Why do Portuguese Railways Languish? An Application of Internalisation of Transport Related Externalities

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Abstract:
For the last ten years Portuguese railways has shown a gradual decrease in passengers' annual figures; nearly 20 million. The major contributors are regional services and Lisbon's commuting lines. Despite the number of passengers in the metropolitan area of Porto remains steady while the long-distance ridership market between the two major Portuguese cities, Lisbon and Porto presents a slightly growth starting in 2014, long-term perspectives for Portuguese railways are not optimistic. Lisbon and Porto, separated by a distance slightly greater than 300 km, are connected by the Northern Line, which was already competing with two parallel highways, is now facing a new threat in the form of an air-bridge launched one year ago with hourly airplane departures at very competitive ticket fares. There are clear indicators that this air-bridge will lure a large number of potential passengers away from long-distance rail therefore pressing up operator revenues over this important rail connection impacting its earning power: this line is responsible for more than 42% of the State-owned railways total earnings. Therefore, the aim of this article is to find why Portuguese rail languishes while air transport grows, increasing perverse results: climate change, health and non-health damages. Fuel exemption and the lack of excise duties produce enough market distortions to explain at some extent how aviation has seen such strong growth in demand at the expense of rail, but this market distortion do not tells the entire story. What is at stake is how to obtain a level playing field between the two modes. In that sense, it is necessary to internalise the social cost of carbon in a way to weight the real costs the society has actually to bear from each option because those costs are not borne by transport operators or users, but by society as a whole. After attach a money value to negative externalities, we identify as the root of the problem for the sustainability of Portuguese long-distance railways the lack of political will towards the internalisation of negative externalities.

Keywords:
Negative externalities; Climate change; Air pollutants; Aviation; Railways, Case-study.

1 INTRODUCTION

Rail transport plays a crucial role in enabling economic development as it responds to the needs of the organization and functioning of the economy and society, acting on improving the conditions and quality of life of the population. Because of its nature as a promoter of social and territorial cohesion and more responsible mobility fashion while reducing the ecological footprint, direct State aid to public railways in the form of subsidies that cover partially the social costs of operations, is fully justified. Yet, for the last decades Portuguese Governments have considered spending taxpayers money on highways as an investment even if the final bill is postponed to future generations, as is the case of the public private partnerships (Pereira, 2011), whilst spending on rail capacity and maintenance is regarded as subsidy (Woodsworth, 2011). It is worth noting that public funding for the railways is in large part to finance operational deficits and not to open new lines in remote areas or reduce the cost of travel for particular vulnerable groups. Railways are broadly considered as promoters of equitable and affordable transport by allowing individuals to meet their basic mobility needs (Ang & Marchal, 2013) and aviation is not and this is a major difference between the two modes of transport. In fact, aviation enjoys a full set of tax exemptions that are at the origin of substantial fiscal savings which makes air travel far too cheap[1]. Moreover, its growth is largely based in the fact that negative externalities are not accounted for so transport users are choosing their transport mode with a wrong price signal (Union Internationale des Chemins-de-Fer – UIC). Alternatively, the results show that if negative externalities are taking into account, rail exhibits less costs for the society as a whole being air tickets fare below market prices for the simple reason that aviation is indeed enjoying implicit subsidies. Since there is a lack of widespread information about the above said from those responsible to communicate it as such - the policy makers - and a somewhat ignorance from the side of consumers about the harsh consequences of their (quasi-involuntary) choices, the aim of this article is to compare and weight the social costs of pollutant emissions between the two modes in a roundtrip journey between the two main Portuguese cities: Lisbon and Porto. We seek therefore to shed light about how it is possible for the operators of such harmful mode to practice airfares below the market price (and if we are not facing a social dumping situation it will be environmental in nature), to explain, to a certain extent at least, railways loss of competitiveness when compared to aviation. The goal is therefore to justify the need to account for negative externalities when we analyse transport modes competing among them within the same customer's niche especially when there is a less damaging alternative option for such short distances. This will be done by quantifying and monetising the carbon costs for society arising from such energy options, for one hand, and for the other hand and in face of the results of the study to send an alert to policy makers and to the general public about the need to maintain railways sustainability as a means to promote territorial cohesion, public mobility and a less climate change contributing mode of transport. Plus, and according to public sector governance and accountability rules, given the fact that the Portuguese State is competing with itself, we need to stress that this managerial posture is far away to what is generally accepted as best practices to run public sector properly referring to the impact of those policies on the community and on the society at large.

[1] This means that each year the aviation industry in the EU receives over 45 billion Euros in tax concessions and other subsidies' (Budd, et al., 2013).

2 THE SUPERIOR PERFORMANCE OF THE RAILWAY TRANSPORT

Although Portugal is allowed to emit 1% more GHGs in the horizon 2020 than it did in 2005 (Decision N. 406/2009/EC), however, "*the number of episodes of tropospheric ozone pollution and of fine particles pollution [remains] higher than the long-term target established*" (European Environment Agency, 2015) urging for a deep understand at sectoral level, namely at transport sector which includes domestic aviation. Aviation is one of the fastest-growing sources of greenhouse gas emissions roughly accounting for more than 2% of global GHG emissions (EC Climate Action). Even crediting that long range flights contributes for around 80% of total worldwide (ATAG – Air Transport Action Group) those flights superior to 1,500 km for which there is no practical substitutes, our case study analysis focuses on a very short distance trip (~300 km) for which a less damaging alternative exists. While kerosene-type jet fuel is at the origin of aviation emissions, accounting for about 99 percent of all aviation fuel consumed (EPA, 2006 apud McCollum et al., 2009), rail transport emissions are mainly upstream emissions from electric generation, making it the less environmental aggressive transport mode.
The following features are amongst the main advantages for railways: i) Lower energy consumption: Rail transport is the most efficient of all transport modes and electric traction can use electricity produced by the most diverse sources of renewable energy. Electric trains powered by renewable energy are practically carbon-free. At a time when the so-called decarbonisation of economies is a global concern, it is imperative to rationalize energy consumption in the transport sector particularly if one looks at the high contribution of oil products for the imbalance of the Portuguese trade balance. As a non-oil producing country, Portugal imports all of its needs of crude resulting in 4.88B euros or 7.7% of total imports, representing the largest share (The Observatory of Economic Complexity); ii) Less pollution: Compared to road and air transport, rail transport accounts for only a small proportion of emissions from transport, about 3% (1.5% in the EU) and it holds the potential for deeper reductions in the future (IEA, 2008). Energy use per passenger/km can be as much as 65 to 80 % less than air travel (IPCC, 2014); Economical use of space: Trains offer a high transport capacity per occupied ground area and can carry a large number of passengers in a single trip (for example, the Alfa Pendular on the Lisbon-Porto route can carry up to 300 passengers); High level of safety: Rail transport is the safest way to travel. Railways have security systems with a high degree of redundancy, strict operating rules and demanding maintenance.

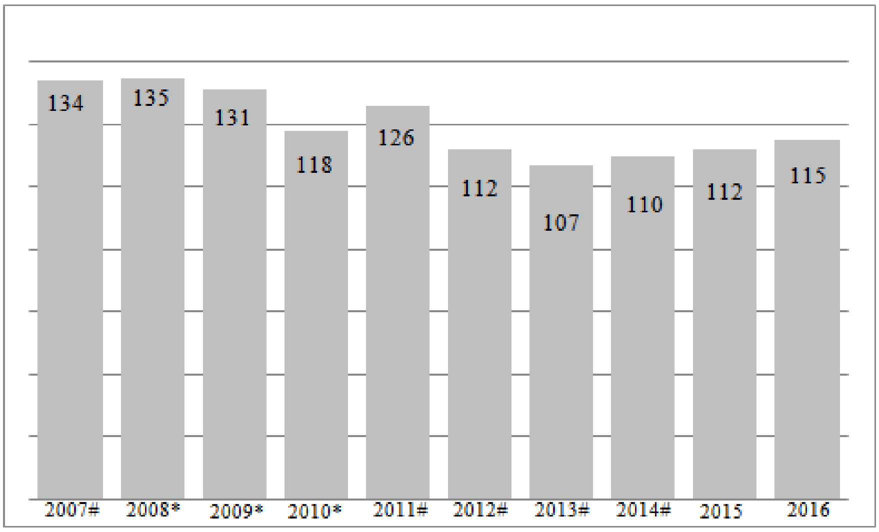
3 DEFINING THE PROBLEM

The larger size of external costs in the transport sector could be spared if the sector had greater energy and environmental efficiency hence reducing negative externalities. Here we assume negative externality as a cost that is imposed on third parties without their consent. As Prof. John Komlos recently suggest (Komlos, 2014), economists (and other scientists alike) should begin estimating all negative externalities and very specifically because the true costs of energy use and emissions were discovered long ago although environmental degradation, harmful effects on health, harvests and materials and space occupancy as externalities generated by transport are still not perceived directly by citizens or accepted as technological "bite-backs" from decision-makers[2].

[2] Technological bite-backs can be seen as the other side of the coin of development which forces us to be into constant vigilance against its side effects or to exercise stronger control over it.

Similarly as for shipping, aircraft emissions were left out of the Kyoto Protocol on curbing emissions namely due to the complexity of assigning national responsibility for gases spewed by international flights. That responsibility falls on the shoulders of the International Civil Aviation Organization (ICAO), the UN international organism for civil aviation which represents the interests of the sector meaning that there is not a true commitment to curb emissions without the support of the members itself. As national demand for air travel strongly grows that explosive growth makes it one of the fastest-growing sources of carbon gases in the atmosphere. Those carbon and soot-particle emissions from jet fuel may double the warming effect because of the altitude at which they're emitted. As jets soar they leave behind vapour threads of condensation that can persist for hours, the so-called contrail cirrus, trapping heat in the atmosphere and therefore having an indirect effect on climate forcing (Burkhardt & Kärcher, 2011). Opposite to the steadily growth demand for aviation, Portuguese rail transport shows substantially lower growth rates and in some lines a decrease is registered for the last ten years (Graphic 1).

Graphic 1 *Global Portuguese railways demand, 2007-2016 in millions.*
(Source: Own elaboration from Comboios de Portugal Annual Reports data).

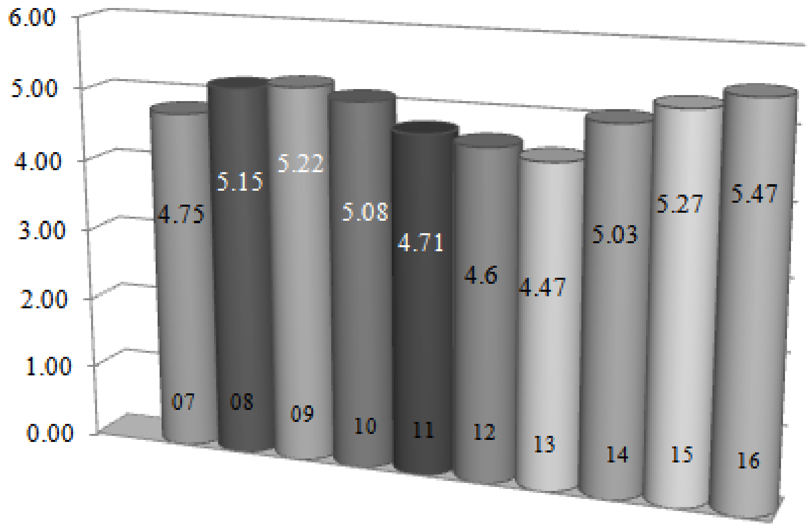


* Excludes International traffic as it comes from the Annual Reports figures. # Years with no disaggregated values for International traffic; 150.000 passengers per year were assumed.

Even though the suburban line of Porto and the long distance Lisbon-Porto lines have reported some growth in demand over the past couple of years (Graphic 2), in fact the option for a less aggressive and less fossil dependent mobility faces several challenges and threats[3].

[3] It may sound a little like a redundancy to look at such growth as a departure point to explain the supposed threat railways are facing. Yet, most probably, this growth can partially be explained with the end in 2014 of the Economic and Financial Assistance Program to which Portugal was bound, providing the conditions for greater mobility, i.e. more time is need until assuming this trend as not merely conjunctural.

Graphic 2 *Northern Line demand 2007-2016, in millions.*
(Source: Own elaboration from Comboios de Portugal Annual Reports data).



Portuguese passenger railways attractiveness has been continuously declining along the years and a very important component of that phenomenon that must not be neglected was the closing of hundreds of kilometres of lines together with the wear and tear and obsolescence of the rolling stock whilst ticket fares have continuously risen. (Wrong) public policies towards the railway infrastructure have created a critical situation due to the disinvestment that has occurred in its maintenance and modernization, limiting its valences in terms of signaling, traction and capacity (Confederation of Portuguese Business – CIP -, 2015). Actual network, which has been neglected for 30 years or so, is now in need of a severe upgrade otherwise we face the risk of getting people off the railways for good. Very worrisomely this is the case of such an important rail connection as the Northern Line, a very busy line for both passenger and freight, which in fact looks somewhat like a patchwork as the result of successive partial interventions along the years. The neglecting of public investment towards railways compares with large investments in new service lines from the aviation side stressing the fact that both train and airline operators are State-owned entities (fully and majority-owned, respectively)[4]. Long distance trains between the two major Portuguese cities, Lisbon and Porto using the Northern Line, which was already competing with two parallel highways, are now facing a new threat: an air-bridge that was opened exactly one year ago with hourly departures and with very competitive ticket fares. This event is expected to captive an important fringe of rail customers therefore pressing up operator revenues impacting its financial health and acts counterproductively against the objectives to achieve lower carbon intensity in the transport sector.

In the case of domestic and intra-EU aviation, by virtue of international agreements[5], jet fuel is exempted of taxation (European Environment Agency, 2015)[6] and this constitutes a market

[4] According to Prof. Manuel Tão, of the University of Algarve, of the 30 million annual trips in the Lisbon-Porto axis, rail mode has less than 10% of the market share (personal statement, 12-01-2017).

[5] It referes to the 'Chicago Convention' – which have established the legal framework for international civil aviation. Most of the nations of the world, including the EU Member States, are parties to this treaty.

[6] Aviation, together with shipping, present an ever growing share of GHG emissions.

anomaly. This leads to situations in which the competition with other modes of transport is far from being equitable (Decision N. 406/2009/EC) and, jointly to this, we should remember that airplane tickets usually do not include VAT, while rail do (at a prevailing rate of 6% in our case). Fuel exemption and the lack of excise duties produce already enough market distortions to explain by themselves how aviation has seen such strong growth in demand and why railways are superseded. Nevertheless, since the marginal social cost of carbon is not imputed, we face a market failure as the most polluting modes will be benefiting from an implicit subsidy causing distortion of competition[7]. In the following analysis we will ignore the mentioned exemptions as key issues; rather we proceed by internalising the social cost of carbon to measure negative externalities from both modes (which are economically quantifiable) as a means to achieve a more balanced and fair price system which involves internalising the external costs.

4 METHODOLOGY

To be able for taking rational decisions about transport options is necessary conceptualise monetary social costs and to compare those negative externalities between modes. As previously mentioned, the emissions calculator uses the assumptions taken from a round-trip Lisbon / Oporto / Lisbon, performed by the State-owned rail operator CP (Comboios de Portugal, EPE) train. Our travel model opts for a scheduled train called Alfa Pendular with regard to CP 4000 series rolling stock. This kind of composition has a maximum capacity up to 299 passengers in each trip (Figure 1). The distances between origin/destination and return are 544 km (277 x 2) and 628 km (314 x 2) for the airplane and for the train, respectively.

Fig. 1 *Image of a CP Alfa Pendular train.*
(Source: CP)

The airplane an Airbus ATR 72 600 (AT7 series) with total capacity up to 70 passengers is operated by the State majority-owned company TAP (Transportes Aéreos Portugueses, SGPS, SA) attached to the so-called air bridge recently launched (Figure 2).

[7] It is not only the carbon dioxide (CO_2) that contributes for the social cost of carbon but also other greenhouse gases (GHG), namely methane (CH_4) and nitrous oxide (N_2O) hence usually referred to as equivalent carbon dioxide units (CO_2e) taking into account the global warming potential, or GWP, within 100 years (most used by The Intergovernmental Panel on Climate Change - IPCC) from each pollutant related to CO_2 (CO_2 = 1). Thus, a CH_4 molecule has a GWP 25 higher than CO_2 and N_2O is 292 times higher than CO_2.

Fig.2 *Image of a TAP ATR 72 600 aircraft.*
(Source: TAP)

We estimate an occupancy rate of 80% for both the airplane and train, which refers to 56 occupied seats in the first case and 239 in the second (according to the CP, occupancy rate in this service line is around 55%, some 160 passengers/trip). The purpose now is to quantify and then monetise, i.e. to assign a monetary value, to the emissions of greenhouse pollutants produced by modes and translated into amounts of CO_2e. For the quantification of emissions per trip, we took hand from the ICAO online calculator.
Figure 3 gives total emissions for an air round-trip travel between the two cities: 0.0887 tons of CO_2e (or 88.7 kg) are produced in 554 travelled kilometres per passenger/roundtrip in a total of **4967.5** kg for the 56 passengers[8]. Values do no include emissions associated with the production and distribution of electricity.

One Way/Round Trip	Cabin Class	Number of Passengers
Round Trip	Economy	56

Leg	From City/Airport	To City/Airport
1	LIS	OPO
Delete All Location(s)	Delete Leg	Add New Leg

Reset Compute

Metric (KG / KM) **Standard** (LBS / MI)

Total

Dep Airport	Arr Airport	Number of passengers	Cabin Class	Trip	Aircraft Fuel Burn/journey (KG)[ab]	Total passengers' CO2/journey (KG)[c]
LIS	OPO	56	Economy	Round Trip	2222.5	4967.5

Flight Stage Detail

Dep Airport	Arr Airport	Distance (KM)	Aircraft	Aircraft Fuel Burn/leg (KG)[a]	Passenger CO_2/pax/leg (KG)
LIS	OPO	277.0	319, 320, 321, 332, 738, 73H, AT7, E90	1124.9	44.4
OPO	LIS	277.0	319, 320, 321, 332, 738, 73H, AT7, E90	1097.6	44.3

Fig.3 *Airplane: emissions calculation.*
(Source: ICAO).

[8] Differently, the ATR 600 Environmental Brochure indicates less than half of those emissions from the ICAO assuming an AT7 aircraft series (2162 Kg/CO_2/56 pax). In: www.atraircraft.com/products.../Brochure-Environment-2014.pdf)

For the case of train emissions from Lisbon-Porto route roundtrip (Northern Line), we resource from two distinct online calculators. The emissions ton/km/passenger varies in accordance with those online calculators: between 0.017 (as of from the UIC calculator for a crowded train) and 0.038 ton/passenger (or between 17 kgCO_2 and 38 kgCO_2). For our assessment we choose the latter as to guarantee a more conservative approach from the train vis-à-vis the airplane which gives a total of **9082** kg for the 239 passengers. Figure 4 shows emissions by person/roundtrip emitted between Lisbon and Porto by train. It is worth to mention that these calculations do not include emissions produced by other modes to ensure train station/airport connection, both at the departure and return.

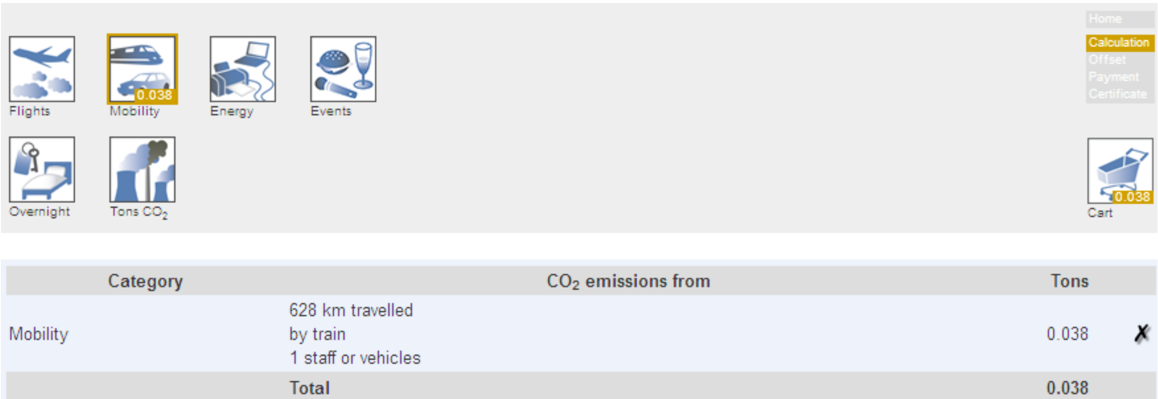


Fig.4 *Train: emissions calculation.*
(Source: South Pole Group).

It should be noted that the emissions in the rail mode are upstream emitted, that is, originated from electricity generation, which is not attributed to the CP per se, i.e. there are no *end-of-pipe* emissions. For trips on electrified routes, as is the case, CP is only responsible for downstream emissions, emissions of chlorofluorocarbons (CFCs) emitted by refrigeration equipment (air conditioning, for example).The next step now is to determine the cost of CO_2e per metric ton. The emissions price measures the marginal cost, i.e. the cost of an additional unit of pollution. For the purpose of calculating the unit costs of climate change, estimates of the marginal costs corresponding to the efforts required to stabilize global warming at 2° C (maximum CO_2e concentration in the atmosphere up to 450 ppm) should be used. This is the goal currently supported by the United Nations Framework Convention on Climate Change (UNFCCC) although the emissions are dangerously approaching the 410 ppm (The Keeling Curve).
Assigning a unit cost of CO_2e emissions is however not an easy task since there is a wide disparity in values that vary from author to author. Korzhenevych et al. (2014) suggest the central value of **€ 90.00**. This value is adopted for the costs of the damages caused by CO_2, but it will serve not as an absolute value but as a proxy. This is not relevant in terms of the proportional costs of the emissions between modes because being the multiplying constant (assuming CO_2 value as the multiplier) the overall costs will be distributed evenly between modes. Table 1 summarises the quantification and monetisation results by mode/trip/passenger.

***Table 1** Summary of the calculation of emissions and their monetization.*

a : Mode	*b* : Emissions/pax (CO_2e)	*c* : Number of passengers	*d* : Cost per passenger (Euro)	*e* : Total emissions cost (Euro) per trip	*f* : Total emission costs (Euro) equivalent (*d* x 239)
TAP	0.088	56	7.92	443.52	1892.88
CP	0.038	239	3.42	817.38	817.38

4.26 Airbus ATR / 72 airplanes are necessary to transport the same number of passengers than those an Alfa Pendular can carry in a single trip which equates to a total cost of € 1892.88. In comparative terms, the air travel is 2.3 times more polluting than the Alfa Pendular, the same is to say, 2.3 times costly. Checking the TAP electronic ticket page we know that a Lisbon-Porto round trip is priced at € 105.99 (departure on 25-05-2017 and return on 29-05-2017, first flights of the morning, hand luggage only). This means that the true price should be € 243.78 after negative externalities being imputed[9]. Comparing with the cost of the roundtrip CP ticket (same days and hours): € 55.00. The airplane ticket does not reflect the true economic cost, only possible because the external costs of carbon are not imputed to it.
It is important nevertheless to mention that TAP is not the only company who operates in such a short distance line; a flight by the operator Ryanair, scheduled for the same day, is roughly half of the price that TAP is. The so-called "low-cost revolution" in aviation has opened up to lower income groups the possibility for air travel and this social and spatial equality has transformed people's desire for air travel into a consumer expectation. The formation of those expectations is based on exogenous factors, it owes its creation to market conjuncture and there is little to do against it. While some can argue that these expectations are all about genuine social aspiration, others can counteract by alleging that costs are in one order of magnitude larger than benefits, especially for those living in airport areas or flight paths (noise discomfort can negatively impact perceptive skills and causing stress fatigue), direct pollution, (including access surfaces, translated into premature deaths and morbidity) and impacts over animal species and their habitats (Budd, et al., 2013) and of course, climate change exacerbation effects.

5 LIMITATIONS TO THE STUDY

Our study focus on quantifying and monetising GHG emissions and their impact in terms of climate change. The descriptive framework would, however, be even more advantageous for railways if the same exercise has had covered public health costs (premature mortality, morbidity), ecosystems (tropospheric ozone formation) and materials (precursors of acid rain) including damage to monuments and cultural heritage. In fact, a major catalyst associated with loss of quality of life and reduction of life years, described as premature mortality, originates from the emissions of inhalable microparticles resulting from the soot produced by the airplane engines, particularly those below 2.5µ (microns), which can easily travel and settle deep into the pulmonary alveoli, promoting the emergence of serious respiratory problems and even cancers. By another side, nitrogen oxide (NOx) emissions are precursors

[9] This specific day was chosen as a mere example and for comparison purposes only. Ticket fares vary with the calendar along the year and with departure hours.

in the formation of tropospheric ozone, which, unlike stratospheric ozone, causes serious health problems and damages to crops. On the other hand, sulfur oxide (SOx) is responsible for the formation of acid rain and corrosion to buildings and limestone statues. These emissions result, as we have learn before, from the burning of diesel fuel including aircraft jet fuel which due to the high altitude exacerbate the potential of GHGs also reducing stratospheric ozone.

6 FINAL REPORT AND RECOMMENDATIONS

Summarising, the resolution of problems related to the excessive use of airplane trips - pollution, energy consumption versus quality of life, plus noise and accidents (not accounted for in this exercise), - is gaining increasing weight. Ensuring sustainable mobility in its three pillars: environmental, social and financial is crucial and must be understood as part of good governance at political and institutional level. However, results will be obtained only if there is strong political will to implement them. Beyond political will, there must be a clear national awareness of the problems and a good diagnosis so that the change of practice can be made intelligently.

There is, however, growing awareness worldwide that solving the aforementioned problems should be through coordinated actions involving spatial planning, research and development policies, energy and environmental policies. The strategic objective of energy and environmental policy in the transport sector should be based on three strands: i) combating climate change and promoting the well-being of citizens by reducing harmful effects on health and premature mortality; ii) to decrease external vulnerability from imports of hydrocarbons; iii) to promote growth and employment by providing safe and clean energy, contributing to the phasing-out of oil dependency, and preferably at affordable prices. In reality these objectives are in accordance with the United Nations development goals for sustainable transport giving support to the development of sustainable transport systems, including public mass transport systems (U.N., 2009).

The internalisation of negative transport externalities thus allows society as a whole to be reimbursed for the costs it has to bear. The more polluting modes must therefore reflect their true costs in social terms, ceasing to be confined to bad economic practices that allow them to be under cover subsidized, allowing the profits to be few and the losses many. As these fares do not reflect those costs, one way of simultaneously promote more responsible and sustainable mobility is through the creation of a carbon tax to be applied to the emissions that may be able to secure the financing of rail allocating part or all of these funds not only to their maintenance but also to their modernization and to increased supply. We stress the fact that all the above conditions should be applied to all operators irrespective of their public or private nature.

The existence and consistency of State aid for environmentally sustainable transport operators must therefore be a reality, in particular by awarding public subsidies or compensatory allowances, to compensate fares below its true market value because those operators provide a social service, but that in reality does not stand for this purpose. This framework may not seem to be the friendliest to the most polluting and environmentally aggressive operators, however, with the exception of a widespread nuclear conflict, climate change is the biggest problem facing mankind, and this menace by itself gives the rationale for those measures to be executed. Those are policy-making recommendations regarding environmental strategies we address to the public authorities.

REFERENCES

Ang, G. & V. Marchal (2013). Mobilising Private Investment in Sustainable Transport: The Case of Land-Based Passenger Transport Infrastructure, OECD Environment Working Papers, No. 56, OECD Publishing. http://doi.org/10.1787/5k46hjm8jpmv-en

ATAG – Air Transport Action Group: http://www.atag.org/facts-and-figures.html, accessed 2017-03-14

Budd, L. et al. (2013). Sustainable Aviation Future. ISBN: 978-1-78190-595-1

Burkhardt, U. & Kärcher, B. (2011). Global radiactive forcing from contrail cirrus. Nature Climate Change. DOI: 10.1038/NCLIMATE1068

CIP – Confederation of Portuguese Business (2015). Logística em Portugal.

Comboios de Portugal. Annual Report 2015

Decision N. 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020

European Commission Climate Action: https://ec.europa.eu/clima/policies/transport/aviation_en, accessed 2017-03-14

European Environment Agency, 2015. http://www.eea.europa.eu/soer-2015/countries/portugal. Accessed 2017-03-17

IEA (International Energy Agency). (2008). Energy Technologies Perspectives. Scenarios and Strategies to 2050. OECD

IPCC (2014). Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Chapter 8: Transport

Komlos, J. (2016). Has Creative Destruction become more Destructive? The B.E. Journal of Economic Analysis & Policy. 2016. 20160179

Korzhenevych, A. et al. (2014). Update of the Handbook on External Costs of Transport. Final Report. RICARDO - AEA/R/ ED57769. Issue number 1

McCollum, D. et al. (2009). Greenhouse Gas Emissions from Aviation and Marine Transportation: Mitigation Potential and Policies. Pew Center on Global Climate Change

Pereira, A. (2011). Portugal na Hora da Verdade. Como vencer a crise nacional. Gradiva. ISBN: 978-989-616-413-3

The Observatory of Economic Complexity: http://atlas.media.mit.edu/en/profile/country/prt/. Accessed 2017-04-11

United Nations Sustainable Development – The Future We Want. https://sustainabledevelopment.un.org/futurewewant.html