WELFARE GAIN FROM CARBON TAX APPLIED TO LEISURE AIR TRAFFIC

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ABSTRACT

The rapid growth in the air transport required satisfying the increased demand for tourism become a factor of unsustainability due to the substantial environmental impact that supports such a development. There is the need to establish an alternative to the traditional air transport pricing structure that reflects the true cost that air market operators impose on others. This paper analyses one application of a Carbon tax by considering the CO_2 emission costs as a valuable input. A tentative tax on CO_2 emissions from air transport is calculated considering its applications in leisure air transport market. Finally, one of the main conclusions of the analysis performed is that the available evidence suggests that international aviation emissions should be restricted. In this case, a Ramsey pricing structure, which involved aviation users bearing the environmental costs, would work reasonably well at restricting inefficient demand and produce a reasonable welfare gain respect to the do-nothing scenerywill be pointed out.

Keywords: Welfare, Carbon Dioxide Emissions, Environmental Costs, Environmental Taxation.

JEL Classification: Q01, Q05, Q53

1. INTRODUCTION

Some years ago, the European Union air market suffered great commotion because of the irruption of a new management model termed "low-cost carrier". This phenomenon obliged traditional air companies to modify their business strategies and, at the same time, it brought about a "price war" in air transport market. Thus, air companies had to focus their attention on cost-cutting plans that consisted mainly in suppressing some on-board services and in improving their cost efficiency. The emerging price structure gave place to new air demands and, in consequence, stimulated tourism and business traffic all around the world. Since then, airlines have been asking for additional airport capacity as a means to carry out their business more competitively.

The unconstrained mobility model emerging from the availability of cheap air transport has opened new tourism markets, which frequently in addition requires additional air transport expansion to accommodate it. The economic benefits of this model are evident: it not only allows local governments to stimulate regional economies through tourism activities but also helps air companies to promote their own business. However, this mobility model is far from being sustainable. The environmental impact at local and global levels increases steadily and, in a sustainable context, the above-mentioned external effects must be evaluated in order to achieve their internalization.

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In the short run, the most relevant environmental problems related to air transport are aircraft noise, which is also the main reason for community opposition to airport growth, and congestion in and around airports. In the long run, by contrast, air quality will be a fundamental concern although it is rarely perceived as an acute environmental problem. Air transport anthropogenic carbon emissions seem very small (3% to 5% of the total worldwide emissions) if compared with other sources. However, the panorama is now changing because some researchers have attributed great economic importance to the phenomenon of climate change (Tol, 2007). This study try to estimate a carbon tax for Gran Canaria airport based on the Ramsey pricing model. Those who use airport infrastructures impose high environmental costs, in terms of pollution upon others, and they should be charged accordingly. An alternative price structure such as the Ramsey approach allows for the inclusion of external emission costs on the basis of airport users' willingness to pay (Oum & Tretheway, 1988).

The main objective of this study is evaluate, through the application of an Ramsey pricing strucuture to Gran Canaria airport, if actual landing fee model (weight-based fee) mispriced flights in presence of external costs. Section 2 describes the background of international aviation related to tourism development as one of the main factor contributing to climate change. Section 3, implement a carbon tax for leisure air traffic and last section pointed out the conclusions.

2. THE BACKGROUND

International aviation is becoming an increasingly important source of CO_2. Previsions indicate that aviation might by 2050 account for over 15% of all emissions of this greenhouse gas (Olsthoorn, 2001). This means that tourism related air transport may, in the future, contribute substantially to global warming. Almost 80% of tourism's contribution to global warming is associated with leisure travel (Gössling, 2002). In the near future tourism will grow fast, and it seems necessary to introduce mechanisms to internalize leisure travel related CO_2 emission costs, if climate change is to be managed. Drastic reductions in leisure air travel would be needed to mitigate emissions worldwide, and might be achieved by applying an airport price structure that shifts holiday leisure travel to more local destinations (Moriarty & Honnery, 2008).

There are several policies regarding international aviation emissions. The main methods could be emission charges, emission trading, rationing demand in air travel and offsetting. In recent years more research into the impact of an emission tax on international aviation has been carried out. The main finding is that a very high kerosene tax has to be applied, if a substantial reduction in emissions is to be achieved (Olsthoorn, 2001). However, an international aviation fuel tax is almost impossible to implement, due to the international bilateral aviation agreement on reciprocal tax exemption for foreign aircraft, the ICAO post-1944 recommendation (ICAO, 1944). In addition, even if an international agreement could be reached, it is not clear how the responsibility for emissions might be allocated among the countries. Is the destination or source country ethically responsible for the greenhouse gas emissions?

Air transport related to tourism account for the most part of the gross ecological footprint associated to tourism activity (Hunter & Shaw 2007; Gösling *et al.*, 2002). The current growth of aviation related to tourism requires strategies trying to reduce CO_2 emissions. A technological solution now is feasible. An initial test has been successfully carried out using a fuel made from biomass (30% vegetable oil methyl ester blended with 70% conventional Jet-A1 fuel) without making any technical changes to the engine. In a few years, the target is a net reduction of 20% in CO_2 emissions compared with current fuels (Gösling *et al.*, 2002).

Nevertheless, technological solutions are expensive and represent a long-term solution. In the short term, however, environmental regulation and taxation can be a suitable way to promote either a shift to less polluting transport mode or reducing emissions in air transport sector because of the leisure-air transport related market is price-sensitive. Moreover, it is crucial to keep in mind that aviation sector is a complementary input to the tourism, the world's biggest industry and any economic intervention must be appraised from a cost benefit analysis. Despite all a tentative simulation of carbon dioxide tax would be implemented (Macintosh & Wallace, 2009).

Economist says that either a tax on kerosene (jet fuel) or per tonne of CO_2 equivalent emitted can be a suitable instrument to control emissions from aviation industry. However, Olsthoorn (2001) point out that only a very high tax could limit the future emissions to 1990 level (reference year of international negotiations). This author concludes that a tax not greater than the marginal external cost of CO_2 emissions (€ 1.1 to € 25.7 per tonne CO_2) only would produce a minor to negligible reduction in CO_2 emissions. A very high tax would be required to stabilising carbon dioxide emissions at International negotiation reference level. Despite the later, an emission tax would be a way to generate environmental corresponsability between tourists, air carrier and governments in the aim of sustainability strategy. Corresponsability criteria must be understood according to willingness to pay for carbon offsetting schemes. Further, governments could use tax earnings for climate change mitigation.

An alternative way to tax emissions could be levied on the amount of actual pollution caused by the flights using airports. The Ramsey pricing structure is a quasi-optimal solution, since it permits the costs to be covered, but without forgetting the principle of the efficient allocation of an airport's available capacity. It also permits the costs generated by externalities such as congestion, noise and pollution to be included in the tariff structure (Rendeiro Martin-Cejas, 2010). Next, a Ramsey pricing model for uncongested tourist airports is implemented, to include air emission costs into the airport pricing structure. A tourist airport was chosen to implement this price structure because of leisure traffic is very sensitive to price changing and thus taxing this kind of traffic could produce a substantial impact in terms of reducing demand. This study estimates the structure of Ramsey pricing for landing at Gran Canaria airport considering two aircraft types.

3. CARBON TAX APPLIED TO LEISURE AIR TRAFFIC

3.1. Ramsey pricing rule in presence of external cost

The basic pricing structure for landing in airports in different continents is a weight-based landing fee. The similarity in landing structures around the world has occurred because most countries have adopted the recommendations made by ICAO and IATA to standardize airport charges. However, current weight-related charge may lead to poor utilization of resources, and airport users gaining at the expense of the rest of society. Oum and Tretheway (1988) derived the normal inverse elasticity mark-up rule for the Ramsey prices when marginal social costs and marginal private costs differ. Ramsey approach allows for the inclusion of external emission costs on the basis of airport users' willingness to pay. That model indicates that the landing right depends on the resulting marginal private cost (MPC_i) and a fraction of the marginal external cost (MEC_i) for the *i*th flight. It also depends on the price-elasticity of passenger demand, which is the absolute value for η_i, and on the total cost of the flight (TC_i). The total cost of a flight depends on the size of the aircraft, as well as the flight distance; this is the key to reflect the true value of the service lies in the size of the aircraft and distance[3]:

$$P_i = [(MPC_i + (k/\lambda) \,.\, MEC_i) + k/\eta_i \,.\, TC_i]/(1- k/\eta_i) \qquad k=\lambda/(1 + \lambda)$$

This is a valuable result, because external costs such as air emission depend on the flight distance and the type of aircraft. So, this price formulation allows us to understand the dimensions of aircraft emission problem. The welfare gain from the imposition of Ramsey prices will be due to include in landing price structure all cost that international aviation imposes on the rest of the society. The adjustments of the flights which are mispriced under current weight-based system without considering marginal external cost of emission would be higher. Thus, if a reasonable price for the tonnes of CO_2 is achieved and at the landing fee level is enough to restrict inefficient air travel demand then the welfare gains for society will be substantial.

Next, we will estimate a Ramsey pricing model including emission costs. For do that we need to estimate some of the parameters related to the activity of air travel; they are the marginal private cost of landing at the airport, the total cost of the flight, the external cost, the airfare elasticity and the constant K.

3.2. The carbon tax design

This section provides an example of a Ramsey pricing model including emission costs for Gran Canaria airport. The above formula shows that we need to estimate some of the parameters related to the activity of air travel; they are the marginal private cost of landing at the airport, the total cost of the flight, the external cost, the airfare elasticity and the constant K. First, the value of K in Ramsey formula depends on the extent to which the revenue constraint is binding, and in the following analysis we used a value of 0.045. This value was chosen because the fees generated were the same order of magnitude as the weight based fees that are currently charged at Spanish airports. A variety of values of K were used, but the general pattern of results remained the same.

The price-elasticity for air travel requires more detailed consideration. It must be said that the values used were estimated by taking several considerations into account. From an economic point of view, the price sensitivity of air travel depends on several factors, such as mode-substitution possibilities, level of income and the distance of the trip[4]. Those factors are correlated, while bearing in mind that a long-distance flight will generally show a smaller number of substitute modes than a short-distance one; this implies an inverse relationship between distance and price sensitivity. Nonetheless, a long-distance flight is more expensive than a short-distance flight, so any cost increase will require a larger share of a passenger's budget. The relationship between flight distance and price elasticity of demand for air travel appears to depend on several forces that counteract one another (Brons *et al.*, 2002).

The point here is whether the substitution effect prevails over the income effect, or vice versa. As leisure travel is generally considered to be a discretionary expenditure, and as airfares for long-distance flights form a substantial part of the total travel costs, it seems that the income effect prevails and leisure travellers show higher absolute price elasticity with respect to the flight distance. The value used in this study was, in absolute terms, 1.17 (Pearce & Pearce, 2000; Tol, 2005)[5].

[3] The users´ willingness to pay depends on the flight distance.
[4] We can assume two hypotheses for η_i. The first is that it is a weighted average of the price-elasticity of passenger demand for different flight distances aboard the same aircraft. Secondly, the flight distance for all the passengers is identical to the flight distance of the aircraft.
[5] According to Brons *et al.* (2002), the overall mean price elasticity found for a set of case studies analysed was equal to 1.146, in absolute terms.

The total cost of the flight for a given type of aircraft and distance can be estimated by multiplying the total operating cost per block hour for that type of aircraft by the number of block hours for the flight:

Total Cost = (cost per block hour) x (number of block hours per flight)

The number of block hours per flight was modelled as a function of the flight distance in the following way. The number of block hours per flight is equal to the average taxiing time plus cruising time. Using as reference BAA (2002) study regarding the average taxiing time for British airports we estimate it by multiplying 0.141 by the runway length, and cruising time was calculated by dividing the flight distance by the aeroplane's average cruising speed.

The cost of delay is often used as a proxy for the marginal cost of an air carrier landing at any airport. It also is frequently used in the cost benefit analysis of air traffic management projects, which are expected to increase capacity and therefore reduce the levels of delay in the system (Eurocontrol, 2008). According to the AENA[6] engineers, the recommended value for marginal private cost to be used in this study was € 72. Although the analysis was carried out for different values of marginal costs, there were no significant changes in the pattern of results. The operating cost per block hour in 2014 for two different types of aircraft that usually fly to Spain (A320 and B737-800), and other information subsequently used are presented in table 1.

Table 1. Aircraft Characteristics

Aircraft characteristics[1]	**Aircraft type**	
	A320	**B737-800**
€/block hour	4,032	3,740
Seats	150	162/189
Maximum range (km)	4,800	5,765
Maximum fuel capacity (litres)	23,860	26,020

[1]The representative aircrafts selected were the Airbus A320 and Boeing B737-800.

Source: Own elaboration using data from Airbus and Boeing website

The marginal CO_2 emission cost was modelled as a function of the flight distance plus the emissions in the landing and takeoff cycle (LTO). First, the tonnes of CO_2 emission were estimated multiplying by a conversion factor, 0.00251 tonnes of CO_2 per litres of fuel, to convert the aircraft efficiency in litres of fuel/km into the number of tonnes of CO_2 per km. By multiplying this figure by the flight distance, we get the total tonnes of CO_2 per flight:

Tonnes of CO_2 = LTO cycle + [(Fuel efficiency) x (Conversion factor) x (Flight distance)]

The emissions for the landing and takeoff cycle (LTO cycle) were considered equal to 6.5 kg per passenger or alternatively to the available seats (Pearce & Pearce, 2000). To obtain the marginal CO_2 emission cost, the tonnes of CO_2 were converted into euros by

[6] Aeropuertos Españoles y Navegación Española.

multiplying the marginal external cost of the CO_2. This marginal external cost ranges from € 1.10 to € 25.70 per tonne of CO_2 (Olsthoorn, 2001). To implement a sensitive analysis three monetary values per tonnes of CO_2 were used to estimate Ramsey price for tourist the Spanish airport; they were € 25.70, € 51.40 and € 257.00.

All the papers on the cost of the damage caused by carbon dioxide emissions conclude that climate change is too uncertain to draw conclusions; nonetheless, the average marginal external cost of carbon dioxide emissions that emerges from all the studies is about € 80 per tonne of CO_2. However, for practical purposes seems unlikely that the marginal external cost of carbon dioxide emissions exceeded 50% of this value (Tol, 2005). One way to complement this low marginal damage cost of carbon dioxide is to include other pollutants such as nitrogen oxides (NO_x), sulphur oxides (SO_x), volatile organic compounds (VOCs), hydrocarbons (NMHC) and carbon monoxide (CO) in the emission costs.

Table 2 shows the relative importance of the Ramsey price, with respect to the total cost of the flight. The Ramsey price, the total flight cost and the external cost for Gran Canaria airport are shown in the context of three values for the marginal external cost of CO_2 emissions; they are 25.70, 51.40 and 257.00 €/tonnes of CO_2. The Ramsey price accounts for 10.5% to 16.8% of the total flight cost. For instance, the current weight-based fee for an Airbus 320 landing at any Spanish airport irrespective of the flight distance is about € 654 per landing, which is only 4.3% of the total cost of flying from Gatwick to Gran Canaria airport. However, according to the values in table 2, the Ramsey price assumes a price penalization of more than 150% for all airports of origin.

Table 2. Ramsey price for the flying to Gran Canaria airport

Origin	Distance (km)	Total Cost (€)†	External Cost (€)*			Ramsey Price (€)*		
Airbus 320								
Gatwick	2,880	15,158	916	1,846	9,161	1,591	2,541	9,806
Heathrow	2,900	15,254	922	1,859	9,224	1,601	2,558	9,873
Dublin	2,930	15,398	932	1,878	9,319	1,616	2,583	9,973
Frankfurt	3,190	16,646	1,015	2,045	10,147	1,748	2,798	10,845
Munich	3,261	16,987	1,037	2,091	10,373	1,784	2,857	11,082
Boeing 737-800								
Gatwick	2,880	13,848	848	1,709	8,479	1,471	2,351	9,075
Heathrow	2,900	13,936	854	1,721	8,538	1,480	2,366	9,137
Dublin	2,930	14,067	863	1,739	8,626	1,494	2,389	9,230
Frankfurt	3,190	15,207	939	1,893	9,391	1,616	2,588	10,036
Munich	3,261	15,519	960	1,935	9,600	1,649	2,642	10,256

†Total cost of the flight in Euro excluding the airport landing fee.

*The Ramsey price and associated external costs for 25.7 are 51.40 and 257.00 € per tonne of CO_2 respectively.

Source: Own Elaboration

If the airlines passed on all the price penalization to passengers, then the ticket prices for an Airbus-320 with 150 seats and 100% load factor flying from Gatwick to Gran Canaria airport would increase by about € 6.20 per passenger for 25.70 €/tonnes of CO_2 and € 12.60 per passengers for 51.40 €/ tonnes of CO_2. This impact on airfares and emission volumes is negligible. However, for 257.00 €/tonnes of CO_2 the Ramsey price would rise steeply. Ticket prices would increase by approximately € 61.00, if all extra emission costs were passed on to passengers. Moreover, a landing fee that represents about 65% of the total flight cost is simply unviable. A compromise to justly internalize the emission costs from air travel is required, without negatively affecting the aviation business. Finally, in terms of aircraft type, B737 performed a cheaper Ramsey tariff because of its better fuel efficiency (see table 1). It is to say that aircraft type play an important role in mitigating emissions. In this sense, it is mandatory that Air Carrier must to choose its aircraft fleet for each route to minimize emissions. However, actually those two variables are chosen only thinking in terms of economics benefits rather than environmental cost.

3.3. The welfare gain

Any efficient allocation of airport resources requires that the price paid by any user reflects the costs they impose on others. If the prices reflect the cost, then the level of demand will represent the true demand. However, if the established price is below this cost, it may stimulate extra demand and to induce investment in facilities that do not cover their full costs; and at the same time the external cost generated would not be optimal. A key issue in assessing the suitability of airport pricing structures is the degree to which they reflect all the costs. Therefore, any price structure that includes all the costs generated by aviation industry would produce welfare gain for the society. In this sense, Ramsey price structure allows this with reasonable costs.

The normalized ratio of Ramsey prices to weight-based fees for each aircraft type and distance, which is shown in table 3, will be used to analyse the relative structure of the Ramsey prices. The fee based on take-off weight was used, because the difference between the take-off and landing weights is fuel; hence the take-off weight based fees incorporate the relevant dimensions of Ramsey prices, which are size and range. It is necessary to choose a normalisation criterion, which is a weight-based fee, as the basis for making a comparison. The normalisation criterion was chosen so that the ratio of fees for the Airbus 320 at its first airport of origin equals one. The weight of the A320 means a weight-based fee of € 21.64 per tonne of take-off weight for Gran Canaria airport.

Table 3. Ramsey prices with respect to price based on take-off weight

Airport of Origin	Dist. (km)	A320	B737-800
Gatwick	2,880	1.00	0.96
Heathrow	2,900	1.00	0.97
Dublin	2,930	1.01	0.98
Frankfurt	3,190	1.09	1.06
Munich	3,261	1.12	1.09

Source: Own Elaboration

According the results shown in table 3, the imposition of Ramsey pricing would result in slightly increased fees for the A320 aeroplanes for all the airports and all distances. For the B737-800 aeroplanes, the take-off weight based fees increased faster than the Ramsey pricing for short distances, but the converse is true for longer distances. Overall, the weight-based fee slightly mispriced the flights. However, according to our results the difference in the Ramsey prices with respect to the take-off weight based fees is negligible. In that sense, the Ramsey pricing does not excessively distort the current weighted based landing fees structure. At the same time, Ramsey price structure permits the introduction of the external costs generated by air travel, and especially those related to greenhouse gas emissions.

The welfare gains from the imposition of Ramsey prices include all the costs that international aviation imposes on the rest of the society, and these are incorporated into the landing price structure. The flight adjustments are underpriced using the current weight-based system, because they don't consider the marginal external cost of the emissions. If a fee, which restricts the inefficient demand, is set for the tonnes of CO_2 at the landing level, then the welfare gains for society will be substantial. An extension of this study would be to include estimations of the impact of pollutants other than CO_2; for example, nitrogen oxides (NO_x), sulphur oxides (SO_x), volatile organic compounds (VOCs), hydrocarbons (NMHC) and carbon monoxide (CO) (Pearce & Pearce, 2000).

On the other hand, if administration cost related to this price structure is considered high, any alternative options would be possible. A simple way to simulate how air carrier capacity for a specific route would fit into the Ramsey price structure is by making an approximation based on the available seat kilometres (ASK). This variable combines size and distance, the two dimensions of the Ramsey price. ASK is the product of available seats and flight distance. By using ordinary least squares, the Ramsey prices for the available seat kilometres on an Airbus-320 flying to Gran Canaria airport, as given in table 2, were regressed as natural logarithms. The results were as follows:

$$\underset{}{\text{Ln(ASK)}} = \underset{(246.6)}{5} + \underset{(394.8)}{1.08}\ \text{Ln(Ramsey price)} \qquad R^2 = 0.99$$

Note: The t-statistics are in brackets.

This estimated price structure incorporates the two key factors of the Ramsey price, aircraft size and flight distance; and at the same time, it allows the elasticity of available seat kilometres offered by an air carrier with respect to the airport landing fees to be estimated simply. So, on a specific route, an air carrier could simulate the total landing fee levied for a given frequency of flight. According to the values estimated by the regression, the elasticity of available seat kilometres (ASK) with respect to the Ramsey price is around 1.08; this means that a 1% increase in landing fees would raise the available seat kilometres by about 1.08%, or that the available seat kilometres and Ramsey prices grow at almost the same rate. Hence, an air carrier can simulate the total landing fee to be levied, if the demand for air travel requires their aircraft, in this case the Airbus-320, to be used on a specific route.

4. CONCLUSION

Carbon emissions from aviation are an international issue that requires an international solution. An internationally accepted airport landing fee, such as Ramsey pricing structure, has been shown to be a reasonable approach to internalizing the aviation industry's carbon emission costs. On the one hand, it is an unambiguous way to overcome the problem of allocating the responsibility for greenhouse gas emissions between the source and destination countries. On the other hand, it must be borne in mind that this is a progressive taxation system, because the air transport users who choose air transport to get a distant destination are more willing to pay the cost they impose upon the rest of the society. Finally, a Ramsey price structure must be applied globally rather than regionally, as this would to avoid a situation whereby a taxed tourism market loses out to a non-taxed region.

The introduction of mandatory measures to address aviation emissions have met with resistance from the industry, which has relied on the improvements in emission intensity by improving the engine emission factor; however, the tendency is for growth in demand for air travel to outstrip emission intensity gains. The available evidence suggests that international aviation emissions are unlikely to be established, unless there is a radical shift in technology, which is a long run objective. The alternative is that demand for air travel should be restricted. In this case, a Ramsey pricing structure, which involved aviation users bearing the environmental costs, would work reasonably well at restricting inefficient demand and produce a reasonable welfare gain in respect to the do-nothing scenery. Conversely, if a landing fee is not established at the environmentally efficient level or has little effect on restricting air leisure demand, then all that will happen is that the government or the airports get the extra revenue.

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