Second degree price discrimination and inter-group effects in the European airline routes

Marco ALDERIGHI, Università della Valle d'Aosta, Aosta, Italy; Università Bocconi, Milan, Italy
Alessandro CENTO, KLM Royal Dutch Airlines, Revenue Management Dept, Milan, Italy
Peter NIJKAMP, Free University, Amsterdam, The Netherlands
Piet RIETVELD, Free University, Amsterdam, The Netherlands

Abstract

We develop a model of second-degree price discrimination and inter-group effects to describe the full-service pricing behaviour in the passenger aviation market. Consumer heterogeneity is assumed both on a horizontal and a vertical dimension and various market structures, some of which including low-cost players, are considered. We find that full-service carriers rivalry reduces fare differences between business and leisure segments. Moreover, the presence of low-cost carriers increases fare gaps between leisure and business travellers, and it also induces full-service carriers to decrease fares in the leisure segment and eventually to increase them in the business one. This last outcome comes from a change in passenger arrangement caused by inter-group effects. Finally, using data on published airfares of Lufthansa, British Airways, KLM and Alitalia for the main city-pairs from Italy to Germany, the UK and the Netherlands, we show that empirical results provide some support to the theory.

1. Introduction

Carriers' pricing behaviour has been amply investigated in transport economics research. Among the plenty of theoretical works describing airline pricing policies, most of them brings back to the third-degree price discrimination approach. Borenstein and Rose (1994), for instance, describes a single route market consisting of two segments, business and leisure travellers, demanding from one or more carriers flight services. Since consumer segments are heterogeneous in terms of demand elasticity and brand allegiances, airlines find profitable to price discriminate by charging full fares to less-elastic brand-sensible business travellers and discounted fares to more-elastic less-brand-sensible leisure travellers.

The simple story, that succinctly describes the functioning of third-degree price discrimination, was often utilized to criticize the dominant view that price dispersion is positively related with market concentration. Indeed, it is possible to show that by moving from monopoly to imperfect competition price differentials increase in those cases where fares for brand-sensible business travellers decrease less than those for less-brand-sensible leisure travellers (Borenstein, 1985; Holmes, 1989). This result is evocated as a theoretical support for a wide empirical literature which found a negative relation between price dispersion and market concentration in airline market (Borenstein, 1985, Borenstein and Rose, 1994; Stavins, 2001; Giaume and Guillou, 2004) as well as in other service markets (Asplund et al., 2008, Borzekowski et al 2008).

The underlying assumption behind the third-degree price discrimination argument is that leisure and business markets are independent, i.e. business travellers do not (or are not allowed to) buy tickets for leisure travellers, and vice versa. In other terms, whatever the gap between leisure and business fares, carriers do not face 'passenger diversion', i.e. there is not a demand switch of business travellers toward less expensive fares.

Relaxing the assumption of market independency moves the analysis toward a second-degree price discrimination approach (Stole, 2007), where previous argument (i.e. increasing price differentials in more dispersed markets) continues to hold only when carriers are able to design different product qualities (e.g. 'unrestricted' vs 'restricted' fares) and price differentials remain below the business traveller quality premium (i.e. the additional value that a business traveller receives from choosing an unrestricted fare with respect to the restricted one).

Literature on revenue management abounds of examples where passenger diversion may occur in airline markets (Botimer and Belobaba, 1999; Zhao and Zheng, 2001; Zhang and Cooper, 2005; Alderighi, 2010). This motivates our choice to abandon the simplifying assumption of market independency and to analyze airline pricing policies using the more sophisticated approach of second-degree price discrimination.

A main consequence of this choice is that, when a route is operated by a monopolist, which is forced to satisfy the quality premium constraint, the entry of a competitor cannot expand price differentials, except when there is a positive shift in quality premium. We, indeed, show that when we compare a market configuration with one (full-service) carrier with that of two (full-service) carriers, we find that price differentials decrease or, at least, remain stable. The former occurs when the quality premium constraint ends up to be slack, while the latter when it remains binding. Price dispersion, indeed can increase even under second-degree price discrimination if we observe an expansion of the leisure market.

In our set-up, we also consider the case where quality premium may be influenced by passenger arrangement. Business traveller as well as some leisure traveller evaluations for a flight may be affected by the participation of some passengers whose behaviour may have a negative impact (e.g. noisy travellers may reduce the ability of business travellers to work during the flight, and therefore their willingness-to-pay). If these inter-group effects play a role (Leibenstein, 1950; Becker, 1991; Katz and Spiegel, 1996), a market structure which induces a sorting of noisy travellers may increase the quality premium of business travellers. In particular, the co-existence of full-service and low-cost carriers may favour a change in passenger arrangement, since low-cost carriers, by charging low fares, can attract those passengers who are not interested in comfort and are mostly motivated by low prices. A more 'selected' arrangement of full-service carrier passengers, can therefore expand the quality premium and raise price differentials. Eventually, it can increase fares in the business segment.[1] Therefore, this set-up does not exclude that price differentials may increase, but it limits this possibility to a case in which there is a carrier asymmetry.

Our modelling choice is based on the recent literature on second-degree price discrimination in oligopolistic markets. A general set-up is provided by Rochet and Stole (2002) and Armstrong and Vickers (2001) and further analyzed by Dessein (2003) and Ellison (2005).[2] Here, authors allow for both horizontal and vertical differentiation between firms, endogenous quality choice, and partial coverage of the weak segment. A main conclusion is that the standard result of 'quality distortion at the button' (Mussa and Rosen, 1978) disappears and efficient quality allocation is usually provided.[3] Similar outcome is obtained by Alderighi (2008), when considering competition among asymmetric players. These results also revaluate some of the previous analyses based on exogenous quality provision (Moorthy, 1984; Katz, 1984). We take this shortcut in our set-up motivated by the fact that previous literature shows that exogenous quality choice is not a severe limit.

This paper is also related with the work of Liu and Serfes (2006) and Hernandez and Wiggins (2009), who provide a model of second-degree price discrimination under the assumption that the quality premium constraint remains binding in all market structures, and competition intensity is measured by the transport cost parameter (Villas-Boas and Schmidt-Mohr, 1999). Their main findings are that the business to leisure price ratio decreases with competition, and there is a U-shaped relation between concentration and price dispersion. Finally, Justin and Myatt (2003), using a model of quality competition, showed that competition of new comers usually occurred in the lower segments with the consequence of pruning or reducing the incumbent participation in that segment. A similar situation emerges in our set-up, when considering low-cost entry.

In the second part of the paper we will test some of the theoretical outcomes in order to verify their correspondence to the factual situation. In the empirical part, we will use half-annual data on the

[1] Other theoretical works find that market dispersion have a price enhancing effect (Blattberg and Wisniewski, 1989; Perloff et al., 1996, Ward et al. 2002, Goolsbee and Syverson, 2004; Chen and Riordan 2006; Alderighi, 2009). None of these, however, combines the inter-group effects with a multi-output pricing firm.

[2] A comprehensive review of the early works in the field is provided by Armstrong (2005).

[3] At least, when the participation of some consumers belonging to the lower segment is guaranteed. In fact, Yang and Ye (2008), show that if there are some segments that remain totally unserved, the number of players increase, quality distortion exibits a non monotonic pattern.

airfares of Lufthansa, British Airways, Alitalia and KLM for the top 41 city-pairs from Italy to Europe (April 2001-July 2003). Contrary to what is done in most of the literature, we do not consider average prices, but perform an analysis on the basis of eight different fare classes identified by using a class map procedure.

Our empirical findings provide support to the theoretical set-up. First, it emerges that the entry of low-cost carriers consistently reduces charged fares. This result is in line with previous works in the field (Bennett and Craun, 1993; Whinston and Collins, 1993; Morrison and Winston, 1995; Windle and Dresner, 1995; Goolsbee and Syverson, 2008). Moreover, we find that full-service carriers rivalry reduces fare differences between business and leisure segments. This is line, for instance, with the findings of Evans et al. (1993) and Gerardi and Shapiro (2009). Finally, the presence of low-cost carriers induces full-service carriers to decrease fares in the leisure segment and to maintain and possibly increase them in the business one, implying that the gap between leisure and business tickets increase. A similar effect has been noted in retail industry where top-premium national brands have increased their prices after the introduction of store brands (Ward et al., 2002; Pauwels and Srinivasan, 2004) and in the fast food industry where the appearance of a closer competitor may slightly increase prices (Thomadsen, 2005).

The rest of the paper is organized as follows. Section 2 presents the theoretical model. Section 3 provides a description of the data, the estimation procedure and the main results. Section 4 concludes. Details of the proofs are presented in Appendix.

2. The Explanatory Model

The model we are going to present, in principle, can be applied to those contexts where firms charge prices following a second-degree price discrimination strategy. However, we have chosen to circumscribe our discussion to the analysis of the airline market.

2.1 Design of the model

We analyze a market where consumers are both horizontally and vertically heterogeneous and incur in inter-personal externalities. Vertical heterogeneity captures the different evaluation for quality and is related to travel motivations. In general, business travellers have a more rigid demand and, therefore, higher willingness-to-pay for high quality products (e.g. unrestricted ticket) than leisure travellers. We refer to the business segment as the strong market (labelled by 2), and to the leisure segment as the weak market (labelled by 1). The willingness-to-pay for quality of travellers belonging to the strong market and the weak market are, respectively, t_2 and t_1, with $t_2 > t_1$, i.e. both types of consumers appreciate quality, although the consumers belonging to the strong market are more interested in quality than the others.

Horizontal heterogeneity is summarized by the location of consumers on a circumference of unitary length, on which, it is supposed, "products", i.e. flights, are also located. This approach is particularly appealing for the airline sector as different points on the circumference can represent the ideal travellers departure time, or the ideal locations of the origin and destination airports (in addition to the usual brand preference argument). Travellers who choose a flight which does not fully correspond to their ideal choice are subject to a constant unit transport cost σ. Since business travellers are less flexible that leisure travellers, we set the unit transport cost of business travellers σ_2 larger than that of leisure travellers σ_1, i.e.: $\sigma_2 > \sigma_1$.

Inter-personal externalities come from a set of reasons, such as status signalling, preferential attachment and group behaviour. In particular, it is supposed that the quality of a flight is affected by the composition of passengers and by carrier reputation. We assume that business travellers as well as a certain proportion $\alpha \in (0,1)$ of leisure travellers evaluate positively having a comfortable and quiet seats on the flight, and the proportion $1-\alpha$ of leisure travellers does not, simply because these are those from whose such environmental externality originate. Similar to Corneo and Jeanne (1999), we model the inter-group externalities of consumers of type i for the flight j as:

$$e_{ij}(n_1, n_0) = \begin{cases} \beta(n_1 - n_0) - \delta_{ij} & for\ comfort-oriented\ travellers \\ 0 & for\ others \end{cases} \tag{1}$$

where n_1 and n_0 are, respectively, the proportion of leisure travellers evaluating positively being quiet (type t_{11}) on the flight or not (type t_{10}), $\beta > 0$ is a measure of the intensity of inter-group externalities and $\delta_{ij} \geq 0$ captures the preferential attachment, i.e. the psychological cost sustained by a passenger when she flies on a low-cost carrier. It is therefore zero when a passenger choose to fly with a full-service carriers, and equals to δ_2, $\delta_1 > 0$ and $\delta_0 = 0$, when passengers choose to fly with a low-cost carrier and are of type t_2 or t_{11} and t_{10}, respectively.

We assume that both groups of travellers are uniformly distributed around the circumference, have 0-1 demand, and we normalize consumer mass to 1; the size of the weak market is $\mu_1 = \mu \in (0,1)$, and the size of the strong market is $\mu_2 = 1 - \mu$; α is set equal to $\frac{1}{2}$ for computational reasons[4]. The utility that a traveller i located at x who purchases a flight of quality q_l from firm j located in y_j at the price p_{jl} is given by:

$$(t_i + e_{ij})q_l - \sigma_i D(x, y_j) - p_{jl}, \tag{2}$$

where e_{ij} is the inter-group externality being in flight j, $D(x, y_j)$ is the shortest time distance on the circumference from the location of the consumer x to that of firm j. Travellers will choose the product providing the maximum utility. The net utility of the outside option is normalized to zero. Note that we are, thus, modelling a situation where heterogeneous consumers are free to choose among different qualities and suppliers.

There are two types of firms on the market, full-service carriers (namely, F) and low-cost carriers (namely L). They differ with regard two aspects. Full-service carriers can offer products of different qualities: a premium product q_2 and a standard product q_1 (e.g. unrestricted and restricted tickets); while low-cost carriers can only offer a standard product q_1 (e.g. restricted tickets).[5] Moreover, low-cost carriers have a cost advantage in production. Let c_{jl} be the unit cost of firm j for a product of quality l; therefore, we have: $c_{F2} > c_{F1} \geq c_{L1}$.[6] In other words, traditional firms can offer a full

[4] This implies that when consumers identically located patronize the same carrier, $n_1 - n_0 = 0$.
[5] Full-service offer includes a wide range of characteristics, e. g. in-flight entertainment, fast check-in, waiting lounges, ground services, which further help to differentiate the product.
[6] Cost differences between full-service and low-cost carriers are amply documented. Low-cost carriers advantage are mainly due to their organization (Franke, 2004). On the contrary, the cost difference between

range of products but at higher cost, while low-cost firms can offer a restricted range of products but at lower cost. To simplify the notation, let $c_l = c_{Fl}$, $c_0 = c_{L1}$, $u_{il} = (t_i + e_{il})q_l$, for $i, l = 1,2$. Note that $u_{i2} > u_{i1}$ for $i = 1,2$, and $u_{22} - u_{21} > u_{12} - u_{11}$. This last inequality is known in literature as single crossing property (Mirrlees, 1971).

We also assume that carriers are not able to explicitly segment consumers on the basis of passenger location on the circumference nor on the basis of passenger willingness-to-pay. Implicit segmentation (i.e. which allows carriers to sort consumers by inducing self-selection) is viable only on the vertical dimension, because the single crossing property does not hold on the horizontal one. Since there are two product qualities, and two segments, the traditional strategy for full-service carriers is to offer the product of lower quality q_1 to the weak market, and the product of higher quality $q_2 > q_1$ to the strong market. Carriers, to avoid diversion, i.e. that a t_2-type consumer will buy a product designed for t_1-type consumers, must choose p_{F1} and p_{F2}, such that the net utility that a t_2-type consumer receives when she buys a product of quality q_2, is at least equal to her net utility when she buys a product of quality q_1. This means in formal terms: $u_{22} - p_{F2} \geq u_{21} - p_{F1}$. This inequality may also be written as:

$$p_{F2} - p_{F1} \leq r, \tag{3}$$

where $r = u_{22} - u_{21}$ is the quality premium of travellers belonging to the strong market. This condition is known as the incentive compatibility constraint for the strong market (ICC).[7]

The simultaneous presence of different firms on the market expands the traveller's choices and makes firm's decisions more complex. We refer to a case where fares are such that, if a consumer decides to fly, she definitely purchases to the closest firms and chooses the fare designed for her type, i.e. all full-service carriers price schedules satisfy the ICC for the strong and weak markets, and that fares are such that undercutting does not occur (we are excluding super-competitive market outcomes, see: Salop, 1979). According to the utility function presented in (2), a consumer of type t_i purchases one unit of product from the firm providing the highest utility. Consider the arc on the circumference between firm j and firm k.[8] The consumer $\hat{x}_i$ who is indifferent between purchasing from the two firms is given by:

$$(t_i + e_{ij})q_l - \sigma_i D(\hat{x}_i, y_j) - p_{jl} = (t_i + e_{ik})q_l - \sigma_i D(\hat{x}_i, y_k) - p_{kl}. \tag{4}$$

A traveller of type t_i belonging to the arc of circumference jk located in x_i will patronize firm j if $D(x_i, y_j) < D(\hat{x}_i, y_j)$ and firm k otherwise. Semi-market demand for firm j by consumers of type t is therefore given by: $n_i D(\hat{x}_i, y_j)$, where n_i is the number of consumers of type t_i on the market,

---

business tickets and leisure tickets are usually explain with differences in the quality service and by higher implicit cost of business seats caused by differences in the load factors (Dana, 1999; Escobari and Gan, 2007).

[7] Anagously, a carrier when designing a product for the weak market has to consider to induce leisure travellers to buy the product designed for them. The incentive compatibility constraint is said to be binding when a firm chooses the prices of high quality and of low quality products in such a way that high willingness-to-pay consumers are indifferent between buying a high quality product at a high price and buying a low quality product at a low price. On the contrary, the incentive compatibility constraint is said to be slack when prices are set in such a way that consumers of the strong (weak) market will strictly prefer a high (lower) quality product to a low (high) quality product. Throughout the paper, we will only discuss the ICC for the strong market since ICC for the weak market is always slack.

[8] When there are two firms we have to define arcs by considering for instance counter-clock directions.

where $i = 2$ (i.e business travellers), 11 (i.e. leisure travellers evaluating positively being quiet on the flight) or 10 (the other leisure travellers). Previous analysis also accommodates the monopoly case by assuming a fictitious firm providing the reservation utility zero at each point on the circumference.

In the next sub-sections we will analyze four main market structures depending on the fact that there are one or two full-service carriers and one or no low-cost carriers (see, figure 1):

1. Monopoly: one full-service carrier F on the market, located on the circumference at $y_F = 0$;
2. Symmetric duopoly: two full-service carriers on the market: namely, F_A and F_B, equidistantly located on the circumference, respectively, at $y_A = 0$ and $y_B = \frac{1}{2}$;
3. Asymmetric duopoly: one full-service carrier F and one low-cost carrier L equidistantly located, respectively, at $y_F = 0$ and $y_L = \frac{1}{2}$;
4. Asymmetric oligopoly: two full-service carriers F_A and F_B, equidistantly located, respectively, at $y_A = 0$ and $y_B = \frac{1}{2}$, and one low-cost carrier L in between, located at $y_L = \frac{1}{4}$;

2.2 Monopoly Analysis

Previous literature suggests that monopoly analysis in case of both horizontal and vertical differentiation produces a large set of cases depending on whether the incentive compatibility constraint (ICC) is slack or binding, and on the different coverage of the weak and the strong markets (See: Desai, 2001; Alderighi, 2007; Yang and Ye, 2008). In order to simplify the analysis (and to provide more stringent predictions) we consider the case that from our view point is the most relevant for the airline market. We therefore study the pricing behaviour in monopoly markets when, in equilibrium, quality premium constraint is effective (the ICC is binding) and the monopolist serves all business travellers (full coverage of the business market) and some of leisure travellers (partial coverage of the weak market). The assumption concerning a binding quality premium can be explained by the diversion argument: if a carrier tries to increase its fares in the business segment above a certain level, some business travellers will decide to buy a less attractive but much cheaper ticket. This risk is much more concrete in the monopoly case as the lack of rivalry with other carriers do not allay its fares. Empirical analysis also motivates our hypothesis on market coverage. It is observed that traffic usually increases by moving from monopoly to more competitive environments and that since business demand is quite rigid, most of the increases is usually caused by leisure passengers. These effects are, for instance, clearly documented on those routes where low-cost carriers enter the market, e.g. the 'Southwest effect' (Morrison, 2001). In mathematical terms, previous situation is obtained under the following assumptions (derived in Appendix):

$$u_{22} - c_2 \geq \sigma_2 \quad \text{(full coverage of the strong market)} \tag{5}$$

$$M\sigma_1 < u_{11} - c_1 < (M+1)\sigma_1 \quad \text{(partial coverage of the weak market)} \tag{6}$$

$$u_{11} - c_1 \leq 2(u_{21} - c_1) - \sigma_2\,, \quad \text{(binding ICC)} \tag{7}$$

where $M = (1-\mu)/(2\mu)$.

We are therefore considering a case in which, the utility that business travellers receive (net of production costs) is sufficiently high, the utility that leisure travellers receive (net of production costs) is small, and business travellers have some interest in the tickets of leisure travellers. Under Assumptions (5)-(7), the profit-maximizing behaviour of the monopolist is:

$$\max 2\mu(u_{11} - p_{F1})\sigma_1^{-1}(p_{F1} - c_1) + (1-\mu)(p_{F1} + r - c_2) \quad (8)$$

The first-order condition implies that:

$$p_{F1} = \frac{1}{2}(u_{11} + c_1 + M\sigma_1) \qquad \text{and} \qquad p_{F2} = p_{F1} + r. \quad (9)$$

Due to the quadratic form of the profit function, second order conditions are satisfied. Let $p_m = p_{F1}$, for future reference.

Note that, due to our modelling choice, the existence of inter-group effects does not affect the pricing decision nor the carrier profitability. In fact the carrier cannot profitably sort travellers belonging to the weak market in two sub-segments: by raising the price in the weak market, the carrier obtains a simultaneous reduction of the number of potential travellers who want to fly in each sub-market, and therefore the inter-group effects are null, i.e. from (1), when both sub-segments participate, then $n_1 = n_0$, and therefore: $e_{ij}(n_1, n_0) = 0$. In order to obtain positive inter-group effects in the monopoly case, a full-service carrier should increase the fare charged in the weak market in such a way to fully exclude the participation of t_{10}-type consumers ($p_E \geq t_1 q_1$). In that case, the carrier is able to guarantee a participation type t_{11} only if inter-group externalities are strong. We exclude this scenario from our analysis by assuming:

$$\sigma_1 - 2\beta q_1 > 0. \quad (10)$$

The following proposition summarizes the results presented in this sub-section.

Proposition 1. *Assume that inter-group externalities are described by (1), and that assumptions (5)-(7) and (10) hold, then*

a) in equilibrium, the monopolist fully covers the strong market, partially cover the weak market and ICC is binding,
b) equilibrium prices are described by (9).

We will compare the results derived in this sub-section with those derived in the following sub-sections.

2.3 Symmetric Duopoly Analysis

In the symmetric duopoly, we restrict our analysis to situations where both markets are covered. We consider two cases depending on whether the ICC is binding or not. When the ICC is not binding, markets are separate and the Vickrey (1964)–Salop (1979) outcome emerges in both segments (Rochet and Stole, 2002):

$$p_{Fi} = c_i + \frac{1}{2}\sigma_i, \qquad i = 1,2. \quad (11)$$

Note that by moving from a monopolistic situation to a more competitive one, pricing strategies vary from those based on willingness-to-pay to those based on the ability of firms to differentiate their products.[9]

From (2) and (11), full coverage of the weak market occurs when: $u_{11} - c_1 > \frac{3}{4}\sigma_1$. Therefore, for any M and σ_1 there is a parameter set for which we have simultaneously full-coverage of the weak market in the duopoly case and partial coverage in the monopoly case:

$$\max\{M\sigma_1, \tfrac{3}{4}\sigma_1\} < u_{11} - c_1 < (M+1)\sigma_1. \quad (12)$$

Results are not particularly affected by assumption (12), that is mainly motivated by the need to reduce the number of possible cases to be analysed. Using (3), we find that ICC is slack when cost differences (i.e. transport costs and production costs) are smaller than the quality premium, i.e. $\Delta = c_2 - c_1 + (\sigma_2 - \sigma_1)/2 < r$. Let $p_d = p_{F1}$ and $p_d + \Delta = p_{F2}$. The second case, when the ICC is binding also in duopoly ($\Delta > r$), is more widely analysed in Appendix, where we show that the equilibrium prices are the result of a mixture of transport and production costs of both segments:

$$p_{F1} = \left(\left(\tfrac{1}{2} + M\right)\sigma_1\sigma_2 + 2M\sigma_1(c_2 - r) + \sigma_2 c_1\right)(2M\sigma_1 + \sigma_2)^{-1} \quad \text{and} \quad p_{F2} = p_{F1} + r. \quad (13)$$

Note that by moving from monopoly to duopoly, we expect that price differentials decrease or, at least, remain stable. The former implies that in the duopoly case, ICC is slack, while the latter that ICC remains binding. Contrary to the third-degree price discrimination approach, this result emerges irrespective to the fact that business demand is more rigid than the leisure demand.

In order to link this set-up with the recent literature on price dispersion, it is useful to analyze percentage price differentials in monopoly and duopoly. Using (9) and (11), it is simple to prove that if monopoly to duopoly price ratio in the weak market p_m/p_d is lower (higher) than r/Δ, then percentage price differentials are larger (smaller) in monopoly than in duopoly. Moreover, when ICC is binding ($\Delta > r$), the model predicts a positive shift in percentage price differences, while when the ICC is slack ($\Delta < r$), both situations can be accommodated. In the second case, since Δ is positively affected by $\sigma_2 - \sigma_1$, our outcome is in line with the argument put forward by Holmes (1989) and Borenstein (1985): the larger the difference in the brand strength between passengers belonging to the strong and the weak markets, the more likely the (percentage) price differentials is increasing.

Predictions concerning a higher or lower price dispersion caused by a change in the market structure may be also accommodated by the model. We use as measure of price dispersion the coefficient of variation, i.e. $CV = \left(n_1(p_1 - \bar{p}) + n_2(p_2 - \bar{p})\right)^{1/2}/\bar{p}$, where $\bar{p} = (n_1p_1 + n_2p_2)/(n_1 + n_2)$, where n_1 and n_2 are, respectively, the total number of passengers of the leisure and business segment.[10] Simple computations imply that:

$$CV_d = \frac{\Delta\sqrt{\mu(1-\mu)}}{\mu p_d + (1-\mu)(p_d + \Delta)}, \quad CV_m = \frac{r\sqrt{MS_1\mu(1-\mu)/(MS_1\mu + (1-\mu))}}{MS_1\mu p_m + (1-\mu)(p_m + r)}.$$

[9] With a similar argument to that of the monopoly case, inter-group externalities do not play a role in the symmetric duopoly.

[10] The coefficient of variation is the ratio of the standard deviation to the mean. When considering only two fare levels, the coefficient of variation is the double of the Gini coefficient.

The comparison of the two expressions is not straightforward.[11] Different parameter values play in different directions. As in the previous case a remarkable role is played by the monopoly to duopoly price ratio in the weak market p_m/p_d and by quality premium to cost difference ratio r/Δ. In addition to this, since in the monopoly equilibrium the weak market is only partially covered, traveller composition plays an additional role. In particular, the characteristics of the CV imply that for a given p_m/p_d and r/Δ, price dispersion is more likely to increase in those market configurations where the size of the business and leisure travellers are more similar. This prediction is consistent with the findings in Gerardi and Shapiro (2009) where price dispersion in 'big-city routes' characterized by both business and leisure travellers is higher than in 'leisure cities routes'.

The following proposition summarizes previous results.

Proposition 2. *Assume that inter-group externalities are described by (1), and that assumptions (5)-(7), (12) hold, then:*

a) *markets are fully covered,*
b) *equilibrium prices are described by (12) when $\Delta < r$ and by (13) when $\Delta > r$,*
c) *when $\Delta < r$, ICC is not binding (i.e. price differences moving from the monopoly to the duopoly case decrease) and, when $\Delta > r$, ICC is binding,*
d) *moving from monopoly to symmetric duopoly, percentage price differences decrease when $p_m/p_d < r/\Delta$ and increase when $p_m/p_d > r/\Delta$,*
e) *if percentage price differences decrease then ICC is slack.*

Some of these implications are tested in the empirical part (Table 4).

2.4 Asymmetric Duopoly Analysis

In this section, we focus on the entry of a low cost carrier in a monopolistic market. Contrary to previous cases, we show that inter-group externalities affect the equilibrium outcome. In particular, we will show how these effects increase full-service price differentials and that they can eventually induce a raise of its fares in the strong market. Intuitively, the presence of a low-cost carrier induces a different allocation of the two sub-segments of leisure travellers between the two carriers. The low-cost carrier attracts more t_{10}-type travellers and less t_{11}-type travellers. Consequently, a lower share of t_{10}-type travellers increases the valuation of t_2-type and t_{11}-type consumers for a flight operated by a full-service carrier.

In the asymmetric duopoly case, we assume that there is a full-service carrier, located at 0, and a low-cost carrier located at $1/2$. The low-cost carrier has a competitive advantage in costs, but it cannot provide the full range of products (i.e. it is not able to produce the quality q_2). As a low-cost carrier cannot provide a high quality product for type t_2, it offers the same quality for both markets, which corresponds to q_1. Depending on the level of vertical heterogeneity, the low-cost carrier may, or may not, attract business travellers. We focus on the case in which, the full-service carrier has no competition on the strong market.[12] It corresponds to a situation in which t_2 and δ_2 are sufficiently

[11] Simulations confirm that the results are consistent with the informal treatement we are going to present.
[12] There is some empirical evidence that in the EU aviation market, low-cost carriers target some business travellers. However, our data refer to an early stage of market liberalization, where the share of business travellers considering to fly with a low-cost carrier was quite small.

high, i.e. it is 'too costly' for a business traveller to choose a low-cost carrier. Consequently, business fares are only subjected to the quality premium constraint, that under similar conditions to the monopoly case is binding.

Due to the presence of low-cost carriers, t_{11}-type and t_{10}-type consumers located in the same place may prefer to patronize different carriers. Using equations (1) and (2), the utility a t_{11}-type traveller located in x receives, when patronizing the full-service carrier, is: $\left(t_1 + 2\beta(x_{11} - x_{10})\right)q_1 - \sigma_1 D(x, y_F) - p_{F1}$ and the utility she receives, when patronizing the low-cost carrier, is: $(t_1 - 2\beta(x_{11} - x_{10}) - \delta_1)q_1 - \sigma_1 D(x, y_L) - p_L$, where $2x_{11}$ and $2x_{10}$ are respectively the number of t_{11}-type and t_{10}-type passengers travelling with the full-service carrier and δ_1 is a measure of the preferential attachment. Note that t_{11}-type evaluation is affected by the composition of passengers, $2\beta(x_{11} - x_{10})$, and by the 'brand' evaluation δ_1, i.e the traveller is damaged by flying in a less prestigious, or a less comfortable carrier. For t_{10}-type consumers, there are no inter-group externalities and therefore, the evaluations for the full-service and low-cost carrier offers are respectively: $t_1 q_1 - \sigma_1 D(x, y_F) - p_{F1}$ and $t_1 q_1 - \sigma_1 D(x, y_L) - p_L$. Let $\hat{x}_{11}$ and $\hat{x}_{10}$ be the corresponding indifferent consumers for the two types. Therefore (details on the rest of the model are provided in Appendix):

$$\hat{x}_{11} - \hat{x}_{10} = (q_1\delta_1)/(2\sigma_1 - 4\beta q_1) > 0. \tag{14}$$

Note that since ICC is binding the price charged in the strong market is such that a business traveller is indifferent from buying a ticket of quality q_2 and a ticket of quality q_1, both offered by the full-service carrier. However, since $x_{11} - x_{10} > 0$ the existence of inter-group effects implies that $p_{F2} = p_{F1} + r_\beta$, where $r_\beta = t_2(q_2 - q_1) + 2\beta(x_{11} - x_{10})(q_2 - q_1)$. Moreover, if the price charged by the full-service carrier in the weak market is not too low when compared to the price charged in monopoly, the existence of inter-group effects may cause higher business fares in the asymmetric duopoly case than in the monopoly case. Solving the maximization problem of the full-service and the low-cost firms, equilibrium prices are (see the appendix):

$$p_L = \frac{1}{6}(3\sigma_1 + 4M\sigma_1 + 4c_0 + 2c_1 - I), \tag{15}$$

$$p_{F1} = \frac{1}{6}(3\sigma_1 + 8M\sigma_1 + 2c_0 + 4c_1 + I) \quad \text{and} \quad p_{F2} = p_{F1} + (t_2 + \beta I/\sigma_1)(q_2 - q_1), \tag{16}$$

where $I = (\delta_1\sigma_1 q_1)/(\sigma_1 - 2\beta q_1)$. The following proposition summarizes the main results of this sub-section.

Proposition 3. *Assume that inter-group externalities are described by (1), and that assumptions (5)-(7), (12) hold, then:*

a) *equilibrium prices are given by: (15)-(16),*
b) *price differentials between business segment and leisure segment are higher in the asymmetric duopoly case than in the monopoly case, and,*
c) *for a sufficiently high cost differential $(c_1 - c_0)$, fares are lower in the asymmetric duopoly case than in the monopoly case in the weak market but higher in the strong market.*

2.5 Asymmetric Oligopoly Analysis

In this sub-section we analyze the case where there are two full-service carriers equidistantly located and a low-cost carrier positioned between them. This market is characterized by two relevant aspects. First, in the weak market full-service carriers sustain quite strong competition, due to the proximity of the low-cost carrier, but they also benefit from inter-group externalities. Second, the strong market competition remains similar to that of the symmetric duopoly case, since competition among the full-service carriers eliminates (when δ_2 is sufficiently high) both the possibility to exploit inter-group externalities and the competitive pressure of low-cost carriers. Therefore, although the complexity of the oligopoly game, a simple solution can be obtained, since pricing behaviour of full-service carriers are separate between the weak and the strong market. In fact, equilibrium prices in the strong market are simply given by equation (11), while in the weak market, prices are obtained by the interplay of the three firms. The methodology to find the market prices in the weak market is similar to that of the asymmetric duopoly case and is reported in Appendix. We find that:

$$p_L = \frac{3}{10}\sigma_1 + \frac{1}{5}(3c_0 + 2c_1) - \frac{2}{5}\frac{\delta_1\sigma_1 q_1}{2\sigma_1 - 3\beta q_1} \tag{17}$$

$$p_{F1} = \frac{7}{20}\sigma_1 + \frac{1}{5}(c_0 + 4c_1) + \frac{1}{5}\frac{\delta_1\sigma_1 q_1}{2\sigma_1 - 3\beta q_1} \tag{18}$$

The following proposition summarizes the main results of this section.

Proposition 4. *Assume that inter-group externalities are described by (1), and that assumptions (5)-(7), (12) hold, then:*

- a) *prices in the strong market are not affected by the presence of a low cost carrier and are given by (11), and equilibrium prices in the weak market are given by (17) and (18),*
- b) *price differentials between business segment and leisure segment are smaller in the asymmetric oligopoly case than in the asymmetric duopoly case,*
- c) *for a sufficiently high cost differential* $(c_1 - c_0)$*, price differentials the between business segment and leisure segment are higher in the asymmetric oligopoly case than in the symmetric duopoly case.*

3. Empirical Analysis

3.1 Data

Data for this analysis refer to the first years (2001-2003) after the end of the European airline deregulation process (1988-1997) which were characterized by some important changes. First, most of the national carriers were privatized or partially privatized and started adopting sophisticated pricing techniques (Talluri and van Ryzin, 2005). Second, although carriers had the freedom to adjust their network structure in accordance to their needs, network modifications were quite limited. For instance, European routes analyzed in this work maintained the same full-service operators for all the period of analysis, and the full-service carries operating that routes were based in the country of one endpoints of the route. Third, a consistent growth of low-cost carriers was observed, even if at the end period (July 2003), in 41 selected routes, we continued to observe a market dominance of the full-service carriers for most of the city-pairs.

The main source of data is posted fares retrieved from the computer reservation system Galileo for 41 city-pairs in the period April 2001 - July 2003. Fares concern operating non-stop direct flights between Italy and three European countries, UK, Germany, and the Netherlands involving for four legacy carriers (Lufthansa, British Airways, Alitalia, and KLM). The use of city-pairs is usually preferred to that of airport-pairs when the analysis also involves low-cost carriers as entry often occurs in secondary airports (see, e.g., Nero, 1998).

Apart from the severe restriction concerning the duration of the period under evaluation and the numerousness of destinations, this data has the value of including detailed information on booking class, cabin, ticketing restriction, etc. An in depth analysis on fare characteristics was conducted in order to obtain 8 homogeneous fare classes reported in Table 1.

Usually, Carriers label classes with capital letters. For example, the promotional classes of Alitalia are O and N, while those of Lufthansa are V or W. Our classification is obtained by analyzing the ticket characteristics of the four full-service carriers for each of their classes, and assigning each original class of each carrier to one of the 8 classes valid for all the carriers. The main attributes we have kept into account are ticket characteristics (ticket cancellation, travel date change penalties, purchase time limits, or minimum stay at the travel destination, Sunday rule, etc) and ground services (in-flight entertainment, fast check-in, VIP waiting lounges).[13]

Additional information concerning passengers, flows, frequencies and seats offered on bi-annual bases are collected from OAG databases and airport authorities. Information on socio-demographics on origin and destination areas is collected from the Eurostat Euregio database.

Contrary to US data, we do not have information on ticket fares but only on posted fares. Although this is a major shortcoming for the analysis of European markets, in this specific case this is not critical since we are interested in studying the change in the fare schedule in different market structures, and not, for instance, fare dispersion (where quantities matter).

The construction of the sample begins by converting posted fares into half-yearly information. We take three different steps. First, we exclude one-way fares from the analysis. This is justified by the fact that one-way tickets are rarely sold by full-service carriers in the European market. Second we have transformed raw data on posted fares into monthly data (obtaining 14,152 different airfares), and added information on the presence or absence of low-cost carriers on the route. Within the sample, we have 12 city-pairs with the following low-cost carriers: Ryanair, easyJet, Basiqair, Volare Web, British Midland, Air Berlin, Virgin Express and Hapag Lloyd Express. Finally, to match data frequency of other sources as well as to account for pricing practices of carriers, we convert previous observations into bi-annual data, averaging information by period, route and carrier. To be consistent with OAG practices, semesters are called Winter (which lasts 5 months and spans from November to March) and Summer (which lasts 7 months and spans from April to October). The

[13] The choice to use a class mapping procedure to classify different fares comes from the observation that high collinearity among fare attributes (which are usually nested moving from the lowest to the highest fare), makes the simultaneous use in the estimation difficult (Stavins, 2001).

resulting database 1269 observations concerns 41 routes, 4 carriers, 8 fare classes for 5 periods (semesters).[14]

Summary statistics are presented in Table 2.

3.2 Empirical model

Our econometric approach is based on the following specification:

$$FARE_{ijtc} = \alpha + \delta_{ij} + \gamma_t + \beta_1 SHARE_{ijt} + \beta_2 LCC_{jt} + \sum_{c=1}^{8} \theta_c CLASS_c + \varepsilon_{ijtc}, \quad (19)$$

where $FARE_{ijtc}$ is the log fare charged by carrier i on route j on period t for a ticket class c, δ_{ij} is route carrier fixed effect, γ_t is period fixed effect, $SHARE_{ijt}$ is the passenger share of carrier i on route j on period t, $CLASS_c$ is dummy variable for fare class c, and LCC_{jt} is market share of low-cost carriers on route j on period t (number of frequencies over the total).

Some extensions include the following dummy variables: TWO_{ijt}^{LEI} is a dummy variable for the presence of a second full-service carrier when the fare is intended for leisure travellers (fare classes 1, 2 and 3) and TWO_{ijt}^{BUS} is a dummy variable for the presence of a second full-service carrier when the fare is for business travellers (fare classes 6, 7 and 8).

Previous literature has emphasized the risk of endogeneity of the variables $SHARE$ and LCC that can be potentially correlated with the error process. Standard econometric techniques suggest, therefore, to estimate equation (19) using instrumental variables (IV). A valid instrument for the variable $SHARE$, proposed by Borenstein (1989) and afterwards utilized by Borenstein and Rose (1994) and Gerardi and Shapiro (2009), is $ENPL_{ijt}$, the ratio between the geometric mean of enplanements of carrier at the two endpoints and the sum across all carriers of the geometric mean of each carrier's enplanement at the endpoints.

Endogeneity issues on the variable LCC are more serious because they concern a main variable of interest in our analysis. Endogeneity should derive from the fact that low-cost carriers are attracted by most profitable markets and full-service carrier fares are also positively related with market profitability. Therefore, if market profitability is not in the explanatory variables, the error process is positively correlated with the low-cost variable, and the estimated fare reduction due to the entry of a low-cost carrier is underestimated.

Recent literature suggests that is difficult to find valid instruments for the entry of low-cost carriers (See: Gerardi and Shapiro, 2009). Berry (1992) suggested that the presence of a low-cost carrier on the two endpoints of a route increases the likely of entry on this route. Goolsbee and Syverson (2008) used this variable in order to capture the potential entry of a low-cost carrier, and showed that full-service carriers react to the threat of entry by reducing their prices some months before the entry. However, their analysis is quite different from ours, because they selected only on those routes in which entry occurs and therefore do not account for those routes that were less affected

[14] This is an unbalanced panel since some carriers on specific routes and on specific periods do not post all the class fares. In particular, some promotional fares are often not posted by Alitalia or Lufthansa, as well as some other economy and business fares may not be posted by KLM. This is an additional rationale to aggregate the initial 8 classes into 3 main classes.

by low-cost carrier entry decision. In our analysis, we cannot rely on this variable since the European market in 2001-2003 has a very different structure from US market. In our study, since there were no bases of low-cost in Italy, this variable was always null.

We therefore decided to provide a new instrument for the presence of a low-cost carrier: the potential demand on the route. The proposed instrument is clearly correlated with the entry decision of the low-cost carriers (since they want to enter on dense markets, see, e.g.: Boguslaski et al., 2004; Sinclear, 1995) but marginally correlated with the error process, since full-service profitability is mainly affected by some un-measurable variable such as the industrial relations among linked areas, etc.. We choose to measure the potential demand with DEN_{ijt} that is the geometric average of the population density in the regions of the two endpoints (in thousands of inhabitants for square kilometre). This variable is preferred to a measure of the population which more affected by the size of the region under consideration.[15]

3.3 Empirical Results

Equation (19) is estimated using panel fixed effects including a carrier-route fixed effect and a time-period fixed effect. Standard errors are clustered by route in order to control for autocorrelation as well as correlation between carriers on the same route. Results are reported in Table 3. All the models are estimated with the two-stage instrumental variable estimator apart from Model 1 that presents the ordinary least square estimates.[16]

Models 1-2 show that the route share of low-cost carriers (LCC) has a negative impact on full-service carrier fares. In order to measure the impact of the entry of a low-cost carrier, we have also estimated the model using a dummy variable for the presence of low-cost carriers. Results are quite similar but the use of the route share of low-cost carriers increase the significance of the coefficient. This is in line with the fact that pricing behaviour of a full-service carrier is more affected when there is a larger involvement of low-cost carriers.

Coefficients of fare classes are statistically significant and have the expected ordering. We choose as reference class CLASS4. As expected, coefficients of the lower classes have a negative sign and those of higher classes a positive one. In those cases, where we split the sample by classes (Models 3-5), the reference class for the leisure segment is CLASS3, for the intermediate segment is CLASS4, and for the business segment is CLASS8. The coefficient of SHARE has the right sign but, in most of the estimates, is not significant (see below, for an explanation).

[15] European geographical partition of member countries is based on NUTS (Nomenclature of Statistical Territorial Units) classification. The size of NUTS territorial areas is quite heterogeneous since it corresponds to the administrative division of countries which are quite different. We use NUTS1 classification for the UK, the Netherlands and Germany and NUTS2 for Italy.

[16] The Durbin-Wu-Hausman chi-sq test in some estimates rejects the assumption of exogeneity of LCC and $SHARE$. We therefore decide to consider these variable as endogenous in line with the current literature. The qualitative results are not affected by this choice. (Estimates where one or both variables are considered exogeneous are available upon request) Standard tests for the detection of weak instruments are applied. For Model 2, the F-statistics for excluded instruments for LCC and $SHARE$ are, respectively 11.83 and 52.79, which are above the value suggested by Staiger and Stock for identifying weak instruments. We also test the instrument relevance comparing the Shea partial R-squared with the Bound et al. (1995) partial R-squared. Both statistics provide similar values for the two variables suggesting that the model is fully identified (in both cases the partial R-squared are 0.19 for LCC and 0.42 for $SHARE$).

The theoretical analysis provides two main arguments concerning the price behaviour of full service carriers. One point is that the entry of low-cost carriers reduces fares in the weak market and possibly increases them in the strong one. The other is that fare differentials (between the strong and the weak market) will decrease (or at least remain unchanged) when one moves from one to two full-service carriers. In Table 4 we summarize the main testable predictions of the theoretical model and the corresponding empirical outcomes.

Models 3-5 analyse the impact of the entry of low-cost carriers on the fare structure. We observe a clear pattern indicating a negative and statistically significant impact of LCC on fares in the leisure segment and in the intermediate segment, while a positive and statistically significant increase for business segment. This confirms the theoretical result that this outcome is likely to emerge if there is a sufficient cost difference between low-cost and full-service carriers and inter-group externalities are at work.

Quite interesting, we also find that $SHARE$ has a negative sign for the leisure and intermediate classes (even if it is not significant) and a positive and highly significant value for the business class. The rationale behind this result is that higher market shares (and therefore higher frequencies and therefore higher quality of the product offered) allow carriers to charge higher fares in the business segment; however, it also induces full-service carriers to play more aggressively on the leisure segment to attract a large number of leisure passengers to fill the excessive capacity. These opposite effects may be the reason of low significance of $SHARE$ when we use a single variable for all classes.

Models 6-8 can be used to investigate the relationship between class prices and market structure. Since our database does not include cases where the number of full-service carriers change on the same route, the empirical analysis cannot address the question whether fares reduce or increase by moving from a case with one full-service carrier to another with two full-service carriers. However, our data are useful in capturing price differentials. Variables TWO^{LEI} and TWO^{BUS} are employed for this goal. Equations (20) and (21) describe full-service carriers fares in the leisure and business segments when there are one or two full-service carriers:

$$FARE_{ONE}^{LEI} = X_{ONE} + CLASS^{LEI}, \qquad FARE_{TWO}^{LEI} = X_{TWO} + CLASS^{LEI} + TWO^{LEI}, \tag{20}$$

$$FARE_{ONE}^{BUS} = X_{ONE} + CLASS^{BUS}, \qquad FARE_{TWO}^{BUS} = X_{TWO} + CLASS^{BUS} + TWO^{BUS}, \tag{21}$$

where X_{ONE} and X_{TWO} summarize all the variables of (19) that are not present in (20) and (21), when there are, respectively, one or two full-service carriers. From previous equations, we obtain:

$$\Delta FARE^{LEI} = FARE_{TWO}^{LEI} - FARE_{ONE}^{LEI} = (X_{TWO} - X_{ONE}) + TWO^{LEI}, \tag{22}$$

$$\Delta FARE^{BUS} = FARE_{TWO}^{BUS} - FARE_{ONE}^{BUS} = (X_{TWO} - X_{ONE}) + TWO^{BUS}. \tag{23}$$

Therefore, fare differentials are: $\Delta FARE^{LEI} - \Delta FARE^{BUS} = TWO^{LEI} - TWO^{BUS}$ that can also be interpreted as $\left(FARE_{ONE}^{BUS} - FARE_{ONE}^{LEI}\right) - \left(FARE_{TWO}^{BUS} - FARE_{TWO}^{LEI}\right)$ i.e. the difference between fare gap when there is only one full-service carrier and when there are two. Table 4 shows that this gap is positive and statistically significant for Models 7 and 8 in line with the theoretical outcome. Therefore, we find that fare gaps reduce moving towards more competitive environments, and that ICC is likely to be slack in non monopolistic markets.

4. Conclusions

In this paper we have investigated the pricing behaviour of full-service carriers by generalizing a simple view of the functioning of the market proposed by Borenstein and Rose (2004). We have relaxed the assumption of market independency, and we have accounted for inter-group effects. Empirical evidence concerning the European market provides some support to our conclusions. When the market structure moves from monopoly to duopoly, price gap reduces suggesting that quality premium constrain becomes slack. Therefore in competitive environments third-degree and second-degree price discrimination approaches reach the same results. Nevertheless, the latter provides more stringent conclusions on the effects of the 'peer' competition in the market. This also helps to enrich the debate concerning market structure and price dispersion. Moreover, we have showed how inter-group effects may have some impact on pricing behaviour in the second-degree price discrimination approach through relaxing the quality premium constraint and allowing full-service carriers to charge larger price differentials between restricted and unrestricted fares. This aspect is too often neglected in the analysis of markets and could be object of future research.

Appendix

Monopoly analysis.

Proof of Proposition 1. Part a) We analyze the conditions under which, profit maximizing prices are given by (9). First note that when the market i is partially covered, the location of the indifferent consumer of type i, $\hat{x}_i \in \left(0, \frac{1}{2}\right)$, when the monopolist position is in 0 is given by: $u_{ii} - \sigma_i \hat{x}_i - p_i = 0$. Therefore, demand in market i is $2\mu_i \hat{x}_i = (2\mu_i/\sigma_i)(v + u_{ii} - p_i)$. When the market i is fully covered, demand in market i is simply μ_i. During the analysis we assume that the weak market is partially covered.

There are 4 cases of interest that we are going to briefly analyze. The first one is that considered in Section 2.2, i.e. full coverage of the strong market and ICC binding (case A). The second one is when there is partial coverage of the strong market and ICC is binding (case B). The third one is when there is partial coverage of the strong market and ICC is not binding (case C). Finally, the case in which the strong market is covered but ICC is not binding (case D).

We start analysing case C and then we study the conditions under which we move to case B or D and finally to case A. The problem can be easily tackled without recurring to Lagrange multiplier approach.

In case C (partial coverage of the strong market and ICC slack), the profit maximizing problem is, therefore:

$$\max 2\mu(u_{11} - p_{F1})\sigma_1^{-1}(p_{F1} - c_1) + 2(1-\mu)(u_{22} - p_{F2})\sigma_2^{-1}(p_{F2} - c_2) \qquad \text{(A1)}$$

From first order conditions, we have: $p_{Fi} = \frac{1}{2}(u_{ii} + c_i)$, with $i = 1,2$. Using (3), it implies that the ICC is slack if and only if

$$u_{22} + u_{11} - 2u_{21} > c_2 - c_1. \qquad \text{(A2)}$$

To be in case C, however, we also need that $MS_2 < 1$ or in equilibrium that $u_{22} < \sigma_2 + c_2$, and therefore, that the total utility received by consumers of type 2 is less than the sum of overall costs. Otherwise, i.e. when

$$u_{22} > \sigma_2 + c_2, \tag{A3}$$

the monopolist will prefer to offer full coverage of the strong market, i.e., to move from case C to case B. Note that in case B, where ICC is slack and there is full coverage of the strong market, the monopolist charge a price $p_2^{co} = u_{22} - \sigma_2/2$, which is sufficient to extract all the utility from the farthest consumer of type 2 in the strong market, and $p_{F1} = \frac{1}{2}(u_{11} + c_1)$ in the weak market. This case holds until equation (3) is not binding, or: $u_{11} - c_1 > 2(u_{21} - c_1) - \sigma_2$. Note that previous inequality is stronger than (A2) since it can be written as $u_{22} + u_{11} - 2u_{21} > (c_2 - c_1) + (u_{22} - c_2 - \sigma_2)$, where the last term is positive due to the full coverage of the strong market. When

$$u_{11} - c_1 \leq 2(u_{21} - c_1) - \sigma_2 \tag{A4}$$

we enter in the case described in Section 2.2 (case A) provided that there is partial coverage of the weak market, i.e.: $0 < MS_1 < 1$. Using (6) and remembering that $M = (1-\mu)/(2\mu)$, we obtain therefore that:

$$M\sigma_1 < u_{11} - c_1 < (M+1)\sigma_1. \tag{A5}$$

Inequalities (A3)-(A5) correspond to assumptions (5)-(7). Case B is the analogous of case A when in inequality (A4) the sign "≤" is replaced by ">".

Part b) In the text.

Symmetric duopoly analysis.

Proof of Proposition 2. Parts a), c)-e) are in the text. Part b) We analyse the case when ICC is binding (the other was already presented in Section 2.3), i.e. when $\Delta = c_2 - c_1 + (\sigma_2 - \sigma_1)/2 > r$. Without loss of generality, we consider the pricing decision of firm j. Using (2), the indifferent consumer on the arc ij is simply: $\hat{x} = \frac{1}{4}(\sigma_i + 2p_{kl} - 2p_{jl})$ and market share of firm j on market i, is $2\hat{x}$. Therefore, the maximization problem of firm j, after using (3), is:

$$\max \mu \left(\frac{1}{2} + \frac{p_{k1} - p_{j1}}{\sigma_1}\right)(p_{j1} - c_1) + (1-\mu)\left(\frac{1}{2} + \frac{p_{k2} - p_{j1} - r}{\sigma_2}\right)(p_{j1} + r - c_2) \tag{A6}$$

Taking the first-order derivative and imposing symmetry, we obtain equation (13).

Part c) We show it for $\Delta < r$. Using (9) and (11), the price difference between monopoly and duopoly in the strong market is positive if:

$$u_{11} - c_1 \leq M\sigma_1 + 2(u_{22} - c_2) - \sigma_2 \tag{A7}$$

From (7), it follows that (A7) is certainly satisfied if $(u_{22} - c_2) > (u_{21} - c_1)$, or $c_2 - c_1 < r$, which is satisfied when $\Delta < r$.

Part d) clear from the text.

Asymmetric duopoly analysis.

The indifferent consumer of type t_{11} and t_{10} are simultaneously obtained by solving the following system:

$$\begin{cases} (t_1 + 2\beta(\hat{x}_{11} - \hat{x}_{10}))q_1 - \sigma_1 \hat{x}_{11} - p_{F1} = (t_1 - 2\beta(\hat{x}_{11} - \hat{x}_{10}) - \delta_1)q_1 - \sigma_1(1 - \hat{x}_{11}) - p_L \\ t_1 q_1 - \sigma_1 \hat{x}_{10} - p_{F1} = t_1 q_1 - \sigma_1(1 - \hat{x}_{10}) - p_L \end{cases} \quad \text{(A6)}$$

We obtain: $\hat{x}_{10} = \frac{1}{4} - \frac{1}{2\sigma_1}(p_{F1} - p_L)$ and $\hat{x}_{11} = \frac{1}{4} - \frac{1}{2\sigma_1}(p_{F1} - p_L) + \frac{q_1\delta_1}{2\sigma_1 - 4\beta q_1}$.

Now, the profit maximization of the full-service carrier is given by:

$$\max \mu(\hat{x}_{10} + \hat{x}_{11})(p_{F1} - c_1) + (1 - \mu)(p_{F2} - c_2), \quad \text{(A7)}$$

where $p_{F2} = p_{F1} + (t_2 + 2\beta(\hat{x}_{11} - \hat{x}_{10}))(q_2 - q_1)$ is the ICC. Note that although we are considering a situation where, low-cost carriers have no direct impact on the strong market, however prices in the strong market are affected by two channels. First, due to the ICC, p_{F2} is linked to p_{F1}, second, p_{F2} is also affected by $(\hat{x}_{11} - \hat{x}_{10})$, depending on the price choice of the low-cost carrier.

The profit maximization of the low-cost carrier is given by:

$$\max \mu(1 - (\hat{x}_{10} + \hat{x}_{11}))(p_L - c_0) \quad \text{(A8)}$$

Taking the first order derivatives, we obtain equilibrium prices reported in (15) and (16). Note that equilibrium prices when ICC is slack are given by (16) with $M = 0$ in the weak market and $p_2 = u_{22} - \sigma_2/2$ in the strong market. Replacing previous expressions in (3), after some computations we find that ICC is binding when:

$$\sigma_1 - 2\sigma_2 - \frac{2}{3}(c_1 - c_0) + \frac{1}{3}(\sigma_1 - 6\beta q_1)I \leq 2(u_{21} - c_1) - \sigma_2 \quad \text{(A9)}$$

where $I = (\delta_1\sigma_1 q_1)/(\sigma_1 - 2\beta q_1)$. Under (7), this restriction is always satisfied apart when I is very large, a case we exclude from our analysis.

Proof of Proposition 3. Part a) of the proposition directly follows from previous discussion. Part b) directly follows by comparing (9) and (16).

In order to prove part c) we compute the price difference Δp_{F1} (Δp_{F2}) between the monopoly and the asymmetric duopoly case in the weak (strong) market. Using (9) and (16), we obtain:

$$\Delta p_{F1} = -\frac{1}{3}(c_1 - c_0) - \frac{1}{2}(u_{11} - c_1 - (M + 1)\sigma_1) + \frac{5}{6}M\sigma_1 + \frac{1}{6}I, \quad \text{(A10)}$$

$$\Delta p_{F2} = -\frac{1}{3}(c_1 - c_0) - \frac{1}{2}(u_{11} - c_1 - (M + 1)\sigma_1) + \frac{5}{6}M\sigma_1 + \frac{1}{6}I + \frac{\beta}{\sigma_1}I(q_2 - q_1). \quad \text{(A11)}$$

The first term is non positive by assumption. The second term is positive by condition A2. Finally, the last two/three terms are positive. Therefore, the price difference can be simultaneously negative in the weak market and positive in the strong market if:

$$\frac{1}{6}I < \frac{1}{3}(c_1 - c_0) - \frac{1}{2}(u_{11} - c_1 - (M + 1)\sigma_1) - \frac{5}{6}M\sigma_1 < \frac{1}{6}I + \beta I(q_2 - q_1)/\sigma_1, \quad \text{(A12)}$$

i.e. cost differentials are sufficiently high.

Asymmetric oligopoly analysis.

Consider the three regions in which the circumference is separate by the three carriers: $A \equiv \left(0, \frac{1}{4}\right)$, $B \equiv \left(\frac{1}{4}, \frac{1}{2}\right)$ and $C \equiv \left(\frac{1}{2}, 1\right)$. Due to the presence of low-cost carriers, t_{11}-type and t_{10}-type consumers located in the same place may prefer to patronize different carriers. Using equations (1) and (2), the utility a t_{11}-type traveller located in $x \in A \equiv \left(0, \frac{1}{4}\right)$ receives, when patronizing the full-service carrier F_A, is: $v + \left(t_1 + \beta(x_{A11} - x_{A10}) - \beta(x_{C11} - x_{C10})\right)q_1 - \sigma_1 D(x, y_A) - p_{A1}$ and the utility she receives, when patronizing the low-cost carrier, is: $v + (t_1 - \beta(x_{A11} - x_{A10}) + \beta(x_{B11} - x_{B10}) - \delta)q_1 - \sigma_1 D(x, y_L) - p_L$, where x_{A11} and x_{A10} are respectively the number of t_{11}-type and t_{10}-type passengers travelling with the full-service carrier F_A on the arc $A \equiv \left(0, \frac{1}{4}\right)$, and analogously for x_{B11}, x_{B10}, x_{C11} and x_{C10}. Similarly, the utility a t_{11}-type traveller located in $x \in B \equiv \left(\frac{1}{4}, \frac{1}{2}\right)$ receives, when patronizing the full-service carrier F_B, is: $v + \left(t_1 - \beta(x_{B11} - x_{B10}) + \beta(x_{C11} - x_{C10})\right)q_1 - \sigma_1 D(x, y_B) - p_{B1}$ and the utility she receives, when patronizing the low-cost carrier, is: $v + (t_1 - \beta(x_{A11} - x_{A10}) + \beta(x_{B11} - x_{B10}) - \delta)q_1 - \sigma_1 D(x, y_L) - p_L$. Finally, the utility a t_{11}-type traveller located in $x \in C \equiv \left(\frac{1}{2}, 1\right)$ receives, when patronizing the full-service carrier F_A, is: $v + \left(t_1 + \beta(x_{A11} - x_{A10}) - \beta(x_{C11} - x_{C10})\right)q_1 - \sigma_1 D(x, y_A) - p_{A1}$ and when patronizing the full-service carrier F_B, is: $v + \left(t_1 - \beta(x_{B11} - x_{B10}) + \beta(x_{C11} - x_{C10})\right)q_1 - \sigma_1 D(x, y_B) - p_{B1}$. The utility of t_{10}-type consumer are as previously described by imposing $\beta = 0$.

Using previous expressions and solving for the indifferent consumer, after some computations, it is possible to derive the market shares of the three firms as a function of the three prices, and after substituting them in the profit functions and solving a 3-equation system of the first order conditions, we obtain equilibrium prices reported in equations (13) and (14).

Proof of Proposition 4. Part a) of the proposition directly follows from previous discussion. Part b) holds since in the asymmetric duopoly ICC is binding, while in the asymmetric oligopoly it is not. In order to prove part c) we compute the price difference Δp_{F1} between the asymmetric oligopoly case and the symmetric duopoly case in the weak market. Using (11) and (18), we obtain:

$$\Delta p_{F1} = -\frac{1}{5}(c_1 - c_0) - \frac{3}{20}\sigma_1 + \frac{1}{5}\frac{\delta\sigma_1 q_1}{2\sigma_1 - 3\beta q_1} \quad \text{(A13)}$$

Here there are two sources of price reduction. The first one is due to cost advantage of the low-cost carrier, which induce full-service carriers to reduce its prices, the second is due to proximity of the low cost carriers, which induce more competition. Inter-group effects play in the opposite direction. Since p_{F2} remains unchanged ($\Delta p_{F2} = 0$), conditions guaranteeing a price fall in the weak market are also those that imply an increase in price differences moving from a symmetric duopoly to an asymmetric duopoly.

References

Alderighi, M., 2007. Non-linear pricing in asymmetric duopoly, Australian Economic Papers 46, 205-22.

Alderighi, M., 2009. Competition (sorting effect) may favour a monopolist, Journal of Economics 98, 2009, 247-255.

Alderighi, M., 2010. The role of fences in oligopolistic airline markets, Journal of Transport Economics and Policy, forthcoming.

Armstrong, M. and Vickers, J. 2001. Competitive Price Discrimination, RAND Journal of Economics 32, 579–605.

Asplund, M., Eriksson, R., Strand, N., 2008. Price discrimination in oligopoly: evidence from regional newspapers, Journal of Industrial Economics 56(2), 333-346.

Becker, G.S., 1991. A note on restaurant pricing and other examples of social influences on price, Journal of Political Economy 99, 1109-1116.

Bennett, R.D., Craun, J.M., 1993. The airline deregulation evolution continues: the Southwest effect. US Department of Transportation, Washington, DC (mimeo).

Blattberg, R., Wisniewski, K., 1989. Price-induced patterns of competition, Marketing Science 8, 291-30.

Boguslaski, C., Ito, H., Lee, D., 2004. Entry patterns in the Southwest airlines rote system, Review of Industrial Organization 25, 317-350.

Borenstein, S., 1985. Price discrimination in free-entry markets, RAND Journal of Economics 16(3), 380-97.

Borenstein, S., Rose, N.L., 1994. Competition and price dispersion in the U.S. airline industry, Journal of Political Economy 102(4), 653-683.

Borzekowski, R., Thomadsen, R., Taragin, C., 2008. Competition and price discrimination in the market for mailing lists, Quantitative Marketing and Economics 7(2), 147-179.

Bound, J., Jaeger, D.A., Baker, R., 1995. Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variables is weak, Journal of the American Statistical Association 90, 443-450.

Dana, J.D., 1999. Equilibrium price dispersion under demand uncertainty: the roles of costly capacity and market structure, Rand Journal of Economics 30(4), 632-60.

Desai, P.S., 2001, Quality Segmentation in Spatial Markets: When does cannibalization affect product line design?, Marketing Science 20, 265-283.

Dessein, W., 2003. Network competition in nonlinear pricing, Rand Journal of Economics, 34(4): 593-611.

Dresner, M., Lin, J.-S.C., Windle, R., 1996. The impact of low-cost carriers on airport and route competition. Journal of Transport Economics and Policy 30(3), 309-328.

Ellison, G., 2005. A model of add-on pricing. Quarterly Journal of Economics, 120: 585-637.

Escobari, D., Gan, L., 2007. Price dispersion under costly capacity and demand uncertainty. NBER Working Paper No. W13075.

Evans,W.N., Kessides, I.N., 1993. Localized market power in the U.S. airline industry. Review of Economics and Statistics 75 (1), 66–75.

Franke M, 2004, Competition between network carriers and low-cost carriers—retreat battle or breakthrough to a new level of efficiency?, Journal of Air Transport Management, 10: 15-21.

Gerardi, K., Shapiro, H, A., 2009, Does Competition Reduce Price Dispersion? New Evidence from the Airline Industry, Journal of Political Economy 117, 1-37.

Giaume, S., Guillou, S, 2004. Price discrimination and concentration in European airline markets, Journal of Air Transport Management 10: 305-310.

Goolsbee, A., Syverson, C., 2008, How do incumbents respond to the threat of entry? Evidence from the major airlines, Quarterly Journal of Economics 123(4), pages 1611-33.

Hernandez, M.A., Wiggins, S.N., 2009. Nonlinear pricing strategies and market concentration in the airline industry, mimeo.

Holmes, T.J., 1989. The effects of third-degree price discrimination in oligopoly, American Economic Review 79(1), 244-50.

Justin, J., Myatt, D., 2003. Multiproduct quality competition: fighting brands and product line pruning, American Economic Review, 93(3):748-774.

Katz, M.L., 1984. Firm-specific differentiation and competition among multiproduct firms, Journal of Business 57, S149-S166.

Katz, E., Spiegel, U., 1996. Negative intergroup externalities and market demand, Economica 63, 513-19.

Leibenstein, H., 1950. Bandwagon, snob, and Veblen effects in the theory of consumers' demand, Quarterly Journal of Economics 64, 183-207.

Liu, Q., Serfes, K., 2006. Second-degree price discrimination and price dispersion: the case of the U.S. airline industry, mimeo.

Moorthy, K. S., 1984. Market Segmentation, Self-Selection, and Product Line Design, Marketing Science, 3: 288–307.

Morrison, S.A., 2001. Actual, Adjacent, and Potential Competition. Estimating the Full Effect of Southwest Airlines, Journal of Transport Economics and Policy 35(2), 239-256.

Morrison, S., Winston, C., 1989. Enhancing the performance of the deregulated air transportation system, Brookings Papers: Microeconomics 1989, 61-123.

Mussa, M. and Rosen, M., 1978. Monopoly and Product Quality, Journal of Economic Theory 18, 301-317.

Pauwels K., Srinivasan S., 2004. Who benefits from store brand entry?, Marketing Science 23, 364-390.

Perloff, J. M., V. Y. Suslow, P. J. Seguin. 1996. Higher prices from entry: Pricing of brand-name drugs. Mimeo, University of California, Berkeley, CA.

Rochet, J.-C., Stole, L.A., 2002. Nonlinear pricing with random participation, Review of Economic Studies 69, 277-311.

Salop, S. C., 1979. Monopolistic competition with outside goods, Bell Journal of Economics 10, 141-156.

Sinclear, R.A., 1995. An empirical model of entry and exit in airline markets, Review of Industrial Organization 10, 541-57.

Staiger, D., Stock, J.H., 1997. Instrumental variables regression with weak instruments, Econometrica 65: 557-86.

Stavins, J., 2001. Price discrimination in the airline market: the effect of market concentration, Review of Economics and Statistics 83, 200-202.

Stole, L., 2007. Price Discrimination in Competitive Environments, in Handbook of Industrial Organization III (M. Armstrong, R.H. Porter, eds.), Ch. 34.

Talluri, K.T., van Ryzin, G.J., 2005. The theory and practice of revenue management, Springer, New York.

Thomadsen, R., 2007. Product positioning and competition: the role of location in the fast food industry, Marketing Science 26(6), 792-804.

Vickrey, W. S., 1964. Microstatics. Harcourt, Brace and World, New York. Reprinted (with foreword) as: Selection, Spatial Competition and Monopolistic Competition, International Journal of Industrial Organization 17, 953-963.

Villas-Boas, M., Schmidt-Mohr, U., 1999. Oligopoly with asymmetric information: Di¤erentiation in credit markets, RAND Journal of Economics 30, 375-396.

Ward, M. B., Shishack, J. P., Perloff, J. M., Harris, J. M., 2002. Effects on the private-label invasion in food industries, American Jounal of Agricultural Economics 84, 961-973.

Whinston, M.D., Collins, S.C., 1992. Entry and competitive structure in deregulated airline markets: an event study analysis of People Express, RAND Journal of Economics 23(4), 445-462.

Wilson, R., 1993, Nonlinear Pricing, Oxford University Press, New York.

Windle, R.J., Dresner, M.E., 1995. The short and long run effects of entry on US domestic air routes, Transportation Journal 35(2), 14-25.

Windle, R., Dresner, M., 1999. Competitive responses to low cost carrier entry, Transportation Research Part E 35:59-75.

Yang, H., Ye, L., 2008. Nonlinear pricing, market coverage, and competition, Theoretical Economics 3, 123-153.

Zhao, W. and Zheng Y.-S., 2001. A Dynamic Model for Airline Seat Allocation with Passenger Diversion and No-Show. Transportation Science 35(1), 80-98.

Zhang, D. and Cooper W. L., 2005. Revenue Management for Parallel Flights with Customer-Choice Behavior, Operation Research 53(3), 415-431.

Figures

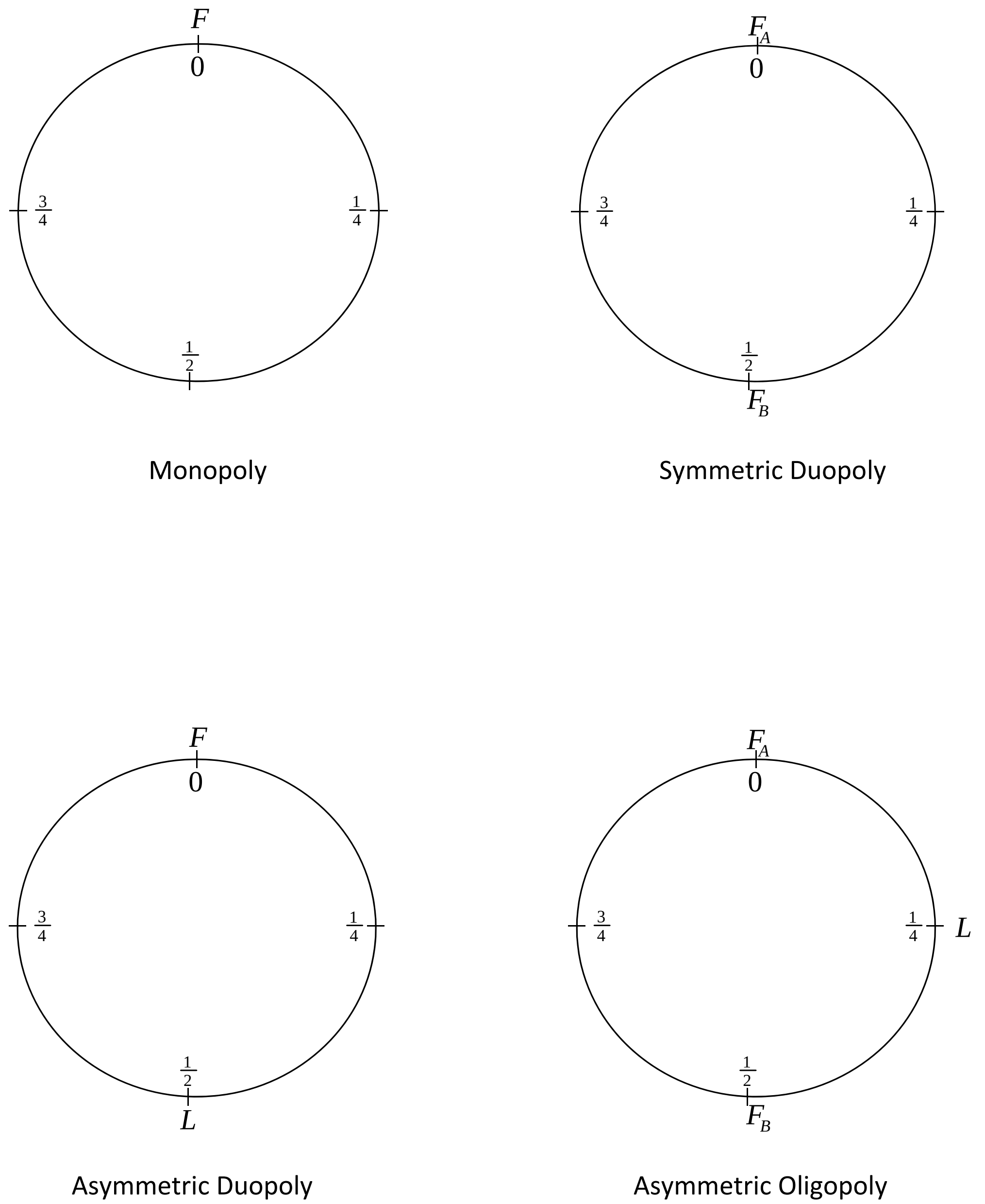

Figure 1. Market Structures.

Tables

Table 1 – Class mapping

TYPE OF FARE (8 classes)	(3 classes)	AZ	KL	BA	LH	mean	std. dev	min	max
Promotional	Leisure	O-N	V-T	Q-N	W-V	167	33.9	99	295
Discounted 1	Leisure	W-T	L	V-L	Q-H	276	60.1	165	411
Discounted 2	Leisure	Q	K	M	M	361	58.7	240	494
Economy 1	Intermediate	B	B	K-H	B	454	102.3	300	732
Economy 2	Intermediate	M	S	B-I	B	580	100.3	320	838
Unrestricted 1	Business	Y	Z	Y	Y	815	161.0	440	1092
Unrestricted 2	Business	I	C	D	D	887	151.7	558	1171
Unrestricted 3	Business	C	J	J	C	898	207.5	574	1459

Table 2 – Descriptive statistics

VARIABLE	MEAN	STD. DEV.	MIN	MAX
FARE	6.1173	0.5862	4.7767	7.2855
LCC	0.0784	0.1481	0.0000	0.6364
SHARE	0.7236	0.2768	0.1456	1.0000
FSC	0.5145	0.4999	0.0000	1.0000
ENPL	0.5117	0.1409	0.2335	0.8698
DEN	0.5125	0.3564	0.1638	1.4136

Table 3 – Main estimations (dependent variable: $FARE$)

VARIABLES	(1) OLS FULL SMPL	(2) IV FULL SMPL	(3) IV LEISURE	(4) IV INTERM.	(5) IV BUSINESS	(6) IV FULL SMPL	(7) IV NO LCC	(8) IV ONLY LCC
LCC	-0.0896**	-0.235**	-0.454**	-0.304**	0.107*	-0.237**		-0.406**
	(0.0452)	(0.105)	(0.206)	(0.149)	(0.0593)	(0.105)		(0.197)
$SHARE$	0.0267	0.0568	-0.0485	-0.174	0.0894***	0.0746	-0.0141	0.290**
	(0.0719)	(0.0761)	(0.140)	(0.136)	(0.0306)	(0.0792)	(0.127)	(0.133)
TWO^{LEI}						0.0617*	0.119***	0.0563
						(0.0355)	(0.0443)	(0.0399)
TWO^{BUS}						-0.00465	-0.0164	-0.0671
						(0.0380)	(0.0363)	(0.0541)
$CLASS1$	-0.992***	-0.994***	-0.755***			-1.023***	-0.970***	-1.089***
	(0.0290)	(0.0293)	(0.0222)			(0.0257)	(0.0337)	(0.0314)
$CLASS2$	-0.550***	-0.553***	-0.309***			-0.586***	-0.582***	-0.603***
	(0.0155)	(0.0159)	(0.0184)			(0.0231)	(0.0324)	(0.0280)
$CLASS3$	-0.240***	-0.240***				-0.269***	-0.272***	-0.279***
	(0.0179)	(0.0179)				(0.0182)	(0.0273)	(0.0192)
$CLASS5$	0.274***	0.271***		0.284***		0.271***	0.267***	0.275***
	(0.0117)	(0.0120)		(0.0112)		(0.0117)	(0.0180)	(0.0141)
$CLASS6$	0.563***	0.560***				0.565***	0.494***	0.649***
	(0.0277)	(0.0280)				(0.0405)	(0.0497)	(0.0533)
$CLASS7$	0.676***	0.672***			0.119***	0.679***	0.612***	0.752***
	(0.0272)	(0.0274)			(0.00984)	(0.0390)	(0.0426)	(0.0518)
$CLASS8$	0.691***	0.691***			0.247***	0.695***	0.649***	0.801***
	(0.0249)	(0.0250)			(0.0211)	(0.0317)	(0.0320)	(0.0663)
Observations	1269	1269	497	375	397	1269	585	684
R-squared	0.960	0.960	0.919	0.798	0.824	0.961	0.966	0.966

Note: Table 3 only reports coefficients and standard errors of the variables of interest. The dependent variable is the log of quoted fare of a return ticket sold in Italy (*FARE*). All models include carrier-route specific fixed effects and period fixed effect. Robust standard errors are clustered by route and are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 4 – Hypothesis testing

PROPOSITION	MODEL PREDICTIONS	TEST	p-value	MODEL
3,4	Low-cost entry decreases full-service fares in the weak market	$LCC^{LEI} < 0$	0.014**	Model 3
3,4	Low-cost entry increases full-service fares in the strong market	$LCC^{BUS} > 0$	0.036**	Model 5
3,4	Low-cost entry increases fare differentials	$LCC^{LEI} < LCC^{BUS}$	0.000***	Models 3-5
2,4	Fare differences moving from one to two full-service carriers decrease (full sample)	$TWO^{LEI} > TWO^{BUS}$	0.135	Model 6
2	Fare differences moving from one to two full-service carriers decrease (no low-cost)	$TWO^{LEI} > TWO^{BUS}$	0.015**	Model 7
4	Fare differences moving from one to two full-service carriers decrease (with low-cost)	$TWO^{LEI} > TWO^{BUS}$	0.036**	Model 8
	OTHER RELEVANT RESULTS			
	Market shares positively affects high fares, but	$MS_{bus} > 0$	0.002***	Model 5
	have no significant result on fares in other classes	$MS_{lei} = 0$	0.728	Model 3
		$MS_{int} = 0$	0.202	Model 4

***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.