On-line Price Discrimination with and without Arbitrage conditions

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Abstract

We introduce an on-line pricing tactic where airlines post, at the same time and for the same flight, fares in different currencies that violate the law of One Price. Unexpectedly for an on-line market, we find that price discrimination may be accompanied by arbitrage opportunities and that both tend to persist before a flight's departure. We find discrimination to be of a competitive type, although arbitrage opportunities are more likely in concentrated routes. Finally, the evidence suggests that discrimination may be used to manage stochastic demand.

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Recent empirical research on electronic commerce has consistently found evidence of price dispersion across on-line retailers, but has not reported any case where the same e-company engages in price discrimination on-line – see Michael Baye *et al.* (2005) and Glenn Ellison and Sara F. Ellison (2005) for a survey. The price transparency of the Internet is implicitly assumed not to be conducive to effective on-line price discrimination because the shoppers of a company setting a low and a high price for the same product (e.g., in two different parts of its website) would very quickly learn to buy only at the low price. To overcome this difficulty and extract surplus from their customers, on-line retailers may engage in obfuscation strategies by proposing add-ons to the product originally sought (Glenn Ellison and Sara F. Ellison, 2004). This is not the case in this paper, where we present evidence of different prices being posted by the same e-seller on the same website at the same time for exactly the same product.

Our data are taken from the websites of six European Low Cost Carriers (hereafter, LCCs) and pertain to both UK domestic and European international flights. A simple example illustrates the nature of the on-line price discrimination tactic employed by our LCCs. Consider a flight from, say, London to Madrid. Normally, this corresponds to the first leg of a round trip by a British traveller, and to the return leg of a Spanish traveller. The origin of the first leg determines the currency used by the LCCs to show the final fares, so the Spanish traveller booking a round trip will be offered a fare in Euro while the Briton one in Sterling. Assume the booking occurs at the same time: in the absence of on-line price discrimination, the ratio of the two fares should be very close to the prevailing exchange rate and the Law of One Price should hold (Pinelopi K. Goldberg and Michael Knetter, 1997). However, about 34% of the almost two million observations in our dataset, collected between June 2002 and June 2004, report a difference between the two fares of at least 5 British Sterling or more. Thus, our LCCs engage in on-line price discrimination, without resorting to any obfuscation strategies aimed at confusing the customer. What enables them to do so is simply that the two prices do not appear simultaneously on the same screenshot, and on-line customers have to be able to actively engage themselves in a search to compare the fares, something they might not be aware of. In addition to presenting a new way to conduct on-line price discrimination, we show therefore that search costs play an important role even in the on-line market for air tickets in Europe.[1]

The above type of on-line price discrimination is innovative with respect to the traditional modes of discrimination associated with airlines, such as the Saturday night stay-over requirement or the surcharge for one-way tickets (Joanna Stavins, 2001; Stephanie Giaume and Sarah Guillou, 2004). Indeed, a feature of European LCCs is to have eliminated completely such restrictions,[2] as well as any service distinction thus further excluding any form of discrimination based on quality (Michael Mussa and Sherwin Rosen, 1978). Finally, price variations due to the inclusion of connecting flights are ruled out by the fact that LCCs issue only "point to point" tickets (Eric Clemons *et al*., 2002).

An interesting aspect of this new form of on-line price discrimination is that it may or may not be associated with arbitrage opportunities. When it is not, the airlines manage to segment the markets perfectly. However, for about 10% of our observations for international flights the gains from arbitrage outweigh the costs. This is surprising because, firstly, arbitrage is assumed to be incompatible with discrimination (Lars Stole, 2005; Jean Tirole, 1988). Secondly, one would hardly expect occasions for profitable arbitrage to be posted systematically on-line. Strikingly, we find strong empirical evidence of persistence over time being a characteristic of discriminatory cases and of arbitrage opportunities.

Dispersion in airline prices may arise from variations in costs of serving different passengers or from discriminatory pricing (Severin Borenstein and Nancy L. Rose, 1994). An important aspect in our study is that the research design rules out any cost-based source of dispersion. Indeed, the two prices in different currencies referred to the same flight and were retrieved on-line within at most one hour from each other. Thus, an airline's demand uncertainty and its shadow cost of capacity were identical for each pair of price queries.[3] Hence, any significant divergence between the two prices has to be ascribed to on-line price discrimination only. The econometric analysis reveals that this pricing scheme is more likely used in less concentrated routes, in larger markets and where charter operators are also present: this is in line with the findings in Borenstein and Rose (1994) of dispersion

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[1] Search engines, e.g. www.traveljungle.co.uk or www.skyscanner.net, are present but they are not capable of detecting the type of on-line price discrimination strategy we consider.

[2] For example, departing on a Monday and returning on a Thursday is likely to cost less than returning on a Sunday. In any case, each leg is priced independently at no extra charge for one-way tickets.

[3] There are, however, cross-sectional variations that we consider in the econometric procedure.

increasing with competition. However, the airlines' decision to post an arbitrage opportunity appears to be more likely in highly concentrated routes.

Some motivating examples, their related theoretical framework and the data collection strategy are defined in the next Section, while Section II draws a parallel between the deviations from the Law of One Price in Asplund and Friberg (2001) and those in our dataset. Section III identifies different types of discriminatory cases by distinguishing whether they present arbitrage opportunities. Such distinctions are further investigated in the econometric analysis of Section IV, and followed by the concluding remarks of Section V.

1. Looking for Price Discrimination on-line.

A. Motivating examples.

Examples from a LCC's web site, exhibiting the type of on-line price discrimination on which we focus, are shown in Figures 1 to 4. These are made up of two parts: the top one shows the fares in British Sterling (hereafter, GBP, i.e. Great Britain Pound) for each leg of a round-trip departing from the UK and arriving in another European destination. The bottom part reports the fares (in the currency of the country from which the flight originates) for the inverted trip, where the outgoing flight is scheduled on the same day of the return flight in the top part.[4] The same flight appearing in both parts is framed in an oval for ease of comparison.

Various features of the queries' results need to be specified. First, the queries reported in the two parts of Figures 1-4 were made only a few minutes after the other, therefore ruling out any bias arising from changes in prices due to changes in seats' availability.[5] Second, it is important to stress that the European LCCs we surveyed set prices for each leg independently and that these fares do not change when a customer books a round-trip or a one-way ticket. E.g., in Figure 1 the price of 119.99 GBP for the Ancona (AOI) - London Stansted flight on July 17th 2005 would have appeared identically even if the query had not been for this single flight only. Third, the programme issuing the queries yields fares expressed in the currency of the country where the first flight originates. Finally, to make their sites look familiar by appearing in the visitor's language the airlines' web sites automatically detect the nation in which the visitor is located. However, we believe that doing so does not affect the level of

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[4] The two parts are taken from two different screenshots, each corresponding to a different query for the same flight. They were edited to facilitate and enhance the comparison of fares expressed in different currencies.

[5] See the Windows bar at the bottom of each part.

fares displayed. Indeed, we tried to access the sites using different languages, but the same fares were returned. Moreover, the hypothesis that each airline extracts the fares from the same dataset (or algorithm) is reinforced by the fact that for most airlines the query results are displayed on the same web page, regardless of the language used.[6]

Figure 1 reports a non-discriminatory case where the ratio of the fare in Sterling (119.99 GBP) and in Euro (169.99 EUR) for the flight coded "FR 125" from Ancona to Stansted on July 17th 2005 is very close to the exchange rate on the date of the query, made on July 9th 2005. No attempt at price discriminating is highlighted in this example and possible differences between the fares are likely to be induced by the differences in the exchange rates used by us and by the airline.

Figures 2 and 3 are essential to capture the nature of our new on-line price discrimination's strategy. It clearly shows how the price in GBP for the flight coded "FR2359" is higher than that in Euro. Consider a British traveller wishing to fly from Stansted to Dinard on Aug 25th 2005 and return on Sept 1st. In theory this person, instead of booking a round-trip ticket and pay 69.99 GBP for the first leg plus 9.99 GBP for the second (which is what a query for a round-trip would automatically allow her to do), could buy two separate one-way tickets and pay only 0.45 EUR for the return, saving about 9.5 GBP. It is noteworthy that arbitrage opportunities can arise only for the return trip. Another example satisfying such a condition is shown in Figure 3, for the flight coded "FR 373" from Biarritz to Stansted, where the difference between the two fares is about 19 GBP.

Figure 4 illustrates a case of on-line price discrimination, which is not associated with the possibility to engage in arbitrage. Note how the price in GBP for the flight coded "FR 195" from Bologna Forli to Stansted is about 33 GBP cheaper than the fare quoted in Euro.[7] However, no arbitrage conditions arise in this case because a British traveller would prefer to buy a return ticket and not two separate ones. A side effect of this perfect segmentation of the two markets is that Italian travellers are adversely discriminated as they are offered a higher fare for the same flight.

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[6] At the time of this draft (June 2006), Ryan Air and EasyJet allow the language to be selected by the visitor. Ryan Air and Bmibaby display the results in the same page regardless of the language selected - http://www.bookryanair.com/skylights/cgi-bin/skylights.cgi and http://www.bmibaby.com/bmibaby/skylights/cgi-bin/skylights.cgi respectively - while Easyjet's fares are shown on a URL that is language-sensitive.

[7] Interestingly, the fare in Euro for the other flight (coded FR 199) available on the same route and day is slightly cheaper, although it falls well within the band of inaction.

There are two aspects associated with the exercise of arbitrage in these examples. First, its benefit has to be weighed against the extra costs it would generate. Indeed, booking two one-way tickets entails having: 1) to pay an extra credit card commission of 4.5 GBP; 2) to print an extra ticket; 3) to fill in an extra on-line booking form; 4) to incur search costs to verify the presence of arbitrage possibilities and 5) to find out the exchange rate used by the credit card provider. The presence of these costs creates a "band of inaction" within which it is not worth pursuing arbitrage conditions (Marcus Asplund and Richard Friberg, 2001).[8]

Second, the possibility of arbitrage does not necessarily translate into its actual implementation. In Figures 2 and 3, a British traveller should have issued two queries, one for each single leg. While this would take only little extra time to perform, most individuals would naturally issue only a query for a return ticket and it is unlikely that even a very expert web-surfer could contemplate the possibility to control for arbitrage opportunities. Such a form of bounded rationality arising from psychological inertia increases search costs and may thus protect LCCs when they engage in on-line price discrimination entailing arbitrage opportunities. This issue is further investigated in Sections III and IV.

B. Theoretical Framework

In order to provide a theoretical background useful to comment the empirical findings in the remainder of the paper, we now interpret informally the various outcomes in Figures 1 to 4 in the light of the existing theoretical explanations for price dispersion and discrimination on and off-line. Two aspects appear to be central, although their importance varies case by case: search costs and the demand uncertainty characterizing the two groups of travellers in each country.[9] The latter is important because of the perishability of the airlines' product, and the ensuing need to maximize a flight's load factor.[10]

The "standard case" with no on-line price discrimination (Figure 1) is consistent with a situation where the airlines are confident that aggregate demand is sufficiently high to fill the flight to capacity. Thus, the single price corresponds to the maximum fare a passenger in either country is willing to pay, which the airlines may have learnt from either past experience or on-line price probes. Search costs are not relevant here, as well as for the case in Figure 4,

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[8] See Section 3 for a discussion.

[9] The latter plays a crucial role in the literature on airline pricing – See James Dana (1998 and 2001).

[10] Very often, some European LCCs offer seats at 0.01 GBP. Leaving any strategic motive aside, this is profit enhancing in the presence of perishability, because a filled seat is likely to generate some extra revenues from sales of on-board services (food, drinks, scratch cards etc.)

where the two markets are perfectly segmented. A difference between Figure 1 and 4 may be that the airline believes aggregate demand is not enough to fill the flight to capacity, and therefore resorts to standard third-degree price discrimination to maximize a flight's load factor. In this case, the group with the more inelastic demand (i.e., the Italians in Figure 4) is located in the country where the flight originates (Bologna Forli' in Italy), and so no arbitrage opportunities arise.

Undoubtedly, the most challenging case is that of on-line price discrimination with arbitrage opportunities (Figures 2 and 3). Demand conditions are the same as in the case of Figure 4, so the airline still wants to practice on-line price discrimination. This time, however, the high demand group is made up of passengers that are returning to their country of residence (the Britons), thereby raising the possibility of arbitrage. Absent search costs, it is likely any price divergence would be arbitraged away. It is reasonable to assume that the presence of consumers with positive search costs makes on-line price discrimination and arbitrage a feasible strategy for the LCCs. Note, however, that even a recent survey on price discrimination states as its pre-condition the absence of arbitrage opportunities (Lars Stole, 2005). It is also worth stressing that in the search-theoretic models surveyed by Michael Baye *et al.* (2005) to explain price dispersion on-line, each firm sets only one price, and price dispersion occurs across firms. In our case, the same firm is posting two fares. A theoretical explanation of this, when consumers are heterogeneous in their level of search costs, is presented in Steven Salop (1977). Assume that within the discriminated group travellers differ in their search efficiencies: the inefficient ones then do not search and pay the high price while the efficient ones recognize the arbitrage opportunity and pay a lower fare. Interestingly, Salop (1977) shows that for high enough search costs, no search activity will be conducted: this is consistent with our discussion of how a (possibly large) proportion of on-line consumers does not envisage the possibility of checking the price of two one-way tickets.

C. Data Collection

Since May 2002, we collected the fares using an "electronic spider", which connected directly to the websites of only the main LCCs (i.e., Ryanair, Buzz, Easyjet, GoFly) operating in Great Britain at the time.

The dataset includes daily flights information from June 2002 up to, and including, June 2004, for a total of 25 months. Over such a period, a number of important events took place, which are reflected in the dataset. First, a series of takeovers occurred: Easyjet acquired

GoFly (December 2002) and Ryan Air took over Buzz (March 2003). Second, new LCCs began their operations: the "spider" was upgraded to retrieve fares from the Bmibaby and MyTravelLite sites.

In order to account for the variety of fares offered by the airlines at different times prior to departure, every day we programmed the spider to collect the fares for departures due, respectively, 1, 4, 7, 10, 14, 21, 28, 35, 42, 49, 56, 63 and 70 days from the date of the query. Henceforth, these will be referred to as "booking days". So, for instance, if we consider London Stansted-Rome Ciampino as the route of interest, and assume the query for the flights operated by a given airline was carried out on April 1st 2003, the spider would retrieve the prices for both the London Stansted-Rome Ciampino and the Rome Ciampino-London Stansted routes for departures on 2/4/2003, 5/4/2003, 8/4/2003, 11/4/2003 and so on. The return flight for both types of directional journey was scheduled one week after the departure, but each leg was recorded independently in the dataset (see Appendix A). For those routes where an airline operates more than one flight per day, all fares for every flight were collected. Thus, for every daily flight we managed to obtain up to 13 prices that differ by the time interval from the day of departure (i.e., the booking day). The main reason to do so was to satisfy the need to identify the evolution of fares - from more than two months prior to departure to the day before departure – which has been noted to be very variable for the case of LCCs (Eric Pels and Piet Rietveld, 2004; Stephanie Giaume and Sarah Guillou, 2004).[11]

The collection of the airfares has been carried out everyday at the same time: in addition to airfares we collected the name of the company, the time and date of the query, the departure date, the scheduled departure and arrival time, the origin and destination airports and the flight identification code. In addition to UK domestic routes, flights to destinations in the following continental European countries were considered: Switzerland, Sweden, Norway, Czech Republic, Italy, France, Spain, Holland, Germany, Belgium, Greece, Ireland, Portugal and Austria.

To complement the price data with market structure characteristics, secondary data on the traffic for all the routes and all the airlines flying to the countries indicated above was obtained from the UK Civil Aviation Authority (henceforth, CAA).[12] For each combination

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[11] While the spider could have retrieved any number of prices, in practice the need to reduce both the number of queries made to an airline server and the time of programme execution to a manageable level, led to the design above.

[12] See www.caa.co.uk

of company, route and departure period (i.e., month/year), the CAA provided the number of monthly seats, the number of monthly passengers and the monthly load factors.

Table 1 illustrates how the prices retrieved from the Internet represent an accurate sample of the activity of each of the LCCs in the markets we consider. It compares the number of routes for which we have price data with the actual total number of routes operated by each airline. The latter figure is taken from the CAA dataset, which also provides the number of routes where our LCCs face competition by either a major Full Service Carrier or another LCC. To test the spider's functionality, initially we limited the number of surveyed routes. Indeed, in August 2002 the percentage of routes with prices was 63% of the total number operated by Ryan Air, 50% for Easyjet, 64% for Buzz and 46% for GoFly. However, thanks to the speed of the programme, within a few months such percentages could be increased significantly for all the airlines, to cover 90% or more of the total routes they operated. Considering that the spider took all the prices for all the daily flights, the price dataset provides an exhaustive illustration of the on-line pricing activity of each airline. Table 1 also shows that the airlines differ in the degree of competition they face. For instance, in about 21-26% of EasyJet's routes at least another competitor is also present. At the other extreme, Ryan Air (and Buzz to a lesser extent) faced competition in a very limited subset of routes. The other airlines operate in a smaller number of routes, which is probably why competitive routes account for about one-third of the total. Such differences may be driven by the choice of the arrival destinations. Ryan Air and Buzz chose almost exclusively secondary airports that may be many miles away from the city of arrival, while the other airlines also fly to major airports where Full Service Carriers also land.

D. Identifying Price discrimination on-line

Each query for a round-trip was carried out separately (but simultaneously) assuming the outgoing flight either originated in UK or in continental Europe.[13] The first procedure created a dataset with fares denominated in GBP, the second one with fares expressed in the currency of the originating country. These two datasets were then matched using a code combining the values of airline, route, flight code, day of departure and booking day. Such a matching strategy enables the comparison of the on-line fares for the same flight available at

[13] For the UK domestic routes, in the second case we simply inverted the direction of the trip.

the same moment to two travellers in different countries. Appendix A provides more insights into the matching procedure.

It was impossible to guarantee that the two fares were collected at exactly the same time. Thus, new ticket purchases occurring between the collections of the two fares may be responsible for the fares' difference. This is because new purchases would change the shadow cost of capacity, a source of price dispersion (Borenstein and Rose, 1994). This potential problem was tackled in two ways. The "spider" operated overnight, thereby minimising the possibility of intervening purchases.[14] Further, the "spider" saved the exact time in which each fare was retrieved: the sample analysed in this study includes only pairs of fares collected within a one-hour interval.[15] Thus, any detection of price dispersion can only be ascribed to on-line price discrimination, as cost conditions refer to the same flight, capacity level and booking day.

2. Deviations from the Law of One Price.

The previous examples in Figures 2 and 3 configure a situation very similar to the one described by Marcus Asplund and Richard Friberg (2001), where customers of Scandinavian duty-free stores could pay the same item choosing a catalogue nominal price expressed either in Swedish kronor (SEK) or in Finnish markka (FIM). Significant deviations from the Law of One Price (LOP) arose because nominal prices were fixed until a new catalogue was printed, while the exchange rate between SEK and FIM was free to fluctuate. Deviations were thus mostly due to the presence of high fixed "menu costs" which led the Duty Free companies to issue a new catalogue only when arbitrage conditions had become particularly conspicuous and costly.

Figures 2 to 4 show cases of deviations from the LOP. However, menu costs are negligible in electronic commerce, which begs the question of *whether* the airlines systematically engage in on-line price discrimination. We try to answer this by detecting the

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[14] As Ellison and Ellison (2005) discuss, inertia in Internet prices is often observed, suggesting that companies do not continually monitor the market situation and reoptimize. In the case at hand, we casually noted that after buying tickets on-line from the LCCs in our study, fares remained unchanged despite the obvious reduction in the seat availability.

[15] Intervening purchases between the collection of the two prices should be more likely as the interval increases. Thus, we should expect a greater discrepancy between the two prices when the interval is large. We find no support to this hypothesis in the data, when we allow only a maximum of a one-hour interval. This is shown in a Table not reported to save on space, but available on request.

presence of deviations from the LOP, which, given our data collection strategy, can only be caused by on-line price discrimination.

Let f_{irtcb} be a flight offered by carrier *i*, on route *r*, with departure scheduled on date *t*, code flight *c* and whose fares are posted *b* days before *t* (that is, *b* is the booking day). Route *r* is defined as an airport pair. The airlines post two prices, which are expressed in the same currency for domestic flights, or in two different currencies depending on the country where the flight originates. The following analysis holds for both domestic and international flights. Let P_{irtcb}^{EU} and P_{irtcb}^{UK} identify the prices for flight f_{irtcb} when offered in a continental European currency (EU) and in the UK currency (i.e., GBP). Define $\Phi = P_{irtcb}^{EU} / P_{irtcb}^{UK}$. Denote $e_{EU/UK}^{b}$ as the nominal exchange rate, the currency *EU* price of currency *UK*, available on the date *(t-b)*. If LOP holds for flight f_{irtcb}, then:

$$\Phi = P_{irtcb}^{EU} / P_{irtcb}^{EU} = e_{EU/UK}^{b} \tag{1}$$

or

$$\Delta = \left[\left(P_{irtcb}^{EU} / e_{EU/UK}^{b}\right) - P_{irtcb}^{UK}\right] = 0\,. \tag{2}$$

Throughout the paper, Δ is expressed in GBP. The LOP fails to hold if $\Phi / e_{EU/UK}^{b} \neq 1$ or $|\Delta| > 0$. For the latter case, Table 2 reports the percentile distribution of the absolute value of Δ by airline and type of flights. Even noting that small values of $|\Delta|$ may be induced by differences between the exchange rates used by us and by the airlines, half of the almost two millions observations for international flights report a |Δ|>3.41, while the LOP holds unconditionally (i.e., |Δ|=0) for at least 95% of the observed domestic fares, with the minor exception of fares posted by Ryan Air. Such a finding suggests two considerations. One, presumably the airlines try to avoid the bad publicity of being found out practicing price discrimination strategies, which can be more easily noted when the fares are in the same currency. Two, the comparability of two fares in different currencies entails the gathering by a passenger of detailed information on $e_{EU/UK}^{b}$, which is a costly activity that not everyone is ready to undertake. Thus for international flights, search costs seem to shield the airlines from the risk of negative publicity. In turn, the airlines have thus more leeway in engaging in on-line price discrimination as a yield management strategy aimed at maximizing load factors. Indeed, Table 2 shows that most airlines, with the exception of EasyJet and Buzz, have at least 25% (or more) of their fares with a |Δ|>*5*.

Table 3 presents values of $\Phi = P^{EU}_{irtcb} / P^{UK}_{irtcb}$ and $e^{b}_{EU/UK}$ broken down by airline and country. It confirms that the LOP holds for UK domestic flights, while it generally does not for international flights, with the exception of those operated by EasyJet, for which the two statistics are very similar across countries. BmiBaby and MyTravel systematically violate the LOP as, in all the countries they serve, their fares expressed in the continental European currency are, on average, higher than the one expressed in GBP. On the other hand, Ryan Air, which Tables 2 and 3 reveal to be the airline which is more heavily reliant on international on-line price discrimination, tends to post a higher fare in GBP for flights to and from Ireland, Holland and Austria, with the opposite holding for most of the other countries. For Buzz and GoFly, deviations from the LOP are particularly large in specific countries, namely Switzerland and France.

To further highlight the deviations from LOP in our dataset, Figure 5 shows, for each airline, the kernel density for $\Phi = P^{EU}_{irtcb} / P^{UK}_{irtcb}$ and $e^{b}_{EU/UK}$ for flights to countries adopting the European common currency, the Euro. The overlapping of the two distribution is indicative of adherence to the LOP: this only seems to be the case of EasyJet, while for all the other LCCs the two distributions are either disjoint (BmiBaby and MyTravelLite) or the distribution of Φ presents thicker and longer tails (Ryan Air, Buzz and GoFly). Generally in Figure 5, Φ appears to be more dispersed than the distribution of the exchange rate between the Euro and the GBP.

Because we observe many cases where the LOP fails to hold, and given the way our data was collected, we conclude that the evidence in this Section supports the notion that most LCCs have actively pursued on-line price discrimination strategies. However, we have not determined the extent to which these are associated with arbitrage opportunities. That is, if the Internet has created a “frictionless market” where arbitrage opportunities are instantly wiped away by costless search and negligible menu costs, we should expect very few cases of on-line price discrimination with arbitrage, as in Figures 2 and 3. This is further investigated in the next Section.

III. Price Discrimination and Arbitrage

In this section we investigate the extent to which LCCs pursue discriminatory tactics and allow the possibility of arbitrage opportunities to arise. To this purpose, we constructed the discrete variable “Discrimination Type”, taking four values, each representing one of the three different situations depicted in Figures 1 to 4, plus a fourth case where arbitrage opportunities are not profitable. Indeed, recall that in order to exercise arbitrage a customer has to incur the following costs: 1) a credit card commission of 4.50 GBP imposed by the airline; 2) a commission on the transaction imposed by the credit card company, normally in the form of exchange rate which is less favourable than the official one we used: we assume such a commission to be 5% of the paid price; 3) other non-pecuniary costs associated with arbitrage, whose value we approximate as 1.50GBP (see Section 1). Hence, the "cost of arbitrage" is given by:

$$AC = 6.0 + 0.05 \min(P_{irtcb}^{UK}, P_{irtcb}^{EU} / e^{b}) \qquad (3)$$

Thus, *AC* increases with the value of the transaction. "Discrimination Type", is defined as follows. A value of "zero" is assigned to non-discriminatory observations, that is, those with $|\Delta|<5$ (see also Figure 1). We deem a price difference of less than 5 GBP to be sufficiently small to consider the two groups of passengers as being offered the same fare. A value "1" for "Discrimination Type" identifies discriminatory observations with no arbitrage conditions, while those with arbitrage opportunities are assigned the values "2" and "3" depending on whether the gain from arbitrage is below or above its cost *AC,* respectively. The formal definitions are reported in the Appendix B. It is noteworthy how for values greater than zero, George Stigler's (1987) definition of price discrimination holds, as the marginal cost for a seat booked at the same time for the same flight has to be the same regardless of whether the booking takes place in UK or in continental Europe.

A. Assessing the presence of arbitrage opportunities on-line.

In Table 4, the frequencies for the values of "Discrimination Type" are broken down by airline and departure location for the sample of international flights.[16] Overall, about 9.4% of the observations are associated with profitable opportunities of arbitrage, 6.4% present non-profitable arbitrage conditions, while 18.2% exhibit characteristics of on-line price discrimination without arbitrage. However, there are clear differences across the airlines. The Total rows show how Ryan Air is the company with the lowest percentage of non-discriminatory cases (47.9%), immediately followed by Bmibaby (59.7%), GoFly (61.1%) and MyTravelLite (61.9%). Ryan Air and GoFly are the companies reporting by far the

[16] From now on, only international flights are considered, given that domestic flights are generally not used for on-line price discrimination purposes.

highest percentage of cases with arbitrage, 19.3% and 13.3% respectively, while only 5% or less of the fares posted by the other companies satisfy the arbitrage conditions. Indeed, these are extremely rare for EasyJet (only 1.1%), which reports 83.7% of non-discriminatory fares. Interestingly, for all the LCCs the total number of observation with "Discrimination Type" equal to 1 is of a similar magnitude to the sum of total observations with and without profitable arbitrage conditions.

Other similarities between Ryan Air and GoFly are shown in Table 4. For both airlines we retrieved a larger proportion of arbitrage opportunities for flights departing from continental Europe (thus possibly benefiting British travellers). These account for 27.3% and 14.6% of Ryan Air and GoFly cases, respectively. At the same time, for the same airlines a larger share of cases with "Discrimination Type" equal to 1 (respectively, 35.8% and 23.2%) is found to depart from the UK, thus adversely discriminating British travellers relative to their continental European counterparts returning from a visit to UK. However, we also found a significant amount of cases where non-UK resident travellers are either offered arbitrage opportunities (11.3% for Ryan Air and 12.0% for GoFly) or are the victims of on-line price discrimination (15.7% and 14.1%, respectively).

Recall from Table 3 how BmiBaby and MyTravelLite systematically recorded values of $P_{irtcb}^{EU} / P_{irtcb}^{UK}$ above the relevant exchange rate. Furthermore, recall that arbitrage opportunities arise only for the second leg, that is, the return flight. Table 4 shows that for BmiBaby, we retrieved 8325 cases of profitable arbitrage opportunities for flights departing from the UK, while only 211 were from continental Europe. That is, BmiBaby offers arbitrage opportunities almost exclusively to travellers residing in a continental European country. However, they are also almost exclusively the victims of on-line price discrimination (i.e., when "Discrimination Type" is equal to 1). Indeed, in 34357 cases (40.8%) departing from continental Europe, BmiBaby offered a fare $P_{irtcb}^{EU} / e_{EU/UK}^{b}$ for a first leg flight, which is at least 5GBP higher than that offered to Britons returning to their country. A similar analysis holds also for MyTravelLite, thus helping to shed further lights on the figures reported in Table 3. Furthermore, both airlines exhibit about 14% of case for which it is not worth exploiting arbitrage opportunities. The figures in Table 4 seem to suggest that, with the exception of Ryan Air and GoFly, all the other airlines were reluctant to offer viable arbitrage opportunities.

Table 5 shows the mean values of $|\Delta|$, of the arbitrage cost AC and of P_{irtcb}^{UK}, broken down by "Discrimination Type". Non-discriminatory observations are generally associated with lower fares. Arbitrage cost does not play a central role in the first two columns; as expected in the third it is higher than the benefit from arbitrage. The opposite holds in the last column where the average net gain from arbitrage, given by the difference between $|\Delta|$ and AC, varies by airline: it is rather small for BmiBaby, and between 8-13 GBP for the other airlines. Arbitrage opportunities are thus worth pursuing, especially considering that bookings may be made for parties of more than one individual.

B. Reconciling the co-existence of Price Discrimination and Arbitrage.

The analysis of Tables 4 and 5 has clearly highlighted how most LCCs have made extensive use of on-line price discrimination strategies. In the theoretical framework we have argued that the economic rationale behind them is likely to lie in the standard textbook analysis of third degree on-line price discrimination combined with the airlines' belief that the group of consumers with a higher willingness to pay is not numerous enough to fill the flight to capacity.

An innovative aspect of our analysis is the simultaneous on-line presence of price discrimination and arbitrage opportunities. As in Asplund and Friberg (2001) we do not have information regarding whether the customers have taken advantage of the opportunities offered. However, the indirect evidence from their case and ours can provide interesting insights. Asplund and Friberg (2001) argue that the practice of dual price setting was abandoned because the high volatility of the exchange rate between SEK and FIM offered large arbitrage opportunities to consumers. In our case, the data covers the period June 2002-June 2004. However, the evidence we retrieved and report in Figures 1 to 4 was collected much later, in 2005 and in April 2006, from Ryan Air's web site. This suggests that amongst the airlines that our evidence reveals to be heavily committed to on-line price discrimination strategies (namely, Ryan Air and GoFly), the one still active has not abandoned them but, on the contrary, has carried on practicing them. This is consistent with two distinct, but not incompatible explanations.

First, the enduring and systematic practice of on-line price discrimination hints that LCCs' customers may have remained largely unaware of the presence of arbitrage opportunities, despite LCCs sell their tickets almost exclusively on-line. This is further evidence that the Internet is providing firms with new and imaginative price setting schemes. But unlike the firms selling computer RAM described by Glenn Ellison and Sarah F. Ellison (2004), LCCs do not need to implement "search obfuscation" techniques. Indeed, different prices for the same flight may be available on the same web site at the same time.[17] However, they can be found out only if the on-line customers run two queries, instead of one. Thus, the hurdle to overcome is not technical, or related to significant differences in the opportunity cost of time to run an extra query, which would only take a few more seconds. It is mainly associated with the natural propensity of the great majority of travellers to search for information on a round-trip ticket (which is the default option in the on-line query form). That is, we argue that consumers' behaviour exhibit a form of psychological inertia. The ensuing bounded rationality reduces the likelihood of searching what the price of two single tickets could be. This is tantamount to thinking of consumers who are less adept in understanding the subtleties of airlines' on-line pricing as having high search costs (Steven Salop, 1977). In turn, the airlines, protected by the presence of search costs, have little to fear that arbitrage opportunities will be extensively exploited. [18] Indeed, in Table 4, about 19% of cases from Ryan Air present arbitrage conditions. This is quite a high proportion, hinting that these opportunities are seldom taken.

Second, arbitrage chances may be intentionally "up for grabs". That is, LCCs post them specifically for the purpose of being exercised or are not too worried if some savvy Internet-surfer recognizes them. This leads to the natural question of under what circumstances the LCCs engage in on-line price discrimination with and without arbitrage.

IV. Empirical model

We begin investigating what drives the different values of "Discrimination Type" by looking at Table 6, where each cell reports the percentage number of observations by seasons (identified by the Summer – April to October - and Winter – November to March - timetables), booking day and classes of fares for P_{irtcb}^{UK} expressed in GBP. Within each of these categories, significant differences can be observed. Discriminatory cases are more likely

[17] Some airlines, however, have recently begun to engage in obfuscation practices similar to the ones described in Ellison and Ellison (2004). For instance, travel insurance is now automatically included in the order, and the customers have to unclick to avoid being charged for it. Moreover, uncertainty about the final price arises also because the charge for landing fees and airport taxes is not specified together with the fares.

[18] It is possible that the airlines may tolerate arbitrage only to a certain extent, and programme their sites accordingly.

during the Summer season, although it is not so for pure arbitrage cases. Non-discriminatory observations increase with the booking day, while generally arbitrage opportunities are more likely for late booking fares, those available from 14 up to 7 days prior to departure. Both findings reflect the fact that summer and late booking fares are generally higher and thus provide more scope for large differences between P_{irtcb}^{UK} and P_{irtcb}^{EU}. Indeed, when $P_{irtcb}^{UK} \geq 70$, more than 65% of the observations are discriminatory in nature, although only 10.6% offer profitable arbitrage opportunities.

A. Econometric methodology and dependent variables

In the econometric investigation, we jointly study: (1) the extent to which some factors may affect the likelihood of observing an airline posting discriminatory fares, and (2) for the sub-sample of discriminatory cases, the impact of the same factors in driving an airline's decision to offer arbitrage opportunities. To model these two discrete variables and take account of the sample selection problem arising because arbitrage can only occur within discriminatory cases, we employ a bivariate probit model with censoring setting (William Greene, 1998 and 2003, pp.713-714; Piga and Vivarelli, 2004). Formally the model can be represented as follows:

$$
\begin{aligned}
&y_{irtcb}^{1} = \beta_1' X^1 + \varepsilon^1,\ y_{irtcb}^{1} = 1\ \textit{if}\ \ y_{irtcb}^{1*} > 0,\ 0\ \textit{otherwise} \\
&y_{irtcb}^{2} = \beta_2' X^2 + \varepsilon^2,\ y_{irtcb}^{2} = 1\ \textit{if}\ \ y_{irtcb}^{2*} > 0,\ 0\ \textit{otherwise} \\
&(\varepsilon^1, \varepsilon^2) \sim BVN(0,0,1,1,\rho) \\
&(y_{irtcb}^{2}, X^2)\ \textit{observed only if}\ \ y_{irtcb}^{1} = 1.
\end{aligned}
\qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)
$$

Subscripts are as in Section 2, while y_{irtcb}^{1*} and y_{irtcb}^{2*} are latent, unobserved variables representing the airlines' net benefit from posting a discriminatory case and an arbitrage opportunity, respectively. Indeed, the discrete variable y^1, which will be denoted as "Discriminatory", assumes the value of zero when "Discrimination Type" is also zero; "Discriminatory" is equal to 1 for values of "Discrimination Type" greater or equal to 1. The other discrete variable y^2, which we denote as "Arbitrage", is zero when "Discrimination Type" is equal to 1 or 2, and takes the value 1 when "Discrimination Type" is equal to 3. No value is attributed to "Arbitrage" when "Discrimination Type" is zero, as arbitrage conditions should be studied only within the sub-sample of cases where "Discriminatory" is equal to 1. Failing to take this sample selection into account by applying a standard bivariate probit model where "Arbitrage" is estimated on the full sample would result in biased estimates.

That is, in a standard bivariate probit approach the factors affecting the probability to observe a non-discriminatory case would not be separated from factors influencing the likelihood of posting a discriminatory fare that is not associated with arbitrage opportunities.[19] Furthermore, estimating two independent equations could lead to wrong inference if their residuals were correlated. Finally, to account for the fact that for each daily flight we have repeated observations, the estimated residuals $\tilde{\varepsilon}^j$, *j=1,2,* are robust to heteroschedasticity and serial correlation within each (*irt)* cluster.

B – The regressors

Imagine an airline has a prior belief that a certain flight is likely to realize a low load-factor. We argue that to counteract this, the airline may want to engage in the pricing schemes we presented, in order to attract demand from the price elastic group of consumers. To test if the airlines specifically choose particular flights to practice on-line price discrimination we check if discriminatory observations persist over time. Recall how for each flight identified by a *irtc* group, we have up to 11 observations of fares' pairs, each one for a different booking day. We create the dummy "Persistence" equal to 1 if the observation in the previous booking day is discriminatory. A strictly positive coefficient for "Persistence" is expected in both equations in (4).

Table 7 shows some descriptive statistics for "Persistence" and the other main regressors, broken down by the values of the dependent variables. For about 50% of discriminatory observations, the airlines persist in applying the same technique in the following booking day. Furthermore, there are about 7% of non-discriminatory cases that belong to a flight for which in the previous booking day we observe a case of discriminatory fares. Table 7 also shows that "Persistence" is distributed almost identically across discriminatory cases with and without arbitrage.

We use the monthly number of flights by an airline in a route to obtain the Herfindahl Index in a route (henceforth, "HHI route").[20] Following Borenstein and Rose (1994), if discrimination is of a "monopoly-type", then the coefficient in the "Discriminatory" equation

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[19] Greene (1998) uses this model to distinguish the factors affecting the probability of default in credit card loans from the determinants of the antecedent decision to obtain a credit card. Similarly, Piga and Vivarelli (2004) argue that the sample of firms engaged in collaborative R&D activity is not randomly selected, but depends on the firms' decision to conduct R&D.

[20] To derive market shares, we used the monthly number of flights by each airline in a route. Flights are preferable to number of passengers as flights are decided in the previous season, remain stable within a season and are therefore not jointly determined with prices.

should be positive. If however, discrimination increases as the route becomes more competitive, then we can infer that the airlines use it as a strategic competitive weapon. A similar argument can be made with regards to the relationship between concentration and arbitrage opportunities. Table 7 does not reveal any significant difference, although it indicates the airlines in our sample generally operate in highly concentrated routes.

Thanks to such post-liberalisation measures as the "grandfather" rights, established carriers (mostly former national `flag-carriers') have continued to enjoy a dominant position in large European markets.[21] "Market Size", obtained as the share of total flights in a city-pair over the total flights in a nation's sub-area,[22] is likely to affect positively the likelihood to post discriminatory fares, as the airlines may use discriminatory pricing as a competitive weapon. By the same token, its impact on an airline's propensity to offer arbitrage opportunities is likely to be positive, although larger markets also provide reasons for curtailing such a strategy, e.g., because too many customers may be available to exercise it.[23]

The presence of competition from charter operators may boost the need to engage in on-line price discrimination and to offer arbitrage opportunities. We expect the monthly share of charter passengers over the total number of passengers in a city-pair ("Shr charter pass.") to be positively correlated with discriminatory conditions and arbitrage opportunities. However, the presence of charter operators seems less strong in route with arbitrage opportunities (Table 7).

If an airline is offering a service to a given destination from many UK departure airports, then the need to realise a sufficiently high load factor in every route is likely to provide a strong incentive to implement on-line price discrimination strategies with and without arbitrage. Hence, the regressor "N UK departures", measuring from how many UK airports the airline is serving the same destination, should positively enter in both regressions.

In the empirical model we also control for a number of fixed effects by using various sets of dummies. In light of previous findings regarding company specificities, a dummy is used to identify each airline. Furthermore, the previous discussion has highlighted that for

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[21] A post-liberalisation measure, the grandfather's rights allocated slots in the main European, most congested airports to airlines on the basis of previous use.

[22] The UK, as well as the largest destination countries, Italy, France, Germany and Spain, were divided in three sub-areas: North, Centre and South. This variable is calculated as the share of total flights in a city-pair (say, London to Rome) over the total flights to the Centre of Italy (the sub-area where Rome is located). For smaller countries, the denominator is given by taking the whole country.

[23] The terms city-pair (which includes all the airports in a city pair) and market are used interchangeably.

each booking day price dispersion is caused only by on-line price discrimination. However, as demand is revealed over time, the airlines' propensity to engage in on-line price discrimination may vary to reflect the shadow cost of capacity (Borenstein and Rose, 1994). That is, stochastic peak-load pricing may still be responsible for cross-sectional variations in our sample. Therefore, we include a set of dummy variables for each booking day, which are summarized in Table 6. Few days before departure the airlines can more precisely gauge if the flight will be full. Both decisions to engage in on-line price discrimination and to offer a discount via arbitrage may be therefore motivated by a high probability of a low load-factor. Thus, we expect such decisions to be positively associated with the dummies identifying the fares posted only a few days before departure.

Load factors' realisation may also vary with the time of day and with the day of the week a flight is scheduled to fly. Indeed, as argued in Borenstein and Rose (1994), pricing decision may differ for peak and off-peak flights. We therefore include dummies for departure times and days of the week.[24] These, together with a dummy for each nation in Table 3, are not reported to save on space. Full sets of estimates are available on request.

C. Results

To estimate equation (4), only the sample of flights to and from continental Europe was used, i.e. UK domestic flights were not considered given their strict adherence to the LOP (see Table 2). Model 1 includes all the airlines; Model 2 excludes EasyJet because of its limited involvement in pursuing on-line price discrimination strategies; Model 3 considers Ryan Air exclusively. Given the sample size and the non-linearity of the method, in order to focus on the economic impact of each regressor we chose to report two marginal effects in Table 8 and not the estimated coefficients, which are available on request. All models present similar results, both quantitatively and qualitatively. The Wald Test for independent equations clearly rejects the hypothesis of no correlation of the two equations' residuals for all models and thus lends support to the bivariate approach, as opposed to two single probit equations.

As far as the impact of "Persistence" is concerned, observing a discriminatory case in the previous booking day increases the probability of observing a similar case in the current booking day by 46%-50%. The extremely high z-statistics indicates that a large proportion of

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[24] The times of day were constructed as follows to reflect schedule convenience: "<=8.20am"; "8.21-10.45am"; "10.46-12.40pm"; "12.41-14.40pm"; "14.41-16.40pm"; "16.41-18.40pm"; "18.41- 20.40pm"; ">20.40pm"

observations for the same flight, collected at different times prior to departure, are discriminatory in nature. We infer that price discrimination is a tactic used by the airline after it has targeted a specific flight. This is further confirmed in Models 2 and 3, where a change from zero to one in “Persistence” enhances the chance of an arbitrage condition by 2-3%. Both results together suggest that arbitrage opportunities, rather than disappearing from the airlines’ web sites, exhibit a tendency to be posted repeatedly before a flight’s departure.

The likelihood of observing a discriminatory case falls by 7-10% with a unit change in the Herfindhal index around its mean value. Price discrimination is thus more likely in the less concentrated routes of our sample and appears to be motivated by the need to meet the competitive pressure of other airlines (see Severin Borenstein and Nancy Rose, 1994 for a discussion). This is further supported by the findings for “Market Size “ and the presence of charter operators, whose unit change increases the probability of a discriminatory case by 15-17% for the former and 34-49% for the latter variable. However, the probability of an arbitrage opportunity increases with route concentration (3-9%), is independent of market size (only significant in Model 3) and increases with the presence of charter airlines (12-14%). As expected, larger markets provide conflicting incentives for the use of arbitrage strategies, which the airlines seem more willing to offer where they enjoy a dominant position and when they face charter operators’ competition. As the variable “N UK departures” indicates, an airline’s network structure appears to have a negligible impact on both marginal effects.

With the exception of Model 1, discriminatory cases appear to be up to 7 percentage points more likely in the last 14 days before a flight departs, when the airlines have been able to gauge quite accurately the demand for a flight. The fact that fares posted 70 days prior to departure have a 4-10% higher chance to be discriminatory also suggest that the airlines identify the flights amenable to price discrimination at an early stage. Particularly in Model 3, the impact of booking days on the likelihood of an arbitrage case is generally stronger for early booking days (4-5%).

The effects of the airlines’ dummies are consistent with the findings in Tables 2 to 4. Finally, no clear indication comes from the analysis of the Summer season dummy.

V. Conclusions

The low search costs of the Internet facilitate price comparisons on-line that may even lead to lower off-line prices (Jeffrey R. Brown and Austan Goolsbee, 2002). To protect themselves from Bertrand-type competition, e-retailers may either try to build brand allegiance or engage in obfuscation strategies (Eric Brynjolfsson and Michael D. Smith., 2000; Ellison and Ellison, 2004 and 2005). Given the high price transparency of the Internet, it would therefore seem unlikely to observe the same company offering two different prices for the same product on-line.

The thrust of this paper is to show, through a particular data collection design, how some important European Low Cost Carriers systematically posted fares on-line that violate the Law of One Price (Fred S. McChesney *et al.*, 2004). Our analysis still supports the notion of low search costs on-line. Indeed we find airlines do not practice on-line price discrimination for U.K. domestic flights, because their fares, being expressed in the same currency, can be more easily compared. As discrimination is applied only to international flights, we argue that other forms of search costs remain important, even if the transaction takes place on-line: an obvious example is learning about the prevailing exchange rate. However, the strongest factor facilitating on-line price discrimination is probably bounded rationality, i.e., the inability of an on-line customer to conceive the possibility to control for the presence of arbitrage opportunities, which make up 9.4% observations in our dataset, but account for about one-fifth of Ryan Air's observations.

Furthermore, we discuss how the airlines may actually benefit from having customers acting as arbitrageurs, as this may help increase a flight's load-factor. Indeed, the evidence indicates discriminatory cases are more likely within the two weeks prior to a flights' departure, when the airlines have better information about demand realization. When associated with the offering of discounts via arbitrage, the form of on-line price discrimination we present is therefore likely to be welfare-enhancing, as it does not penalize the airlines and allows consumption by customers that otherwise would not have purchased the ticket. The usual ambiguous effects on welfare remain when the airlines charge differing fares that cannot be arbitraged away. However, the pricing strategies we analyse do not seem to meet the conditions to be deemed discriminatory pursuant to Article 82(c) of the Treaty of the European Community because, although such strategies "apply dissimilar conditions to equivalent transactions", Article 82 (c) does not apply to transactions with final consumers (Damien Geradin and Nicolas Petit, 2005).

Asplund and Friberg (2001) document how the exploitation of arbitrage opportunities, arising in cases of deviations from the Law of One Price, likely led to a change in the way prices were listed in Scandinavian Duty-Free shops' catalogues. This does not seem to have happened for at least some of our LCCs. We complement our data set covering the period June 2002 - June 2004 with screen shots, retrieved as late as April 2006, showing examples of on-line price discrimination cases. We infer that at least one large low-cost carrier (namely, Ryan Air) has been actively pursuing on-line price discrimination strategies for many years even if they entailed offering arbitrage opportunities.

We use a bivariate model with sample selection to study the factors affecting the airlines' decisions to both post discriminatory fares and offer arbitrage opportunities. The evidence suggests that the probability to observe on-line price discrimination is inversely related to a route concentration. This is similar to the findings in Borenstein and Rose (1994) of competitive price dispersion. Arbitrage, on the contrary, seems to be more likely in situations where the airlines enjoy a high degree of market power. A striking result is that over a period of 70 days discriminatory cases for a flight are observed repeatedly before a flight's departure. Even more strikingly for an on-line market, arbitrage opportunities also tend to persist over time. This is in shark contrast with the conventional wisdom of arbitrage being incompatible with discriminatory pricing, especially in markets with low search, menu or transportation costs. On the whole, the evidence seems to suggest how airlines do not seem particularly worried by the price transparency of the Internet, but, rather, use it to maximize their yield in a route.

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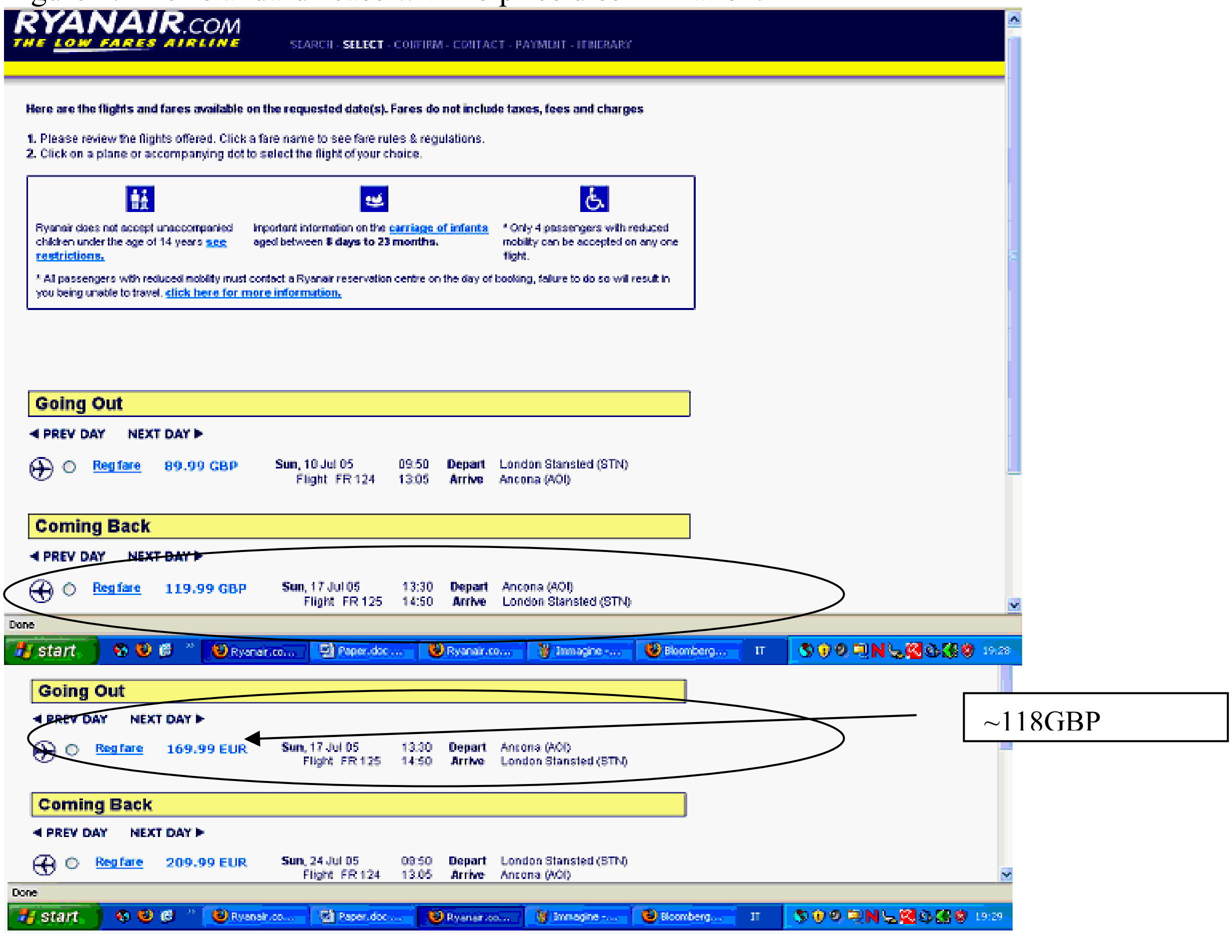
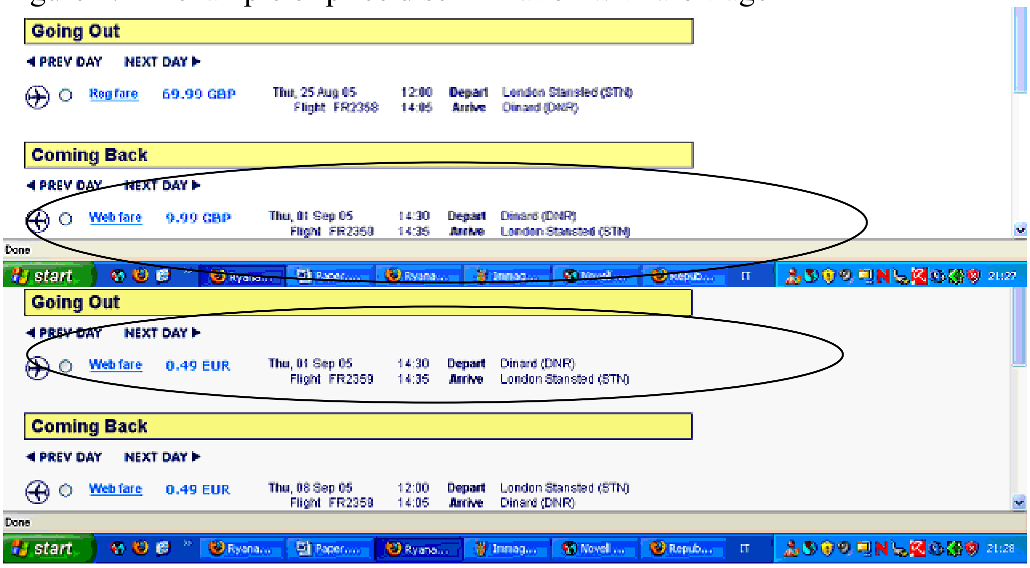
Figure 1: The “standard” case with no price discrimination.



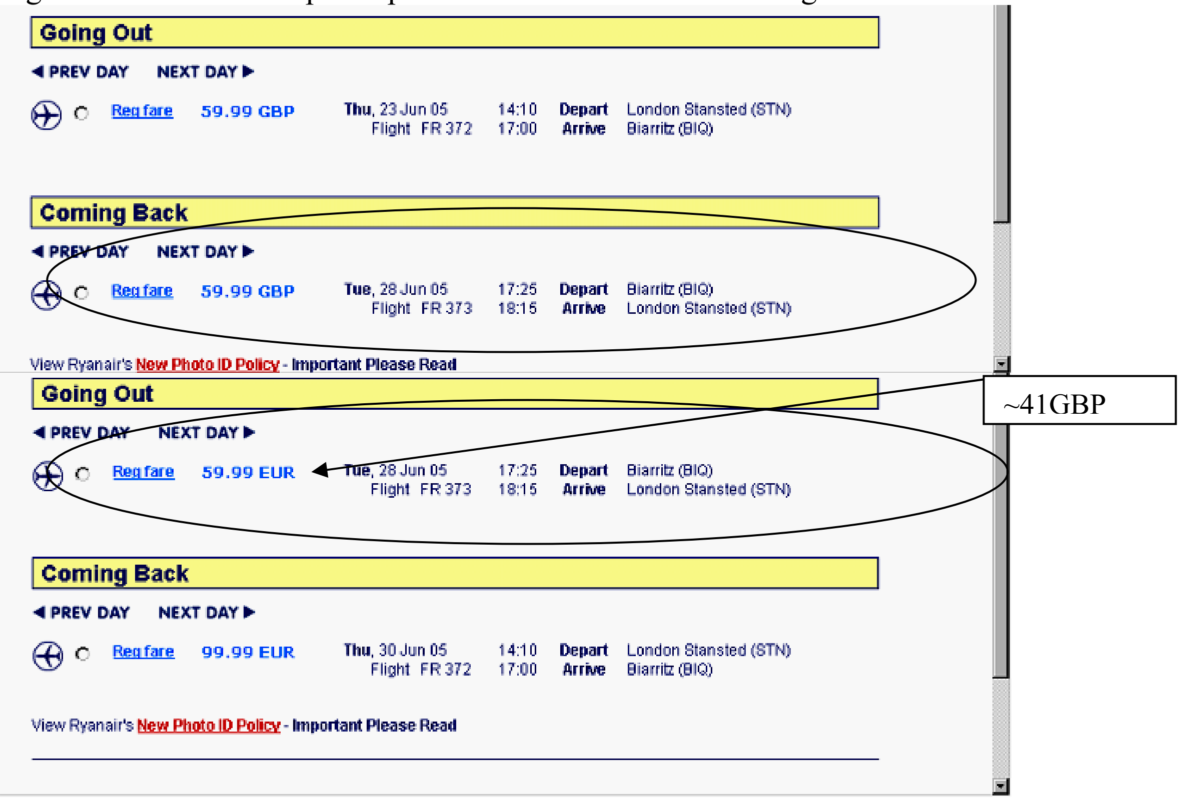
Note: The top part shows the fares for a round-trip originating in the UK. The bottom part reports the fares for a round-trip originating in a continental European location. The “Coming Back” flight enclosed in the oval in the top part is the same as the “Going Out” flight in the oval of the bottom part. The fare in the European currency is translated using the current exchange rate on the date of the query.

Figure 2: An example of price discrimination with arbitrage



Note: The top part shows the fares for a round-trip originating in the UK. The bottom part reports the fares for a round-trip originating in a continental European location. The "Coming Back" flight enclosed in the oval in the top part is the same as the "Going Out" flight in the oval of the bottom part. The fare in the European currency is translated using the current exchange rate on the date of the query.

Figure 3: Another example of price discrimination with arbitrage.



Note: The top part shows the fares for a round-trip originating in the UK. The bottom part reports the fares for a round-trip originating in a continental European location. The "Coming Back" flight enclosed in the oval in the top part is the same as the "Going Out" flight in the oval of the bottom part. The fare in the European currency is translated using the current exchange rate on the date of the query.

Figure 4: An example of price discrimination without the possibility of arbitrage.

Note: The top part shows the fares for a round-trip originating in the UK. The bottom part reports the fares for a round-trip originating in a continental European location. The "Coming Back" flight enclosed in the oval in the top part is the same as the "Going Out" flight in the oval of the bottom part. The fare in the European currency is translated using the current exchange rate on the date of the query.

Figure 5 – Kernel Densities of $\Phi = P_{irtb}^{EU} / P_{irtb}^{UK}$ and $e_{EU/UK}^{b}$.

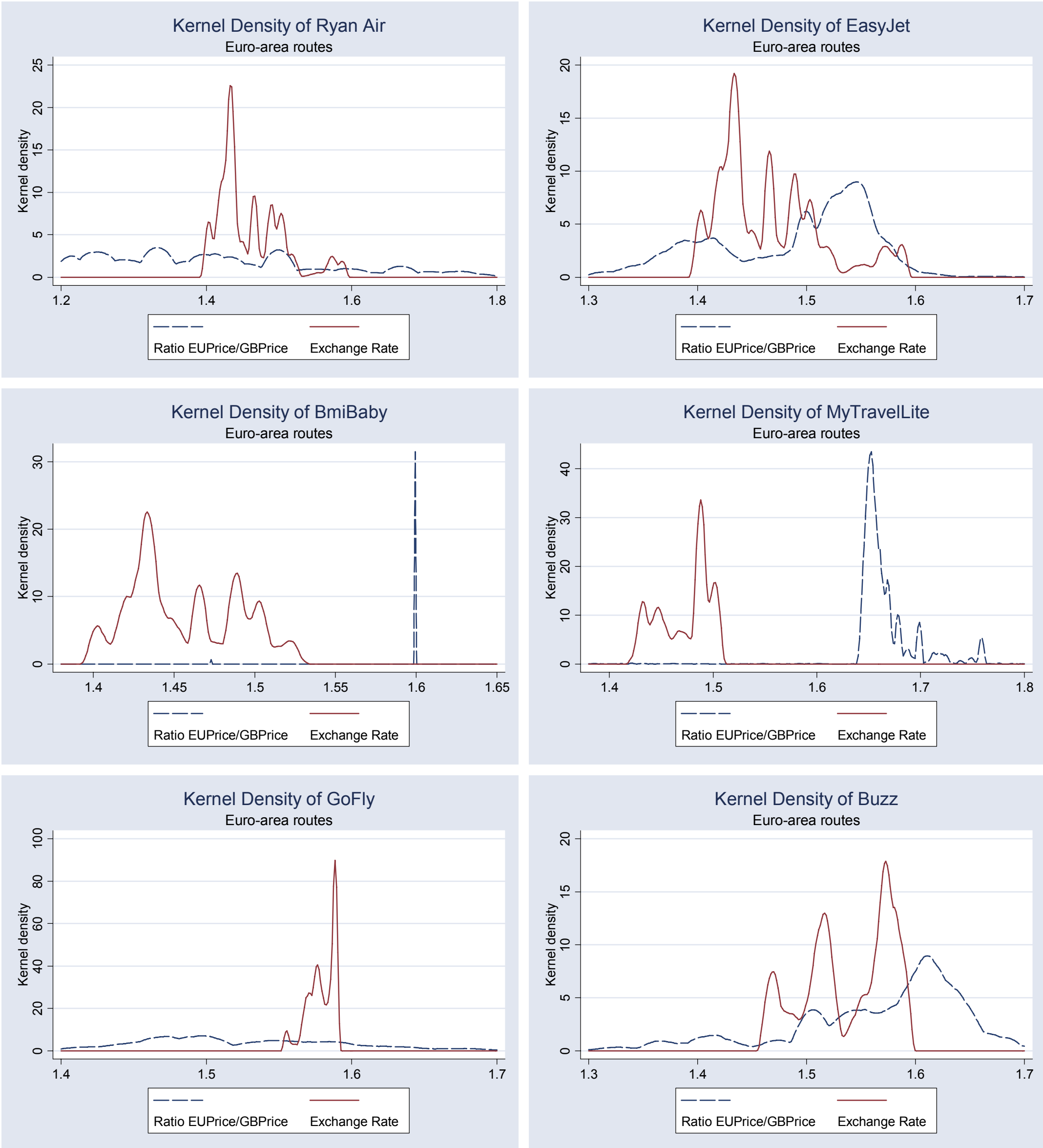


Table 1 – Number of routes, and their percentage relative to the total number operated by the company, by type of sample, airline and period.

	BMIBABY		RYANAIR		EASYJET		BUZZ		GOFLY		MyTRAVELLITE	
Year_ month	Routes with fares	Compet. Routes	Routes with fares	Compet. Routes	Routes with fares	Compet. Routes	Routes with fares	Compet. Routes	Routes with fares	Compet. Routes	Routes with fares	Compet. Routes
02_07			34 (57.6)	7 (11.9)	19 (50.0)	9 (23.7)	21 (63.6)	3 (9.1)	17 (45.9)	11 (29.7)		
02_08			37 (62.7)	8 (13.6)	19 (50.0)	9 (23.7)	21 (63.6)	5 (15.2)	17 (45.9)	11 (29.7)		
02_09			37 (62.7)	7 (11.9)	28 (70.0)	9 (22.5)	21 (63.6)	5 (15.2)	30 (85.7)	9 (25.7)		
02_10			37 (62.7)	7 (11.9)	28 (68.3)	10 (24.4)	21 (65.6)	5 (15.6)	30 (76.9)	11 (28.2)		
02_11			37 (61.7)	8 (13.3)	29 (70.7)	9 (22.0)	20 (100.0)	0 (0.0)	32 (84.2)	11 (28.9)		
02_12			37 (61.7)	8 (13.3)	61 (77.2)	20 (25.3)	22 (100.0)	0 (0.0)	32 (84.2)	11 (28.9)		
03_01	26 (74.3)	10 (28.6)	49 (80.3)	9 (14.8)	61 (76.3)	20 (25.0)	22 (100.0)	1 (4.5)				
03_02	26 (74.3)	11 (31.4)	50 (78.1)	7 (10.9)	63 (76.8)	21 (25.6)	22 (100.0)	0 (0.0)				
03_03	30 (81.1)	12 (32.4)	50 (78.1)	7 (10.9)	66 (78.6)	22 (26.2)	22 (84.6)	4 (15.4)				
03_04	26 (70.3)	9 (24.3)	56 (86.2)	7 (10.8)	66 (75.0)	19 (21.6)						
03_05	31 (77.5)	10 (25.0)	69 (78.4)	6 (6.8)	67 (75.3)	19 (21.3)						
03_06	32 (74.4)	10 (23.3)	69 (78.4)	6 (6.8)	67 (75.3)	20 (22.5)						
03_07	33 (73.3)	11 (24.4)	69 (78.4)	6 (6.8)	67 (75.3)	21 (23.6)						
03_08	34 (75.6)	11 (24.4)	83 (93.3)	8 (9.0)	88 (95.7)	24 (26.1)						
03_09	35 (79.5)	11 (25.0)	83 (93.3)	6 (6.7)	88 (95.7)	23 (25.0)						
03_10	35 (72.9)	13 (27.1)	84 (91.3)	8 (8.7)	89 (92.7)	26 (27.1)						
03_11	37 (88.1)	12 (28.6)	87 (93.5)	8 (8.6)	88 (92.6)	23 (24.2)						
03_12	38 (80.9)	15 (31.9)	87 (92.6)	8 (8.5)	88 (89.8)	25 (25.5)					13 (92.9)	5 (35.7)
04_01	33 (67.3)	15 (30.6)	42 (42.9)	8 (8.2)	46 (46.9)	25 (25.5)					13 (92.9)	5 (35.7)
04_02	36 (76.6)	14 (29.8)	84 (89.4)	8 (8.5)	88 (89.8)	25 (25.5)					13 (100.0)	5 (38.5)
04_03	38 (88.4)	13 (30.2)	84 (89.4)	8 (8.5)	89 (88.1)	25 (24.8)					13 (100.0)	4 (30.8)
04_04	34 (70.8)	17 (35.4)	87 (87.9)	10 (10.1)	89 (83.2)	27 (25.2)					13 (100.0)	4 (30.8)
04_05	34 (68.0)	16 (32.0)	81 (86.2)	9 (9.6)	89 (80.9)	27 (24.5)					10 (100.0)	3 (30.0)
04_06	34 (61.8)	18 (32.7)	84 (87.5)	9 (9.4)	88 (77.2)	29 (25.4)					9 (100.0)	3 (33.3)

Source: Price sample is retrieved from the airlines' web sites. The airlines' total routes and the competitive routes are from the Civil Aviation Authority dataset. Percentages with respect to the total number of routes are in parentheses.

Table 2: Descriptive statistics of $|\Delta| = \left|\left(P_{irtcb}^{EU} / e_{EU/UK}^{b}\right) - P_{irtcb}^{UK}\right|$ by company and destination.

	Company						
Statistic	Bmibaby	RyanAir	EasyJet	Buzz	GoFly	MyTravel	Total
			International Flights				
p1	0.60	0.06	0.05	0.03	0.05	0.50	0.06
p5	1.23	0.39	0.24	0.23	0.29	0.91	0.32
p10	1.67	0.88	0.46	0.45	0.62	1.37	0.63
p25	2.56	2.32	1.07	1.03	1.91	2.53	1.50
p50	4.25	5.32	2.35	2.05	3.62	4.20	3.41
p75	7.15	9.93	4.15	3.45	9.56	6.32	6.53
p90	10.67	17.20	5.92	8.17	16.95	10.13	12.13
p95	14.58	23.51	8.53	14.01	23.23	14.35	17.50
p99	22.79	36.81	17.58	29.50	42.21	32.96	34.08
mean	5.56	7.68	3.17	3.65	7.05	5.53	5.38
min	0.00	0.00	0.00	0.00	0.00	0.01	0.00
max	79.99	79.84	79.97	79.91	79.98	79.36	79.99
sd	4.85	8.08	3.81	5.62	8.65	5.94	6.53
N	168750	803782	849313	42333	30957	23289	1918424
			Domestic Flights				
p1	0	0	0	-	0	0	0.00
p5	0	0	0	-	0	0	0.00
p10	0	0	0	-	0	0	0.00
p25	0	0	0	-	0	0	0.00
p50	0	0	0	-	0	0	0.00
p75	0	0	0	-	0	0	0.00
p90	0	0	0	-	0	0	0.00
p95	0	2.52	0	-	0	0	0.00
p99	0	10	5.00	-	10	0	5.00
mean	0.05	0.40	0.12	-	0.26	0.00	0.18
min	0	0	0	-	0	0	0.00
max	55.50	63.00	75.00	-	39.15	3.99	75.00
sd	0.88	2.05	1.39	-	2.20	0.13	1.54
N	54601	71408	137083	-	7534	1772	272398
Total N	223351	875190	986396	42333	38491	25061	2190822

Source: Fares are from the airlines' web sites. Δ is expressed in GBP

Table 3 – Ratio of prices in different currencies and exchange rates, by company and country.

	countries		Bmi baby	Ryan Air	Easy Jet	Buzz	Go Fly	My Travel	Total	N
No Euro-Zone	UK	$e^{b}_{EU/UK}$	1.00	1.00	1.00	-	1.00	1.00	1.00	272398
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	1.00	1.01	1.00	-	1.00	1.00	1.01	
	Switzerland	$e^{b}_{EU/UK}$	2.22	-	2.23	2.22	-	-	2.23	108534
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	2.49	-	2.26	3.29	-	-	2.26	
	Sweden	$e^{b}_{EU/UK}$	-	13.45	-	-	-	-	13.45	57275
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	-	13.41	-	-	-	-	13.41	
	Norway	$e^{b}_{EU/UK}$	-	11.80	-	-	-	-	11.80	19849
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	-	16.99	-	-	-	-	16.99	
	Czech Rep.	$e^{b}_{EU/UK}$	48.24	-	48.42	-	-	-	48.37	10933
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	56.69	-	44.88	-	-	-	48.12	
Eurozone	Italy	$e^{b}_{EU/UK}$	1.44	1.46	1.46	-	1.58	-	1.46	266918
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	1.61	1.75	1.48	-	1.64	-	1.68	
	France	$e^{b}_{EU/UK}$	1.46	1.46	1.47	1.54	1.58	-	1.47	287646
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	1.61	1.57	1.46	1.61	1.73	-	1.53	
	Spain	$e^{b}_{EU/UK}$	1.45	1.46	1.46	1.54	1.58	1.47	1.47	501131
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	1.61	1.47	1.50	1.68	1.60	1.67	1.52	
	Holland	$e^{b}_{EU/UK}$	1.46	1.45	1.47	1.52	-	-	1.47	151541
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	1.60	1.25	1.46	1.65	-	-	1.46	
	Germany	$e^{b}_{EU/UK}$	1.45	1.46	1.45	1.54	1.58	-	1.47	109645
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	1.60	1.50	1.46	1.57	1.53	-	1.51	
	Belgium	$e^{b}_{EU/UK}$	1.45	1.47	-	-	-	-	1.46	25006
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	1.61	1.41	-	-	-	-	1.46	
	Greece	$e^{b}_{EU/UK}$	-	-	1.47	-	-	-	1.47	18941
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	-	-	1.51	-	-	-	1.51	
	Ireland	$e^{b}_{EU/UK}$	1.46	1.46	-	-	-	1.47	1.46	300059
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	1.61	1.17	-	-	-	1.74	1.22	
	Portugal	$e^{b}_{EU/UK}$	1.48	-	1.46	.	1.58	1.47	1.47	35268
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	1.60	-	1.49	.	1.57	1.67	1.51	
	Austria	$e^{b}_{EU/UK}$	1.50	1.47	-	-	-	-	1.47	25678
		$P^{EU}_{irtcb} / P^{UK}_{irtcb}$	1.60	1.32	-	-	-	-	1.33	

Source: Datastream for the exchange rates, price data from the airlines' web sites.

Table 4 – Type of discrimination by company and departure location.

	Departure From	Variable "Discrimination Type" – Frequency (row %) 0- Non discriminatory	1 Discriminatory - no arbitrage	2 Discriminatory -no prof. arbitrage	3 Discriminatory - with arbitrage
Bmi Baby	Cont. Europe	49534 (58.9%)	34357 (40.8%)	18 (0.0%)	211 (0.3%)
	UK	51281 (60.6%)	112 (0.1%)	24912 (29.4%)	8325 (9.8%)
	Total	100815 (59.7%)	34469 (20.4%)	24930 (14.8%)	8536 (5.1%)
Ryan Air	Cont. Europe	193133 (48.1%)	62909 (15.7%)	36163 (9.0%)	109552 (27.3%)
	UK	191923 (47.7%)	143864 (35.8%)	20756 (5.2%)	45482 (11.3%)
	Total	385056 (47.9%)	206773 (25.7%)	56919 (7.1%)	155034 (19.3%)
Easy Jet	Cont. Europe	329673 (78.7%)	77628 (18.5%)	7665 (1.8%)	4143 (1.0%)
	UK	381208 (88.6%)	16873 (3.9%)	27315 (6.3%)	4808 (1.1%)
	Total	710881 (83.7%)	94501 (11.1%)	34980 (4.1%)	8951 (1.1%)
Buzz	Cont. Europe	17673 (84.2%)	2463 (11.7%)	169 (0.8%)	679 (3.2%)
	UK	18437 (86.4%)	1221 (5.7%)	767 (3.6%)	924 (4.3%)
	Total	36110 (85.3%)	3684 (8.7%)	936 (2.2%)	1603 (3.8%)
Go Fly	Cont. Europe	9317 (60.6%)	2170 (14.1%)	1636 (10.6%)	2240 (14.6%)
	UK	9595 (61.5%)	3624 (23.2%)	504 (3.2%)	1871 (12.0%)
	Total	18912 (61.1%)	5794 (18.7%)	2140 (6.9%)	4111 (13.3%)
MTL	Cont. Europe	6657 (61.0%)	4021 (36.9%)	62 (0.6%)	167 (1.5%)
	UK	7762 (62.7%)	188 (1.5%)	3244 (26.2%)	1188 (9.6%)
	Total	14419 (61.9%)	4209 (18.1%)	3306 (14.2%)	1355 (5.8%)
	N	1266193	349430	123211	179590
	%N	66.0%	18.2%	6.4%	9.4%

Source: Our elaboration of the fares retrieved from the airlines' web sites.

Table 5 – Mean of absolute difference of fares, arbitrage costs and fares by type of discrimination.

		Variable "Discrimination Type"			
	Departure From	0- Non discriminatory	1 Discriminatory - no arbitrage	2 Discriminatory -no prof. arbitrage	3 Discriminatory - with arbitrage
Bmi Baby	Mean $\|\Delta\|$	2.9	9.7	7.1	15.9
	Arbitrage Cost	7.7	10.1	9.3	11.3
	Mean P_{irtcb}^{UK}	33.5	82.1	66.6	107.5
Ryan Air	Mean $\|\Delta\|$	2.3	12.8	6.4	14.8
	Arbitrage Cost	7.2	7.6	7.8	7.5
	Mean P_{irtcb}^{UK}	24.6	41.0	40.7	40.5
Easy Jet	Mean $\|\Delta\|$	2.1	8.4	7.0	19.2
	Arbitrage Cost	8.0	10.1	10.6	8.8
	Mean P_{irtcb}^{UK}	41.0	83.0	93.7	65.3
Buzz	Mean $\|\Delta\|$	1.9	13.6	6.4	19.2
	Arbitrage Cost	8.1	8.7	10.0	7.2
	Mean P_{irtcb}^{UK}	42.9	58.8	80.6	32.5
Go Fly	Mean $\|\Delta\|$	2.3	14.7	7.3	18.2
	Arbitrage Cost	9.0	9.2	10.6	9.0
	Mean P_{irtcb}^{UK}	61.3	73.6	98.1	70.6
MTL	Mean $\|\Delta\|$	2.9	9.7	6.9	17.4
	Arbitrage Cost	7.1	9.3	9.0	10.3
	Mean P_{irtcb}^{UK}	22.5	66.5	60.5	89.3

Source: Our elaboration of the fares retrieved from the airlines' web sites.

Table 6 – Type of Discrimination by Season, time of booking, and price category.

			Variable "Discrimination Type" – Row %			
Type	Variable	N	0 - Non discriminatory	1 Discriminatory no arbitrage	2 Discriminatory no prof. arbitrage	3 Discriminatory with arbitrage
	Summer	1419069	63.5%	19.8%	7.1%	9.6%
	Winter	499355	73.1%	13.7%	4.6%	8.6%
Booking Days	7	173358	59.9%	22.1%	8.0%	10.0%
	10	206143	62.8%	20.2%	6.4%	10.6%
	14	229889	64.5%	18.8%	6.3%	10.4%
	21	165725	66.5%	18.2%	6.5%	8.7%
	28	165957	64.4%	18.9%	7.2%	9.4%
	35	160698	65.5%	18.6%	7.2%	8.7%
	42	161806	66.8%	17.7%	6.2%	9.4%
	49	154176	67.9%	17.3%	6.2%	8.6%
	56	154252	68.6%	16.4%	5.9%	9.1%
	63	196572	70.3%	15.6%	5.1%	9.0%
	70	149848	70.4%	15.6%	5.8%	8.2%
Class P^{UK}	0-9.99	204601	81.2%	9.1%	2.8%	6.8%
	10-19.99	328400	71.7%	13.7%	5.3%	9.2%
	20-39.99	562978	70.2%	14.9%	3.2%	11.8%
	40-69.99	540862	68.3%	18.1%	6.3%	7.2%
	>=70	281583	35.5%	36.9%	16.9%	10.6%

Source: Airlines' web sites. Price class expressed in GBP.

Table 7 – Mean and Standard Deviation (SD) of main regressors

	Discriminatory			Arbitrage		
	0	1	Total	0	1	Total
Persistence	0.07 (0.25)	0.50 (0.50)	0.22 (0.41)	0.50 (0.50)	0.51 (0.50)	0.50 (0.50)
HHI route	0.90 (0.20)	0.89 (0.19)	0.90 (0.20)	0.89 (0.20)	0.91 (0.18)	0.89 (0.19)
Market Size	0.22 (0.19)	0.21 (0.20)	0.22 (0.19)	0.21 (0.20)	0.22 (0.19)	0.21 (0.20)
Shr Charter Pass	0.10 (0.20)	0.13 (0.22)	0.11 (0.21)	0.16 (0.24)	0.06 (0.16)	0.13 (0.22)
N UK departures	4.70 (4.13)	4.99 (5.40)	4.80 (4.60)	4.79 (5.02)	5.50 (6.27)	4.99 (5.40)
N	1266193	652231	1918424	472641	179590	652231

Source: Civil Aviation Authority; "Persistence" was calculated using the price data from the airlines' web sites. Note: SD in parentheses.

Table 8 — Marginal Effects for Bivariate Probit with Sample Selection – *y=Pr(Discriminatory=1)* and *z=Pr(Arbitrage=1|Discriminatory=1)*

	Model 1 – Full Sample		Model 2 – without EasyJet		Model 3 – Only Ryan Air	
	$\partial y / \partial x$	$\partial z / \partial x$	$\partial y / \partial x$	$\partial z / \partial x$	$\partial y / \partial x$	$\partial z / \partial x$
Persistence	0.50 (296.0)[a]	0.00 (0.52)	0.46 (245.0)[a]	0.02 (13.0)[a]	0.41 (188.5)[a]	0.03 (13.9)[a]
HHI_route	-0.07 (12.8)[a]	0.03 (4.98)[a]	-0.07 (6.88)[a]	0.05 (5.83)[a]	-0.10 (7.24)[a]	0.09 (8.49)[a]
Market Size	0.15 (23.4)[a]	0.01 (1.12)	0.17 (17.7)[a]	0.01 (1.23)	0.15 (14.1)[a]	0.02 (2.31)[b]
Shr Charter Pass	0.34 (59.6)[a]	-0.03 (4.72)[a]	0.49 (38.8)[a]	0.12 (10.6)[a]	0.37 (15.0)[a]	0.14 (10.7)[a]
N UK departures	0.00 (11.0)[a]	0.00 (2.11)[b]	0.00 (7.17)[a]	0.00 (4.82)[a]	0.00 (0.60)	0.00 (3.19)[a]
10 days	-0.03 (12.4)[a]	0.03 (14.5)[a]	0.00 (0.11)	0.01 (6.11)[a]	0.00 (0.71)	0.02 (6.60)[a]
14 days	0.01 (5.67)[a]	0.03 (13.0)[a]	0.06 (17.1)[a]	0.03 (11.8)[a]	0.07 (16.7)[a]	0.03 (10.9)[a]
21 days	-0.04 (19.0)[a]	0.02 (6.75)[a]	-0.02 (5.32)[a]	0.00 (0.71)	-0.01 (2.68)[a]	0.01 (1.69)[c]
28 days	-0.02 (8.56)[a]	0.03 (12.1)[a]	-0.03 (7.7)[a]	0.03 (10.0)[a]	-0.02 (4.31)[a]	0.04 (11.2)[a]
35 days	-0.03 (11. 8)[a]	0.02 (7.07)[a]	-0.04 (11.2)[a]	0.01 (2.68)[a]	-0.03 (7.34)[a]	0.01 (3.80)[a]
42 days	-0.05 (18.5)[a]	0.04 (14.9)[a]	-0.05 (12.9)[a]	0.04 (12.4)[a]	-0.04 (7.98)[a]	0.05 (13.7)[a]
49 days	-0.06 (23.4)[a]	0.03 (9.78)[a]	-0.06 (15.1)[a]	0.01 (3.72)[a]	-0.05 (9.82)[a]	0.02 (5.19)[a]
56 days	-0.08 (33.5)[a]	0.04 (14.1)[a]	-0.08 (19.3)[a]	0.04 (10.4)[a]	-0.06 (12.7)[a]	0.05 (12.8)[a]
63 days	-0.06 (24.2)[a]	0.03 (12.9)[a]	-0.03 (7.43)[a]	0.03 (9.58)[a]	-0.02 (4.18)[a]	0.04 (10.7)[a]
70 days	0.04 (12.2)[a]	0.02 (8.58)[a]	0.09 (21.0)[a]	0.03 (7.23)[a]	0.10 (19.6)[a]	0.04 (9.80)[a]
Summer Season	0.03 (14.8)[a]	-0.02 (9.97)[a]	0.00 (0.76)	-0.01 (4.95)[a]	-0.03 (9.20)[a]	-0.02 (6.95)[a]
Ryan air	0.15 (43.0)[a]	0.19 (47.3)[a]	0.18 (44.7)[a]	0.25 (67.1)[a]		
Buzz	-0.12 (27.1)[a]	0.14 (13.0)[a]	-0.17 (27.9)[a]	0.21 (16.9)[a]		
GoFLY	-0.04 (7.05)[a]	0.26 (27.1)[a]	-0.05 (6.75)[a]	0.31 (32.6)[a]		
MyTravelLite	-0.03 (5.43)[a]	0.05 (4.47)[a]	-0.03 (4.13)[a]	0.07 (5.16)[a]		
EasyJet	-0.26 (79.3)[a]	-0.07 (16.2)[a]				
Wald Test Indep. equations (ρ=0)	$\chi^2 = 322.6$[a]		$\chi^2 = 21.25$[a]		$\chi^2 = 14.28$[a]	
N	1918424	652231	1069111	513799	803782	418726

Note: A constant was included in all regressions. Observations clustered by company, route and date of departure.
z-statistics in parentheses: [a,b,c] significant at 1%, 5% and 10% level, respectively.
Dummies for Nations, Time of flight and Day of the week included in all regressions but not reported to save space. Full set of estimates available on request.

Appendix A

Table A1 illustrates two main features of the data collection strategy, that is, the matching of records and the control for the booking day. We begin with the latter. The first column identifies the date of the query for a round-trip journey: the second leg is normally due seven days after the first leg, with one exception on which we shall focus shortly. The second and the third column describe the dates of departure of each leg for trips originating in UK, when the date of departure is assumed to be respectively, 1, 4, 7, 10, 14, 21, 28, 35, 42, 49, 56, 63, 70 days from the date of the query (booking days are reported in brackets). The fourth and fifth column do the same for trips originating in Italy, as we chose the route London Stansted – Rome Ciampino for example. Note the exception of bookings made four days prior to the departure of the first leg, which are combined with a second leg due ten (not eleven) days from the time of the query.

As for the matching of records, consider the third row. It reports the dates of departure when the first leg is booked 7 days before. Now consider the first row. The second legs are booked exactly the same number of days as the first legs in the third row.

For convenience, we have used Greek capital letters to identify the match of the two fares available, for each booking day, for the Stansted-Ciampino flight, and Greek lowercase letters for the two fares available for the Ciampino-Stansted flight for each booking day. Note how the procedure makes it impossible to match fares for departures 1, 4, 17 and 77 days from the date of the query. Finally, it is worth clarifying how each row identifies a distinct query for each "directional" round-trip. Repeating the same procedure every day yields the possibility to collect up to eleven prices for each flight.

Table A1. Strategy for data collection.

	Booking from UK		***Booking from Italy***	
	First Leg Flight (£)	***Second Leg Flight (£)***	***First Leg Flight (€)***	***Second Leg Flight (€)***
date of booking	*Stansted-Ciampino*	*Ciampino-Stansted*	*Ciampino-Stansted*	*Stansted-Ciampino*
	date of departure (days from booking day)	***date of arrival (days from booking day)***	***date of departure (days from booking day)***	***date of arrival (days from booking day)***
01/04/2003	*02/04/2003 (1)*	*08/04/2003 (7)*$^{\alpha}$	*02/04/2003 (1)*	*08/04/2003 (7)*^{A}
01/04/2003	*05/04/2003 (4)*	*11/04/2003 (10)*$^{\sigma}$	*05/04/2003 (4)*	*11/04/2003 (10)*$^{\Sigma}$
01/04/2003	*08/04/2003 (7)*^{A}	*15/04/2003 (14)*$^{\beta}$	*08/04/2003 (7)*$^{\alpha}$	*15/04/2003 (14)*^{B}
01/04/2003	*11/04/2003 (10)*$^{\Sigma}$	*18/04/2003 (17)*	*11/04/2003 (10)*$^{\sigma}$	*17/04/2003 (17)*
01/04/2003	*15/04/2003 (14)*^{B}	*22/04/2003 (21)*$^{\chi}$	*15/04/2003 (14)*$^{\beta}$	*22/04/2003 (21)*^{X}
01/04/2003	*22/04/2003 (21)*^{X}	*29/04/2003 (28)*$^{\delta}$	*22/04/2003 (21)*$^{\chi}$	*29/04/2003 (28)*$^{\Delta}$
01/04/2003	*29/04/2003 (28)*$^{\Delta}$	*06/05/2003 (35)*$^{\varepsilon}$	*29/04/2003 (28)*$^{\delta}$	*06/05/2003 (35)*^{E}
01/04/2003	*06/05/2003 (35)*^{E}	*13/05/2003 (42)*$^{\phi}$	*06/05/2003 (35)*$^{\varepsilon}$	*13/05/2003 (42)*$^{\Phi}$
01/04/2003	*13/05/2003 (42)*$^{\Phi}$	*20/05/2003 (49)*$^{\gamma}$	*13/05/2003 (42)*$^{\phi}$	*20/05/2003 (49)*$^{\Gamma}$
01/04/2003	*20/05/2003 (49)*$^{\Gamma}$	*27/05/2003 (56)*$^{\eta}$	*20/05/2003 (49)*$^{\gamma}$	*27/05/2003 (56)*^{H}
01/04/2003	*27/05/2003 (56)*^{H}	*03/06/2003 (63)*$^{\iota}$	*27/05/2003 (56)*$^{\eta}$	*03/06/2003 (63)*^{I}
01/04/2003	*03/06/2003 (63)*^{I}	*10/06/2003 (70)*$^{\lambda}$	*03/06/2003 (63)*$^{\iota}$	*10/06/2003 (70)*$^{\Lambda}$
01/04/2003	*10/06/2003 (70)*$^{\Lambda}$	*17/06/2003 (77)*	*10/06/2003 (70)*$^{\lambda}$	*17/06/2003 (77)*

Appendix B – Defining "Discrimination Type"

Recalling equation (2) and that discrimination is possible only on the second leg of a round-trip, the values assigned to "Discrimination Type" satisfy the conditions outlined in Table B1, where "UK" and "Cont.EU" identify the location of the departure airport and *AC* is defined in (3).

Table B1 – Conditions used to derive the values for Discrimination Type in the text.

Discrimination Type values	Condition	Logic Oper.	Condition
0 – Non Discriminatory.	|Δ|<5		
1- Discrimin. no arbit.	(UK AND Δ≤-5)	OR	(Cont.EU AND Δ≥5)
2 – Discrimin. No prof arbit.	(UK AND Δ≥5 AND Δ≤AC)	OR	(Cont.EU AND Δ≤-5 AND Δ≥-AC)
3– Discrimin. with prof arbit.	(UK AND Δ≥5 AND Δ≥AC)	OR	(Cont.EU AND ≤-5 AND Δ≤-AC)

To explain the conditions, we refer to the first column, since the same logic applies to the conditions used in the last column. No discrimination is observed if the absolute difference between the two fares is less than 5 GBP. When P_{irtcb}^{UK} is at least 5GBP higher than $P_{irtcb}^{EU} / e_{EU/UK}^{b}$, then a continental European will prefer to buy the fare in her national currency: in any case, the Britons are adversely discriminated (value 1). Even when $P_{irtcb}^{EU} / e_{EU/UK}^{b}$ is at least 5GBP more expensive than P_{irtcb}^{UK}, a continental European may not find it profitable to exercise arbitrage as its benefit (i.e., Δ) may be smaller than its costs (value 2). In this case, the continental Europeans are adversely discriminated. Finally, the arbitrage is profitable in the case of value 3.

Material for the referees – not to be published.

Table R1 - Distribution of "Discrimination Type" by the time interval separating the retrieval on-line of P^{EU} and P^{UK}.

Time Interval	Total (N)	Non Discriminatory	Discriminatory No Arbitrage	Discriminatory Arbitrage
<=10 min	556,263	75.78%	12.71%	11.52%
10-20 min	473,693	76.78%	12.24%	10.98%
20-30 min	268,894	78.01%	10.20%	11.80%
30-40 min	190,912	79.45%	10.99%	9.57%
40-50 min	225,625	76.82%	12.26%	10.92%
50-60 min	203,037	78.99%	10.73%	10.28%
Total	1,918,424	77.17%	11.81%	11.03%

Note for the referees: This Table was constructed using a previous classification of "Discrimination Type". The main gist does not chance with the classification used in the submitted article. Indeed, the majority of observations were constructed using prices collected within a 20 minutes interval. However, the Table shows that Discriminatory and non-Discriminatory cases are very similarly distributed across time intervals. This suggests that no bias is induced by intervening events separating the retrieval of the two prices.

Table R2 – Correlation Tables for the continuous regressors.

	(1)	(2)	(3)	(4)	(5)
HHI route (1)	1				
Persistence (2)	-0.01	1			
Market Size (3)	-0.04	-0.03	1		
Shr charter pass. (4)	-0.09	0.03	-0.23	1	
N UK departures (5)	-0.22	0.07	-0.10	-0.03	1

Table R3 – Estimates from the Bivariate Probit model with Sample Selection.

	Model 1 – Full Sample		Model 2 – without EasyJet		Model 3 – Only Ryan Air	
	Discrimi-natory.	Arbitrage	Discrimi-natory	Arbitrage	Discrimi-natory.	Arbitrage
Persistence	1.37 (269.6)[a]	0.41 (25.9)[a]	1.26 (205.6)[a]	0.23 (7.29)[a]	1.11 (164.7)[a]	0.21 (6.42)[a]
HHI_route	-0.19 (12.8)[a]	0.03 (1.42)	-0.16 (6.88)[a]	0.11 (4.59)[a]	-0.24 (7.24)[a]	0.20 (6.81)[a]
Market Size	0.43 (23.7)[a]	0.17 (8.41)[a]	0.43 (17.7)[a]	0.09 (3.65)[a]	0.39 (14.1)[a]	0.10 (4.00)[a]
Shr Charter Pass	0.99 (59.7)[a]	0.22 (8.23)[a]	1.23 (38.8)[a]	0.51 (13.2)[a]	0.94 (15.0)[a]	0.49 (12.4)[a]
N UK departures	0.01 (11.0)[a]	0.01 (5.67)[a]	0.01 (7.17)[a]	0.01 (5.68)[a]	0.00 (0.60)	0.00 (3.19)[a]
10 days	-0.08 (12.2)[a]	0.06 (10.3)[a]	0.00 (0.11)	0.04 (6.10)[a]	0.01 (0.71)	0.05 (6.68)[a]
14 days	0.04 (5.71)[a]	0.10 (15.0)[a]	0.15 (17.1)[a]	0.11 (13.2)[a]	0.17 (16.4)[a]	0.11 (11.7)[a]
21 days	-0.13 (18.4)[a]	0.01 (1.14)	-0.05 (5.31)[a]	0.00 (0.13)	-0.03 (2.68)[a]	0.01 (1.30)
28 days	-0.06 (8.44)[a]	0.08 (9.90)[a]	-0.07 (7.69)[a]	0.08 (8.80)[a]	-0.05 (4.32)[a]	0.11 (10.5)[a]
35 days	-0.09 (11.5)[a]	0.03 (3.57)[a]	-0.11 (11.2)[a]	0.01 (0.89)	-0.08 (7.35)[a]	0.03 (2.64)[a]
42 days	-0.14 (17.9)[a]	0.09 (10.2)[a]	-0.13 (12.8)[a]	0.10 (10.1)[a]	-0.09 (7.99)[a]	0.13 (12.3)[a]
49 days	-0.18 (22.3)[a]	0.03 (3.04)[a]	-0.15 (15.0)[a]	0.01 (1.26)	-0.12 (9.82)[a]	0.04 (3.55)[a]
56 days	-0.25 (31.1)[a]	0.05 (4.85)[a]	-0.20 (19.0)[a]	0.07 (6.73)[a]	-0.15 (12.7)[a]	0.11 (10.1)[a]
63 days	-0.18 (23.1)[a]	0.05 (5.43)[a]	-0.08 (7.41)[a]	0.07 (8.17)[a]	-0.05 (4.18)[a]	0.09 (9.83)[a]
70 days	0.10 (12.4)[a]	0.12 (11.8)[a]	0.23 (20.8)[a]	0.11 (8.28)[a]	0.24 (19.1)[a]	0.14 (10.0)[a]
Summer Season	0.09 (14.7)[a]	-0.04 (5.25)[a]	-0.01 (0.76)	-0.04 (4.91)[a]	-0.09 (9.18)[a]	-0.07 (7.67)[a]
Ryan air	0.43 (43.2)[a]	0.81 (55.8)[a]	0.47 (43.1)[a]	0.91 (51.5)[a]		
Buzz	-0.10 (5.28)[a]	0.27 (9.32)[a]	-0.44 (26.2)[a]	0.46 (13.1)[a]		
GoFLY	-0.77 (75.6)[a]	0.68 (29.0)[a]	-0.12 (6.70)[a]	0.79 (30.1)[a]		
MyTravelLite	-0.38 (23.6)[a]	0.12 (3.68)[a]	-0.08 (4.12)[a]	0.17 (4.96)[a]		
EasyJet	-0.12 (6.82)[a]	-0.52 (32.0)[a]				
Wald Test Indep. equations (ρ=0)	$\chi^2 = 322.6^a$		$\chi^2 = 21.25^a$		$\chi^2 = 14.28^a$	
N	1918424	652231	1069111	1918424	652231	1069111

Note: A constant was included in all regressions. Observations clustered by company, route and date of departure.
z-statistics in parentheses: [a,b,c] significant at 1%, 5% and 10% level, respectively.
Dummies for Nations, Time of flight and Day of the week included in all regressions but not reported to save space. Full set of estimates available on request.