wages. One reason for doing this is to keep the model tractable. However, we believe that during the sample period under investigation this is not unrealistic. Only with the recent pressures from deregulation have unions and management begun to explicitly reduce their wage demands in exchange for employment security. In addition, 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 be subject to negotiation, it is not unreasonable to assume that in Europe the main issue for bargaining is wage demands[7]. To the extent that other factors are not correlated with wages (and enter the objective functions of management or the unions differently) our results need to be qualified.

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 "cake" 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

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[7] Note that in our model unions consider the effect that wages will have on profit in the second stage. They do not consider the effect on employment. Such an assumption seems realistic to the extent that unions are mostly concerned about the fate of insiders.

on a subsidy *prior* to the wage bargaining process. Since the subsidy is given ex ante, we can include the subsidy by imposing a non-negativity constraint on π_i.

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

$$\frac{\partial \pi_i}{\partial \omega_i} + \left(\frac{\delta}{1-\delta}\right)\frac{\pi_i}{\left(\omega_i - \omega_i^c\right)} = 0 \qquad (4)$$

Differentiating the profit function π_i with respect to ω_i and using (3) yields

$$\frac{\partial \pi_i}{\partial \omega_i} = (p_i - MC)\frac{\partial q_i}{\partial p_j}\left\{\frac{\partial p_j}{\partial \omega_i} - \theta \frac{\partial p_i}{\partial \omega_i}\right\} - \frac{\partial C}{\partial \omega_i}$$

which allows us to write the first-order condition (4) as,

$$(p_i - MC)\frac{\partial q_i}{\partial p_j}\left\{\frac{\partial p_j}{\partial \omega_i} - \theta \frac{\partial p_i}{\partial \omega_i}\right\} - \frac{\partial C}{\partial \omega_i} + \frac{\delta}{1-\delta}\frac{\pi_i}{\omega_i - \omega_i^c} = 0. \qquad (5)$$

The effect of the stage 1 variable (wages) on stage two variables (prices) is given in (5) by $\partial p_i / \partial \omega_i$ and $\partial p_j / \partial \omega_i$. One can obtain those effects by implicit differentiation of (3) with respect to ω_i and ω_j, yielding,

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

where $A = \frac{\partial^2 \pi_i}{\partial p_i^2}$, $B = \frac{\partial^2 \pi_i}{\partial p_i \partial p_j}$ and $H^p = A^2 - B^2$. Moreover, $\Delta_i = \left(\frac{\partial q_i}{\partial p_i} + \theta \frac{\partial q_i}{\partial p_j}\right)$ and $\Delta_j = \frac{\partial q_i}{\partial p_j}$ are own and cross partial demand derivatives.

In a simultaneous Nash game, wages and prices are chosen simultaneously, which implies that $\partial p_i / \partial \omega_i$ and $\partial p_j / \partial \omega_i$ must be zero. Note from (6) that whenever $\frac{\partial MC}{\partial \omega_i} = 0$ then $\partial p_i / \partial \omega_i$ and $\partial p_j / \partial \omega_i$ are zero, i.e. there is no strategic link between the two periods. Therefore, we are able to perform a specification test for the appropriateness of the sequential set-up by testing whether wages affect marginal costs, i.e. whether $\frac{\partial MC}{\partial \omega_i} = 0$.

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,

$$q_i = \alpha_0 + \alpha_1 p_i + \alpha_2 p_j + \alpha_3 GASOLINE_i + \alpha_4 GDP_i + \alpha_5 GCONS_i + \alpha_6 RAIL_i + \alpha_7 NETWORK_i + \varepsilon_{1i} \qquad (7)$$

where ε_{1i} denotes the error term. The variables influencing demand are as follows. p_i is a price index for airline i, p_j is an index of the price of all other airlines, *GASOLINE* is an index of the price of gasoline, *GDP* is a measure of country size, *GCONS* is consumption growth and a measure of economic activity, *RAIL* is an index for the price of rail transportation, and *NETWORK* is a measure of the size of the carriers' network. 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)[8].

Regarding the cost function, we must specify the derivatives of (2), since they enter into the first-order conditions. The marginal cost equation ($\partial C / \partial q_i$) defined implicitly in (2) is assumed to be linear in wage (ω), 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,

$$
\begin{aligned}
MC = \beta_0 &+ \beta_1 \omega_i + \beta_2 PK_i + \beta_3 PM_i + \beta_4 LOADF_i + \beta_5 STAGE_i \\
&+ \beta_6 PWIDEB_i + \beta_7 PTURBO_i + \beta_8 NETWORK_i
\end{aligned}
\qquad (8)
$$

Using these functional specifications, we can express the first-order condition for the product market (3) as,

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[8] We have checked robustness with respect to using different subsets of our demand and cost shifters. The results below are essentially unaffected by this.

$$p_i = MC - \frac{q_i}{\alpha_1 + \theta\alpha_2} + \varepsilon_{2i}$$

(9)

where ε_{2i} is the error term.

Regarding the first-order condition for wages, i.e. equation (5), we have that $A = 2\alpha_1 + \theta\alpha_2$ and $B = \alpha_2$. Moreover, we make use of Shephard's lemma such that $\frac{\partial C}{\partial \omega_i} = L_i$. Substituting this into (5), making use of (6), we arrive at our empirical specification for the management-union bargaining process,

$$-(p_i - MC)\frac{\alpha_2\beta_1(\alpha_1 + \theta\alpha_2)[2\theta\alpha_1 + (1+\theta^2)\alpha_2]}{(2\alpha_1 + \theta\alpha_2)^2 - \alpha_2^2} - L_i + \frac{\delta}{1-\delta}\frac{\pi_i}{(\omega_i - \omega_i^c)} + \varepsilon_{3i} = 0 \qquad (10)$$

where *MC* is again given by (8). Note that the estimation of (10) involves information on ω_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 ω_i^c.

Using non-linear three stages, we estimate the above system of three equations (7), (9), and (10), where the endogenous variables are given by wages, prices and output. The results are reported in Table 2, which we turn to in the next section[9].

3.1 Specification Tests

Before interpreting the results in more detail, we perform several specification tests of the structural model. In particular, we test whether the maintained assumptions of the theoretical model are in line with the empirical estimates. These tests can be thought of as specification tests of having chosen the "right" structure for the data in hand. Given that we have imposed a considerable amount of structure, there are a number of conditions, which need to be satisfied but have not been imposed *ex ante*. The purpose of this subsection is to investigate whether the "data reject the model".

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[9] Note that the above specification assumes that both the conduct parameter as well as the degree of union power parameter are 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 conditions, which need to be satisfied by the demand estimates. As can be seen in Table 2, the demand estimates are in line with our maintained assumptions. Both the own-price elasticity (-1.026) and cross-price elasticity (0.671) have the expected signs at sample mean. In addition, our maintained assumption that the own-price effect is larger in absolute value than the cross-price effect is confirmed by the data at each sample point[10]. As required by the theory, the estimates in Table 2 imply that the partial own-demand effect is negative ($\Delta_i < 0$) while the cross-demand effect is positive $\Delta_j > 0$, and that $-\Delta_i > \Delta_j > 0$. All these restrictions are met at all sample points.

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, $\partial MC/\partial \omega_i$, 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 4.21), we reject a one-stage model in favor of our two-stage specification.

Finally, a specification test can be based on whether the second-order conditions and the stability conditions of the theoretical model are met by the empirical estimates. Note that we do not impose any of these conditions on the empirical estimates. Appendix B derives the second order conditions for both stages of the game as well as the stability conditions, which need to be met by our empirical estimates. We find that the second order condition in stage 1 is satisfied, i.e. $\dfrac{\partial^2 \left(\left(\omega_i - \varpi_i^c \right)^\delta \pi_i^{1-\delta} \right)}{\partial \omega_i^2} < 0$, which guarantees the existence of stage 1 equilibrium. We also find that the second order conditions (for both existence and stability) in stage 2 are met, i.e. $A < 0$ and $H^p = A^2 - B^2 > 0$ (see Appendix B).

In sum, the estimates in Table 2 are consistent with the restrictions and maintained assumptions of theoretical model developed above.

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[10] For example at the sample mean, we have $-\partial q_i/\partial p_i = 2106701 > \partial q_i/\partial p_j = 1381027$.

3.2 Interpretation

We now interpret the results given in Table 2 in more detail. The price elasticity of demand is estimated at -1.026, while the cross-price elasticity is estimated at 0.671, 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 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. This might be explained by the fact that gasoline prices are highly correlated with fuel prices. 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.

The estimated conduct parameter θ is -0.308 (t-stat of -1.90). This implies that θ is not significantly different from zero (at the 5% level). In other words we find that the product market is consistent with Bertrand-Nash behavior. We also reject cartel behavior (t-stat of 8.07). Regarding competition in the product market, we can therefore conclude that the data is consistent with a rather non-cooperative environment. In particular, the conduct estimate for the product market is substantially lower than previous estimates for the European airline industry may have suggested. For instance, in the usual two-equation set-up where costs are exogenously treated, Röller and Sickles (2000) find conduct that is closer to monopoly. We find that the endogenous treatment of costs does matter empirically and that it reduces the conduct parameter in the airline industry.

Turning to market imperfections on the input side, we find significant evidence suggesting that unions do have considerable bargaining power. Our model estimates the union bargaining power parameter δ at 0.909 with a t-statistic of 15.35. This implies that unions have a positive and significant impact on wages and that price-cost margins are affected by the presence of unions. Putting these results together, we find that in a model that accounts for endogenous costs, input market power (as measured by δ) is considerable, while output market imperfections (as measured by θ) are estimated to be small.

In order to assess the importance of input vs. output market effects on prices and wages we use our estimated model and perform several simulation exercises. We consider four alternatives by allowing the labor market to be unionized ($\delta = .909$, i.e. the estimated degree of union power) or not ($\delta = 0$), as well as the output market to be collusive ($\theta = 1$) or not ($\theta = -0.308$, i.e. the estimated level). The simulation of these four scenarios involves solving three simultaneous equations (7), (9), 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 set at the estimated value (i.e. $\theta = -0.308$), we find that the impact of unions on prices and price-cost margins are small. Product market prices increase from 1.38 to 1.53 (some 11%), while price-cost margins increase from 31% to 38%. A similar picture emerges, when we let output markets be perfectly monopolized ($\theta = 1$), which corresponds to the right column in Table 3. Again, the impact of unions on prices and price-cost margins is negligible.

Turning to the impact of output market imperfections, we find that prices and price-cost margins are more affected. This is true independently of whether input markets are subject to union power or not. For example, price-cost margins are increased from 31% to 48% (for $\delta = 0$) and from 38% to 50% (for $\delta = 0.909$). Similarly, prices are increased from 1.377 to 1.821 and from 1.528 to 1.890, respectively.

Overall, we find that output market monopolization has a more pronounced effect on prices and price-cost margins than input market imperfections. This arises because the effect of rent sharing on marginal cost is quantitatively small. In the context of our estimates, rent sharing thus appears to be mostly about redistribution.

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.

We find that the endogenous treatment of costs does matter empirically and that it reduces the conduct parameter, which is estimated for the airline industry. Input market power (as measured by δ) is considerable while output market imperfections (as measured by θ) are estimated to be small. Our simulation results show that even though the output market imperfections are actually small, they are potentially very damaging to consumers. We find that output market monopolization has potentially a more pronounced effect on prices and price-cost margins than input market imperfections. This arises because the effect of rent sharing on marginal cost is quantitatively small. In the context of our estimates, rent sharing thus appears to be mostly about redistribution. Hence, the extent to which observed margins are deflated by rent sharing is not very large. In any event, the claim that monopoly margins would be observed in the airline industry if cost were controlled for rent sharing is not supported by our estimates. As can be seen in Table 3, prices under perfect cartelization with no union power are estimated at 1.821, while actual prices are at 1.528. We therefore find no evidence for claim that "monopoly" margins are hidden. Observed margins are lower than true margins but only to modest extent.

These results have several implications for policy. First, endogenous costs do matter significantly for the assessment of conduct in the product market conduct. Our results show that the estimated conduct in the product market is reduced when accounting for endogenous costs. Second, in the context of the airline industry, the impact of product market monopolization is potentially more serious for consumers than the presence of unions. If the output market was perfectly cartelized, the impact of input market imperfections would be negligible.

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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 ω): 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 and strategic complementarity condition

In this appendix we derive the second order conditions in stage 1 and 2 and also the strategic complementarity condition. We start with stage 2 by rewriting its first order condition (3) as,

$$\frac{d\pi_i}{dp_i} = q_i + (p_i - MC)(\frac{\partial q_i}{\partial p_i} + \theta \frac{\partial q_i}{\partial p_j}) = 0$$

For a linear demand function and constant marginal cost, the second order conditions and its Hessian can be derived as,

$$A = \frac{\partial^2 \pi_i}{\partial p^2_i} = 2\frac{\partial q_i}{\partial p_i} + \theta \frac{\partial q_i}{\partial p_j}, \quad B = \frac{\partial^2 \pi_i}{\partial p_i p_j} = \frac{\partial q_i}{\partial p_j} \text{ and } H^p = A^2 - B^2 .$$

The usual assumption on price elasticity of demand $-\frac{\partial q_i}{\partial p_i} > \frac{\partial q_i}{\partial p_j} > 0$ guarantees that prices are strategic complements, i.e. $B > 0$, as well as the existence and stability condition in stage 2, i.e. $A < 0$ and $H^p > 0$.

At stage 1, denoting $U_i = (\omega_i - \omega_i^c)^\delta \pi_i^{(1-\delta)}$, for linear demand function and constant marginal cost, we can simplify the second order condition into

$$D = \frac{\partial^2 U_i}{\partial \omega_i^c} = (\omega_i - \omega_i^c)^{\delta-1} \pi_i^{-\delta} \left[\frac{\partial \pi_i}{\partial \omega_i} + (1-\delta)\omega_i \frac{\partial^2 \pi_i}{\partial \omega_i^2} \right],$$

Note that $\frac{\partial \pi_i}{\partial \omega_i} = -\frac{\delta}{1-\delta} \frac{\pi_i}{\omega_i - \omega_i^c}$. Furthermore $\frac{\partial^2 \pi_i}{\partial \omega_i^2} = (\frac{\partial p_i}{\partial \omega_i} - \frac{\partial MC_i}{\partial \omega_i}) \frac{\partial q_i}{\partial p_j} (\frac{\partial p_j}{\partial \omega_i} - \theta \frac{\partial p_i}{\partial \omega_i}) < 0$, since

$\frac{\partial p_i}{\partial \omega_i} - \frac{\partial MC_i}{\partial \omega_i} = -2(\frac{\partial q_i}{\partial p_i})^2 - \theta \frac{\partial q_i}{\partial p_i} \frac{\partial q_i}{\partial p_j} + (\frac{\partial q_i}{\partial p_j})^2 < 0$ and $\frac{\partial p_j}{\partial \omega_i} - \theta \frac{\partial p_i}{\partial \omega_i} > 0$ for any $\theta < -\frac{B}{A}$. Therefore,

$D < 0$.

Table 1
Summary Statistics

Variable	Number of Observations	Mean	Minimum	Maximum
p_i	141	1.123	0.626	2.021
q_i	141	2304691.910	69085.130	8839172.470
ω_l	141	32019	8677	88391.72
ω^c_i	141	14233	6104	25776
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
Demand Equation		
INTERCEPT	-2.173	-5.24
p_i	-1.026	-3.05
p_j	0.671	7.54
GASOLINE	-1.835	-5.13
GDP	0.452	5.18
GCONS	0.235	3.07
RAIL	0.539	4.45
NETWORK	0.113	0.86
Marginal Cost $(\partial c\,/\,\partial q_i)$		
INTERCEPT	1.194	1.36
ω_l	0.015	4.21
PK	0.0003	2.34
PM	0.008	3.38
LOADF	-1.575	-1.07
STAGE	0.049	0.39
PWIDEB	-4.217	-2.84
PTURBO	-4.989	-2.51
NETWORK	-7.43E-7	-2.34
Union Power		
δ	0.909	15.35
Product Market Conduct		
θ	-0.308	-1.90

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

		Product Market	
		$\theta = -0.308$ (estimated product market conduct)	$\theta = 1$ (monopoly)
Labor Market	$\delta = 0.909$ (estimated degree of union power)	$p_i = 1.528$ $\dfrac{p_i - MC_i}{p_i} = 38\%$	$p_i = 1.890$ $\dfrac{p_i - MC_i}{p_i} = 49.9\%$
	$\delta = 0$ (no unions)	$p_i = 1.377$ $\dfrac{p_i - MC_i}{p_i} = 31.2\%$	$p_i = 1.821$ $\dfrac{p_i - MC_i}{p_i} = 48\%$

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