

# The Resident Subsidy Impact on Regional Air Carrier Route Development: A Case Study

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## Research Article

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**Title:** The resident subsidy impact on regional air carrier route development: a case study

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### **Abstract**

Subsidizing air mobility for Canary Island residents may have an unforeseen impact on regional air carrier route development and this could exacerbate congestion in airports that operate near to their maximum threshold. Regional routes often require the use of small aircraft such as those from the ATR (Avions de Transport Régional) family. These aircraft types have [some specific characteristics related to its time performance. If airports manage a large proportion of ATR aircrafts, one of their main activities, such as landing and taking off operations (LTO), may become congested, and affect airport capacity. Air carrier economies might be negatively affected because of delays in airport operations. For instance, air carriers' fuel costs might rise due to aircraft's increased LTO time. This paper seeks to analyze the impact of regional aviation route development for the Canary airport network; specifically, the effect that it has on airport capacity and air carrier economies.

**Keywords:** airport; capacity; landing; taking off; fuel cost; air route development.

### **Glossary terms**

AENA: Aeropuertos Españoles y Navegación Aérea

ATM: air transport movement

ATR: Avions de Transport Régional

Knots: approach speed units

LPA: Las Palmas Airport (Gran Canaria Airport)

PSO: public service obligation

TFN: Tenerife North Airport

TFS: Tenerife South Airport

## 1. Introduction

The importance of regional (inter-island) air transport at Canary airports is remarkable even at airports with international traffic. In fact, in 2019, 71% of air traffic at Canary airports was of the inter-island variety. Obviously, the fragmented territory of the Canary Islands is the determining factor in the importance of regional (inter-island) air traffic. Insularity increases access costs to social and economic opportunities for the Canary Island inhabitants. In that sense, the Spanish government has always given priority to the need to facilitate the movement of inhabitants, both in connection with the mainland and in terms of inter-island mobility. For this reason, air and sea traffic from the islands to the mainland and between islands has been subsidized since 1982. The purpose is to compensate for the extra costs incurred by freight and passenger traffic as a result of the Canary Islands' remoteness from the Spanish mainland and Europe. Recently, this allowance has increased from 50% to 75% of the travel price.

Subsidy, at the first time, attracts new operator to air market, however, existent air company, very often, implement an aggressive price strategy make the start difficult for new operators and drive out then from the market. The final outcomes could be more market concentration and monopoly power. In the case of Canary Island, Binter Canaria S.L., the only one air operator in Canary Island, began to develop, after subsidy increase to 75%, an expansion strategy. The main results has been to develop new routes and increase frequency for the existent one to capture subsidies.

Air transport for peripheral areas such as the Canary Islands has been recognized as a fundamental factor for its development. Trans-Insular Axis (the subsidiary of the Trans-European Network) in the Canaries is a factor of territorial cohesion in the sense that it provides greater accessibility for air passengers from peripheral islands (Hernández, 2004). In that context, this work seeks to assess the impact that this compensation scheme has on the inter-island air market, specifically on the creation of air routes and available airport capacity. Hence, this work is organized as follows: section 2 analyzes the air transport market in the Canary Islands with emphasis on inter-island air traffic. Section 3 describes the importance of route development in the subsidy scenario. Section 4 attempts to estimate the airport operational impact of subsidizing air routes from the Canary Islands. Finally, the conclusions highlight the main findings of the study.

## 2. The Canary Island air traffic market

The Canary Islands have eight airports, with two being on Tenerife. Table 1 shows air traffic movements for the three main Canary airports. These airports jointly manage more inter-island traffic than all the others together. Inter-island or regional routes often require the use of small aircraft, such as those from the ATR (Avions de Transport Régional) family. Table 1 also shows that, LPA and TFN Canary airports have a disputed distribution between regional turboprop (ATR) and other aircraft, which are mainly short or medium-range such as those from the B737 and A320 families. This aircraft mix is understandable because of the environment in which the airports are located; that is, on an archipelago where small aircraft are of great importance in the transportation of people and cargo. This is one of the main operational singularities of Canary airports that must be taken into account.

**Table 1.** Traffic evolution (ATMs) by aircraft type for the main Canary airports

Airport	Aircraft type	2017	2018	2019	2020
LPA <sup>2</sup>	ATRs	37,068 (31.3%) <sup>1</sup>	48,175 (36.8%)	50,746 (40.1%)	36,254(53.9%)
	Others	81,483	82,852	75,706	31,028
TFS	ATRs	974 (1.4%)	1,392 (2%)	3,274 (4.7%)	3,308(11%)
	Others	68,872	68,518	67,003	26,617
TFN	ATRs	40,074 (65.6%)	45,391 (62%)	47,681 (63.2%)	33,796(36.4%)
	Others	21,028	27,845	27,704	12,304

<sup>1</sup>The figures in brackets show the percentage of ATR aircraft type over total aircraft.

<sup>2</sup>Airport IATA code: LPA-Gran Canaria, TFS-Tenerife Sur, TFN-Tenerife Norte.

Source: Compiled by authors with data from AENA.

In 2019 there were 163,909 ATM (ATR turboprop aircraft) flights. In contrast, the B737 and A320s families, verified 230,654 ATM (AENA, 2019). In terms of percentage, 41.5 % of all aircraft movements at Canary airports were ATRs. Turboprop aircraft have particular characteristics, such as slow speed landing, which might affect operations of other aircraft families and cause congestion. Consequently, the inter-island traffic on airports can interfere with traffic from elsewhere. The effect of COVID-19 is apparent from table 1, total air traffic decreased for the three main canary airports. However, we have to point out that ATRs aircraft movement decreased minus than the short range aircraft.

The inter-island routes are operated by Binter Canarias S.L. (Binter henceforth) under the Public Service Obligations (PSO) regime (Santana, 2009). Currently, there are two air operators on the Canary Islands, Binter and Canaryfly; however, the latter has been a Binter filial since 2017. Binter started operating in the Canary Islands in 2003, and in 2007 it began consolidating the inter-island routes and expanding to other routes; both on the Iberian Peninsula and internationally. Binter Canarias has a hub and spoke air traffic network configuration for interisland traffic. There are two hub airports, Gran Canaria (LPA) and Tenerife Norte (TFN). For international destinations, LPA airport acts as the main hub.

In 2019, three new routes to the Iberian Peninsula were created; to Murcia, Pamplona and Zaragoza. In the current year Binter were planning to introduce more Peninsula destinations. However, the emergence of Covid-19 could halt Binter's expansion strategy. Inter-island air transport plays a major role in the mobility of Canary Island inhabitants. In 2019, inter-island passenger flow represented 16.8 % of total passengers managed by the Canary airport network. In this sense, there are serious doubts about when regional mobility will be able to start to recover in the post-Covid-19 era. The Binter expansion strategy for year 2020 perhaps has to be postponed depending on the evolution of Covid-19 and its response.

The Spanish government started to subsidize resident mobility by air and sea in the Canary Islands in 1982. This market intervention sought to improve the populations' air mobility within and from peripheral regions. Benefits from improved mobility can include better job opportunities, easier access to health services, increased leisure travel, regional tourism, and so on. Aviation subsidies can lead to the creation of additional capacity at airports and encourage regional development in tourist areas (Gössling *et al*, 2017). This subsidy sought to make Canary inhabitants feel closer to the Iberian peninsula and to incentivize inter-island mobility. The government's objectives

included favouring access to health care and increasing job opportunities for those inhabitants on the peripheral islands. In 2018, as a consequence of the 75% subsidy for Canary Island residents, inter-island air traffic increased by 30% in respect to the previous year (AENA, 2019). The increase in inter-island traffic has mainly been due to ATR turboprop aircraft flow. Next, this study turns to an analysis of the impact of subsidy increase on regional air carrier route development and airport capacity on the Canary Islands.

### 3. Subsidy and Binter route development

The islands of Gran Canaria and Tenerife generate the highest proportion of inter-island traffic. Those two islands alone represented 61.8% of total inter-island air traffic volume in the Canary Islands in 2019. LPA airport attracted 2,576,739 passengers and the two Tenerife airports conjointly managed 2,633,486 passengers. Inter-island traffic is managed by two hub airports: LPA and TFN airports. For the main inter-island routes, table 2 estimated for April 2019 that, on average, the allowance per pax-km was about 0.15 €/pax-kms.

**Table 2.** Inter-island routes and subsidy per pax-km (April 2019)

Routes <sup>1</sup>	Seat/route	Pax/route	Subsidy <sup>2</sup> /pax	Route distance (kms) <sup>3</sup>	Subsidy(€) /Pax-km
LPA-FUE	37,800	27.489	43€	176	0.12
LPA-TFN	57,888	42.677	38€	91	0.20
LPA-ACE	47,952	34.318	54€	222	0.12
LPA-VDE	2,736	1.854	74€	225	0.16
LPA-SPC	8,712	7.149	67€	224	0.15
TFN-FUE	13,968	11.933	68€	238	0.14
TFN-ACE	19,368	16.505	65€	271	0.12
TFN-GMZ	4,320	2.672	44€	94	0.23
TFN-SPC	46,728	31.413	38€	140	0.13

<sup>1</sup>Airport IATA code: LPA-Gran Canaria, TFN-Tenerife Norte, ACE-Lanzarote, VDE-El Hierro, SPC-La Palma, FUE-Fuerteventura, GMZ-La Gomera.

<sup>2</sup>Subsidy = price for non-resident – price for resident.

<sup>3</sup>One way

Source: Compiled by authors with data from AENA and Binter.

As is apparent from table 2, the main route, in terms of monthly passenger transport, was the connection between LPA and TFN airports. This route also had one of the highest subsidies per pax-km. In 2019 a total of 8,522,870 million inter-island passengers passed through Canary airports. The potential to generate revenue from subsidies in the Canary air market is extraordinary. Data from table 2 shows that the total revenue generated in April 2019 for those nine routes was 4.1 millions euros. This is a great incentive for Binter Canarias to open new routes. In fact, Binter's expansion has been spectacular in recent years. In addition to inter-island routes, in the last few years, Binter Canarias has flown to 11 international destinations such as Morocco, Portugal, Cape Verde, Gambia, Senegal and Mauritania. Also, the company won the public tender to fly interior routes in Cape Verde and the Madeira islands. Binter's fleet consists of 16 ATR 72 aircrafts (of 72 seats) and 3 Embraer 195-E2 (of 132 seats). At the beginning of 2020, 3 new ATR and 2 new Embraer aircrafts were ordered.

The Binter matrix of connectivity and frequency in April 2019 is shown in table 3. LPA and TFN are the main (hub) airports in terms of direct air connectivity. The general

network connectivity could be estimated by a called  $\beta$  index. This index measures the existent connections per node. With data from table 3, this index verifies a value of 2.75 (22/8) connections per node. This value has to be compared to the  $\beta$  maximum, which means the maximum connectivity for this network, at a value of 7. Hence, in terms of network analysis, this is a 39% connected network. If Binter Canarias want to increase revenue from subsidies it has two alternatives; increase inter-island air traffic frequency or open new routes. The subsidy is not available for international routes. Table 3 also shows the daily frequency between nodes. The route LPA-TFN had a frequency of 26 (in brackets in table 3) operations per day in April 2019.

**Table 3.** Connectivity matrix and frequency<sup>2</sup> for Binter network (April 2019)

<b>Nodes<sup>1</sup></b>	<b>LPA</b>	<b>TFN</b>	<b>ACE</b>	<b>VDE</b>	<b>SPC</b>	<b>FUE</b>	<b>TFS</b>	<b>GMZ</b>	<b>Connectivity</b>
<b>LPA</b>	-	1(26)	1(21)	1(1)	1(4)	1(17)	1(4)	0	6
<b>TFN</b>	1	-	1/10	1	1(19)	1(7)	0	1(2)	6
<b>ACE</b>	1	1	-	0	0	0	0	0	2
<b>VDE</b>	1	1	0	-	0	0	0	0	2
<b>SPC</b>	1	1	0	0	-	0	0	0	2
<b>FUE</b>	1	1	0	0	0	-	-	0	2
<b>TFS</b>	1	0	0	0	0	0	-	0	1
<b>GMZ</b>	0	1	0	0	0	0	-	-	1

<sup>1</sup>Airport IATA code: LPA-Gran Canaria, TFS-Tenerife Sur, TFN-Tenerife Norte, ACE-Lanzarote, VDE-EI Hierro, SPC-La Palma, FUE-Fuerteventura, GMZ-La Gomera.

<sup>2</sup> Daily frequency between airports in brackets.

Source: Compiled by authors with data from AENA and Binter.

As is apparent from table 3, the alternative to increased frequency is not feasible because there are airport slot restrictions on LPA and TFN airports. Thus, if Binter seek more revenue from subsidies the only way is to create new routes between the Canary Islands and the Iberian Peninsula. A correlation coefficient assesses the extent to which one variable is related or statistically explains another variable. The Pearson coefficient for seat demand and seat offer per route and subsidy was estimated for the last three years and those values were respectively 0.46 and 0.61. This means that those variables increased together. It was also found out that the variable distance explains 67% of the subsidy growth. In that sense, there is a great incentive to create new routes from the Canary archipelago to the mainland Iberian Peninsula. In 2019 Binter opened four new routes to the northern part of the mainland: Pamplona, Santander, Victoria and Zaragoza; and another for the south: Murcia. Binter seeks to focus on regions with different seasonal patterns, such as the north of Spain. However, this market sector is highly competitive due to low cost airlines, mainly Ryanair and Norwegian. In that sense, Binter has to compete on price rather than quantity (Gundelfinger-Casar & Coto-Millán, 2018). In 2019 the air company managed around 200 daily flights. Nevertheless, route development based on the two Canary hub airports could produce congestion in those airport with the associated economic losses. Next, this study turns to an analysis of subsidies on the main inter-island hub airports.

#### **4. Subsidy impact on LTO cycle for the main Canary airports**

Subsidizing regional traffic can exacerbate airport congestion and it can produce delays on air regional routes. Airport capacity is determined by runway capacity, and that depends on the type of aircraft (Kariya *et al*, 2011). Therefore, to quantify how

much increased traffic from subsidies makes airport ground operations delay flights, the ‘disturbance’ between aircraft types in landing and take off operations must be considered. Different aircraft types interact at the airport in landing and take off operations and compete for airport capacity use. The mix of aircraft is crucial in optimizing capacity and allowing air services to be adequately controlled (Yu & Lau, 2013). The ‘disturbance’ between aircraft will be evaluated by employing a simple model of landing intervals (Harris, 1974), considering two aircraft types (i.e., the ATR and B737/A320 aircraft families). Canary airports are seasonal and have peak periods where demand is very close to saturation level. This means that taxiing operations may cause congestion during peak periods and make air carriers waste time, increasing fuel consumption and Greenhouse Gas (GHG) emissions.

#### 4.1. The methodology

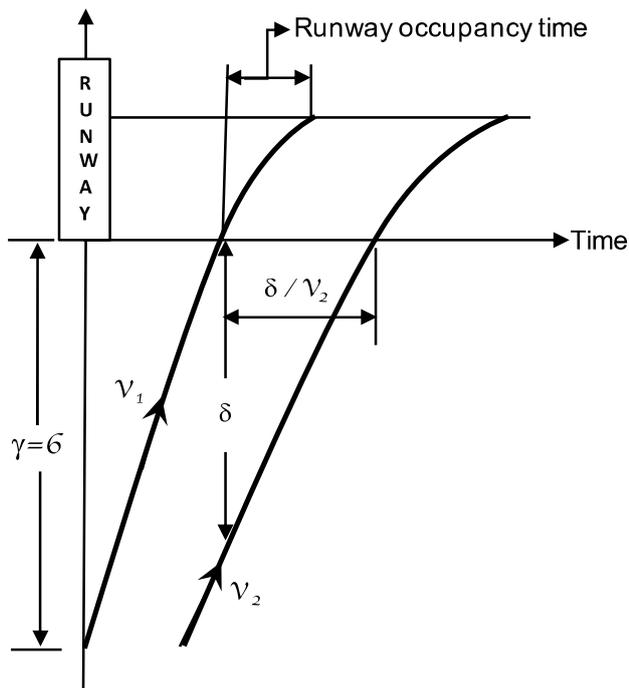
Airport ground operations delay is analyzed through aircraft congestion during taxiing departure operations. Congestion occurs due to the concentration of departures near the runway. A simple model of landing intervals was developed to estimate the average rate of processing aircraft on runways (Harris, 1974). This methodology gives an approximation of the average processing rate for take off using the ‘ultimate capacity concept’ for a mix of aircraft landing on a single runway of the airport. The landing intervals model assumes error-free approaches and that pilots are able to precisely maintain the required separations and speeds. Two situations were considered (see figure 1), the ‘overtaking case’, in which the trailing aircraft has a speed equal to or greater than that of the lead aircraft, and the ‘opening case’, in which the speed of the lead aircraft exceeds that of the trailing aircraft. The following minimum separation function can be applied. In this function aircrafts are grouped into  $n$  discrete speed classes and a matrix of minimum intervals, so that the minimum time separation for each combination of approach speeds can be estimated:

$$m(v_j, v_i) = \frac{\delta}{v_j} \quad (v_j \geq v_i) \quad (1)$$

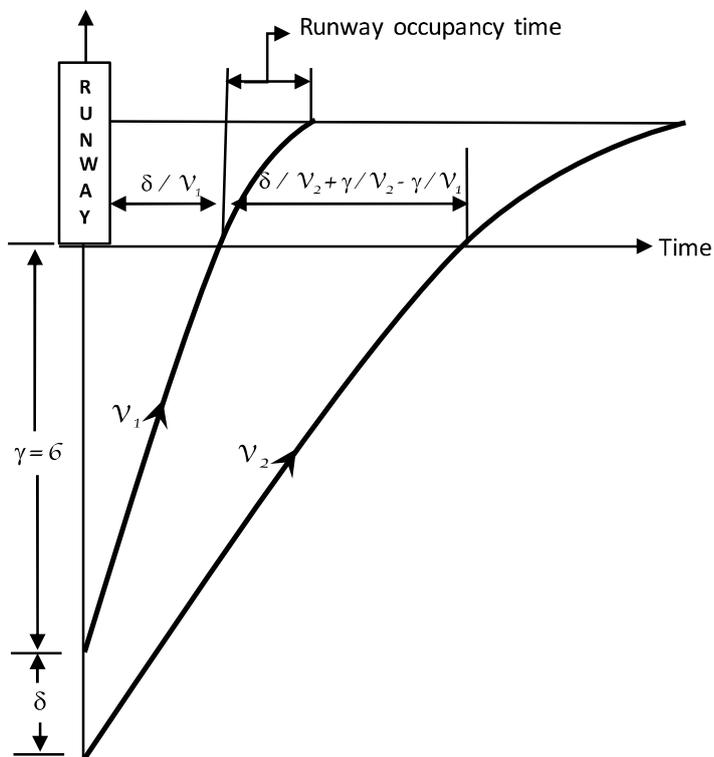
$$m(v_j, v_i) = \frac{\delta}{v_j} + \gamma \left( \frac{1}{v_j} - \frac{1}{v_i} \right) \quad (v_j < v_i) \quad (2)$$

Where  $v_i$  the speed of aircraft is  $i$ ,  $\gamma$  is the length of common approach path,  $\delta$  is the minimum safety separation between aircraft and  $m(v_j, v_i)$  is the error-free minimum time separation over threshold for aircraft  $j$  following aircraft  $i$ . The matrix of minimum intervals for each aircraft with speed class  $i$  following aircraft with speed class  $j$  is:

$$M = [m(v_i, v_j)] = \begin{bmatrix} m_{i,i} & m_{i,j} \\ m_{j,i} & m_{j,j} \end{bmatrix} \quad (3)$$



(a) overtaking situation



(b) opening situation

**Figure 1.** Landing interval model ‘overtaking case’ (a) and opening case’ (b)

This matrix associates each one of the  $n$  speed aircraft class with a probability of occurrence  $[P_1, \dots, P_n]$ . These probabilities are the percentages of the various speed classes in the aircraft mix divided by 100. Thus, the expected minimum landing interval or weighted mean service time can be approximated by the formula:

$$\bar{m} = \sum_{ij} P_i m_{ij} P_j \quad (4)$$

Finally, the hourly saturation capacity (ultimate capacity) is the inverse of the weighted mean service time:

$$C = \frac{1}{\bar{m}} \quad (5)$$

This model assumes that runway occupancy time during landing is less than the time separations during approach and has no effect on capacity. The weighted mean of service time ( $\bar{m}$ ) can be used as a proxy of the waiting time for taking off. The ultimate capacity ( $C$ ) has to be multiplied by 3,600 (seconds) to calculate the arrivals saturation per hour (arrivals/hour). The ground delay model was implemented for a peak month, which was established by inspecting the flow data for the last three years for the airports in study. December was the peak month for those three years. Thus, specifically, the model was implemented for a peak day in December 2018.

#### 4.2. Estimation and results

The matrix of minimum intervals for the airports was estimated using 6 nautical miles as the length of common approach path and a minimum separation for aircraft landings of 3 nautical miles. The approach speed for ATRs was 85 knots and for B737s/A320s families was of 115 knots. The complete matrix  $M$  shows the minimum time separation between aircraft for each combination of approach speeds. Hence, the ultimate capacity  $C$  computed for the airports is as follows:

$$M = \begin{bmatrix} 127 & 193 \\ 28 & 94 \end{bmatrix}$$

To estimate the ultimate capacity, the last three years (2017-2019) were analyzed in terms of ATM evolution for the LPA, TFN and TFS airports. December 2018 was found to be the main peak month in terms of traffic volume. For this period, an average mix of aircrafts was considered for those three airports. The percentage for LPA was 37% for ATRs and 63% for B737s/A320s families; for TFS and TFN airports those values were 2% (ATRs) and 98% (B737s/A320s), 62% (ATRs) and 38% (B737s/A320s) respectively. Under these conditions, the ultimate capacity estimations for the airports were:

$$C_{LPA} = \frac{1}{\bar{m}} = \frac{1}{(127 \times 0.37 + 28 \times 0.63 + 193 \times 0.37 + 94 \times 0.63)} = 18.4 \text{ arrivals/h}$$

$$C_{TFS} = \frac{1}{\bar{m}} = \frac{1}{(127 \times 0.02 + 28 \times 0.98 + 193 \times 0.02 + 94 \times 0.98)} = 28.6 \text{ arrivals/h}$$

$$C_{TFN} = \frac{1}{\bar{m}} = \frac{1}{(127 \times 0.62 + 28 \times 0.38 + 193 \times 0.62 + 94 \times 0.38)} = 14.7 \text{ arrivals/h}$$

On the one hand, LPA and TFN airports had less operating capacity than TFS airport; this can be explained by the aircraft mix. The model estimated around 29 arrivals/h for TFS. This value is around the double the capacity estimated for TFN airport. In other words, if we compare the aircraft mix for both airports, this means that this variable has a significant impact on airport capacity. TFN is a regional hub for inter-island traffic and, therefore, ATR aircraft families verify 66.3% of total airport ATMs in 2019, while TFS showed only 4.6% of ATR aircraft movement. Avions de Transport Régional (ATR) aircraft uses turboprop engines and thus, generally have lower flying speeds than short and medium range aircraft such as B737s/A320s. This means that the LTO cycle for those aircrafts are more time consuming.

On the other hand, formula (4) (see above) provides the weighted mean service time of landing ( $\bar{m}$ ). TFN verify a weighted mean of the landing time of 245 seconds, while TFS and LPA verify around 126 and 195 seconds respectively. While aircraft landing runways remain occupied, aircraft cannot take off. Thus, those times can be approximated to the waiting time at the head of the runway before taking off. Delay in landing and taking off operations for TFN airports might appear if new routes have to be developed. Next, this study performed a sensitivity analysis for TFN airport, in terms of aircraft mix. There is no possibility to develop a smart solution such as airport-within-airport, as proposed for LPA airport (Lorenzo-Aparicio & Rendeiro Martín-Cejas, 2017) by separating operational flux depending on aircraft types and creating a turboprop regional subsystem. The alternative to the current scenerios would be to divert 50% of ATR plane traffic from TFN to TFS during peak time. However, as is apparent from table 4 this solution produces a negligible improvement in the saturation capacity level for TFN airport.

**Table 4.** Aircraft mix sensitivity analysis

Airport*	Aircraft type	Aircraft mix (%)	New waiting time ( $\bar{w}$ )	Variation seg. ( $\bar{w}$ )
TFS	ATRs	26	173.5	47.5
	Other	74		
TFN	ATRs	45	211.1	-34
	Other	55		

\*Airport IATA code: TFS-Tenerife Sur, TFN-Tenerife Norte.

Source: own elaboration.

According to data published in Avions de Transport Régional (2000) and the International Airport Review (2010), the fuel consumption for taxiing for ATR aircraft families, is approximately 6 kg/min. The relationship of 3.15 kg of CO<sub>2</sub> per kg of fuel burnt allows us to estimate the volume of CO<sub>2</sub> emissions. Additionally, the fuel price published in IATA (2019), for December 2018 was 1.81 €/kg (using a conversion factor of 1\$ = 0.84€ and a kerosene density of 817 kg/m<sup>3</sup>). Using those values, it is possible to estimate the economic values for waiting time before take off. The fuel cost and CO<sub>2</sub> emissions for TFN airport for the 50% diverting traffic to TFS are shown in Table 5.

**Table 5.** Fuel cost and CO<sub>2</sub> emissions saving (December 2018)

Airport	Diverted ATM	Variation sec. (´)	Fuel (kg)	Fuel cost (€)	CO <sub>2</sub> (Tons.)
TFN	22,695	34	77,163	139,665	243

Source: own elaboration.

The values in table 5 have been estimated to take into account the decrease in take off waiting time as a consequence of diverting 50% of air traffic from TFN to TFS airport. However, in terms of waiting time before take off, the effect per ATM is negligible however, as is apparent from table 5, there is a potential economic and environmental saving associated with the implementation of this alternative scenario.

#### 4. Conclusions

The subsidy applied to travel between the islands, and from the Canary Islands to mainland Spain, now represents about 75% of market price. The subsidy increased from 50% to 75% in June 2018 (BOE, 2018). Because of that, an airport delay model was implemented to establish if this subsidy increase had affected the main canary airports capacity. For do that, the flow data for the last three years for those airports were inspected. December was the peak month for those three years and for the airports because of the Christmas holiday. Thus, the model was implemented for December 2018. The results in Table 5 shows an increase in fuel consumption and carbon dioxide emission.

The study has shown that the implementation of a subsidy for Canary residents might produce substantial economic and environmental impacts in the air transport market. On the one hand, from the regional air carrier point of view this subsidy produces incentives to develop new routes from the Canary Islands to the mainland Iberian Peninsula. This is so because, this study demonstrated that a regional air carrier can improve its revenue, on average, by about 0.15 €/pax-km. On the other hand, flying more new routes means increasing fuel consumption, especially for taxiing operations and CO<sub>2</sub> emissions. It has to be pointed out that the subsidy produces an increase in ground operations time and, therefore, an increase in runway occupancy for the main Canary airports. A sensitivity analysis, in terms of rebalancing air traffic between airports, showed that it would be possible to save fuel cost and emissions.

Nevertheless, we have to keep in mind that the impacts have been underestimated because the taxiing time *on route* was not considered and consequently the waiting time before take off probably would be greater. Furthermore, it has to be taken into account that the subsidies go to those Canary Island inhabitants who have a higher than average income and fly more. In consequence, the policy results in regressive income redistribution and subsequent environmental cost for society. These impacts, however, have to be balanced with the social and economic benefits that each regional inhabitant derives from the subsidy in terms of improvement of their mobility for any purpose.

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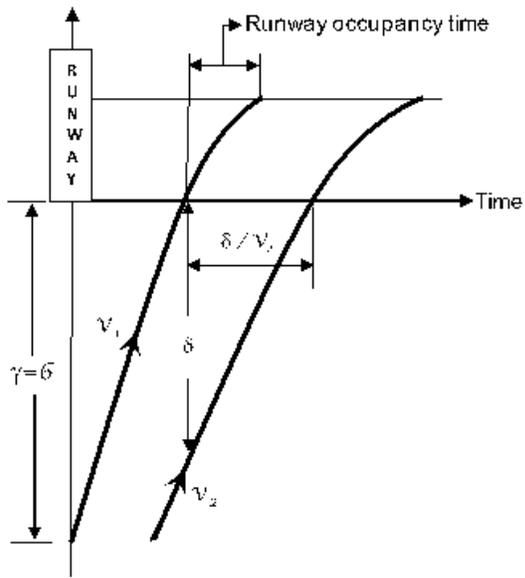
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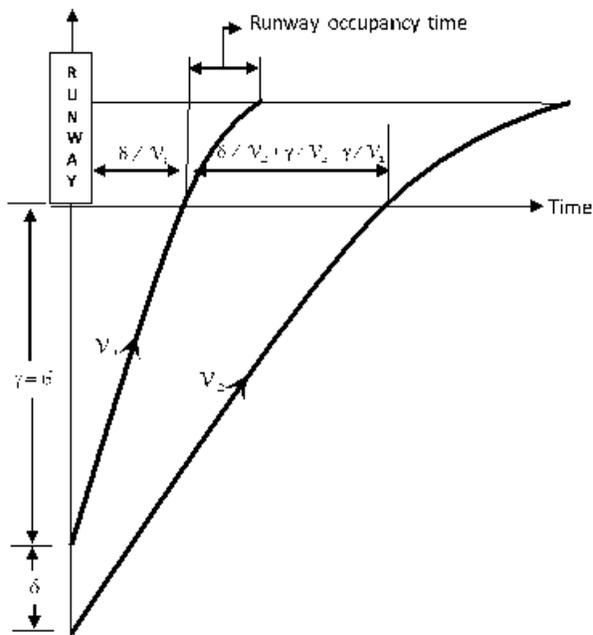
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# Figures



(a) overtaking situation



(b) opening situation

**Figure 1.** Landing interval model 'overtaking case' (a) and opening case' (b)

## Figure 1

See image above for figure legend.