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Discounts and Public Service Obligations in the Airline Market: Lessons from Spain

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Abstract We examine the impact of the universal service policy that was applied to the Spanish airline market during the period 2001–2009. Our analysis shows that routes that benefit from price discounts that were granted by the government to island residents enjoy higher demand than the rest of the country's domestic routes. However, the lower elasticity of demand of these routes allows airlines to set higher prices. We also find that airlines that operate inter-island routes on which their services are regulated by price caps and frequency floors charge lower prices and schedule higher flight frequencies than is the case on unregulated routes. Overall, our analysis suggests that price discounts for island residents help guarantee the profitability of routes that are regulated by public service obligations.

Keywords Air transportation · Residents discounts · Price caps · Frequency floors

1 Introduction

The number of competitors in European air travel has increased significantly in recent decades as a consequence of liberalization and the entry of low-cost carriers on many short-haul routes. However, not all regions benefit from competition. Thin and/or peripheral routes can only survive through a reduction in the frequency of flights and

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an increase in prices, and even so private airlines may decide to abandon them. The traditional way of dealing with this problem in the EU has been to subsidize the population that live in peripheral communities and/or to impose public service obligations (PSOs) on the airlines that serve protected routes.

This paper analyzes the effects of the universal service policy that was applied in the Spanish airline market during the period 2001–2009. First, we assess the effects of the 50% discount on airfares that is granted by the government to island residents when they travel on the domestic routes that have an island as an endpoint. And second, we assess the effects of PSOs, price caps and frequency floors, that are imposed on the routes that connect Spanish islands with each other. To the best of our knowledge, this is the first empirical paper to study the impact of universal service regulations at the route level in a European country.[1] Our analysis assesses the effectiveness of these regulations and identifies the main beneficiaries.

We estimate demand, price, and frequency equations at the route level. Our results show that airlines set higher prices on routes that connect the Spanish mainland with the Canary and Balearic islands, where the government offers discounts to island residents. The intuition is that discounts reduce the island residents' elasticity of demand, thereby allowing the airlines to set higher prices. As a result, non-residents pay higher prices than on unregulated routes of similar characteristics. However, we do not find evidence that the discounts increase flight frequency. The additional demand that is generated by the discounts might not be enough to schedule more flights, or the airlines might face difficulties in obtaining additional airport takeoff/landing slots.[2]

The second contribution of the paper is to show that the price caps and frequency floors that are set for inter-island routes lead to lower prices and higher frequencies than those encountered on unregulated domestic routes. This result suggests that the Spanish Government is "over-protecting" the passengers on these routes, in the sense that they receive better price and frequency conditions than do passengers on unprotected routes. This situation might respond to certain policy goals such as regional development and social cohesion that are not the focus of this study.

The rest of the paper is organized as follows. Section 2 reviews the literature on universal service obligations in the airline industry and describes the Spanish regulatory framework. Section 3 explains the estimation strategy, Sect. 4 presents the data, and Sect. 5 shows the main results. Finally, Sect. 6 summarizes our conclusions.

2 Literature Review and Spanish Regulation

2.1 Literature Review on Universal Service Obligations

Before the liberalization reform that was initiated in Europe in the 1990s, universal services in network industries were provided by public or regulated monopolies and

[1] Santana (2009) analyzes the effect of PSOs on the productive efficiency of European airlines for the period 1991–2002. She also compares the effects of PSOs in Europe and in the US. On the other hand, Starkie and Starrs (1984) analyze the prices in thin routes in Australia, and Bitzan and Junkwood (2006) in the US.

[2] Several Spanish airports suffer problems of congestion that limit the number of slots that are available for each route. The significance of this problem is discussed in Sect. 4.

financed through subsidies from the public budget and through cross-subsidies from profitable to unprofitable consumers. For example, in the telecommunications sector, uniform prices involved a cross-subsidization from low- to high-cost regions and from long distance to local calls. In the postal sector, loss-making public companies received direct transfers from the public budget. In air transportation, thick routes subsidized remote/unprofitable routes.

After liberalization these financing mechanisms became unsustainable, and new universal service policies were developed in the EU to counterbalance the negative effect of the reform on certain consumer groups and regions. Under these policies, governments, first, define the basic services that must be guaranteed to the whole population; second, select the operators in charge to provide them (universal service providers); and, third, choose the instruments necessary to finance these operators. Next, we briefly review the economic literature that studies these three regulatory problems.

The definition of the basic universal services that must be made available to all citizens is a controversial issue. Usually the services offered depend on the social preferences and the economic situation of individual countries. Cremer (2009, p. 32) has pointed out that the main problem in defining universal services is determining when the social benefits generated by these services justify their costs and, more importantly, the restriction in competition they usually entail.

Following Cremer et al. (2001) and Cremer (2009), we can identify a number of economic justifications for facilitating access to air transportation to the whole population: (1) Redistribution of income: Universal service policies are an alternative redistributive mechanism to taxes and direct transfers; (2) Network externalities: By subsidizing some passengers on a route others might enjoy additional frequencies, and by subsidizing some routes others might receive more traffic; (3) The public good: A national network of air transportation enhances social cohesion and equity; and (4) Regional policy: Prices and frequencies can be regulated to facilitate regional development.

A number of papers have studied the method for determining which firms should provide the PSOs and the subsidy that they should receive. Most studies consider the use of auctions (Anton et al. 1998; Chone et al. 2000; Sorana 2000). In the case of air transportation, Williams (2005) analyzes the tendering system that was implemented in Norway. Interestingly, tenders of this type are not used in Spain because there is free entry on the routes that are protected by PSOs.

A third group of papers focuses on the distortions generated by the PSO financing mechanisms (Armstrong 2001; Calzada 2009; Mirabel et al. 2009; Valletti et al. 2002). For the case of air transportation, Nolan et al. (2005) examine the social welfare implications of different regulations: direct subsidies, protected route packages, and revenue guarantees. In general, these papers distinguish two forms of financing the firm that provides the service: cross-subsidies from one group of consumers to another, and direct subsidies to the firm. The second option is generally considered more efficient and transparent. Subsidies can be financed through the public budget or by all airlines through a universal service fund.

Finally, very little attention has been paid to the optimal universal service financing mechanism. Billette de Villemeur (2004) shows that optimal allocations of price and frequency in the airline industry can be reached by means of a price-cap constraint that depends on the frequency of the service. In the Appendix we present an extension of this model that is useful for analyzing the effects of price discounts and PSOs.

2.2 Universal Service Policy in the Spanish Airline Market

In the EU, universal service policies are used to promote the mobility of the population in remote and peripheral areas.[3] France, Italy, Portugal, Spain and the UK establish *discount schemes* that cover the residents of selected islands and regions. For example, the residents of Madeira and Azores in Portugal and those of Sardinia in Italy benefit from price discounts.

Some countries, such as France, the Irish Republic, Spain and Norway, complement this direct social aid with *PSOs* that are imposed on airlines that serve peripheral regions or thin routes. However, other countries such as the UK scarcely use them. In most cases, protected routes must offer a minimum daily service frequency and/or satisfy specific timetable obligations. In addition, governments usually fix maximum fares, which vary widely both between and within countries. In recent years many of these policies have come under general criticism for their inconsistency across EU countries and for the lack of transparency of the instruments used to finance them.[4]

In Spain, in recent decades, the government has implemented several measures to promote the mobility of its island residents and the residents of the cities of Ceuta and Melilla. Below we summarize the measures that affect air transportation:

Residents discount scheme: Between 2001 and 2004 the residents of the Canary and Balearic Islands and the cities of Ceuta and Melilla enjoyed a 33% price discount.[5] Between 2004 and 2007 the discount increased progressively from 33 to 50%. According to the sector authorities, this measure has increased the yearly subsidy that is offered to island residents from 173 to 371 million euros.[6] These discounts are financed through public funds.

Subsidies of airport fees: Airport fees on domestic routes that link the mainland and the islands are about 40% lower than on the rest of Spain's domestic routes. Moreover, airport fees on inter-island routes are almost five times cheaper than on the rest of the domestic routes.[7]

Public Service Obligations: 13 inter-island routes in the Canary islands and 3 inter-island routes in the Balearic islands are subject to PSOs, which guarantee the continuity, frequency, capacity, quality, and affordability of the service. On November

[3] For a detailed explanation see Santana (2009, Table 1) and Williams and Pagliari (2004, Tables 2 and 4).

[4] Williams and Pagliari (2004) and Williams (2005) claim that PSOs typically respond to local political pressure and bear little relation to issues such as accessibility and economic development goals.

[5] The discount only applies to citizens of the EU and the European Economic Area who can prove that they are residents in the Spanish islands or in Ceuta and Melilla.

[6] See the debate concerning these subsidies between the Ministry responsible for the sector, and the regional authorities of the Balearic Islands in: http://www.Diariodemallorca.es/mallorca/2010/0915/blanco-apuesta-reducir-ayuda-billetes-aereos-caros/603081.html.

[7] This information has been obtained from the Spanish airport operator (AENA).

2003, the Spanish government established the following conditions for operating these routes:

1. Timetable requirements. Airlines must provide the service from 07:00 to 09:00 in the morning. Return flights at night must be provided from 20:00 to 22:00, depending on the route.
2. Frequency floors. Each route must operate several flights per day. For example, between Mallorca and Menorca at least 4 daily flights must be offered in the winter and 5 daily flights in the summer. Between Gran Canaria and Tenerife, at least 12 daily flights must be offered in the winter and at least 14 in the summer.
3. Seating capacity. Airlines must offer minimum levels of seating capacity. For example, on the Mallorca-Menorca route they must offer at least 63,000 seats in winter, and on the Gran Canaria-Tenerife route at least 295,000 seats in winter. Note that in comparison to other EU countries, PSOs in Spain are applied to routes with relatively high demand (in some routes, the size of the population and the intensity of tourism is significant).
4. Price caps. Fares must not exceed 82 euros for each round of the trip between Mallorca and Ibiza and Mallorca and Menorca. On the Canary routes, fares on the 13 protected routes vary from 56 euros between Gran Canaria and Tenerife to 94 euros between La Palma and Lanzarote.[8]

An important feature of the Spanish regime is that airlines serving a route with PSOs do not obtain any exclusive rights and do not receive any public subsidy. Despite this, protected routes are often dominated by one operator. In the Balearics, Air Nostrum, a regional airline owned by Iberia, operates most of the flights. In the Canaries, the main operator is Binter, which is an airline that specializes in inter-island flights. In this paper we show that the profitability of these routes might be due to the increase in air traffic that is generated by the discounts that are given to island residents.

3 Estimation Strategy

This section analyzes the effects of the universal service policies that were implemented in the Spanish market during the period 2001–2009. Following the empirical literature on the airline industry,[9] we estimate a three equation model at the route level that includes the demand for air transportation (X_{kt}), the price charged by airlines

[8] Since 2003, these fares have been updated each year in accordance with the Retail Price Index and the adjustment in airport fees. In 2008, the Spanish government modified the pricing regime to promote entry. According to the new regulation, when more than 50% of the seats are occupied, the maximum fares are replaced by reference fares. For example, this implies that in the balearics airlines can fix a price that exceeds 82 euros for some passengers if the average price is not higher than this figure. See Ministerio de Fomento, FOM/1085/2008, April 7th.

[9] Borenstein (1989), Brander and Zhang (1990), Berry et al. (1996), Brueckner and Spiller (1994), Dresner et al. (1996), Evans and Kessides (1993), Fageda (2006), Fisher and Kamerschen (2003), Hofer et al. (2008), Marín (1995), Mirabel (2001) and Oum et al. (1993) estimate how prices are influenced by route competition, airport dominance, or the presence of low-cost carriers. Bilotkach et al. (2010), Borenstein and Netz (1999), Brueckner and Pai (2009), Pai (2010), Salvanes et al. (2005), Schipper et al. (2002) and Wei and Hansen (2007) examine the effect of factors such as route distance, competition, or aircraft size on flight frequencies.

(p_{kt}), and the weekly frequency offered by airlines (f_{kt}), where k is the route and t the time period. Note that we model demand as a function of prices and frequencies, while prices and frequencies depend on demand. Taking this into account demand, prices and frequencies may be simultaneously determined.

The novelty of our analysis lies in the inclusion of explanatory variables that are related to the Spanish universal service policy: $D_{kt}^{discount}$ is a dummy variable that interacts with the price discount granted by the government to island residents and D_{kt}^{pso} is a dummy variable that takes a value of 1 on routes with PSOs. The equations we estimate are the following:

Demand equation:

$$X_{kt} = a_0 + a_1 Pop_{kt} + a_2 GDPc_{kt} + a_3 Tour_{kt} + a_4 p_{kt} + a_5 f_{kt} + a_6 D_{kt}^{discount} + a_7 D_t^{summer} + c_8 TimeTrend_t + e_{kt}. \quad (1)$$

Pricing equation:

$$p_{kt} = b_0 + b_1 X_{kt} + b_2 Dist_k + b_3 Dist_k^2 + b_4 HHI_{kt} + b_5 D_{kt}^{discount} + b_6 D_{kt}^{pso} + b_7 D_t^{summer} + b_8 TimeTrend_t + e_{kt}. \quad (2)$$

Frequency equation:

$$f_{kt} = c_0 + c_1 X_{kt} + c_2 HHI_{kt} + c_3 Dist_k + c_4 D_{kt}^{discount} + c_5 D_{kt}^{pso} + c_6 D_t^{summer} + c_7 TimeTrend_t + e_{kt}. \quad (3)$$

The remaining explanatory variables are related to endpoint characteristics, distance, and route competition. We define as Pop_{kt} the population, and as $GDPc_{kt}$ the gross domestic product per capita. These two variables are measured as the mean of the population and the GDP per capita at the two endpoints of the route. $Tour_{kt}$ is the intensity of tourism at both endpoints of the route, $Dist_k$ is the distance that separates the route's origin and destination airports, and HHI_{kt} is the route concentration Herfindahl–Hirschman index (HHI) in terms of frequency shares.

Next, we discuss the expected effect of the explanatory variables in the three estimated equations:

Demand equation. The amount of traffic between two cities should be positively related to their population size and wealth. High tourism intensity at either of the two endpoints may also affect traffic volume on the route positively.

Demand on a route also depends on the price charged and the flight frequency. A higher price should lead to a fall in demand. However, the price also reflects the route length, since there is a strong correlation between price and distance. To account for this situation, in the demand equation we include the price per kilometer, instead of the price in absolute values, since this variable identifies more accurately the combined effect of price and distance on demand.

On the other hand, a high frequency reduces the schedule delay cost that is incurred by passengers, which is defined as the difference between the actual and desired times of departure. Hence, it should increase the demand for air services on the route.

Demand, prices, and frequencies can be determined simultaneously at the route level. In order to avoid any endogenous bias in the demand equation we use instruments for price and frequency: the concentration index at the airport level is the instrument for the price, and distance is the instrument for frequency.[10]

A PSO dummy is not included as an explanatory variable in the demand equation, since PSOs are regulations that are imposed on prices and frequencies and their effects should be captured by these two variables. Discounts that are given to island residents, by contrast, may have two effects on demand: First, island residents may fly more because the prices that they have to pay are lower than the nominal prices posted by airlines on their web sites. Second, discounts reduce the demand-price elasticity of island residents, as is shown in the appendix.

Price equation. The expected sign of the coefficient of demand in the pricing equation is ambiguous. Intense traffic on a route makes it possible to gain density economies, as airlines can use bigger planes at higher load factors and optimize the use of the crew and the planes. In a competitive environment, this should lead to lower prices. However, more traffic might lead to higher mark-ups over costs if capacity constraints are present.[11]

As discussed above, at the route level, prices and frequencies can be determined simultaneously with demand. In order to avoid any endogenous bias, in the price equation we consider three instruments for demand: the mean population in the route's origin and destination provinces (Pop); gross domestic product per capita ($GDPc$); and tourism ($Tour$) at the regional level.[12]

Route length is a major determinant of an airline's costs, and we expect these costs to increase less than proportionally with an increase in the number of kilometers flown. Long-haul routes involve higher average speeds, less intense consumption of fuel, and lower airport charges per kilometer. [13] This implies that the coefficient of distance in the price equation should be positive. Given that the relationship between prices and distance may not be linear, we include the square of distance as explanatory variable.

The HHI at the route level reflects how competition affects the price. We expect the coefficient that is associated with this variable to be positive in the pricing equation, since less competition should imply higher prices. Note that route concentration can be determined simultaneously with prices. To account for a possible bias due to the endogeneity of this variable we follow Fageda (2006) and instrument the

[10] By using prices per kilometer we are forcing a specific relationship between prices and distance. However, if we include distance as an exogenous explanatory variable, we lose one of the instruments and then we can not use instrumental variables regression.

[11] Since Caves et al. (1984), the literature distinguishes between density and scale economies. The former is related to the decrease in average costs that results from an increase in traffic on the route, since companies can use larger aircraft at higher load factors. By contrast, scale economies show the decrease in average costs from increasing both traffic on the route and the number of routes served.

[12] Note that the proportion of tourists is higher on routes with an island as their endpoint. Unfortunately, we are unable to construct a variable of tourism intensity for the summer and the winter season, which would be more appropriate to capture the effect of tourism.

[13] We obtain similar results when we use price per kilometer as the dependent variable. In this case, the coefficient that is associated with the distance variable is negative.

HHI at the route level through the HHI at the airport level. This variable is constructed by calculating the concentration index of airline departures at the airports (we consider the mean value of the HHI at both the airports of origin and destination).

The use of this instrument could carry an endogeneity bias if airport concentration levels depend on the pricing choices of firms. However, we consider that this effect is greatly diluted because pricing choices refer to the route level, while concentration at the airport level refers to all of the routes that depart from a given airport.

Our predictions concerning the effect of discounts on prices are based on the theoretical analysis presented in the Appendix. The expected effect of the government subsidy to island residents is an increase in the price that is set by airlines, since these discounts make the demand of island residents less elastic and, as a consequence, airlines can set higher mark-ups. The discount should also increase the amount of traffic on the route, although in our price equation this effect is captured by the demand variable.

Frequency equation. We expect a positive sign for the coefficient of the demand variable. Indeed, airlines may be interested in increasing flight frequency on a route if demand rises. However, airlines may also absorb demand increases with larger aircraft and/or higher load factors.

We expect a negative relationship between frequency and the distance of routes. On longer routes airlines may prefer to reduce frequencies and use bigger planes as their efficiency increases with distance. In addition, given that on long-haul routes intermodal competition with cars, trains, and ships is soft, airlines may offer lower flight frequencies. On the other hand, we expect the coefficient for HHI to present a negative sign, since airlines will tend to offer fewer flights as the competition on a route weakens.

The variables of demand and route concentration may be endogenous. To solve this situation we use the same instruments as in the price equation: population (Pop), gross domestic product per capita ($GDPc$), and tourism ($Tour$) for demand; and concentration at the airport level ($HHIairport_{kt}$) for route concentration.

Finally, our theoretical prediction concerning the effect of island resident price discounts is that they should increase flight frequency because discounts increase demand. However, in equation (3) this effect may be already captured by the demand variable. Note, moreover, that frequencies cannot increase if there are capacity restrictions such as limited takeoff/landing slots.

As explained above, a particular feature of the Spanish market is that airlines that operate a service on routes that connect two islands are subject to a price cap and a minimum frequency requirement. In the Appendix we analyze the effects of these two types of PSOs. Notice, however, that we expect the coefficient of this dummy variable to be non-significant if the regulator fixes the maximum price and the minimum frequency at rates that are equal to those fixed by airlines on non-regulated routes.

4 The Data

We have data for 86 domestic routes. Of these, 23 are routes that link islands with the mainland, and 14 that link two islands (inter-island routes). Data of prices refer to the route that has as its origin the airport that handled more traffic. Thus, for example, we include the route Madrid-Barcelona-Madrid but not Barcelona-Madrid-Barcelona. Since airline supply is nearly identical in both directions, treating airline services on a given route as directional adds little to the analysis.

The frequency of the data is semi-annual, as we differentiate between summer and winter seasons for a time period that starts in the winter of 2001 and finishes in the winter of 2009. As we use the lags of some variables, the data for the initial periods are lost. Additionally, our panel is unbalanced, either because data are not available for some periods or because there was no air traffic. As a result, we have 1,092 observations in the pricing regression and 1,217 observations in the demand and frequency regressions.

Information on round-trip prices (p) has been collected each half year in the period 2001–2009 using two procedures. For all routes, except the inter-island routes of the Canary Islands, we consider the lowest prices that are charged by each airline and compute the mean price using airline market shares as weights.

Airlines can offer different fare classes that are associated with different commercial conditions (e.g. business class, full fare economy class, economy class without restrictions, economy class with restrictions such as non-refundable fares, advance purchase, length of stay). Data on prices have been obtained from each airline's web site using a homogeneous procedure that involved choosing the lowest available economy fare class with restrictions for each airline. This information was collected one month before traveling. The prices refer to the first trip in the week, and the return is on a Sunday. Finally, prices are corrected for inflation.

For the inter-island routes of the Canary Islands we do not have any information regarding the prices that are set by the airlines. However, we use the price cap that is established by the government, which is published in the Official Journal of the European Union. This means that the prices charged by airlines may well be lower than the ones that we consider. As we argue later, we consider this approach to be useful in assessing whether the prices that are fixed by the government differ from those established by airlines on unregulated routes with similar observed features.

The frequency variable (f) shows the weekly number of flights that are offered by airlines for each route. Data refer to one-way flights. This information has been obtained from the web site of the Official Airlines Guide (OAG), and it refers to the same sample week as the prices. Data for inter-Canary routes come from RDC Aviation Limited (capstats data).

Many airports in Spain suffer problems of congestion that limit the number of take-off/landing slots that are available for each airline. The International Air Transport Association (IATA), when establishing procedures for slot allocation classifies airports according to the degree of excess demand. In particular, it distinguishes between: (1) non-coordinated airports where there is no excess demand and the allocation of slots is at the discretion of the airport operator; (2) airports where flight schedules have to be supervised; and (3) coordinated airports where excess demand requires the application of standard procedures for slot allocation (e.g., 'grandfather rights'; 'use-it or lose-it'; some proportion of new slots reserved for new entrants).

Most Spanish airports are classified in the third category, meaning that access to slots and the possibility of increasing frequencies is restricted. [14] This situation has been recognized by a European Commission report on the merger of three Spanish airlines (COMP/M.5364 Iberia/Clickair/Vueling). Specifically, it documents the lack of slots at peak times at several Spanish airports, including Alicante, Barcelona, Bilbao, Gran Canaria, Ibiza, Madrid, Málaga, Menorca, and Valencia.

Demand data (X) refer to the number of passengers that are carried by airlines on the route, including direct and connecting traffic. In contrast to data of frequencies, demand data refer to both directions of the route. Information has been obtained from the web site of the Spanish Airports and Air Navigation agency (AENA).

Population (Pop) is constructed as the mean population in the route's origin and destination provinces (NUTS 3).[15] Data have been obtained from the Spanish National Statistics Institute (INE). We use data for population at NUTS 3 level rather than at NUTS 2 level, because this variable captures more accurately the size of the urban agglomeration that is close to the airport.

Gross domestic product per capita ($GDPc$) is the mean GDP per capita in the route's origin and destination regions (NUTS 2). Data have been obtained from the Spanish National Statistics Institute (INE). We use this variable at the region level because the information is not available at the province level for the whole period analyzed.

The tourism variable ($Tour$) refers to the percentage of total employees in the region that is employed in hotels and restaurants. Data have been obtained from Cambridge Econometrics (European regional database publication). Information at the province level is not available.

Distance ($Dist$) is the number of kilometers that separates the route's origin and destination airports. Data have been collected from the WebFlyer site.

The HHI at the route level (HHI) is computed as the sum of the squared shares of airlines in terms of flight frequencies in the routes. Data on the departures of each airline on each route have been obtained from the OAG web site and RDC Aviation limited.

The first variable that is related to Spain's universal service policy is the island residents price discounts ($D^{discount}$), which are financed by the government. This variable takes the value 0 if the route is not affected by a price discount, and it takes the value of the discount otherwise. As explained in Section 2, in the period 2001–2004 the discount was 33%, from 2004 to 2007 it increased progressively from 33 to 50%, and since then it has not changed. In our sample, island resident discounts apply to 23 domestic routes that connect the islands and the mainland and to 14 inter-island routes.

[14] In the latest edition of the worldwide scheduling guidelines of IATA only the airports of La Coruña, Santiago, Vitoria and Zarazoza were classified in the second category (http://www.iata.org/events/sc128/Documents/wsg21_edition.pdf).

[15] According to the Statistical classification of Eurostat, a "NUTS 2' area should have a population ranging between 800,000 and 3,000,000 inhabitants, while NUTS 3 areas should range between 150,000 and 800,000 inhabitants. In practice, the statistical territorial units are defined in terms of the existing administrative units in the Member States and do not necessarily fulfill these population limits. In Spain, NUTS 2 are "Comunidades Autónomas' and NUTS 3 are "provincias".

Table 1 Descriptive statistics of the variables that are used in the empirical analysis

Variable	Mean	Standard errors	Minimum values	Maximum values
Prices (euros)	182.43	101.26	43.77	887.35
Prices per kilometre (euros)	0.46	0.28	0.06	1.56
Frequency (weekly number of flights)	45.98	54.22	2	559
Demand (number passengers)	201,279.2	288,342.3	3,558	2,514,338
Distance (kilometres)	576.61	474.56	86	2,190
Herfindahl–Hirschman index (HHI)	0.73	0.27	0.21	1
Population (inhabitants)	2,560,949	1,082,865	892,718	5,766,091
GDP per capita (euros)	21,912.74	3,366.45	14,878	31,622
Tourism (percentage of employment in hotels and restaurants)	0.09	0.05	0.04	0.21

The dummy variable for PSOs (D^{pso}) reflects the presence of price caps and frequency floors on the route. More specifically, it takes the value of 1 for inter-island routes in the Canary islands since the winter of 2001 and for inter-island routes in the Balearics since the summer of 2004, when the obligations were first imposed, respectively. This dummy variable affects 14 routes.

The dummy variable for summer (D^{summer}) is constructed on the assumption that the summer season starts on the last Sunday in March and finishes on the last Saturday in October, both inclusive. Finally, the Time Trend ($TimeTrend$) is constructed as an index that takes the value of 1 in 2001, the value 2 in 2002, and so on.

Table 1 presents the descriptive statistics for all the variables that are used in the empirical analysis. Table 2 shows the mean values of the variables for three sub-groups of routes: (1) routes with no islands as endpoints (unregulated); (2) routes that link islands with the mainland (routes with price discounts); and (3) inter-island routes (routes with price discounts and PSOs).

This information reveals that the price per kilometer and the frequencies on routes with no islands as endpoints and routes that link islands with the mainland are similar. However, routes that link islands with the mainland are longer and thicker. Inter-island routes show the lowest mean price and the highest number of frequencies, but are shorter and thinner. As a consequence, these routes have a higher price per kilometer.

Note that the number of firms operating on a route is heavily dependent on the traffic that this route can generate. A number of the thin routes regulated with PSOs have several operators, since in Spain these routes are not subject to entry restrictions. This suggest that, in spite of the regulation, the traffic of these routes is sufficiently high and they can be profitable. On the other hand, the traffic on several unregulated routes is not particularly high.

Table 2 provides an initial picture of the Spanish market and of the relation between the variables. In the next section we undertake an econometric multivariate analysis in order to assess more accurately the effects that are created by the universal service policy.

Table 2 Mean values of the variables that are used in the empirical analysis

Variable	Routes with no islands as endpoints	Routes that link islands with the mainland	Inter-island routes
Prices (euros)	184.21 (90.37)	236.39 (129.80)	137.53 (28.70)
Prices per kilometre (euros)	0.39 (0.20)	0.39 (0.30)	0.83 (0.21)
Frequency (weekly number of flights)	44.27 (62.10)	46.60 (43.05)	50.44 (38.59)
Demand (number passengers)	191,664 (326,403)	266,168 (262,435)	130,556 (111,379)
Distance (kilometres)	509.97 (180.04)	972.80 (723.31)	175.95 (57.56)
Herfindahl–Hirschman index (HHI)	0.80 (0.24)	0.53 (0.23)	0.87 (0.19)
Population (inhabitants)	3,024,522 (831,961)	2,534,382 (957,774)	978,640 (46,011)
GDP per capita (euros)	22,417 (3,401)	22,425 (3,060)	19,399 (2,364)
Tourism (percentage of employment in hotels and restaurants)	0.06 (0.009)	0.12 (0.06)	0.14 (0.02)
Number of routes	49	23	14

Standard errors are shown in parenthesis

5 Estimation and Results

We estimate the demand, pricing, and frequency equations using the two-stage least squares estimator (2SLS-IV). The reason is that in the pricing and frequency equations the demand and route concentration may be endogenous, and in the demand equation frequency and prices can also be endogenous.

The instrument suitability tests, the partial R^2 of the first stage regression, and Hansen's J test of the possible endogeneity of the instruments show a high correlation between the variables instrumented and the instruments and indicate the exogeneity of the instruments. Furthermore, the LM test shows that the equations are not under-identified.

Note also that we compute standard errors that are robust to any bias from heteroskedasticity. Additionally, we adjust our estimates by clustering observations from the same route.

Our estimation procedure does not take into account the panel data nature of the sample. The use of a fixed-effects model is not appropriate here since this technique discards anything that is time-invariant from the model, such as route distance or being an island. A random-effects model is also inappropriate as the individual effects that are related to routes are probably correlated with the error term, as indicated by the Hausman test. Finally, we are unable to use the Hausman-Taylor estimator because it assumes that all explanatory variables are exogenous.

We report two additional tests in the estimates of the demand, price, and frequency equations (Tables 3, 4, and 5). First, the augmented Dickey-Fuller Test whose null hypothesis is that the dependent variable contains a unit root. Second, the Wooldridge test for autocorrelation in panel data whose null hypothesis is that there is no first-order autocorrelation. The unit root test shows that the dependent variable is stationary so that there is no need to use cointegration techniques. On the other hand,

Table 3 Demand equation estimates (2SLS-IV)

Explanatory variables	All sample	Routes with an island as endpoint
Prices	−225,057.3 (545,35.68)***	−126,760.7 (84,677.23)
Frequency	4,785.97 (318.99)***	3,854.09 (527.47)***
Population *(pop)*	0.021 (0.011)*	0.05 (0.02)**
GDP per capita *(GDPc)*	3.36 (2.63)	4.52 (3.46)
Tourism	−53,788.19 (161,521.1)	−35,831.07 (251,463.3)
$D^{discount}$	176,809.5 (52,044.27)***	–
D^{Summer}	39,705.56 (7,239.86)***	23,567 (11,352.7)**
Time Trend (T)	−7,818.07 (3,887.11)**	−2,406.07 (3,552.40)
Intercept	−51,028.65 (45,430.09)	−86,441.52 (69,600.03)
N	1217	518
R^2	0.91	0.84
F (Joint significance)	155.02***	24.04***
Augmented Dickey-Fuller Test (H_0: the dependent variable contains a unit root)	−16.30**	−10.40*
Wooldridge test for autocorrelation in panel data (H_0:no first-order Autocorrelation)	0.31	2.9
Tests of instruments:		
Partial R^2: prices	0.37	0.25
Partial R^2: frequency	0.19	0.29
Underidentification LM test (H_0: equation is underidentified)	227.38***	143.34***

Standard errors in parenthesis (robust to heteroscedasticity). Statistical significance at 1% (***), 5% (**), 10% (*), Instrument for prices and frequency are distance and concentration at the airport level. Hansen J test is not applicable because the number of instruments equals the number of instrumented variables

after including the lag of the dependent variable as a regressor in the price equation we find no problems of autocorrelation.

The demand, price, and frequency equations are estimated using the whole sample and sub-sets of routes. Recall that we do not have information about the price of the inter-Canaries routes and that for this reason we consider the price cap set by the government. To check the implications of this approach we report the estimates of the price equation with the exclusion of the inter-Canaries routes, and we obtain similar results to those obtained when using the whole sample. Additionally, we present separately the results of the sub-sample of routes that have an island as one of their endpoints. As a result, we can differentiate more accurately between the effects that are created by price caps and frequency floors and those of resident price discounts.

Table 4 Pricing equation estimates (2SLS-IV)

Explanatory variables	All sample	All sample excluding intra-Canarian routes	Routes with an island as endpoint
Demand (X)	0.000032 (0.000033)	0.000044 (0.000038)	0.00017 (0.00016)
Distance *(dist)*	0.16(0.04)***	0.18 (0.04)***	0.13 (0.08)*
Distance^2 $(dist)^2$	−0.00003 (0.000017)*	−0.000033 (0.000019)*	−0.000017 (0.00003)
$\text{HHI}_{\text{route}}$	168.30 (47.33)***	205.46 (53.64)***	246.80 (148.24)*
$\text{Discount}^{discount}$	136.85 (33.78)***	155.93 (38.34)***	–
D^{pso}	−47.75 (13.05)***	−31.61 (17.80)*	−56.26 (31.27)*
D^{Summer}	46.14(7.45)***	56.87 (8.61)***	51.99 (18.00)***
Time Trend (T)	−4.96 (1.29)***	−5.38 (1.54)***	1.12 (3.19)
Lag (prices)	0.18 (0.07)***	0.13 (0.06)**	0.22 (0.16)
Intercept	−65.77 (52.18)	−98.77 (60.53)*	−123.69 (145.07)
N	1,092	936	459
R^2	0.46	0.42	0.41
F (Joint significance)	40.42***	35.63***	15.59 * **
Augmented Dickey-Fuller Test (H_0: the dependent variable) (contains a unit root)	−19.95***	−16.99***	−11.78**
Wooldridge test for autocorrelation in panel data (H_0: no first-order autocorrelation)	0.04	0.19	0.09
Tests of instruments			
Partial R^2: X	0.41	0.42	0.40
Partial R^2: $HHI_{airport}$	0.40	0.42	0.39
Underidentification LM test (H_0: equation is) underidentified	122.726***	106.28***	21.58***
Hansen J test (H_0: instruments exogenous)	4.06	3.76	1.25

Standard errors in parenthesis (robust to heteroscedasticity). Statistical significance at 1% (***), 5% (**), 10% (*). Instruments for the demand and route concentration variables are the following: GDP per capita, population and tourism, and the concentration index at the airport level

Note also that on some routes with islands as endpoints, competition from ships is relevant, especially on inter-island routes and on the routes that connect the Mediterranean towns and the Balearic islands.[16]

[16] To account for intermodal competition, we have run regressions that exclude short-haul routes within the mainland, but we have found only small differences in the results. We have also run additional regressions that include a dummy for the routes with high-speed train services as an explanatory variable. This variable is not statistically significant and does not alter the results obtained for the rest of the variables.

Table 5 Frequency equation estimates (2SLS-IV)

Explanatory variables	All sample	Routes with an island as endpoint
Demand (X)	0.00017 (0.000014)***	0.00008 (0.00005)
Distance *(dist)*	−0.014 (0.003)***	−0.019 (0.006)***
HHI	−6.73 (14.94)	−119.43 (68.28)*
$D^{discount}$	−10.62 (7.94)	–
D^{pso}	16.03 (5.79)***	41.63 (20.87)**
D^{Summer}	−3.89 (1.06)***	0.48 (2.45)
Time Trend (T)	−0.25 (0.30)	−2.06(1.25)
Intercept	26.94 (15.75)*	114.80 (57.73)**
N	1,217	518
R^2	0.92	0.62
F (Joint significance)	112.13***	23.65***
Augmented Dickey-Fuller Test	−18.15***	−10.54*
(H_0: the dependent variable contains a unit root)		
Wooldridge test for autocorrelation in panel data (H_0: no first-order autocorrelation)	2.66	0.21
Tests of instruments		
Partial R^2: HHI_{route}	0.42	0.37
Partial R^2: demand	0.43	0.39
Underidentification LM test	145.64***	25.69***
(H_0: equation is underidentified)		
Hansen J test		
(H_0: instruments exogenous)	0.22	0.17

Standard errors in parenthesis (robustto heteroscedasticity). Statistical significance at 1% (***), 5% (**), 10% (*). The instrument for route concentration is the concentration at the airport level

The estimates of the demand equation are shown in Table 3. As expected, while a high price reduces the demand of air services, a high frequency increases demand due to the reduction in schedule delay costs. Our results show that the discount policy increases the demand for air services: The coefficient of this variable is positive and statistically significant at the 1% level. Furthermore, we find evidence that the discounts reduce demand elasticity. Indeed, the estimated demand elasticity for all routes in our sample is −0.51, while it is just −0.32 for routes with islands as endpoints. Demand seems to be higher for more populated endpoints and in the summer, and we find a negative time trend during the period studied.

Table 4 shows the results of the estimation of the pricing equation. The demand variable is not statistically significant, which might be attributed to the fact that the density economies generated by demand are offset by the airlines' market power and the prevailing capacity constraints. The distance variable is statistically significant and the sign of its coefficient is positive. We confirm the non-linear relationship between prices and distance, since the variable of distance squared is statistically significant and negative when we consider the complete route sample.

The coefficient of the variable route concentration is positive and statistically significant, indicating that prices are higher when competition is not strong. Furthermore, prices are higher in the summer when tourism is more intense, and they decrease over time in the period studied.

The most interesting aspect of our findings is that airlines set higher prices on routes for which the government gives price discounts to island residents than they do on the rest of the domestic routes. This occurs because discounts reduce the elasticity of demand, which thereby provides an incentive for airlines to set higher prices. This result has important implications for the universal service policy that is applied in the sector, since it shows that the subsidies that are given to island residents are partly offset by the higher airfares that are set by airlines.

Unfortunately, we do not have data concerning the percentage of island residents that use each route, though in practice the share can differ considerably from one route to another. As a result, we are unable to analyze how this percentage might affect the pricing strategy of the airline. Our conjecture is that the higher is this figure, the greater is the price increase on the route.

A second result that is derived from the price equation is that inter-island routes that are subject to PSOs have lower prices than do other unregulated domestic routes of similar observed features. Although we cannot verify this, we believe that the sustainability of air services on these protected routes can be attained by the demand increases that are generated by island resident discounts. In other words, the government could be indirectly subsidizing the airlines that operate these routes by fostering traffic via the price discounts.

Finally, recall that all routes that have an island as an endpoint also benefit from lower airport fees. Our empirical analysis accounts for domestic routes with no islands as endpoints (not regulated), routes that link the mainland and the islands (routes with price discounts and subsidized airport fees), and inter-island routes (routes with price discounts, PSOs, and subsidized airport fees). We are therefore unable to disentangle empirically the effect of price discounts and PSOs from the effect of lower airport fees. However, we expect that the lower airport fees on these routes moderate the price increases that are generated by price discounts and, in addition, increase the profitability of routes that are regulated with PSOs.

The results for the frequency equation are shown in Table 5. The coefficients of the demand and concentration variables have the expected sign, but they are not always statistically significant. Furthermore, airlines reduce flight frequencies on longer routes and during the summer season. Airlines may reduce flights during the summer because in this season there is a higher proportion of leisure passengers that value less frequency than do business passengers. Finally, we do not find a clear time trend for the period 2001–2009.

The coefficient of the variable for discounts is not statistically significant in the frequency equation, which might occur because the effects of discounts are captured by the demand variable. Also, recall that in Spain airlines have few possibilities of increasing route frequencies due to airport congestion and the restrictive system of slot allocation. Additionally, a higher frequency implies more fixed costs (landing fees, gate renting, etc.), thereby limiting the possibility of exploiting density economies through the use of larger aircraft, with higher load factors. In this context, the traffic increase that is generated by the discounts could be adjusted via price increases. This result is consistent with our findings for the price equation.

Finally, we have found that frequencies on inter-island routes that are protected with frequency floors are higher than those on other routes with similar features, even though the prices on these routes are lower because of price caps. This result might be attributed to the fact that the use of regional aircraft on very short-haul routes allows firms to optimize their use of planes and crew.[17] Furthermore, although these routes are protected, they have significant traffic (most passengers are island residents who enjoy price discounts), which can make them profitable. In fact, in many cases the frequencies that are offered by the airlines are higher than those established by the PSOs.

We conclude this discussion by showing the magnitude of the effects of the universal service policies that are applied in Spain on demand, prices and frequencies. Table 6 shows the elasticities (evaluated at sample means) obtained from the previous regressions when considering all the routes in our sample.

The demand estimates show that the policy of discounts has increased the demand for air services. The elasticities in Table 6 show that a 10% increase in the discount increases the demand for air services by 4.3%. Note that airlines can adjust to this increase in demand by raising their prices or increasing supply. Additionally, we find a lower elasticity of demand on routes that have an island as an endpoint (all of these routes enjoy price discounts) than that found in the sample as a whole. Recall that the demand elasticity for all routes in our sample is −0.51, while it is just −0.32 for routes with islands as endpoints.

The price and frequency regulations that are imposed by the PSOs on certain routes may have had an indirect effect on demand. Indeed, our estimates show that demand rises as prices fall and as frequencies increase. The elasticities reported in Table 6 indicate that this effect may be relevant.

Finally, Table 7 shows that the prices of round-trip flights that benefit from island resident price discounts are about 65 euros higher than the prices on the rest of Spain's domestic routes. By contrast, the prices on inter-island routes that are protected with price caps are 45 euros lower than those on the rest of the country's domestic routes.

Our findings do not indicate that discounts increase frequencies directly; but discounts may have indirectly increased frequencies through their effect on demand. Moreover, our results are clear that the discounts have increased prices. Therefore, at least a part of the increase in demand that is generated by the discounts is offset by the price and not by an increase in flight frequency. Table 7 also reports that the effect of frequency floors is quite important since airlines offer about 15 more flights a week on inter-island routes than they do (cet. par.) on the rest of their domestic routes.

[17] For a more detailed analysis of the effects of regional aircraft see Brueckner and Pai (2009).

Table 6 Estimated elasticities evaluated at sample means (sample of all routes)

Explanatory variables	Demand equation	Pricing equation	Frequency equation
Demand (X)	–	0.03	0 75***
Prices	−0.51	–	
Frequency	1 09***	–	–
distance *(dist)*	–	0.50***	−0.18***
distance^2 $(dist)^2$	–	−0.09*	–
Population *(pop)*	0.26*	–	–
GDP per capita (GDP_c)	0.35	–	–
Tourism	−0.02	–	–
HHI_{route}	–	0.64***	−0.11
$D_{discount}$	0.43***	0.36***	−0.11
D^{pso}	–	−0.25***	0.34***
D_{Summer}	0.19***	0.24	−0.08***
Time Trend (T)	−0.17**	−0.13	−0.02
Lag	–	0.18***	–

Table 7 Impact of island residents price discounts and public service obligations on prices and frequencies (evaluated at sample means)

	All Sample		Routes with an island as endpoint	
	Prices	Frequency	Prices	Frequency
Mean	182.43 euros	45.97 weekly flights	191.62 euros	47.94 weekly flights
Estimated elasticity for $D^{discount}$	0.36	−0.11	–	–
Change in values for $D^{discount}$=1	65.83 euros	−5.05 flights	–	–
Estimated elasticity for D^{pso}	−0.25	0.34	−0.28	0.84
Change in values for D^{pso} =1	−45.93 euros	15.85 flights	−53.82 euros	40.26 flights
Overall change in routes with price discounts and PSOs ($D^{island} = 1 + D^{pso} = 1$)	19.83 euros	10.80 flights	–	–

6 Conclusions

We have examined the impact of the universal service policy that was applied to the Spanish airline market in the period 2001–2009, showing that prices were higher on the routes for which the government gave price discounts to island residents. However, we did not find a clear effect of these discounts on flight frequencies.

The logic behind these findings is that the discounts caused the demand of island residents to be less elastic, thereby allowing airlines to increase their prices. Yet, it is unclear as to whether the increase in traffic generated among island residents by the discounts induced airlines to increase their frequencies. Indeed, when airlines want to offer more frequencies they have to incur in higher costs and they must acquire more takeoff/landing slots, which is not always a realistic option in Spain.

These results suggest that part of the benefits of the price discounts that are granted to Spain's island residents are transferred to the airlines via price increases, which are detrimental to both island residents and other passengers on these routes. Hence, as well as playing a role in citizen mobility, social cohesion, and regional development, discounts serve as a subsidy for the airlines.

We have also shown that the price caps and frequency floors that are imposed on inter-island routes in the Canary and Balearic Islands lead to lower prices and higher frequencies on these routes than is the case for unregulated routes with similar observed features. Interestingly, airlines can meet their PSOs without receiving direct subsidies from the government, lower airport fees aside. We believe that a key element in the viability of these routes is the increased demand that is generated by island resident price discounts.

Universal service policies in air transportation have received very little attention, in spite of their importance in the EU and other countries. Further research needs to focus on identifying the effects that these measures have on competition, and on examining the mechanisms that are used to finance them.

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Appendix

This appendix extends the theoretical model of Billette de Villemeur (2004) to analyze the impact of universal policies in the airline industry. Consider that the demand of a monopolist airline depends on the price p and on the flight frequency f. Consumer preferences as regards departure times are uniformly distributed over time, and their expected schedule delay cost (i.e. the difference between the preferred and the actual flight times) is $v > 0$. Therefore, a consumer's average waiting-time cost is $v/2f$. Imagine that $0 \leq d \leq 1$ is the price discount that is granted by the government to all travelers and that it is financed from public funds. Moreover, X is the total traffic, and $S(X)$ is the consumers' gross surplus that is generated by the flight. Taking this into account, demand takes the form:

$$X(p, f) = argmax_X \left\{ S(X) - \left(p(1-d) + \frac{v}{2f} \right) X \right\}. \tag{4}$$

The airline faces a cost $C(K)$ for each flight, where K is the capacity of the aircraft (number of seats). In the long run, the aircraft's capacity is adjusted to the total number of passengers and it is satisfied that $X = Kf$. The airline's costs can be reduced with a subsidy for airport fees $s \geq 0$, which is also financed from public funds. Moreover, the airline has a fixed cost F, which is independent of the aircraft's capacity. Using this information, the airline profits are:

$$\Pi(p, f) = pX(p, f) - f[C(X/f) - s] - F. \tag{5}$$

In addition to the discount and the subsidy, the government can protect thin routes by imposing PSOs.[18] In particular, it can set a price cap, $p \leq \overline{p}$, and a frequency floor, $\frac{v}{2f} \leq \overline{v}$. In this case, the airline maximizes the profit in (5) with respect to p and f, subject to the PSOs. The FOCs of the airline's problem are:

$$\frac{\partial L}{\partial p} = X + (p - C'(K))\frac{\partial X}{\partial p} - \lambda_1 = 0; \tag{6}$$

$$\frac{\partial L}{\partial f} = (p - C'(K))\frac{\partial X}{\partial f} - (C(K) - s) + \frac{X}{f}C'(K) + \lambda_2\frac{v}{2f^2} = 0; \tag{7}$$

where λ_1 and λ_2 are the Lagrange multipliers that are associated with the price and frequency constraints, respectively. From (4) these conditions can be simplified by using the fact that $\frac{\partial X(p,f)}{\partial f} = \frac{-v}{2f^2(1-d)}\frac{\partial X(p,f)}{\partial p}$. Calling $\varepsilon = -\frac{p}{X(p,f)}\frac{\partial X(p,f)}{\partial p}$ the price elasticity of demand, these expressions can be written as:

$$\frac{p - C'(K)}{p} = \left(\frac{X - \lambda_1}{X}\right)\frac{1}{\varepsilon}; \tag{8}$$

$$\left[\left(\frac{X - \lambda_1}{X}\right)\left(\frac{1}{1-d}\right) + \frac{\lambda_2}{X}\right]\frac{v}{2f} = \frac{C(K) - s}{K} - C'(K). \tag{9}$$

To interpret these results, imagine first that the PSOs are not binding ($\lambda_1 = 0$ and $\lambda_2 = 0$). In this case, price and frequency are determined as in the standard case that is defined by Billette de Villemeur (2004): the airline sets a mark-up over the price that is inversely related to the elasticity of the demand[19] and the frequency is increased to the point where the average waiting time (corrected by the discount) is equal to the average cost (corrected by the subsidy) minus the marginal cost.

The price mark-up in Eq. (8) increases with the discount, because it makes the demand less elastic. On the other hand, the left-hand side of Eq. (9) shows that the discount provides an incentive for the airline to increase the frequency, because it makes each flight more profitable.

In Eq. (9), the idea that higher costs reduce the frequency is obtained by assuming that $C(K)/K$ is decreasing in K. This expression also shows that the frequency increases when the airline receives a subsidy s.

Our empirical model for the Spanish market shows that the routes that benefit from subsidies and discounts exhibit higher prices than do the rest of the unregulated routes.

[18] Billette de Villemeur (2004) shows that a conveniently designed "price-and-frequency" cap constraint of the form $p + \frac{v}{2f} \leq \overline{p}$ can implement the second-best allocations for p and f. In our model, we consider separate constraints for price and frequency to analyze the Spanish regulation.

[19] The price also depends on the frequency and on the discount as the elasticity ε is a function of both.

However, these regulations do not appear to increase flight frequencies. One possible explanation is that airlines compensate for the scarcity of slots by using bigger aircraft, and higher load factors. Capacity restrictions may also explain the higher prices on routes that benefit from discounts.

Consider now that the price cap is binding. In this case, λ_1 is positive, and it is fixed such that $p = \overline{p}$. On the other hand, the presence of λ_1 in (9) shows that the airline reacts to the price regulation by reducing flight frequencies.

Finally, Eq. (9) shows that the airline sets the frequency by taking into account the price cap, the discount and the subsidy. While the price cap reduces the frequency, the discount and the subsidy increase it. In this situation, λ_2 is binding only if the frequency that the airline would set under these regulations is lower than the floor that is fixed by the government. Our estimates show that in Spain the routes that are protected with PSOs have lower prices and higher frequencies than do those of other domestic routes.

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