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Subsidies for resident passengers in air transport markets[§]

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Abstract

In this work, we analyse from a theoretical perspective the efficiency of an *ad valorem* and a specific subsidy for resident passengers in air transport markets. In particular, we consider passengers with high and low willingness to pay that may be residents in a given geographical area (and therefore entitled to a subsidy). All passengers are served by a monopoly air carrier that wants to get as much of their willingness to pay as possible. We show that if the proportion of resident passengers is high enough, non-resident passengers may be expelled from the market. Taken into account this undesirable situation we compare *ad valorem* and specific subsidies. We conclude that if the proportion of passengers with high willingness to pay is low (high) enough applying a specific (*ad valorem*) subsidy for resident passengers is better in social terms. We apply these results to a specific case study in the Canary Islands where *ad valorem* subsidies for resident passengers have been extensively used. We conclude that in most routes the specific subsidy is undoubtedly better in social terms.

Keywords: resident passengers, specific subsidy, *ad valorem* subsidy

JEL Classification: L12, L93, H25

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1. Introduction

In Europe air transport markets are usually free. Any European airline may fly wherever it likes without further restrictions than the normal requirements regarding the availability of an operating licence and access to the airport infrastructure desired.

Free markets are by definition not subject to regulatory interventions, but only when justified by the existence of market failures or for equity reasons. In this paper we aim to analyse interventions in air transport markets that take the form of a subsidy on the ticket prices. These subsidies are an exemption within the general European legislation on state aid rules, aiming to protect passengers from peripheral areas on a territorial equity basis.[1] It is for example the case of passengers living in the ultrapherical regions of Canary Islands (Spain); Madeira and Azores (Portugal); Martinique, Reunion Islands, Guadeloupe and French Guyana (France). In all cases the type of subsidies varies from specific to *ad valorem* ones, with some variants in the administrative procedures. The goal of the intervention is to compensate passengers for the travel costs when air transport is an essential mode of transport that also ensures territorial continuity (Cabrera *et. al*, 2011).

In Spain, for example, these subsidies are granted to passengers living in the archipelagos of the Canaries and Balearic Islands and also for passengers living in the Spanish autonomous cities of Ceuta and Melilla in the north of Africa when travelling by air to mainland Spain and in interisland air routes.[2] This subsidy currently corresponds to 50 percent of the air ticket price.[3] It is worth to mention that being a subsidy aimed for passengers it is finally paid directly to air carriers on a yearly basis.

Most academic papers concerned with subsidies in air transport markets focus on the analysis of subsidies in the context of public services obligations declarations (see for example Reynolds-Feighan, 1999; Williams, 2005, Williams and Pagliari 2004, or Nolan *et al*., 2005). To our knowledge only Cabrera *et al.* (2011), Calzada and Fageda

[1] Note that these subsidies are different than those granted to air carriers under a public service obligation declaration that are intended to compensate air carriers for the losses incurred during the provision of declared services.
[2] The subsidy is also granted if passengers travel by boat but in this paper we focus on air transport.
[3] Although there are some limitations on the type of fares. For instance business fares are just entitled to a limited amount of subsidy given by the subsidy that corresponds to the complete economy fare.

(2012) and Fageda *et al*. (2012), attempt to empirically assess the effectiveness of this type of intervention.

The approach of our paper is theoretical, aiming to analyse the efficiency of subsidies for passengers in its various forms. We are not aware of similar papers in the same area, but the literature about specific versus *ad valorem* taxes/subsidies is extensive. *Ad valorem* and specific taxes are completely equivalent in competitive markets, that is, they raise the same revenue and lead to the same consumer and producer prices. However, as first shown by Wicksell (1959, originally published in 1896) and Suits and Musgrave (1953) this equivalence does not apply in a monopoly environment. Several papers in the literature have explored this non-equivalence between specific and *ad valorem* taxes and subsidies with imperfect competition. Some papers in the literature conclude that *ad valorem* taxes are better in social terms than specific taxes (see, for example, Suits and Musgrave, 1953 and Skeath and Trandel, 1994 (also extended to oligopoly), for monopoly; Cheung, 1998, or Schröder, 2004, for monopolistic competition; or Delipalla and Keen, 1992, and Denicolò and Matteuzzi, 2000, for oligopoly). However, other authors show that specific taxes may be more welfare enhancing (see, for example, Hamilton, 1999, for monopsony; Grazzini, 2006, or Blackorby and Murty, 2007, for general equilibrium; Anderson *et al*., 2001a, 2001b, Hamilton, 2009, and Wang and Zhao, 2009, for differentiated or multiproduct oligopolies; Pirttilä, 2002, in the presence of externalities; Kind *et al*., 2009, in two-sided markets; or Goerke, 2011, and Kotsogiannis and Serfes , 2012, under uncertainty). Moreover, with subsidies the ranking of the two types of instruments may be reversed (Collie, 2006; Brander and Spencer, 1984).

In this paper we analyse the efficiency of an *ad valorem* and a specific subsidy for resident passengers in air transport markets. In particular, we develop a theoretical model in which there are two types of passengers with high and low willingness to pay for an air transport service. In addition both types of passengers may be resident in a given geographical area and hence, entitled to a subsidy, or non-residents. All passengers are served by a monopoly air carrier that wants to get as much of their willingness to pay as possible. By doing so it risks leaving out of the market some type of passengers or leaving others with a surplus, which in turn would be dependent on the proportion of resident passengers.

This model allows us to show that the establishment of passengers' subsidies based on the residential condition leads to a result that critically depends on the proportion of resident passengers. In particular, for a high enough proportion of resident passengers, non-resident passengers may be expelled from the market. Taken into account this undesirable situation we compare the possible effects of both, an *ad valorem* and a specific subsidy. We conclude that if the proportion of passengers with high willingness to pay is low (high) enough, applying a specific (*ad valorem*) resident subsidy is better in social terms. Finally, we apply our results to the case of the Canary Islands. Even though *ad valorem* subsidies for resident passengers have been extensively used in the Canary routes, we can never conclude that this kind of subsidy is the most efficient one. In most routes we can undoubtedly state that the specific subsidy would be socially better.

The structure of the paper is the following: after this introduction, section 2 develops the model setup and section 3 the benchmark case of no subsidies. Sections 4 and 5 expand the framework to include the analysis of an *ad valorem* and a specific subsidy, respectively. Both types of subsidies are compared in section 6. Our conclusions are presented in section 7.

2. The theoretical model

We consider an air transport market operated just by one airline. Let us denote by N the number of passengers that may be willing to fly in this market. We assume that there are only two types of passengers that differ in their willingness to pay for an air transport service: type h passengers, that is, passengers with a high willingness to pay, and type l passengers, that is, passengers with a low willingness to pay.[4] High willingness to pay passengers are present in the market in a proportion $\alpha \in [0,1]$. Necessarily, the proportion of low willingness to pay passengers is given by $(1-\alpha)$.

Let us denote by H and L the maximum willingness to pay by type h and type l passengers, respectively. By definition, $H > L$. Both types of passengers share the same aircraft cabin and therefore, enjoy the same quality of the air service (i.e. there is a single class cabin).

[4] High willingness to pay passengers may correspond to passengers flying for business reasons and low willingness to pay passengers may correspond to passengers flying for leisure reasons.

The utilities of both types of passengers are given by the following equations:

$$U^h = H - p^h,\\ U^l = L - p^l, \tag{1}$$

where p^h and p^l denotes the ticket price charged to type h and type l passengers, respectively.

Passengers of any type are divided into residents and non-residents in a proportion δ and $(1-\delta)$, respectively, with $0 \le \delta \le 1$. Resident passengers are entitled to a special discount on the ticket price enjoying either an *ad valorem* subsidy denoted by τ or a specific subsidy denoted by S.

For the sake of simplicity we assume that the air carrier has a constant marginal cost per passenger equal to *c*.[5] In order to have the model well-defined we assume that $H > L > c$.

3. Benchmark case: No subsidies for resident passengers

The airline cannot perfectly distinguish the type of the passenger and thus, faces an adverse selection problem. Under perfect information conditions, the airline charges a ticket price equal to the maximum willingness to pay for the air transport service (first-degree price discrimination), but with asymmetric information it needs to rely on a second-degree price discrimination system. The second-degree price discrimination consists of charging different prices to different types of passengers. To do so, the airline needs to induce self-selection.

In particular, in order to induce passengers to reveal their real type, the airline offers restricted and non-restricted tickets. Restricted tickets are cheaper (p^l) than non-restricted tickets (p^h), but they are subject to a set of limitations that make passengers to incur in an additional cost (for example, they are non refundable tickets needed to be bought some days in advance, no changes are allowed, a Saturday stay is required, etc.).

[5] The literature on transport cost functions is quite extensive. In particular, Oum and Waters (1997) find many examples of constant returns to scale for the air transport industry in the case of airlines (seven out of ten studies).

Let us denote by c_h and c_l the additional cost faced by type *h* and type *l* passengers if they acquire a restricted ticket, with $c_h > c_l$. For the sake of simplicity and without loss of generality, we normalize $c_l = 0$. Moreover, we assume that $H \geq L + c_h$. The self-selection or incentive compatibility constraints are given by:

$$\begin{aligned} &H - p^h \geq H - p^l - c_h, \\ &L - p^l \geq L - p^h. \end{aligned} \tag{2}$$

So the airline induces self-selection by charging the following prices for restricted and non-restricted tickets:

$$\begin{aligned} &p_0^l = L, \\ &p_0^h = p_0^l + c_h = L + c_h, \end{aligned} \tag{3}$$

where the subscript "0" refers to the benchmark situation in which there is no subsidy.

Lemma 1: *If there are no subsidies for resident passengers, type l passengers are always charged their maximum willingness to pay. On the contrary, type h passengers are charged a higher price than type l passengers, keeping a consumer surplus equal to* $H - L - c_h$.

The optimal profits for the airline in the benchmark situation are given by the following expression:

$$\pi_0 = \alpha N\left(L + c_h\right) + \left(1 - \alpha\right) NL - Nc. \tag{4}$$

4. An *ad valorem* subsidy for resident passengers

Let us consider now the case in which the government subsidizes air travel for resident passengers. This subsidy takes an *ad valorem* form, that is, it is established as a percentage of discount on the ticket price and it is equal to τ, with $\tau \in (0,1)$. Let us denote by p_d^k the final price paid by a type *k* passenger, and by p_s^k the price charged by the airline to a type *k* passenger, with $k = h, l$. If the type *k* passenger is non-resident, no subsidy is applied and $p_d^k = p_s^k$. On the contrary, if the type k passenger is resident, he enjoys an *ad valorem* subsidy and pays a ticket price $p_d^k = p_s^k(1-\tau)$.

In this context, the airline needs to decide the best pricing strategy and we can distinguish four alternative pricing strategies.

Strategy 1**:** *Set* $p_s^l = L/(1-\tau)$ *and* $p_s^h = L + c_h$.

Strategy 1 implies charging type l resident passengers a ticket price equal to their maximum willingness to pay increased by the amount of the subsidy. This leaves out of the market type l non-resident passengers. On the contrary, type h passengers are charged the same price as in the situation without subsidies. Thus, all type h passengers buy the air transport ticket and type h resident passengers are left with an additional surplus given by the amount of the subsidy.

Strategy 2: *Set* $p_s^l = L/(1-\tau)$ *and* $p_s^h = (L + c_h)/(1-\tau)$.

Strategy 2 implies charging to type l and type h resident passengers a ticket price equal to their maximum willingness to pay increased by the amount of the subsidy. This leaves out of the market type l and type h non-resident passengers.

Strategy 3: *Set* $p_s^l = L$ *and* $p_s^h = (L + c_h)$.

Strategy 3 implies charging both type l and type h passengers the same ticket prices as in the situation without subsidies. Thus, all passengers buy the air transport ticket and both type l and type h resident passengers are left with an additional surplus given by the amount of the subsidy.

Strategy 4: *Set* $p_s^l = L$ *and* $p_s^h = (L + c_h)/(1-\tau)$.

Strategy 4 implies charging type l resident passengers the same price as in the situation without subsidies. Thus, all type l passengers buy the air transport ticket and type l

resident passengers are left with an additional surplus given by the amount of the subsidy. On the contrary, type *h* resident passengers are charged a ticket price equal to their maximum willingness to pay increased by the amount of the subsidy. This leaves out of the market type *h* non-resident passengers.

Notice that each strategy implies a trade-off between increasing the ticket price and losing the non-resident passengers demand. Let us denote by π_i^{AV} the airline profits obtained by applying strategy *i* when an *ad valorem* subsidy for resident passengers is introduced. The airline profits for each strategy are then given by the following expressions:

$$\pi_1^{AV} = N\left(\alpha(L+c_h)+(1-\alpha)\delta\frac{L}{1-\tau}\right)-\left(\alpha+(1-\alpha)\delta\right)Nc. \tag{5}$$

$$\pi_2^{AV} = N\left(\alpha\delta\frac{L+c_h}{1-\tau}+(1-\alpha)\delta\frac{L}{1-\tau}\right)-\left(\alpha\delta+(1-\alpha)\delta\right)Nc. \tag{6}$$

$$\pi_3^{AV} = N\left(\alpha(L+c_h)+(1-\alpha)L\right)-Nc. \tag{7}$$

$$\pi_4^{AV} = N\left(\alpha\delta\frac{L+c_h}{1-\tau}+(1-\alpha)L\right)-\left(\alpha\delta+(1-\alpha)\right)Nc. \tag{8}$$

In order to find the optimal strategy we need to compare the profits given by expressions (5), (6), (7), and (8). The optimal pricing decision, as we will show, is conditional on the resident proportion δ.

We start by comparing profits by pairs. This comparison gives us the critical value of δ_{ij}^{AV} that makes both profits equal, with $i, j = 1,...,4$ and $i \neq j$.[6] Afterwards, we analyze which strategy is dominant and the condition for that to happen.

Proposition 1: *If* $0 \leq \delta < \delta_{13}^{AV} = \delta_{24}^{AV}$ *strategy 3* is strictly dominant. However, for intermediate values of δ ($\delta_{13}^{AV} = \delta_{24}^{AV} < \delta < \delta_{21}^{AV} = \delta_{43}^{AV}$), *strategy 1* is strictly dominant. Finally, if $\delta_{21}^{AV} = \delta_{43}^{AV} < \delta \leq 1$, *strategy 2* strictly dominates.

[6] The order of the sub-index indicates that, for values of δ greater than the critical value δ_{ij}^{AV}, the airline's profit associated with strategy *i* is greater than the profit associated with strategy *j*.

Proof: In order to know which profit is preferred, we compare strategies two by two, obtaining six critical values of δ_{ij}^{AV}, that is, $\delta_{21}^{AV}, \delta_{13}^{AV}, \delta_{14}^{AV}, \delta_{23}^{AV}, \delta_{24}^{AV}$, and δ_{43}^{AV}. Starting with *strategy 1* and *strategy 2*, we obtain the critical value δ_{21}^{AV}. Following the same procedure for *strategy 3* and *strategy 4* we get the critical value δ_{43}^{AV}.

We are also interested in knowing how profits behave when δ_{ij}^{AV} is different from the critical value. To do that we need to compute the partial derivatives of the previous comparison of profits with respect to δ. Formally:

$$\pi_1^{AV} - \pi_2^{AV} = \pi_3^{AV} - \pi_4^{AV} = 0 \rightarrow \delta_{21}^{AV} = \delta_{43}^{AV} = \frac{\left(L - c + c_h\right)(1-\tau)}{L - c(1-\tau) + c_h}.$$

$$\frac{\partial(\pi_1^{AV} - \pi_2^{AV})}{\partial\delta} = \frac{\partial(\pi_3^{AV} - \pi_4^{AV})}{\partial\delta} < 0 \text{ for all } \alpha, \tau \in (0,1).$$

We observe that $\delta_{21}^{AV} = \delta_{43}^{AV}$. Moreover, for $\delta > \delta_{21}^{AV} = \delta_{43}^{AV}$, $\pi_1^{AV} < \pi_2^{AV}$ and $\pi_3^{AV} < \pi_4^{AV}$, respectively.

Similarly, we get $\delta_{13}^{AV} = \delta_{24}^{AV}$ and $\pi_1^{AV} > \pi_3^{AV}$ and $\pi_2^{AV} > \pi_4^{AV}$ for $\delta > \delta_{13}^{AV} = \delta_{24}^{AV}$.

$$\pi_1^{AV} - \pi_3^{AV} = \pi_2^{AV} - \pi_4^{AV} = 0 \rightarrow \delta_{13}^{AV} = \delta_{24}^{AV} = \frac{\left(L - c\right)(1-\tau)}{L - c(1-\tau)}.$$

$$\frac{\partial(\pi_1^{AV} - \pi_3^{AV})}{\partial\delta} = \frac{\partial(\pi_2^{AV} - \pi_4^{AV})}{\partial\delta} > 0 \text{ for all } \alpha, \tau \in (0,1).$$

Moreover, δ_{23}^{AV} and $\pi_2^{AV} > \pi_3^{AV}$ for $\delta > \delta_{23}^{AV}$. Formally:

$$\pi_2^{AV} - \pi_3^{AV} = 0 \rightarrow \delta_{23}^{AV} = \frac{\left(L - c + \alpha c_h\right)(1-\tau)}{L - c(1-\tau) + \alpha c_h}.$$

$$\frac{\partial(\pi_2^{AV} - \pi_3^{AV})}{\partial\delta} > 0 \text{ for all } \alpha, \tau \in (0,1).$$

Finally, we also obtain the critical value of δ_{14} by comparing profits from *strategy 1* and *strategy 4*. To know how profits behave for values of δ different from this critical value, we need an extra condition depending on the proportion of type *l* and type *h* passengers. Formally:

$$\pi_1^{AV} - \pi_4^{AV} = 0 \to \delta_{14}^{AV} = \frac{(1-\tau)\big((L-c)(1-2\alpha)-\alpha c_h\big)}{(1-2\alpha)(L-c(1-\tau))-\alpha c_h}.$$

$$\frac{\partial(\pi_1^{AV} - \pi_4^{AV})}{\partial\delta} > 0 \text{ if } \alpha < \frac{L-c(1-\tau)}{2(L-c(1-\tau))+c_h}.$$

$$\frac{\partial(\pi_1^{AV} - \pi_4^{AV})}{\partial\delta} < 0 \text{ if } \alpha > \frac{L-c(1-\tau)}{2(L-c(1-\tau))+c_h}.$$

Therefore, for any $\delta > \delta_{14}^{AV}$, $\pi_1^{AV} > \pi_4^{AV}$ if $\alpha < \alpha^*$ and $\pi_4^{AV} > \pi_1^{AV}$ if $\alpha > \alpha^*$, with $\alpha^* = \dfrac{L-c(1-\tau)}{2(L-c(1-\tau))+c_h}$.

Consequently, ranking the critical values δ_{ij}^{AV} we will obtain the following conditions:

If $0 < \alpha < \alpha^*$, $\delta_{14}^{AV} < \delta_{13}^{AV} = \delta_{24}^{AV} < \delta_{23}^{AV} < \delta_{21}^{AV} = \delta_{43}^{AV}$.

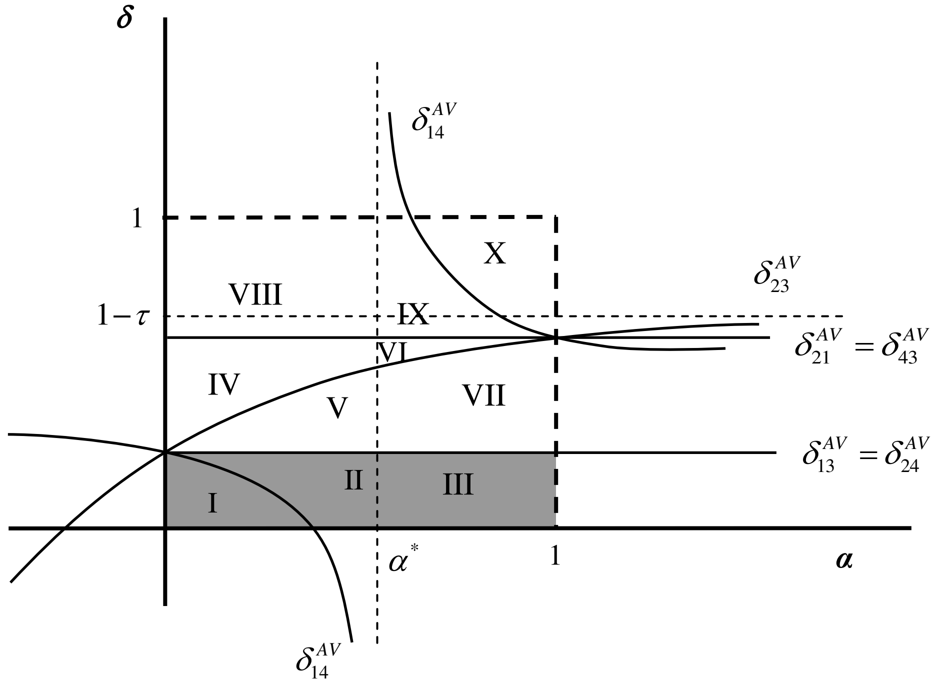
If $1 > \alpha > \alpha^*$, $\delta_{13}^{AV} = \delta_{24}^{AV} < \delta_{23}^{AV} < \delta_{21}^{AV} = \delta_{43}^{AV} < \delta_{14}^{AV}$.

We conclude that if $0 \le \delta < \delta_{13}^{AV} = \delta_{24}^{AV}$, *strategy 3* is strictly dominant. However, for intermediate values of δ ($\delta_{13}^{AV} = \delta_{24}^{AV} < \delta < \delta_{21}^{AV} = \delta_{43}^{AV}$), *strategy 1* is strictly dominant. Finally, if $\delta_{21}^{AV} = \delta_{43}^{AV} < \delta \le 1$, *strategy 2* strictly dominates.

This completes the proof. ■

In order to determine which strategy dominates we can distinguish ten different areas (see Figure 1) in the space (δ, α). In regions I, II and III, *strategy 3* is preferred. In regions IV, V, VI and VII *strategy 1* is dominant, while in regions VIII, IX and X, *strategy 2* is the preferred one. Finally, *strategy 4* is strictly dominated for every $\alpha \in (0,1)$.

Figure 1. Dominant strategies for different regions with an *ad valorem* subsidy for resident passengers



The depicted areas show what strategies are preferred. The shadow area represents the space where *strategy 3* is dominant, the white one represents the space for *strategy 1* and the striped area indicates where *strategy 2* dominates.

From Proposition 1 and Figure 1, it is observed that the critical values δ_{14}^{AV} and δ_{23}^{AV} are irrelevant in the analysis. This means that optimal strategies are independent of the values of α (δ_{14}^{AV} and δ_{23}^{AV} are the only critical values that depend on α and they do not play any role in the previous analysis).

Corollary 1: *The airline chooses a strategy independently of the proportion of type h and type l passengers,* α.

Type *h* passengers pay a higher price than type *l* passengers. The airline takes into account this difference in prices and never chooses a strategy such that type *h* non-resident passengers are expelled from the market and type *l* non-resident passengers are not. In other words, if the airline does not provide services for type *h* non-resident passengers, neither does it for type *l* non-resident passengers. Thus, for every $\alpha \in (0,1)$, strategy 4 is never optimal. This is formally stated in the following proposition.

Proposition 2: *If* $\alpha \in (0,1)$ *strategy 4 is never strictly dominant. In the extreme cases where all passengers have a high willingness to pay, that is* $\alpha = 1$, *or a low willingness to pay, that is* $\alpha = 0$, *strategy 4 coincides with strategy 2 or strategy 3, respectively, and thus it may be chosen.*

Proof: On the one hand, if $\alpha = 0$ we can see that π_3^{AV} is equal to π_4^{AV}, that is, *strategy 3* and *strategy 4* are equivalent. In addition π_1^{AV} and π_2^{AV} are also identical what implies that *strategy 1* and *strategy 2* are also equivalent. On the other hand, if $\alpha = 1$ π_1^{AV} is equal to π_3^{AV}, and π_2^{AV} is equal to π_4^{AV}. This means that *strategy 1* and *strategy 3* are equivalent and *strategy 2* and *strategy 4* are equivalent too. Formally:

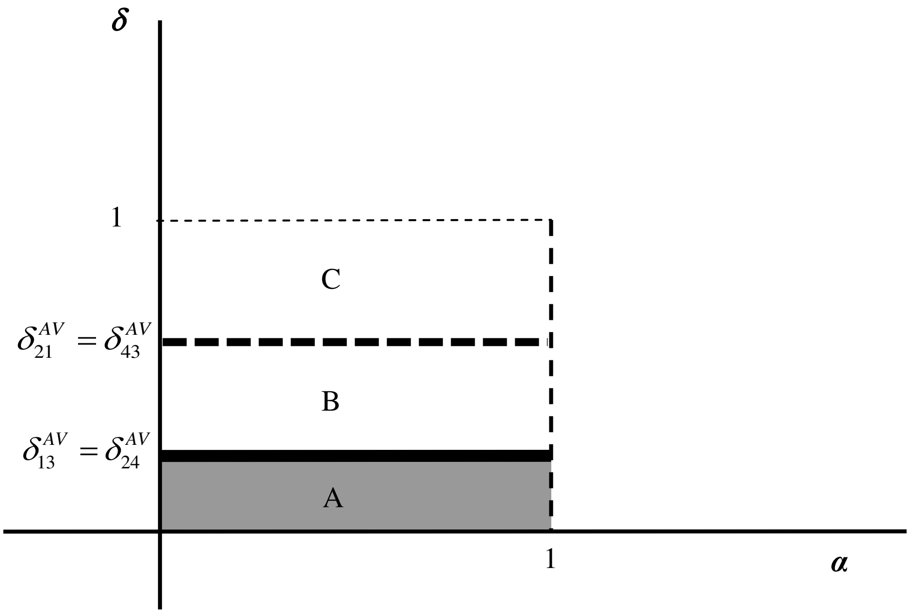
- If $\alpha = 0$ and:
  - $0 \le \delta < \delta_{14}^{AV} = \delta_{24}^{AV} = \delta_{13}^{AV} = \delta_{23}^{AV}$, *strategy 3* and *strategy 4* are strictly dominant.
  - $\delta = \delta_{14}^{AV} = \delta_{24}^{AV} = \delta_{13}^{AV} = \delta_{23}^{AV}$, all strategies are equivalent.
  - $\delta_{14}^{AV} = \delta_{24}^{AV} = \delta_{13}^{AV} = \delta_{23}^{AV} < \delta \le 1$, *strategy 1 and strategy 2* are strictly dominant.

- If $\alpha = 1$ and:
  - $0 \le \delta < \delta_{14}^{AV} = \delta_{12}^{AV} = \delta_{34}^{AV} = \delta_{23}^{AV}$, *strategy 1* and *strategy 3* are strictly dominant.
  - $\delta = \delta_{14}^{AV} = \delta_{12}^{AV} = \delta_{34}^{AV} = \delta_{23}^{AV}$, all strategies are equivalent.
  - $\delta_{14}^{AV} = \delta_{12}^{AV} = \delta_{34}^{AV} = \delta_{23}^{AV} < \delta \le 1$, *strategy 2* and *strategy 4* are strictly dominant.

This completes the proof. ■

Figure 2 replicates the results in Figure 1, highlighting the three relevant regions. Region A represents the space where *strategy 3* is dominant, region B represents the space for *strategy 1* and region C indicates the region where *strategy 2* dominates.

Figure 2. Dominant strategies for different values of (δ, α) with an *ad valorem* subsidy for resident passengers



Corollary 2: *Depending on the value of δ (proportion of resident passengers), when an ad valorem subsidy for resident passengers is introduced we will end up in one of the following regions:*

- *Region A: corresponds to a situation in which ticket prices remain as in the situation without subsidies.*
- *Region B: corresponds to a situation in which the ticket price for type l passengers is increased by the amount of the subsidy and type h passengers are charged the same price as in the situation without subsidies. This leaves out of the market type l non-resident passengers.*
- *Region C: corresponds to a situation in which all ticket prices are increased by the amount of the subsidy. This leaves out of the market all non-resident passengers.*

The aim of air transport subsidies for resident passengers is to protect passengers from peripheral areas on a territorial equity basis. Thus, the purpose of the regulator is to guarantee that the subsidy does not affect the final price charged by the airline, allowing resident passengers to enjoy the whole subsidy and pay cheaper tickets but without affecting the ticket price charged to non-resident passengers. Thus, region A represents the most desirable situation, since ticket prices remain as in the situation without subsidies. Following the same reasoning, region C represents the less desirable situation in which the airline captures all resident passengers' surplus and non-resident passengers are driven out of the market. This is formally stated in the following corollary.

Corollary 3: *When an ad valorem subsidy for resident passengers is introduced, region A corresponds to the most desirable situation and region C corresponds to the worst situation in social terms.*

5. A specific subsidy for resident passengers

Let us consider now that the government grants a specific subsidy instead of an *ad valorem* one. Thus, the government pays a fixed amount of money for each air transport ticket bought by a resident passenger, independently of the ticket price. Recall that p_d^k denotes the final price paid by a type *k* passenger, and p_s^k the price charged by the airline to a type *k* passenger, with $k = h, l.$ If the type *k* passenger is non-resident, no subsidy is applied and $p_d^k = p_s^k$. On the contrary, if the type *k* passenger is resident, he enjoys a specific subsidy and pays a ticket price $p_d^k = p_s^k - S.$

Again, the airline needs to decide its best strategy in pricing terms. The airline has four different price possibilities to consider:

Strategy 1': *Set* $p_s^l = L + S$ *and* $p_s^h = L + c_h.$

Strategy 2': *Set* $p_s^l = L + S$ *and* $p_s^h = L + c_h + S.$

Strategy 3': *Set* $p_s^l = L$ *and* $p_s^h = L + c_h$.

Strategy 4': *Set* $p_s^l = L$ *and* $p_s^h = L + c_h + S$.

The intuitions behind *strategies 1', 2', 3'* and *4'* are similar to those already explained in the previous section for *strategies 1, 2, 3* and *4*.

Let us denote by π_i^S the airline profits obtained by applying strategy *i* when a specific subsidy for resident passengers is introduced. The airline profits functions for each strategy are given by:

$$\pi_1^S = N\left(\alpha(L + c_h) + (1-\alpha)\delta(L+S)\right) - \left(\alpha + (1-\alpha)\delta\right)Nc. \tag{9}$$

$$\pi_2^S = N\left(\alpha\delta(L + c_h + S) + (1-\alpha)(L+S)\right) - \left(\alpha\delta + (1-\alpha)\delta\right)Nc. \tag{10}$$

$$\pi_3^S = N\left(\alpha(L + c_h) + (1-\alpha)L\right) - Nc. \tag{11}$$

$$\pi_4^S = N\left(\alpha\delta(L + c_h + S) + (1-\alpha)L\right) - \left(\alpha\delta + (1-\alpha)\right)Nc. \tag{12}$$

We follow the same procedure as in the previous section. Therefore we compare profits by pairs in order to obtain the critical values of δ_{ij}^S. This allows us to find which strategy is dominant and under what conditions this dominance takes place.

Proposition 3: *If* $0 \le \delta < \delta_{13}^S = \delta_{24}^S$ *strategy 3'* is strictly dominant. However, for intermediate values of δ ($\delta_{13}^S = \delta_{24}^S < \delta < \delta_{21}^S = \delta_{43}^S$), *strategy 1'* is strictly dominant. Finally, if $\delta_{21}^S = \delta_{43}^S < \delta \le 1$, *strategy 2'* strictly dominates.

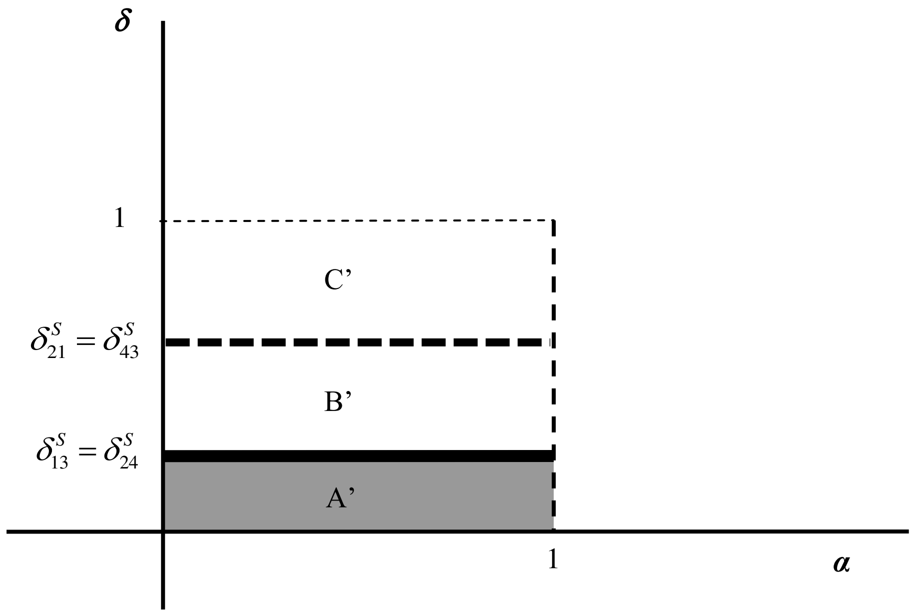
Proof: The proof of this proposition is similar to the one of Proposition 1■

Proposition 4: *If* $\alpha \in (0,1)$ *strategy 4' is never a strictly dominant strategy. In the extreme cases where all passengers have a high willingness to pay, that is* $\alpha = 1$, *or a low willingness to pay, that is* $\alpha = 0$, *strategy 4' coincides with strategy 2' or strategy 3', respectively, and thus it may be chosen.*

Proof: The proof of this proposition is similar to the one of Proposition 2■

Our ranking between profits and strategies do not vary with respect to the previous section. That is, our results are qualitatively identical but the magnitude and the critical values are numerically different. We illustrate the situation now in Figure 3.

Figure 3. Dominant strategies for different values of (δ, α) with a specific subsidy for resident passengers



Similarly to Figure 2, we have that in region A' *strategy 3'* is strictly dominant (all passengers are served); in region B' *strategy 1'* is strictly dominant (only type *l* resident passengers and all type *h* passengers are served); while in region C' *strategy 2'* is strictly dominant (only resident passengers are served).

Corollary 4: *Depending on the value of δ (proportion of resident passengers), when a specific subsidy for resident passengers is introduced we will end up in one of the following regions:*

- *Region A': corresponds to a situation in which ticket prices remain as in the situation without subsidies.*
- *Region B': corresponds to a situation in which the ticket price for type l passengers is increased by the amount of the subsidy and type h passengers are charged the same price as in the situation without subsidies. This leaves out of the market type l non-resident passengers.*
- *Region C': corresponds to a situation in which all ticket prices are increased by the amount of the subsidy. This leaves out of the market all non-resident passengers.*

Once again, region A' corresponds to a situation in which prices remain as in the case without subsidies. This is the best situation in social terms—the subsidy benefits the resident passenger and non-resident passenger are unaltered. On the contrary, region C' corresponds to a situation in which all prices are increased and all non-resident passengers are expelled from the market. This latter situation is the worst situation in social terms. This is formally stated in the following corollary.

Corollary 5: *When a specific subsidy for resident passengers is introduced, region A' is the most desirable situation and region C' is the worst situation in social terms.*

6. Comparison between *ad valorem* and specific subsidies for resident passengers

6.1. Ad valorem vs. specific subsidies: the critical values

In this subsection we compare the two proposed subsidy mechanisms and we show under what conditions one is preferred to the other. To approach this problem, we compare the depicted areas of Figures 2 and 3, taking into account that the greater regions A and A' and/or the lower regions C and C' are, the better in social terms.

Let us consider the same public expenditure for a specific and an *ad valorem* subsidy for resident passengers, that is, $S=(1-\alpha)\tau L+\alpha\tau(L+c_h)$. With such a specific subsidy, type l (type h) resident passengers are receiving a higher (lower) subsidy than the one obtained with an *ad valorem* subsidy, $\tau L < S < \tau(L+c_h)$. Keeping constant the government expenditure, a specific subsidy would be socially preferred to an *ad valorem* subsidy if region A' is greater or equal than region A and/or region C' is smaller or equal than region C. This comparison strongly depends on α, that is, on the proportion of high willingness to pay passengers.

Proposition 5: *There is a critical threshold* $\overline{\alpha} = (\tau L)/(c_h(1-\tau))$ *such that, for every* δ, *if* $\alpha \leq \overline{\alpha}$, *a specific subsidy for resident passengers is socially preferred to an ad valorem one.*

Proof: We can obtain the condition that makes region A' greater or equal than region A. By solving $\delta_{13}^{AD} \leq \delta_{13}^{S}$ we get that $S \leq \dfrac{\tau L}{1-\tau}$. This specific subsidy also implies that region C' is lower than C ($\delta_{12}^{AD} > \delta_{12}^{S}$), since this holds if $S < \dfrac{\tau(L+c_h)}{1-\tau}$.

Since $S = (1-\alpha)\tau L + \alpha\tau(L+c_h)$, we need $(1-\alpha)\tau L + \alpha\tau(L+c_h) \leq \dfrac{\tau L}{1-\tau}$, that is, $\alpha \leq \overline{\alpha} = (\tau L)/(c_h(1-\tau))$. This completes the proof. ■

Proposition 5 states that if the proportion of high willingness to pay passengers in the market is low enough, for a given public expenditure, a specific subsidy for resident passengers is socially better than an *ad valorem* one.

Proposition 6: *There is a critical threshold* $\overline{\overline{\alpha}} = (\tau L + c_h)/(c_h(1-\tau))$ *such that, for every* δ, *if* $\alpha \geq \overline{\overline{\alpha}}$ *an ad valorem subsidy for resident passengers is socially preferred to a specific one.*

Proof: We can obtain the condition that makes region C' greater or equal than region C. By solving $\delta_{12}^{AD} \leq \delta_{12}^{S}$ we get that $S \geq \frac{\tau(L+c_h)}{1-\tau}$. This specific subsidy also implies that region A' is lower than region A ($\delta_{13}^{AD} > \delta_{13}^{S}$), since this holds if $S > \frac{\tau L}{1-\tau}$.

Since $S = (1-\alpha)\tau L + \alpha\tau(L+c_h)$, we need $(1-\alpha)\tau L + \alpha\tau(L+c_h) \geq \frac{\tau(L+c_h)}{1-\tau}$, that is, $\alpha \geq \overline{\overline{\alpha}} = \tau(L+c_h)/(c_h(1-\tau))$. This completes the proof. ■

Proposition 6 states that if the proportion of high willingness to pay passengers in the market is high enough, for a given public expenditure, by applying an *ad valorem* subsidy for resident passengers the society is more likely to end up in the most desirable situation, and less likely to end up in the worst situation. Thus, an *ad valorem* subsidy for resident passengers is better from a social point of view than a specific one.

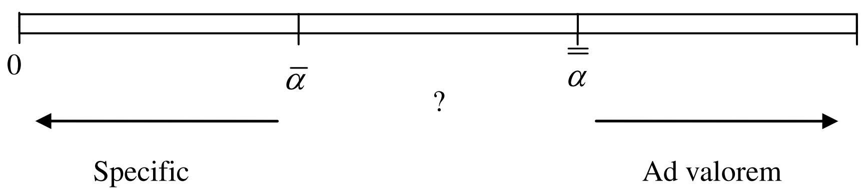
Notice that for intermediate values of α we cannot undoubtedly conclude which subsidizing system is better in social terms. The reason is that for intermediate values of α region A may be greater than region A', but also region C may be greater than region C' and hence, the optimality of one policy over the other depends on δ, that is, on the specific region that we are considering.

Finally, we would like to highlight that, though the value of α must belong to the close interval $[0,1]$, the critical values of $\overline{\alpha}$ and $\overline{\overline{\alpha}}$ are always positive but not necessarily lower than one. Thus, if $\overline{\alpha} > 1$ every α will be lower or equal than $\overline{\alpha}$ and a specific subsidy for resident passengers will be always socially better than an *ad valorem* one. This is formally stated in the following corollary.

Corollary 6: *If $\overline{\alpha} > 1$ a specific subsidy for resident passengers is always socially preferred to an ad valorem one.*

In summary, if α is lower than or equal to $\overline{\alpha}$**,** a specific subsidy for resident passengers is socially better. In contrast, if α is greater than or equal to $\overline{\overline{\alpha}}$, an *ad valorem* subsidy for resident passengers is preferred. Finally, for intermediates values of α we cannot undoubtedly conclude anything about the optimal policy. We can summarise these results in Figure 4.

Figure 4. Critical values of *α*



Notice that both thresholds, $\bar{\alpha}$ and $\bar{\bar{\alpha}}$, depend on the low and high willingness to pay passengers' tickets prices in the absence of subsidies ($p_0^l = L$ and $p_0^h = L + c_h$) and on the inconvenience costs faced by type *h* passengers when buying a restricted-ticket (c_h). Both thresholds are strictly increasing in τ and the ticket prices. However, the lower the difference between the restricted and non-restricted ticket prices, the greater the value of these thresholds.

Notice that on the one hand, for a given α, the lower the difference between the restricted and non-restricted ticket prices is, that is the lower c_h is, the more likely is to stay in the area in which the specific subsidy is preferred and, the less likely is to stay in the area in which the *ad valorem* subsidy is preferred. On the other hand, for a given c_h, the lower α is the more likely is to stay in the area in which the specific subsidy is preferred. In other words, the closer is the specific subsidy S to the value τL (the *ad valorem* subsidy for type *l* passengers), the more likely is that the specific subsidy dominates the *ad valorem* one.

6.2. An empirical application: The case of the Canary Islands

In order to illustrate the relevance of our theoretical findings we make use of the case of interisland air transport in the Canary Islands. Hence, we proceed by estimating with real data the critical values of α that make one type of subsidy socially preferred to the other for the same government expenditure.

Our theoretical model fits quite well within the current situation of interisland air transport in the Canary Islands. At the moment there is just one air carrier (Binter Canarias) that provides these services. The type of aircraft flown is unique (ATR 72-500) and all passengers share the same cabin class. In addition, the pricing structure is pretty simple what facilitates our estimation of critical values of α.

At the moment passengers with residence in the islands are entitled to a 50 per cent subsidy on the ticket price. Nevertheless this subsidy has evolved along time, since a 10 per cent (in application from 1987 to 1998), to a 33 per cent (in application from 1998 to 2004), to a 38 per cent (in application from February to December 2005), to a 45 per cent (in application in 2006), and to the current 50 per cent (in application from 2007 to nowadays). In order to enjoy the subsidy passengers needs to facilitate the relevant data to the airline, which in turn, will get the money corresponding to this subsidy directly from the government on a yearly basis. At the moment this issue is under review, and we would expect a change in the scheme in the coming future.

In order to check the possible values of the thresholds we have calculated them for the cases of some interregional flights between islands. We select the main routes in terms of number of passengers (See Table 2).

Table 2. Main inter islands routes in the Canary Islands

Routes	Passengers (2011)
Tenerife North - Gran Canaria	698.457
Tenerife North - La Palma	616.552
Gran Canaria - Fuerteventura	599.049
Gran Canaria - Lanzarote	590.899
Tenerife North - Lanzarote	286.454
Tenerife North - Fuerteventura	193.789
Tenerife North - El Hierro	139.536
Gran Canaria - La Palma	115.074

Source: AENA.

Price data are taken from the company website for a one way ticket with two months in advance of the flight. We consider that the value for c_h is given by the difference between the cheapest and the more expensive ticket. We also need to take into account that $\tau = 0.5$. τ^* represents the value of τ for which $\overline{\overline{\alpha}} = 1$, and hence the *ad valorem* subsidy for resident passengers may be socially better than a specific subsidy. The results are presented in Table 3.

Table 3. Threshold values for main inter islands routes in the Canary Islands

	$p_0^l = L$	$p_0^h = L + c_h$	c_h	$\overline{\alpha}$	$\overline{\overline{\alpha}}$	τ^*
Tenerife North - Gran Canaria	41	77	36	1,14	2,14	0,32
Tenerife North - La Palma	41	81	40	1,03	2,03	0,33
Gran Canaria - Fuerteventura	43	87	44	0,98	1,98	0,34
Gran Canaria - Lanzarote	50	100	50	1,00	2,00	0,33
Tenerife North - Lanzarote	60	130	70	0,86	1,86	0,35
Tenerife North - Fuerteventura	61	123	62	0,97	1,97	0,34
Tenerife North - El Hierro	48	87	39	1,23	2,23	0,31
Gran Canaria - La Palma	58	122	64	0,91	1,91	0,34

Note: Prices are in euros for a one way ticket. Data was collected on the 2nd of November 2012.

We can see that in most routes the value of $\overline{\alpha}$ is greater than one. Thus in those routes, for any value of α, a specific subsidy for resident passengers is socially preferred. Moreover, in all the routes for which the value of $\overline{\alpha}$ is lower than one, $\overline{\overline{\alpha}}$ is around two. Thus, we can never conclude that the *ad valorem* subsidy is the preferred one.

We can compute the value of τ that makes $\overline{\overline{\alpha}} = 1$, that is, τ^*. We find that for any τ higher or equal than 33 per cent on average an *ad valorem* subsidy for resident passengers (which is indeed the policy that has been applied in the Canary Islands since 2001) is never socially preferred to a specific subsidy. For τ lower than 33 per cent on average, the *ad valorem* subsidy will be only socially better than a specific subsidy if the proportion of high willingness to pay passengers, α, is high enough.

7. Conclusions

In this work we have developed a theoretical model that aims to analyse the efficiency of passengers' subsidies in European air transport markets. These subsidies are not frequent, and when applied they are intended to protect the interest of passengers from outermost regions within the EU, being based on a residential feature.

Our model distinguishes between two types of passengers: passengers with a high and with a low willingness to pay. The proportion of both types of passengers and the proportion of resident passengers in each group appear to be playing a very important role in the market.

On the one hand, depending on the proportion of resident passengers, it may even happen that non-resident passengers would be expelled from the market. If the objective of the policy is the protection of peripheral resident passengers without damaging the interest of non-resident passengers, this is an undesirable equilibrium.

On the other hand, we have also compared our results for two variants of subsidies: an *ad valorem* and a specific one. In both cases the danger of leaving non-resident passengers out of the market arises. In turn, both type of subsides would be more or less damaging for non-resident passengers depending on the proportion of high and low willingness to pay passengers. We use the Canary Islands case in order to illustrate how our findings can be empirically applied. We find that for these routes we can never conclude that the *ad valorem* subsidy is the preferred one.

Finally, we would like to highlight that in this paper we are not justifying the use of subsidies for resident passengers but only discussing their possible effects and the best way of applying such subsidies (either with an *ad valorem* or a specific subsidy). It remains to be shown whether a passenger subsidy based on other criteria (e.g. route criterion) should be socially better than subsidies for resident passengers. This is an issue that deserves another research.

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