PRICE COMPETITION IN THE
INTERCITY PASSENGER TRANSPORT MARKET:
A SIMULATION MODEL

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Acknowledgement

We are grateful to two anonymous referees, Moneim Eltohami, Guido Friebel, Markus Ksoll, Erhard Michel, Marko Niffka, Paul Seabright, Frank Wagner and Christiane Warnecke for valuable comments and insights on earlier versions. We express our gratitude to Gerard McCullough for his careful reading of our manuscript. We also thank participants to the Second Conference on Railroad Industry Structure, Competition and Investment, (Evanston, October 7-8, 2004), to Séminaire d'Economie Industrielle (Direction de la Prévision, Ministère de l'Economie, des Finances et de l'Industrie, Paris, September 30, 2004), and to the International Industrial Organization Conference (Atlanta, April 8-9, 2005) for their useful comments. The authors acknowledge with gratitude the support of Die Bahn that provided data. However the views expressed remain those of the authors and in no way represent the official or unofficial views of Die Bahn or its representatives.

Abstract

We elaborate a simulation model to analyze inter- and intra-modal competition in the transport industry, based on game theory models. In this game, consumers choose a transport mode and an operator to travel on a given city-pair; operators strategically decide on prices for the services they provide. We derive the market equilibrium and simulate potential regulatory and structural scenarios. Hence our framework is a tool to measure the effectiveness of competition on a relevant market, to design marketing strategies or to evaluate the net benefit of new transport infrastructures. It can be effectively used with a limited set of detailed data.

Date of this version: January 2007

1 Introduction

In the context of liberalization of passenger transport markets, operators are required to permanently design and reform their business strategies while regulators are required to assess the effectiveness of competition rules and the definition of relevant markets. As a response to both requirements, we propose here a simulation model to analyze inter- and intra-modal competition in the transport industry, which is based on game theory models. In this game, consumers choose a mode and an operator to travel on a given city-pair, and firms decide on service quality and prices. From these assumptions we derive a market equilibrium and simulate potential scenarios. The model allows us to evaluate the effects of both structural and regulatory changes on a particular market. More precisely, we illustrate its use by measuring the impacts of the entry by a new rail operator and a change in the regulatory framework with the introduction of a kerosene tax. However the model can be applied to other purposes, such as the cost-benefit analysis of different transport infrastructures.

The markets for transport services have experienced important changes in recent years everywhere in the world, especially in Europe. The airline industry was the first passenger transport sector to be deregulated and open to competition. In Europe, the process started in 1987 to end up in 1992 with the “third package”, the full implementation of liberalization laws becoming effective in 1997. Airlines are then free to set prices; there are no limits in capacity shares; and all airlines from the community have free access to the market. Moreover, the evolution of the general network configuration into a hub-and-spoke network, and the incentives for companies to reduce costs, to increase connections and to boost demand, have changed the scope and the intensity of competition in this sector. While the hub-and-spokes network structure could have imposed barriers to entry on the quasi-monopolistic routes originating from the hub, easier and cheaper accessibility of smaller airports to more efficient aircrafts has certainly contributed to the entry of a new category of airlines into some niche markets, especially point-to-point routes. These companies are characterized by very low costs allowing them to offer lower prices. Some Low Costs Airlines are highly profitable and are gaining more and more market share in the European market. These two main changes in the structure of the air transport industry, deregulation and the entry of Low Cost Airlines, make intra-modal competition much tougher in this sector.

The liberalization process of the European railways industry started in 1991. The European Commission, in its Directive 91/440, sets three main objectives to promote railways: to increase their market share, to reduce subsidies and to liberalize access to infrastructure to enhance competition. However, the provisions of Directive 91/440 did not go far enough as they only apply to international agreements on cross border transport and do not include cabotage. A few countries went beyond the EU regulation, introduced competition and experienced the entry of new competitors on their rail networks, notably the UK and Germany. On 3 March 2004 the European Commission adopted its third railway package containing measures to revitalize the European railways by gradually opening up the market for international passenger services. Once the market is open, competition should be expected to happen quite rapidly as existing railways companies face lower entry costs than totally new entrants. This new intra-modal competition in the railways sector is expected to develop in all European countries, including the most recent additions to the EU. It would change the whole nature of competition in this industry.

Before the 1990's, rail and air transport were considered as two modes not competing with each other, because of the large differences existing in the services provided, especially in travel time and reliability. This is not true anymore. The development of High Speed technology has reduced considerably the gap between air and train travel time from city-center to city-center; and the appearance of new marketing strategies by Low Cost Airlines has allowed new customers to access air transportation. So, not only airlines and train operators are facing separately intra-model competition, but now these technical and structural changes introduce a real and fierce inter-modal competition between airlines and train operators. [Antes, Friebel, Niffka and Rompf (2004) investigate these effects in a case study on the entry of Low Cost Airlines on the German passenger transportation market.] Air and train are also subject to a strong competitor, namely private car, which has the almost unbeatable advantage of providing full scope for the driver to travel at any time.

The preceding analysis leads us to consider transport between an origin and a destination as one market with differentiated products competing with each other. Here, passengers can choose among several modes and even among several companies within each mode providing the desired transport service.

Product differentiation is due to the fact that passengers have different valuations for the service offered by an operator, and it is used strategically by competitors to avoid fierce price competition. By proposing different services, operators are able to target different segments of the population, and this behavior affects pricing decisions.[1] When one turns to the question of performing an empirical analysis of a differentiated-products market, several elements must be properly specified. The first element concerns the determination of the number of products on the market, requiring a precise analysis of consumers' choices, sometimes collected through questionnaires. Fortunately, for a given origin-destination market, the number of alternatives is usually small in mode choice modeling as the number of existing transport modes is limited as well as the number of transport service providers. Secondly, precise information is required concerning the socioeconomic status of the traveler (income, household composition, etc), the nature of the trip (motivation), and the characteristics of alternative modes (travel time, frequency, etc). These data are usually gathered through time

[1] IDEI (2003) discusses the role of product differentiation in the competition process in details.

demanding and costly questionnaire surveys, each of which is specific to the city-pair under consideration, as well as the category of consumers. We present later a methodology for avoiding the difficult task of collecting rare and detailed data for a specific application while addressing the competition issues and taking into account the existence of different types of travelers.

For this particular differentiated-product market between an origin and a destination, we model demand and supply in order to recover equilibrium outcomes. Market demand is derived from a general class of discrete choice models of consumer behavior. Travelers can first choose the mode they want to use; then within this mode, they decide on a specific transport service. For this discrete choice structure, an appropriate specification for an empirical analysis is the nested logit model. On the supply side, firms choose the prices of the service they provide, given a quality of service which is exogenously determined in our framework. Market outcomes are derived within the context of a Nash equilibrium. Firms behave strategically: Each firm determines its prices knowing that its competitors do the same. An increase in one firm's price has a positive impact on its margin but a negative impact on its traffic. This can lead to a traffic increase for the other competitors who may want in turn to set slightly higher prices to increase their margins. The equilibrium outcomes are then dependent on own and cross price demand elasticities as well as marginal costs.

The strategic behavior of transport operators is an essential aspect of competition which is often left aside in models only based on the demand side of the market. Even though the estimation of partial equilibrium models in markets with product differentiation has been undertaken recently as in Berry *et al*. (1995) or Besanko *et al*. (1998), it has not been done in the passenger transport industry. To analyze the impact of entry on an inter-city rail line, Preston, Wardman and Whelan (1999) estimate a demand model, a cost model, and simulate different forms of competition. More recently, Johnson and Whelan (2003) present a demand-cost model developed by the Institute of Transport Studies (University of Leeds) to look at the potential for on-track competition in the UK. Another study conducted by Glass (2003) applies the same demand-cost model as the one used by Johnson and Whelan to another case. All these studies concentrate on intra-modal competition only; they do not consider inter-modal competition and they do not account for competitors' reactions to a change in the market, leading to a new equilibrium. However, the importance of strategic behavior and equilibrium has been already illustrated by Brander and Zhang (1990) and by Oum, Zhang and Zhang (1993) in the transportation area using models with homogeneous goods.

Intra- and inter- modal competition on a city-pair in Germany, specifically the link Cologne-Berlin, serves to motivate our model and to develop our methodology. This link is of particular interest here because all forms of competition described earlier are present as it is explained below. The analysis is organized as follows. Section 2 details the Cologne-Berlin market for passenger transport services and the associated data that are used to apply our methodology. Section 3 presents the demand-and-supply model on this market and discusses the equilibrium features. The calibration method is explained in section 4. Finally, section 5 provides the results of counterfactual experiments, which allows us to evaluate the implications of potential evolutions of the market configuration, including the plausible entry of a low cost rail competitor, or regulatory changes affecting costs of the companies present in the market. Section 6 draws some concluding remarks.

2 Data on a generic example

To motivate our modeling framework, we consider competition for passenger traffic on the Cologne-Berlin link in Germany. This origin-destination pair is appropriate for three main reasons. First, this link, which is a 600 km long route connecting two of the largest German cities from west to east of the country, represents a significant share of total long distance passenger traffic in Germany. Second, because of these geographical features, the link involves a diversity of travelers (namely passengers for business and leisure purposes) which certainly explains the differentiation in transport services provided between Cologne and Berlin. Not only are there several transport modes, but there are also several active operators. Three main passenger travel modes are available on this link: Rail (operated by Deutsche Bahn AG, DB herein), road (operated by private cars) and air.[2] The air service is provided by three recently entered Low Cost Airlines (LCA), namely DBA, Germanwings (GW) and Hapag-Lloyd Express (HLA) in the market, in addition to the national carrier Lufthansa (LH). The LCAs' growing popularity is fueled by their offer of competitive prices, which, according to these airlines, are mainly driven by a low cost structure. This alternative is attractive as the air service is no longer an expensive solution while it is often considered as a faster transport mode than rail. Moreover, not only these LCAs are direct competitors to Lufthansa and DB, but, by challenging Lufthansa, they force this airline to enter into a fiercer competition with DB. Finally, the Cologne-Berlin market already saw intramodal competition in passenger rail transport. Indeed, during 2003, a French rail operator, Connex, operated a daily service on this link. It was not successful and eventually it was closed.

All of these elements motivate our interest in analyzing the functioning of inter- and intra-modal competition in this context and in simulating the effects of possible exit or entry on this market recently opened to competition on the rail segment, as well as the changes of public policy aiming for example at encouraging rail travel or reducing exhaust emissions.

Data on traffic, characteristics of transport services and prices have been provided by Deutsche Bahn AG for one year, namely 2003. All data available are gathered in Table 1. Only these data are used at the calibration stage. We use daily traffic data for one-way tickets

[2] We do not consider buses here as this mode is negligible on the link Cologne-Berlin.

on the Cologne-Berlin link for the two business and leisure segments. For every transport mode and the two main categories of passengers, the price measured in Euros corresponds to the most common price that a representative customer usually pays for a trip between Cologne and Berlin during year 2003. Concerning the characteristics of services, three variables are available: Speed measured in kilometers per minute (km/mn), frequency per day, and capacity per day (seats available per trip).[3]

Values for marginal costs are provided by DB for the rail alternative. Moreover, DB collects cost data on competitors. For LCAs, DB can provide a measure of average variable cost per seat-kilometer, computed by dividing the variable part of total costs by the total number of seat-kilometers. We then multiply this measure by the distance of a trip between Cologne and Berlin to derive a measure of average variable cost per seat. It is a relatively correct approximation of marginal costs for this link. Indeed, given that these values are only based on the variable costs of each different transport alternative (and not on their fixed costs) and given that we take into account the distance, they are relatively correct measures of incremental costs for a specific link, which, in turn, are generally the relevant variables to look at when entering or exiting a market is the decision at stake.[4] Note that these data were not available for the different segments (business and leisure). However, we attribute the derived measures specifically to the leisure market because the business models of LCAs and, to a lesser extent, the one of DB are mainly driven by the leisure traffic according to different

[3] Note that capacity should not be confused with frequency. For airlines, we consider the capacity of the type of aircrafts operated on the link. For train, we use the capacity of a train run on the link. For car, we assume 5 seats available per trip in a car.

[4] According to Jara-Diaz (1982) and Brander and Zhang (1990), the best method to obtain marginal costs would be to estimate the overall cost function and to derive marginal costs for a specific link from this cost function. Unfortunately this is not possible here due to a lack of adequate data. In addition, note that marginal costs are defined per seat and not per passenger; this is because we do not have information on load factors. However, as we use transport variable costs in the process of approximating marginal costs, DB's representatives consider that our measure is a reasonable approximation of marginal costs per passenger. This is in part because variable costs are much lower than fixed costs in the transport industry.

experts.[5] It means that we must consider the marginal costs for the business market as missing data. In Appendix 3 we explain how to deal with this issue.

3 The economic model

In this section we present a framework for describing intra- and inter- modal competition between transport alternatives, with the example of the Cologne-Berlin link as a background. In the next section this model is calibrated using the data collected on this specific link and applied to evaluate the effects on prices of the exit or entry of a new competitor and changes in product characteristics.

In such a differentiated-products framework and oligopoly structure, firms are competing both in terms of prices and product characteristics. Here we focus on price competition assuming that, in the short run, product characteristics are fixed. First we describe the demand side, and then we derive the pricing strategy of firms involved in a Bertrand-Nash competition.

3.1 Demand side

We consider the choices made by potential travelers willing to travel from Cologne to Berlin in terms of mode and service provided. Three transport modes (rail, air, road) are present on the link, with diversification on the air segment: three LCAs and the incumbent carrier, Lufthansa. The alternatives are characterized by a quality parameter and a price. In addition we assume the existence of an outside alternative: Instead of choosing one of the services offered to travel from Cologne to Berlin, consumers may decide not to travel. Hence

[5] This assumption was also confirmed by the representatives of DB who provide the data used in this model.

the total market size is defined as the number of consumers who would be potentially interested in making the trip.

The potential travelers for a one way trip from Cologne to Berlin are heterogeneous. We consider two main categories in the passengers' population: Business and leisure travelers. There are N_B (respectively, N_L) potential travelers on the business (leisure) market who may either travel using one of the transport services supplied, or otherwise choose not to travel (the outside alternative). These two types of travelers differ by their own valuations for the characteristics of transport services and their own sensitivity to prices. In what follows, we account for these two types of passengers by considering two separate markets: The business market and the leisure market. In this way, the calibration procedure we follow produces two sets of parameters characterizing the different tastes and willingness-to-pay of the two groups of customers. In the sequel, the two markets are treated symmetrically and we skip indexes *B* and *L* without loss of generality and ambiguity.

Assume that each consumer makes its choice in a sequential way: She decides about the transport mode and then the service to travel with. The consumer choice structure is depicted in Appendix 1.[6] A choice, i.e., an alternative or a product, is a combination of a transport mode and a service provided by a transport operator. Note that, for road, the transport operator is the driver in her car. There are J alternatives classified into G groups. Here we have four groups $g = 0,1,...,G$ where group 0 corresponds to the outside alternative (herein, OG), the other groups correspond to the three modes, i.e., rail, air, road.

[6] The choice of a structure of transport alternatives can affect the results drastically as noted by Berry (1994). Two main criteria should be satisfied when selecting a choice tree. The latter should reflect the differentiation of products and it should not be perturbed by endogenous factors. For instance, a sequence of nests based on the structure and levels of observed prices must be avoided because it presupposes the choice of customers which select an alternative by comparing the different price/quality bundles. When several structures of choices are conceivable, the econometric literature proposes statistical tests, like the Hausman test, in order to select one of them. Here, because of the lack of data, we can just compare the different possible structure of nests and check for the realism of results under the different structures. Here fortunately, there are not too many nested structures that we can envision. Note that, in particular, we have a model structure where the airline incumbent (LH) is separated out from the LCAs. The results (available from the authors) are very similar to the ones presented in this text.

Consumers' utility depends on quality and prices. We attribute a quality index ψ_j, and a price p_j, to every alternative. This quality index is later decomposed as a weighted sum of different service characteristics, where each weight reflects the own evaluation of each component by the customer. The utility function associated with alternative j ($j = 1, 2, ..., J$) is written as follows:

$$U_{ij} = V_j + \varepsilon_{ij} , \tag{1}$$

where V_j represents the mean utility level common to every passenger (the deterministic part) and ε_{ij} (the random part) corresponds to the departure of consumer i from the common utility level, specific to product *j,* i.e., to the unknown consumer *i*'s tastes on product *j*. This mean utility level can be further decomposed as:

$$V_j = \psi_j - hp_j , \tag{2}$$

where *h* represents the sensitivity of utility to price, or *marginal utility of income*.

We adopt here a nested logit specification for the random preferences. In this framework, products within the same group are closer substitutes than products from different groups. To allow for this dependence and correlation between the utilities of alternatives in common groups, the random part can be specified as the weighted sum of unobserved variables, which represent consumer *i*'s taste for any alternative belonging to group *g*:

$$\varepsilon_{ij} = \sigma \nu_{ig} + (1 - \sigma) \nu_{ij} \quad \forall i = 1, ..., N . \tag{3}$$

The parameter σ is to be estimated and gives a measure of degree of correlation between alternatives belonging to the same group: The parameter σ must lie between 0 and 1. The higher σ, the higher the correlation between alternatives of the same group. For this reason, σ is the *degree of intragroup correlation*. The random components ν_{ig} and ν_{ij} are assumed to be distributed such that each term, and consequently ε_{ij}, has the standard extreme value distribution.

The consumer decides on a mode to travel with and on a service provider operating this transport mode. Consumer *i* chooses the utility-maximizing alternative j belonging to group *g* that satisfies:

$$U_{ij} > U_{ij'} \quad \forall j' \neq j. \tag{4}$$

Given the preceding specification of the random indirect utility function, the distribution assumptions on the error terms, the consumer's choice, and a standard assumption that the mean utility of the outside good is set to 0, the nested logit probability of choosing alternative *j* is defined as[7]

$$s_j = s_{j|g} s_g, \tag{5}$$

that is to say, as the product of the probability of choosing alternative *j* conditional on choosing group *g*, i.e.,

$$s_{j|g} = e^{V_j/(1-\sigma)} \Big/ D_g \tag{6}$$

[7] A detailed derivation of the nested logit model is proposed by Ben-Akiva and Lerman (1985).

and the probability of choosing group g, i.e.,

$$s_g = \frac{D_g^{(1-\sigma)}}{\left(\sum_g D_g^{(1-\sigma)}\right)}, \tag{7}$$

where

$$D_g = \sum_{j \in g} e^{V_j/(1-\sigma)}. \tag{8}$$

Observed market shares are measures of these probabilities. Then, applying the methodology developed by Berry (1994) and expressing now the mean utility level as a function of observed market shares as measures of choice probabilities, the specification of the demands associated with alternative j is given by

$$\ln\left(s_j\right) - \ln\left(s_0\right) = \psi_j - hp_j + \sigma \ln\left(s_{j|g}\right). \tag{9}$$

The observed market shares s_j and $s_{j/g}$ are computed as $s_j = \frac{q_j}{N}$, and $s_{j|g} = \frac{q_j}{N_g}$, $j = 1, 2, ..., J$, respectively, where in turn, q_j is the quantity of product j on the market (either business or leisure), N is the size of that market and N_g the size of market segment g. s_0 is the market share of non-travelers: $s_0 = 1 - \sum_{j=1}^{J} s_j$. With this specification, we obtain the own price elasticities of demand as:

$$\eta_j = \frac{dq_j}{dp_j} \times \frac{p_j}{q_j} = hp_j \left(s_j - \frac{1}{1-\sigma} + \frac{\sigma}{1-\sigma} s_{j|g} \right) \quad \forall j \,, \tag{10}$$

and the cross price elasticities as

$$\begin{aligned} \eta_{j,k} &= \frac{dq_j}{dp_k} \times \frac{p_k}{q_j} = hp_k s_k \quad \text{if } j \neq k \quad k \notin g,\ j \in g, \\ \eta_{j,k} &= \frac{dq_j}{dp_k} \times \frac{p_k}{q_j} = hp_k s_k \left(\frac{\sigma}{1-\sigma} \times \frac{s_{k|g}}{s_k} + 1 \right) \quad \text{if } j \neq k \quad j,k \in g. \end{aligned} \tag{11}$$

According to Anderson, de Palma and Thisse (1992), the consumer surplus is defined as the expected value of the maximum of utilities and is computed as:

$$CS = \frac{1}{h} \ln \left[1 + \sum_{g=1}^{G} \left(\sum_{i \in g} \exp\left(\frac{V_i}{1-\sigma} \right) \right)^{1-\sigma} \right]. \tag{12}$$

3.2 Supply side

In our framework, each firm provides one product, i.e., one transport service between the origin and the destination. We assume that the mode-service 'road and car,' is offered by a firm competing with the other alternatives. If c_j is the marginal cost of providing transport service by firm *j* and if K_j represents fixed costs, the profit function of firm *j* is

$$\pi_j = \left(p_j - c_j \right) q_j - K \,. \tag{13}$$

For all transport services supplied on the city-pair under consideration, firms choose prices of transport services so as to maximize profits knowing that their competitors do the same. That is to say, we assume Bertrand-Nash competition.[8,9] As in Ivaldi and Verboven (2005), the outcome of this Nash equilibrium is defined by a set of *J* necessary first order conditions:

$$p_j = c_j + \frac{1-\sigma}{h\left(1-\sigma s_{j|g} - \left(1-\sigma\right) s_j\right)}, \tag{14}$$

where $s_{j/g}$ is the market share of alternative *j* in group *g* and s_j is the market share of alternative *j* in the total market. The price of product *j* is equal to the marginal cost of product *j* plus a markup term. This expression is related to the values of own price elasticities in the following way:

$$\frac{p_j - c_j}{p_j} = -\frac{1}{\eta_j}. \tag{15}$$

In other words, the price-cost margin is equal to the inverse of the elasticity which is the measure of the willingness-to-pay for the service. It means that the firm prices the transport service so as to extract all the rent from the customer.

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8 One may question the assumption that the service 'road and car' is provided by a profit maximizing firm. Alternatively we could assume that the firm sets the price just to cover average cost. When we estimate a model in which prices for car are set equal to average costs, we do not find a significant difference with the case of profit maximizing firms.

9 The choice of an assumption on the conduct of firms may affect the results. On a city-pair market, a competition in terms of service frequencies, i.e., in terms of quantities *à la* Cournot could also be relevant. Given the lack of data, we cannot statistically test the relevance of conduct assumptions. We believe that the Bertrand assumption is adequate as we look at the working of the market when players have already entered and specified the characteristics of their offer of transport services.

Summing up, the equilibrium is fully characterized by Equations (9) and (14). Solving these equations provides a unique solution.

4 Calibration

As a set of consistent data collected on a regular basis is not available here, we cannot proceed to a statistical estimation of the previous equilibrium model. We instead calibrate it using the available data on prices, markets shares, characteristics of transport services, and some values for marginal costs. In other words, we use the available data to construct compatible values for the unknown parameters of the model. A calibrated model does not allow us to perform a statistical analysis but it can be used as a tool to decipher the working of an industry. Calibrating the model consists in numerically solving the system of equilibrium equations in terms of the unknown parameters, namely demand parameters.[10] Using the available data this task is performed by an algorithm that reflects the structure of our model.

4.1 Algorithm

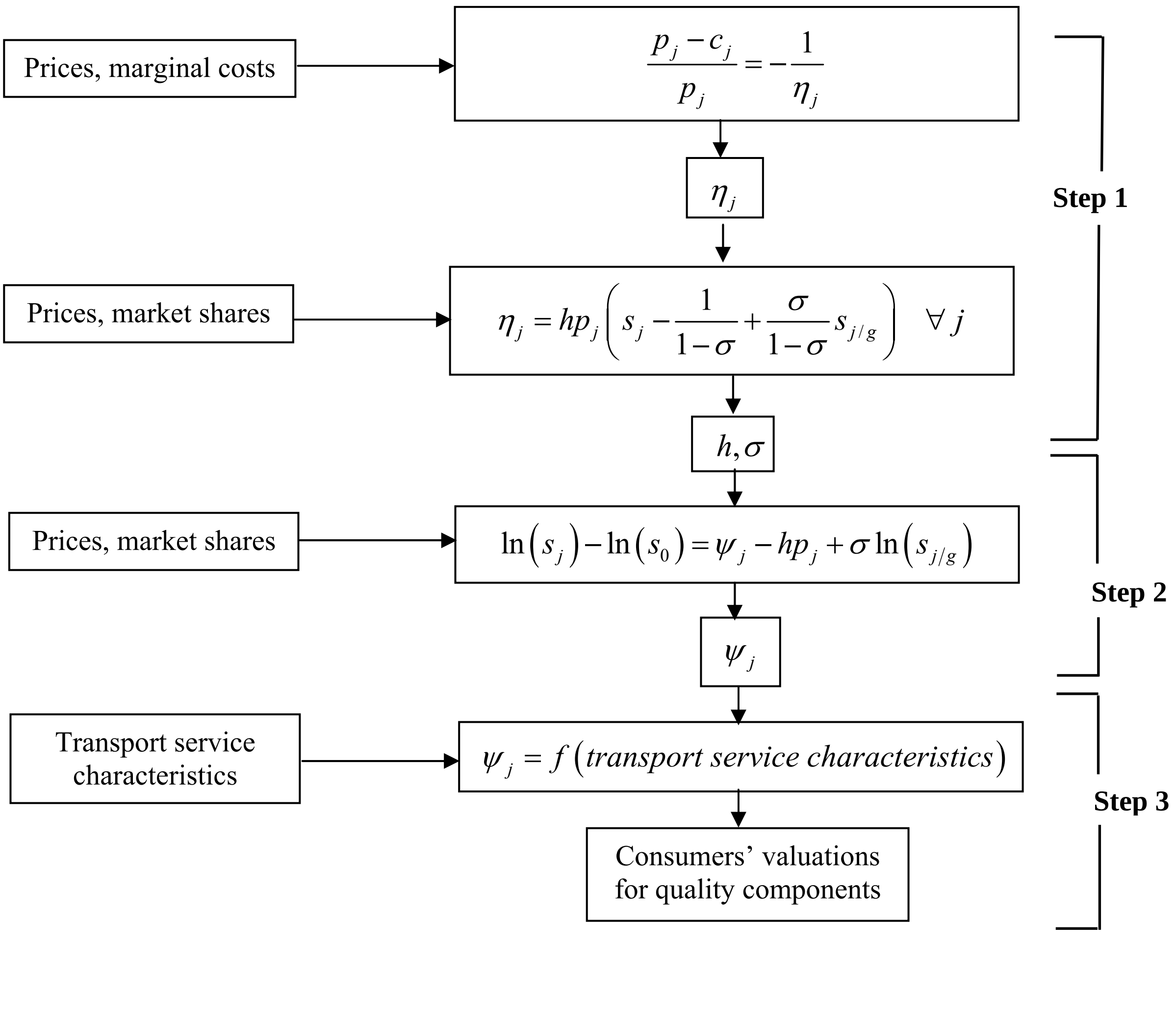
The objective of the calibration is to recover values for the parameters describing market equilibrium, using available data on the Cologne-Berlin link. We briefly describe the calibration algorithm and then we present it in a diagram form. In Appendix 3 we provide details of the computations implemented at each step and we show how we adapt this general algorithm to the data available in our example.

The calibration algorithm consists of three main successive steps. The first step is to numerically solve the system of Equations (10) and (14) which allows us to compute values for the demand parameters h and σ. The second step is to recover the values for the quality

[10] All computations for the calibration and later for the simulations are performed using the GAUSS software.

index ψ_i. This is done by inverting the system of demand Equations (9). Finally, in order to compute consumers' valuations for the different service characteristics, we express the quality index as a linear combination of these characteristics and we solve this system of equations. Diagram 1 displays this algorithm in a graphical way.

Diagram 1: Calibration Algorithm



Applying this procedure yields the results gathered in Table 2.a, Table 2.b and Table 3. Table 2.a provides the values of market shares when one accounts for potential travelers who did not make the trip. It also provides values for the calibrated parameters h and σ, and we finally give measures of own price elasticities. Table 2.b displays the measures of cross price elasticities computed at equilibrium. Table 3 presents the results of the last two steps of the calibration, giving measures for quality indexes and their decompositions. The following subsection discusses the results.

4.2 Results for the Cologne-Berlin market

As mentioned earlier, we consider two separate markets: one for business travelers and one for leisure travelers. We also assume arbitrarily that the share of the outside alternative, i.e., customers who do not travel, represents 15 percent, 30 percent or 60 percent of the total population of potential travelers, i.e., the market size. The results are displayed in Appendix 2. The first half of Table 2.a presents the values of market shares of the different alternatives, measured according to our market size based on potential travelers. Table 2.a also provides the values of two parameters of consumers' utility function: Marginal utility of income and coefficient of intragroup correlation. The first value is interpreted as the sensitivity of utility to price. This measure is higher for leisure passengers ($h \approx 0.035$) than for business passengers ($h \approx 0.022$), as we could expect. The second parameter is a measure of correlation of alternatives belonging to the same mode. This parameter is closer to zero than to one ($0.15 < \sigma < 0.50$) in both markets, which implies that customers do not value more the mode than the a particular provider. (See the definition of σ in Section 2.) This may be due to the fact that there is not much variability between LCA attributes, or that LCAs can be interpreted as substitutes for surface modes as well. Nevertheless, as this parameter is different from zero, some modal effects play a role in the consumers' decisions.

Table 2.a also provides estimates for own price elasticities of demand. First, note that these values are specific to the Cologne-Berlin city-pair and as such, they may not be comparable to national level measures. Indeed, here the traffic distribution between modes and types is different from what we observe from time series tables for European countries (European Commission: Energy and Transport in figures, 2003). In addition, on this link the degree of competition is higher, leading to higher elasticities (within Germany, other OD pairs are operated by less than 3 airlines). Second, we note that the ranking of these elasticities with respect to services differs with passengers types. For business travelers the elasticity is higher for airlines services, whereas it is higher for car in the leisure segment.

Finally, Table 2.a provides values for consumer surplus showing that the consumer surplus derived from traveling decreases as the number of non-travelers increases.

Table 2.b displays the measures of cross price elasticities computed at equilibrium. The values are relatively intuitive. They express the higher degree of substitutability between rail and air transport on the leisure market compared to the business market, when considering an increase in train prices. As noted earlier, rail is the mode preferred by leisure passengers in terms of quality, but consumers are also attracted by the available low airlines fares.

Table 3 summarizes the measures of quality of service. The upper part of Table 3 displays the values for the quality effect of each provider of transport service on consumers' utility. Note again a discrepancy between the two categories of travelers. Business passengers value services provided by Lufthansa or another airline more than any other mode. Leisure passengers are more attracted to train or car services than to airlines. This is quite reasonable, as schedules and travel time matter more for someone on a business trip.

The second half of Table 3 provides the valuations of the different components of quality. Recall that the quality index is expressed as the linear combination of components affecting quality (idiosyncratic effect of the transport service provider, speed, frequency, capacity). As expected we see that speed has a positive effect on quality, as well as frequency[11] and capacity. The parameters associated with the alternative-specific dummy variables have to be interpreted as a fixed effect on quality once the effects of speed, frequency and capacity are taken into account, relatively to the quality of the omitted mode, car. It is not surprising to find a negative coefficient for the three dummy variables, as the most attractive aspects of quality for an operator have already been accounted for (speed, frequency and capacity). What remains is flexibility, the possibility of stopping during a trip for example, for which car performs better.

In our simulation, the weights are now transformed into a monetary valuation of these different components of quality for each of the two categories of travelers. Consider the case where the outside alternative has a market share of 15 percent on the business market and 30 percent on the leisure market.[12] The values for the quality characteristics are interpreted as follows. For business travelers, an increase in speed by 1 kilometer per minute, or 60 kilometers per hour, is equivalent to a reduction in price by 56 Euros, while for leisure travelers it is equivalent to a price reduction of 27.7 Euros. Business passengers have a higher valuation for speed than leisure passengers do. If we look at a unit positive variation in the alternatives respective frequencies, we find on the business market that it has the same effect as reducing price by 0.95 Euros for DB, 3.7 Euros for DBA, 8.7 Euros for HLX, 13.5 Euros for GW and 2.95 Euros for LH. These effects are similar on the leisure market, with lower magnitudes in price changes. Moreover, increasing the frequency of DB service by 2 for business travelers is equivalent to increase speed by 2 kilometers per hour, and this corresponds to a price reduction of 1.82 Euro. Business travelers are almost indifferent in a frequency improvement of train service. However, adding 2 more flights per day to the GW

[11] In our specification the inverse of frequency has a negative effect on quality, implying a positive effect for frequency.
[12] A smaller share for the outside alternative on the business market compared to the leisure market seems to be a reasonable assumption for comparison purposes.

schedules results in the same increase in utility as a 28 kilometers per hour faster trip or a reduction of 20.6 Euros in the plane ticket. This is due to the fact that business travelers favor air transport more than land transport and that DB has already a high number of daily trips compared to GW. There is a decreasing marginal utility to frequency. Overall these results comfort our intuition.

5 Simulations

Once the equilibrium parameters are known, simulations for new market configuration can be run. The impact of any change in prices, quality characteristics, marginal costs, or even the entry or exit of a competitor can be measured, in terms of variations in the other firms' prices and market shares. Variations in consumer surplus can also be evaluated.

We present four simulations. The first two simulations are aimed at assessing the robustness of our methodology. To do so we simulate the entry of the train operator Connex and the entry of the three LCAs in 2002, two events for which we observe the actual realizations, which can then be compared with the predicted outcomes in our model. The last two simulations are motivated by the policy debate in Germany and Europe. They are aimed at evaluating the impact of the entry of a more efficient rail operator on the state of modal competition and the effect of a kerosene tax as an instrument to affect modal choice and hence the state of the environment. The outcomes of these four simulations are now presented in detail, and some numerical results are displayed in Appendix 2.

5.1 The entry of InterConnex on the Cologne-Berlin link

The train operator Connex decided to operate on the market in 2002 and exited in 2003. To simulate this entry allows us to measure the impacts on market shares of each competitor, taking into account their price reactions; hence it allows us to evaluate the commercial feasibility of this entry. We find that the simulated market shares of Connex are very low, mostly due to a low service quality level offered to travelers, particularly with respect to travel time, and to price levels that were not as attractive as those of LCAs. In other words, our model explains the effective exit of Connex.[13]

5.2 Entry of Low Cost Airlines

In order to validate the prediction power of our methodology, we apply it to the same market in 2001, before the entry of LCAs. At that time, only DB, DBA and Lufthansa were operating the market, and the cost structure of DBA was closer to that a regular company. Here we look at the impact of the entry of two LCAs, namely HLX and GW, on the market in 2002, taking into account the changes in costs for DBA which is now considered as an additional LCA. For this simulation, we have information on prices and market shares only for the leisure market in 2001. For this reason we only look at the leisure segment.

In this case we first have to calibrate the equilibrium before entry. To do we apply the methodology presented previously. One main difficulty is that, given the need to compare the simulations with realizations in year 2003 when entry actually occurs, we must be sure that the size of the before-entry and after potential markets are comparable. This adds another constraint in the simulation process.

Then we can proceed to the simulation of the LCAs' entry using the entrants' observed characteristics and the marginal costs for each alternative as observed in 2003. This allows us to compare the predicted and observed market shares on an equal footing.

The simulation results are presented in Table 4. By comparing the predicted prices and market shares with their observed values provided in Table 1, we observe that they are of the

[13] It should be noted, however, that the InterConnex service was not primarily directed at Cologne-Berlin travelers. But apparently, the market share on intermediate ODs was not on a sustainable level either.

same magnitude. The sources of differences come from several changes happening at the same time, such as the entry of two new operators and the changes in the characteristics and marginal costs for every alternative. These changes lead to a new and somewhat different market structure for which we can expect equilibrium parameters to have varied slightly between 2001 and 2003 as well.

Nonetheless, this exercise shows that our model is able to approximate the realized equilibrium and hence that our methodology is relatively robust.

5.3 On-rail competition: The entry of a Low Cost Train

Our third simulation consists in a structural change in the market, directly related to the liberalization process in the railways industry. We evaluate the consequences of the entry of a new operator on the link, providing exactly the same service as DB's, but benefiting from a more efficient cost structure: This new entrant is assumed to face half DB's marginal costs, and this is why we call this experiment the Low Cost Train scenario. It is aimed at evaluating the scope for on-rail competition. In this sense it is a test of one of the major elements of the rail policy supported by the most recent European directives and the White Paper on the European transport policy.

Results on this simulation are presented in Table 5. What happens in this context of tougher competition? First, prices decrease for all alternatives, particularly for the incubent railway, and especially in the leisure market where passengers favor this transport mode: Prices drop by almost 30 percent. Secondly, the entry of a new player has the expected effect on market shares for all firms already on the market. Indeed all incumbents loose traffic, particularly airlines, which experience a fall of 25 percent to 55 percent of their market shares on the leisure segment depending on the share of the outside alternative. The new competitor affects the airlines more than it affects DB, which loses less than 27 percent of its market share.

The mechanisms here are as follows. First, a new competitor starts to operate the link proposing very competitive fares, thanks to low marginal costs. The entrant, which has the same characteristics as DB, offers tariffs closer to (or even lower than) Low Costs Airlines. On the business market, where land transport is less valued by customers, we observe a moderate reaction of airlines for which the threat of a new train, even with low prices, does not have a major impact. The most significant changes in this market configuration are for traffic on the leisure segment. Before the entry of the Low Cost Train, people were more willing to travel by train than any other mode. (See Table 3.) However, some passengers were still attracted by the lower tariffs offered by airlines. Now, the new train, which provides exactly the same highly valued service as DB, proposes prices even smaller than the ones of LCAs, which are not able to match these changes in prices by the same amount. The Low Cost train eventually captures a significant proportion of the traffic. However, the incumbent train operator is not driven out of the market because it remains competitive with other modes, thanks to the structure of the nested logit model.

This scenario exhibits an important effect that bears on the portion of potential travelers. The Low Cost train being less expensive, it forces all transport services incumbents to reduce their prices. As a result, traffic on both leisure and business markets is induced, with a larger effect on the leisure segment. In Table 5, we can read that the outside option market shares decrease by a significant negative magnitude, from 26 percent to 55 percent for leisure travelers. Consumer surplus rises by a considerable amount.

This scenario shows that on-rail competition is viable and beneficial to consumers.

5.4 Effect of a new kerosene tax

Our fourth simulation here consists in evaluating the effects of a change in the regulatory framework. In view to affect the modal choice so as to achieve a more balanced situation in favor of the rail which produces much less atmospheric pollution, the German government has envisioned the introduction of a kerosene tax of 65.45 cents per litre. This tax could feed a fund that could be used to improve rail infrastructure and services.

The introduction of a kerosene tax of 65.45 cents per litre amounts to increase in airline cost (per passenger-kilometer) of 15 percent. We simulate this change in airline costs and compute the new equilibrium. The results are presented in Table 6. We notice first that this increase in airlines costs induces an increase in airline prices by 11 percent. This is also true for the other modes but to a lesser extent. Given the higher airline prices, the railway company anticipates a gain in traffic and increases its fares by a small amount to increase its profit. This phenomenon is observed in both markets, but it is slightly more pronounced in the business market where the fare increases are greater because air carriers know that business passengers are less sensitive to variations in prices than leisure travelers. These changes in tariffs imply changes in demand and market shares. As expected, airlines loose a relatively high proportion of traffic, between 8 percent and 25 percent for LCAs and between 11 percent and 40 percent for LH. These losses are diverted to other modes and to the outside alternative category. The higher prices and losses in global traffic have a negative impact on consumer surplus (absent of environmental gains).

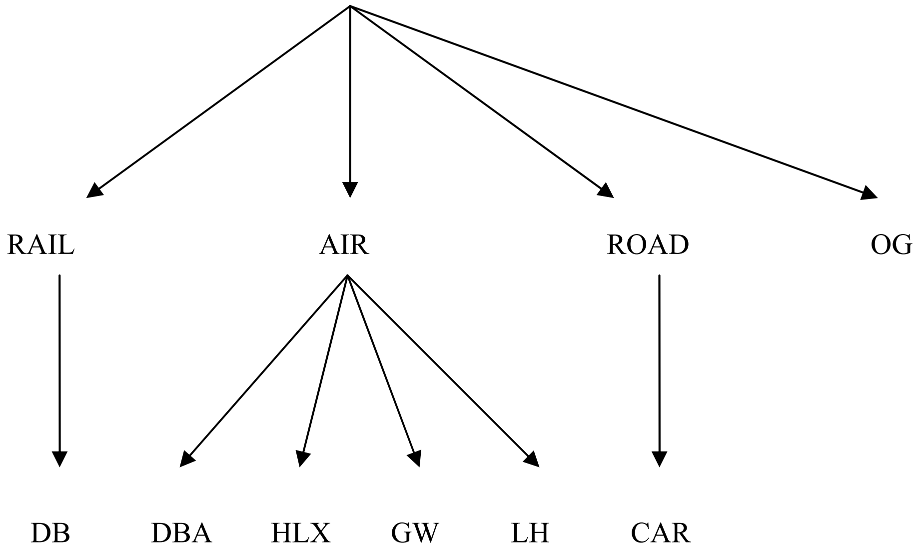
6 Conclusion

A first important conclusion to be drawn from this study concerns competition policy in the transport industry. To evaluate the effectiveness of competition in a particular market of transport services, we need to account for all potential travelers, all modes and all firms. This result should be useful for defining relevant markets. A second important conclusion is that, based on our framework and the lessons drawn from the counterfactual experiments we have discussed, a small number of competitors is enough to create a high degree of competition.

The model and methodology elaborated in this study constitute a useful and practical tool in the evaluation of market changes, both from the firms' viewpoints and the regulator's viewpoint. This instrument allows us to predict market outcomes and welfare effects following some political or structural changes. It can be used as a tool for evaluating the costs and benefits generated by the access provided by a new transport infrastructure when it affects the characteristics of a transport service in terms of speed, frequencies and reliability. The novelty is to perform this exercise in the context of an equilibrium model of oligopolistic competition, without requiring detailed data.

The method has proved to be performing well already, but further research is needed to capture specific or hidden effects, by relaxing some assumptions of our model. For instance, it would be interesting to incorporate flexible forms for the marginal costs instead of considering them as constant, and to introduce non linear prices as this is more appropriate to both air and rail pricing. It would also be interesting to consider a larger network with more than two nodes and a more complex structure of hubs and spokes.

APPENDIX 1: Consumer choices



APPENDIX 2: Tables

Table 1. Data on the link Cologne-Berlin.

		Traffic Modal Shares %	*Alternatives Shares %*		*Prices Euros*		*Speed Km/Min*	*Frequency Trips/Day*	*Capacity Seats/Trip*	*Marginal Costs**	
			Business	*Leisure*	*Business*	*Leisure*				*Business*	*Leisure*
Rail	***DB***	**31.1**	**16.9**	**56.4**	**90.0**	**60.0**	**138.5**	**16**	**736**	**Na**	**13**
Air	***DBA***	**14.8**	**18.4**	**7.1**	**169.0**	**51.2**	**404.6**	**8**	**136**	**Na**	**26**
	HLX	**13.8**	**17.1**	**6.6**	**169.0**	**46.7**	**404.6**	**5**	**148**	**Na**	**26**
	GW	**8.2**	**10.2**	**3.9**	**169.0**	**46.1**	**404.6**	**4**	**144**	**Na**	**26**
	LH	**14.3**	**17.8**	**6.9**	**240.0**	**53.4**	**404.6**	**9**	**115**	**Na**	**26**
Car	***Car***	**17.9**	**19.6**	**19.1**	**110.0**	**80.0**	**114.5**	**Infinity**	**5**	**Na**	**na**

* Estimates provided by DB.

Table 2.a. Equilibrium outcomes.

			BUSINESS			***LEISURE***		
Share of the outside alternative			***15%***	***30%***	***60%***	***15%***	***30%***	***60%***
Market Shares %	***Rail***	***DB***	**14.4**	**11.8**	**6.8**	**47.9**	**39.5**	**22.6**
	Air	***DBA***	**15.6**	**12.9**	**7.4**	**6.0**	**5.0**	**2.8**
		HLX	**14.5**	**12.0**	**6.8**	**5.6**	**4.6**	**2.6**
		GW	**8.7**	**7.1**	**4.1**	**3.3**	**2.7**	**1.6**
		LH	**15.1**	**12.5**	**7.1**	**5.9**	**4.8**	**2.8**
	Car	***Car***	**16.7**	**13.7**	**7.8**	**16.2**	**13.4**	**7.6**
	Outside alternative		**15**	**30**	**60**	**15**	**30**	**60**
Marginal Utility of Income			**0.023**	**0.022**	**0.021**	**0.040**	**0.035**	**0.027**
Coeff. of Within Group Correlation			**0.15**	**0.17**	**0.17**	**0.20**	**0.33**	**0.48**
Own Price Elasticities	***Rail***	***DB***	**-1.77**	**-1.76**	**-1.76**	**-1.25**	**-1.25**	**-1.26**
	Air	***DBA***	**-3.77**	**-3.79**	**-3.80**	**-2.29**	**-2.28**	**-2.27**
		HLX	**-3.82**	**-3.84**	**-3.83**	**-2.11**	**-2.10**	**-2.10**
		GW	**-4.13**	**-4.10**	**-4.01**	**-2.18**	**-2.19**	**-2.21**
		LH	**-5.39**	**-5.42**	**-5.41**	**-2.40**	**-2.39**	**-2.38**
	Car	***Car***	**-2.10**	**-2.10**	**-2.12**	**-2.67**	**-2.39**	**-2.00**
Consumer Surplus			**82.7**	**54.4**	**24.4**	**47.5**	**34.9**	**18.9**

Table 2.b. Cross Price Elasticities of Demand.

			BUSINESS						***LEISURE***					
Share of the outside alternative			***15%***						***30%***					
Price increase for alternatives			***DB***	***DBA***	***HLX***	***GW***	***LH***	***Car***	***DB***	***DBA***	***HLX***	***GW***	***LH***	***Car***
Cross Price Elasticities	***Rail***	***DB***	**-1.77**	**0.60**	**0.56**	**0.34**	**0.83**	**0.42**	**-1.25**	**0.09**	**0.07**	**0.04**	**0.09**	**0.37**
	Air	***DBA***	**0.30**	**-3.77**	**0.75**	**0.45**	**1.11**	**0.42**	**0.82**	**-2.28**	**0.28**	**0.17**	**0.34**	**0.37**
		HLX	**0.30**	**0.81**	**-3.82**	**0.45**	**1.11**	**0.42**	**0.82**	**0.33**	**-2.10**	**0.17**	**0.34**	**0.37**
		GW	**0.30**	**0.81**	**0.75**	**-4.13**	**1.11**	**0.42**	**0.82**	**0.33**	**0.28**	**-2.19**	**0.34**	**0.37**
		LH	**0.30**	**0.81**	**0.75**	**0.45**	**-5.39**	**0.42**	**0.82**	**0.33**	**0.28**	**0.17**	**-2.39**	**0.37**
	Car	***Car***	**0.30**	**0.60**	**0.56**	**0.34**	**0.83**	**-2.10**	**0.82**	**0.09**	**0.07**	**0.04**	**0.09**	**-2.39**

Table 3. Calibration of the quality index and its components.

			BUSINESS			LEISURE		
Share of the outside alternative			*15%*	*30%*	*60%*	*15%*	*30%*	*60%*
Quality, Mode Ranking	***Rail***	***DB***	**2.02**	**1.06**	**-0.30**	**3.56**	**2.34**	**0.65**
	Air	***DBA***	**4.11**	**3.10**	**1.65**	**1.39**	**0.37**	**-1.06**
		HLX	**4.04**	**3.04**	**1.59**	**1.15**	**0.17**	**-1.22**
		GW	**3.61**	**2.61**	**1.16**	**0.71**	**-0.21**	**-1.51**
		LH	**5.71**	**4.65**	**3.11**	**1.45**	**0.43**	**-1.02**
	Car	***Car***	**2.63**	**1.65**	**0.27**	**3.27**	**1.95**	**0.11**
Quality characteristics	***DB Dummy***		**-24.88**	**-24.27**	**-23.84**	**-17.24**	**-14.20**	**-10.25**
	LCA Dummy		**-8.33**	**-5.83**	**-2.37**	**-12.11**	**-8.14**	**-2.66**
	LH Dummy		**-6.12**	**-3.69**	**-0.32**	**-11.64**	**-7.75**	**-2.36**
	Speed		**1.29**	**0.78**	**0.06**	**1.65**	**0.97**	**0.02**
	1 / Frequency		**-6.11**	**-6.01**	**-5.98**	**-6.95**	**-5.92**	**-4.55**
	Capacity		**0.03**	**0.03**	**0.03**	**0.02**	**0.02**	**0.02**

Table 4. Simulation of the entry of Low Cost Airlines in 2002.

			LEISURE					
Share of the outside alternative 2001			*30%*		*50%*		*80%*	
Changes: Values, %			***Value***	***Change %***	***Value***	***Change %***	***Value***	***Change %***
Prices	***Rail***	***DB***	**39.8**	**-20.5%**	**41.3**	**-17.5%**	**39.0**	**-22.0%**
	Air	***DBA***	**40.7**	**-32.2%**	**41.8**	**-30.4%**	**42.0**	**-30.0%**
		HLX	**40.6**		**41.8**		**42.0**	
		GW	**40.6**		**41.8**		**42.0**	
		LH	**49.7**	**-37.8%**	**50.5**	**-36.9%**	**68.1**	**-37.6%**
	Car	***Car***	**65.4**	**-12.8%**	**67.6**	**-9.8%**	**79.8**	**-9.3%**
Market Shares %	***Rail***	***DB***	**32.2**	**-19.2%**	**27.0**	**-5.2%**	**15.2**	**33.0%**
	Air	***DBA***	**7.2**	**3.3%**	**5.7**	**13.0%**	**2.7**	**33.9%**
		HLX	**7.1**		**5.6**		**2.7**	
		GW	**7.1**		**5.6**		**2.7**	
		LH	**21.7**	**138.3%**	**16.3**	**150.5%**	**7.9**	**203.2%**
	Car	***Car***	**10.9**	**-21.9%**	**8.9**	**-11.3%**	**4.4**	**10.5%**
	Outside alternative		**13.8**	**-54.1%**	**31.0**	**-37.9%**	**64.5**	**-19.3%**
Consumer Surplus			**35.9**	**76.8%**	**24.1**	**19.7%**	**9.7**	**15.5%**

Table 5. Simulation of the entry of a Low Cost Train.

			BUSINESS						***LEISURE***					
Share of the outside alternative			***15%***		***30%***		***60%***		***15%***		***30%***		***60%***	
Changes: Values, %			***Value***	***Change %***	***Value***	***Change %***	***Value***	***Change %***	***Value***	***Change %***	***Value***	***Change %***	***Value***	***Change %***
Prices	***Rail***	***DB***	**83.1**	**-7.7%**	**83.0**	**-7.7%**	**83.7**	**-7.0%**	**43.8**	**-27.1%**	**42.5**	**-29.2%**	**40.4**	**-32.6%**
		New Train	**68.2**		**67.9**		**67.5**		**41.0**		**39.5**		**37.1**	
	Air	***DBA***	**167.8**	**-0.7%**	**168.2**	**-0.5%**	**168.7**	**-0.2%**	**50.6**	**-1.2%**	**50.8**	**-0.7%**	**51.1**	**-0.2%**
		HLX	**167.9**	**-0.7%**	**168.3**	**-0.4%**	**168.8**	**-0.1%**	**46.1**	**-1.2%**	**46.4**	**-0.7%**	**46.6**	**-0.2%**
		GW	**168.4**	**-0.4%**	**168.6**	**-0.2%**	**168.9**	**-0.1%**	**45.8**	**-0.7%**	**45.9**	**-0.4%**	**46.0**	**-0.1%**
		LH	**238.8**	**-0.5%**	**239.2**	**-0.3%**	**239.8**	**-0.1%**	**52.8**	**-1.1%**	**53.0**	**-0.7%**	**53.3**	**-0.2%**
	Car	***Car***	**108.3**	**-1.5%**	**108.9**	**-1.0%**	**109.6**	**-0.3%**	**77.4**	**-3.3%**	**78.0**	**-2.5%**	**79.2**	**-1.0%**
Market Shares %	***Rail***	***DB***	**11.8**	**-18.0%**	**10.0**	**-15.7%**	**6.0**	**-11.2%**	**35.2**	**-26.6%**	**30.6**	**-22.4%**	**19.4**	**-13.9%**
		New Train	**17.6**		**14.9**		**9.0**		**40.4**		**35.7**		**23.2**	
	Air	***DBA***	**13.0**	**-17.2%**	**11.0**	**-14.3%**	**6.7**	**-8.5%**	**2.8**	**-54.0%**	**2.8**	**-44.7%**	**2.1**	**-25.8%**
		HLX	**12.0**	**-17.4%**	**10.2**	**-14.4%**	**6.3**	**-8.6%**	**2.6**	**-54.1%**	**2.6**	**-44.7%**	**2.0**	**-25.8%**
		GW	**7.1**	**-18.4%**	**6.1**	**-15.1%**	**3.7**	**-8.8%**	**1.5**	**-54.7%**	**1.5**	**-45.2%**	**1.2**	**-26.0%**
		LH	**12.5**	**-17.3%**	**10.7**	**-14.4%**	**6.5**	**-8.6%**	**2.7**	**-54.0%**	**2.7**	**-44.7%**	**2.0**	**-25.8%**
	Car	***Car***	**13.9**	**-16.3%**	**11.8**	**-13.7%**	**7.2**	**-8.3%**	**8.1**	**-50.1%**	**7.8**	**-41.5%**	**5.8**	**-24.4%**
	Outside alternative		**12.1**	**-19.4%**	**25.3**	**-15.8%**	**54.6**	**-9.0%**	**6.7**	**-55.1%**	**16.4**	**-45.4%**	**44.4**	**-26.0%**
Consumer Surplus			**92.1**	**11.4%**	**62.2**	**14.3%**	**28.9**	**18.4%**	**67.6**	**42.3%**	**52.5**	**50.4%**	**30.0**	**58.7%**

Table 6. Simulation of the effect of a kerosene tax.

			BUSINESS						LEISURE					
Share of the outside alternative			***15%***		***30%***		***60%***		***15%***		***30%***		***60%***	
Changes: Values, %			***Value***	***Change %***	***Value***	***Change %***	***Value***	***Change %***	***Value***	***Change %***	***Value***	***Change %***	***Value***	***Change %***
Prices	***Rail***	***DB***	**91.9**	**2.2%**	**91.2**	**1.3%**	**90.3**	**0.4%**	**60.8**	**1.3%**	**60.4**	**0.7%**	**60.1**	**0.2%**
	Air	***DBA***	**186.8**	**10.5%**	**186.8**	**10.6%**	**187.1**	**10.7%**	**55.4**	**8.2%**	**55.4**	**8.2%**	**55.4**	**8.3%**
		HLX	**186.9**	**10.6%**	**187.0**	**10.6%**	**187.2**	**10.8%**	**50.3**	**7.7%**	**50.4**	**7.8%**	**50.4**	**7.9%**
		GW	**187.7**	**11.1%**	**187.7**	**11.1%**	**187.7**	**11.1%**	**49.8**	**8.0%**	**49.8**	**8.1%**	**49.9**	**8.2%**
		LH	**266.8**	**11.2%**	**267.1**	**11.3%**	**267.8**	**11.6%**	**57.9**	**8.4%**	**57.9**	**8.4%**	**57.9**	**8.5%**
	Car	***Car***	**112.3**	**2.1%**	**111.4**	**1.3%**	**110.4**	**0.4%**	**80.2**	**0.3%**	**80.1**	**0.2%**	**80.0**	**0.0%**
Market Shares%	***Rail***	***DB***	**17.5**	**21.9%**	**13.9**	**17.2%**	**7.4**	**9.2%**	**48.8**	**1.7%**	**40.0**	**1.4%**	**22.7**	**0.8%**
	Air	***DBA***	**13.4**	**-14.3%**	**10.6**	**-18.0%**	**5.6**	**-23.9%**	**5.3**	**-11.3%**	**4.4**	**-11.1%**	**2.6**	**-10.1%**
		HLX	**12.4**	**-14.6%**	**9.8**	**-18.3%**	**5.2**	**-24.1%**	**5.1**	**-8.8%**	**4.2**	**-8.6%**	**2.4**	**-7.6%**
		GW	**7.2**	**-16.4%**	**5.7**	**-19.9%**	**3.1**	**-25.0%**	**3.0**	**-9.1%**	**2.5**	**-9.0%**	**1.4**	**-8.1%**
		LH	**10.1**	**-32.9%**	**8.0**	**-35.9%**	**4.2**	**-40.4%**	**5.1**	**-12.7%**	**4.2**	**-12.5%**	**2.4**	**-11.5%**
	Car	***Car***	**20.2**	**21.0%**	**16.0**	**16.6%**	**8.5**	**9.0%**	**16.9**	**4.0%**	**13.7**	**2.5%**	**7.7**	**1.0%**
	Outside alternative		**19.1**	**27.5%**	**36.1**	**20.3%**	**66.0**	**10%**	**15.7**	**5.0%**	**31.0**	**3.0%**	**60.7**	**1.1%**
Consumer Surplus			**72.1**	**-12.8%**	**46.0**	**-15.4%**	**19.9**	**-18.4%**	**46.3**	**-2.5%**	**34.1**	**-2.3%**	**18.4**	**-2.6%**

APPENDIX 3: Calibration Algorithm

We present here a detailed description of the different stages in the calibration process. We start by supposing that information is available for prices, market shares, marginal costs and transport service characteristics. We will see later that some data are in fact missing and we will show how we can adapt slightly the methodology to deal with this issue, and recover values for the parameters.

In step 1, we calibrate the values of parameters h and σ. For this we solve numerically the system of Equations (10) and (14). We proceed by implementing two successive calculations. In a first stage, with information on prices and marginal costs, we compute a vector of own price elasticities for our six alternatives (DB, DBA, GW, HLA, LH, road), according to Equation (15) which can be written:

$$\eta_j = \frac{-p_j}{p_j - c_j}. \tag{A.1}$$

We have then six values of own price elasticities.

A second stage, in this first step of the calibration procedure, consists in recovering parameters h and σ from the system of Equations (10). First we reparameterize these equations as:

$$\eta_j = hp_j\left(s_j - \frac{1}{1-\sigma} + \frac{\sigma}{1-\sigma}s_{j|g}\right) \quad \Leftrightarrow \quad \eta_j = a\left(p_j s_j - p_j\right) + b\left(p_j s_{j|g} - p_j\right), \tag{A.2}$$

with $h = a$ and $\sigma = \dfrac{b}{a+b}$. We run OLS on the reparameterized system using our six data points on elasticities in order to estimate *a* and *b,* and then to estimate *h* and σ.

Recall that the values of market shares used in (A.2) take into account potential travelers who do not travel, i.e., the outside alternative. We assume arbitrarily that the share of the outside alternative represents 15 percent, 30 percent or 60 percent of the total population of potential travelers, i.e., the market size. These three values give rise to three sets of market shares and hence we obtain three sets of estimates for *h* and σ using the preceding OLS regression. Note that, at this stage, we can compute the values of cross price elasticities according to Equation (11) This ends step 1. With these calibrated values of *h* and σ, we are now able to proceed to step 2.

In step 2 we obtain a measure of the quality index ψ_j that enters in the demand Equation (9). With data on prices and market shares, this vector can be calculated using Equation (9) rewritten in the following way:

$$\psi_j = -hp_j + \sigma \ln\left(s_{j|g}\right) - \left(\ln\left(s_j\right) - \ln\left(s_0\right)\right). \tag{A.3}$$

Each of our six alternatives is characterized by the level of the quality index which allows us to rank the different transport options with respect to consumers' tastes in terms of global service quality. This ends step 2.

In step 3, we are interested in determining passengers' valuations for the different components of quality. Assume we had information on speed, frequency, and capacity. We can express each of the six quality index ψ_j as a linear combination of these characteristics and some dummy variables:

$$\psi_j = \alpha_1 D1_j + \alpha_2 D2_j + \alpha_3 D3_j + \beta_1 speed_j + \beta_2 \left(\frac{1}{freq_j} \right) + \beta_3 cap_j, \tag{A.4}$$

where the dummy variable *D1* takes on the value 1 if $j = DB$ and zero otherwise, *D2* takes on the value 1 if $j = DBA$, *HLX*, or *GW* (and zero otherwise) and *D3* takes on the value 1 if $j=LH$ (and zero otherwise). These dummy variables are introduced to capture the unobserved valuations for quality, specific to DB, LCAs and LH relatively to car (the omitted category). In this equation we do not introduce the variable frequency, but the inverse of this variable. For car, which allows one to start driving and make the trip at any moment during the day, the frequency of trips is infinite. Then, for tractability, it is more convenient to consider the inverse of the frequency which is equal to zero for the mode car.

At this point we can solve this system of six Equations (A.4) and six unknowns, i.e., the α s and β s, and recover travelers' valuations for the different components of quality. This ends step 3.

As mentioned in the introduction of this section, we do not have access to a complete dataset which would allow us to perform the calibration strictly as we have just presented it. Some values for marginal costs are missing, and at this point we have to make a distinction between the leisure market and the business market. On the leisure segment, observations for marginal costs are missing for LH and for car, and on the business segment we do not have any measure of marginal costs. The calibration methodology can be slightly adapted to this data issue, but not in the same way for both markets. We describe the changes which have to be implemented in the calibration process, especially in step 1, for the leisure segment and the business segment respectively.

For the leisure market, the only difference with the procedure just described bears on the computations in step 1. Given that the marginal costs for LH and car are unknown, we solve the system of Equations (A.1) and (A.2) for the four alternatives for which a complete dataset is available, i.e., the alternatives DB, DBA, HLX and GW. This gives us some values for h and σ. For the next two steps, marginal costs are not required, and we proceed exactly as explained above, calculating ψ_j and travelers' valuations for quality components for every alternative, including LH and car. Now, with the equilibrium parameters at hand, we recover the measures of marginal costs for LH and car using Equation (14), that is to say:

$$c_j = p_j - \frac{1-\sigma}{h\left(1-\sigma s_{j|g} - \left(1-\sigma\right) s_j\right)}. \tag{A.5}$$

Calibration for the leisure market is then achieved.

Now let us turn to the calibration of the model for the business market. For this market we do not have any information on marginal costs. It means we can not compute values for elasticities and solve for h and σ as in the step 1 described above. We have to adapt the approach in order to account for this lack of data. First we assume that each elasticity is drawn from a Gaussian distribution, for which we specify the mean and variance parameter values as follows. Some relatively recent estimates of own price elasticities for business travelers can be found in the literature. Hensher (1996) provides an elasticity of -3.2 for airlines business travelers. More precisely, we assume that the elasticity for each alternative follows a Gaussian distribution with the Hensher's estimate as the mean. We specify its standard deviation to be 4, which is large enough to take into account deviations from that mean value for land transport elasticities as reported in the literature, as well as differences existing between the market we analyze and the one studied by Hensher. However, we restrict the set of potential random values for these elasticities.

Recall that elasticities can be computed from values of marginal costs. Assume further that marginal costs for business services are higher than marginal costs for leisure services, which it is a reasonable assumption.[14] By applying Equation (15), this lower bound for business marginal costs implies an upper bound for business elasticities since:

$$c_j^{Business} \geq c_j^{Leisure} \quad \Leftrightarrow \quad \eta_j^{Business} \leq \frac{p_j^{Business}}{c_j^{Leisure} - p_j^{Business}}. \tag{A.6}$$

These upper bounds for the business elasticities are computable since the vector of leisure marginal costs is composed of the four observations we have for DB, DBA, HLX, GW, and the values for LH and car calibrated earlier for the leisure segment.

So now we randomly generate a vector of elasticities from the Gaussian distributions so specified, under the constraints (A.6). When this vector is obtained, and imposing the constraints that h must be greater than 0 and σ between zero and one, we can come back to step 1 and implement its second stage. For each draw, we can then compute one value for h and one value for σ. We repeat this process 1000 times. The average value of h and the average value of σ, over this sample of size 1000, give us an estimate for the equilibrium parameters h and σ. In other words, what we do here is to use some uninformative priors for the mean and variance of elasticities to build, by Monte-Carlo method, posterior estimates for our structural parameters.

Then we can implement the next two steps of the calibration procedure as presented above. Calibration for the business market is then achieved.

[14] This seems reasonable when considering costs associated to service quality, which is of higher level for business flights.

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