TRABAJO FIN DE MÁSTER

Estructuras Sociales e Innovación: Un enfoque de Sostenibilidad en el sector de la Aviación

(Social Structures and Innovation: A Sustainable Approach in the Aviation Sector)

Autor: Dª Belén Payán Sánchez

Tutor/es: D. Miguel Pérez Valls

D. José Antonio Plaza Úbeda

Máster en Administración y Dirección de Empresas
(Itinerario de Investigación)

Facultad de Ciencias Económicas y Empresariales

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Content

ABSTRACT

Aviation plays a key role in modern economies development. This industry has uninterruptedly grown since the second half of the 20th Century and is not expected to stop its development. This sector has huge economical and social contributions but also threatens the environment with aircraft noise or gas releases, among others.

Because of this, the aim of this final project is to identify a collaborative framework between the academy, institutional and company level from three different perspectives: using Open innovation practices; Stakeholder engagement and Alliances, in an attempt to make aviation companies reduce their environmental impact.

An exploratory descriptive and regression analysis over the companies' vision definition in a sample of 72 airlines has been done with the objective of testing the correlation of these issues with the environmental performance of the airlines. The results show the need of making a qualitative empirical analysis addressed to the managers of these companies in order to delve into the consciousness of this gap.

RESUMEN

Se ha demostrado que el sector de la aviación es muy importante en las economías modernas, un sector que no ha parado de crecer desde mediados del siglo XX y no se espera que pare de hacerlo en las próximas décadas. El transporte aéreo tiene un inmenso impacto tanto económico como social pero también amenaza al medio ambiente con el ruido de las aeronaves o la liberación de diferentes gases, entre otros factores.

Por ello, el objetivo de este trabajo de fin de máster es identificar una infraestructura de colaboración a nivel de academia, de instituciones y empresas desde tres perspectivas diferentes usando prácticas de Innovación abierta, de integración de los grupos de interés y de alianzas, en un intento de hacer que las empresas aeronáuticas reduzcan su impacto medioambiental.

Un análisis exploratorio descriptivo y de regresión sobre la definición de visión de las empresas de una muestra de 72 aerolíneas se ha realizado con objeto de sondear la correlación de estas cuestiones con el rendimiento ambiental de las empresas. Los resultados muestran la necesidad de realizar un estudio empírico cualitativo dirigido a los directivos de estas empresas para profundizar en el conocimiento de este gap.

INTRODUCTION

Air transport has traditionally experienced higher growth than most other industries, due to the incessant increasing demand present in this sector (IATA, 2013), which is closely linked with economic development and economic cycles and is likely to continue until at least 2030 (Daley and Thomas, 2011). This sustained growth of demand has been reinforced by globalization, which allows for a more integrated world economy and is responsible for economic, social and environmental transformations all over the world (Adey et al., 2007; Hettne, 2008); and by the growth of tourism, a sector dependent on the availability of fast, long-distance air services (Cabrini, 2005).

Consequently, aviation has become an essential sector and a driver for the world's overall economy and development, creating connections between businesses, countries, economies and global markets, and enabling worldwide access to all kind of products.

The contribution of this industry to local, regional and national economies comes through the generation of direct and indirect employment, increased productivity, flow of tourists and trade, flow of ideas, capital and, also, competition. In addition, Bishop and Grayling (2003) condensed the economic benefits of aviation in reference to access to markets, specialisation, economies of scale and Foreign Direct Investment (FDI).

The International Civil Aviation Organization (ICAO) (2011b) estimated the direct contribution of civil aviation, in terms of the consolidated output, as $370 billion for the year 1998 and directly contributed no less than 6 million jobs to world economies in that year. Already in 2013, according to the ICAO's Chief, Environment Branch and Secretary of the Committee on Aviation Environmental Protection (CAEP) Jane Hupe (2013), aviation has supported 56.6 million jobs worldwide, up to 3.5% of global GDP and it has carried 2.9 billion passengers per year. In Europe this sector has contributed with more than 5.1 million jobs, adds €365 billion, or 2.4%, to European GDP and, in 2013, the total number of passengers carried by air transport in the EU was about 842 millions of people, an increase of 1.7 % compared with 2012 (Eurostat).

And if that were not enough, in words of the ICAO Council President Olumuyiwa Benard Aliu, the worldwide air transport sector "is expected to continue to grow exponentially and will double by 2030 to over 6 billion passengers annually" (ICAO, 2014, p. 5).

Besides the economic advantages, in recent years many studies have defined aviation, according to Fasone and Maggiore (2014), as able to play also a crucial role in increasing territorial competitiveness, improving accessibility and cohesion between the member states, therefore generating important social benefits, such as, faster and easier access to family and friends, worldwide educational and research opportunities, leisure and recreation experiences (tourism), cultural and sporting events, cultural exchange and development, and social inclusion (Daley and Thomas, 2011), making possible a "global village" that connects thousands of airports with scheduled services. Other social benefits of air transport include the support for disaster relief and medical evacuation, as it is the United Nations Humanitarian Air Service (UNHAS), law enforcement, international diplomacy and environmental monitoring (Caves, 2003; ICAO, 2011a).

Thus, air transport is consequently regarded as an important tool for economic and social development, although it has also considerable environmental impacts, given that aviation is a source of pollution, fundamentally reliant on fossil fuels and involving major infrastructure requirements, compromising then the sustainability of our planet.

Among all the effects that air transport has on the environment, there are some that are local to airports, such as, aircraft noise, local air pollution, water use and pollution, waste production and habitat modification and destruction, whereas there are others that are of global concern, such as, climate change.

Consequently, the objective of this paper is, in the first part, to identify a collaborative framework between three levels of knowledge/expertise: the academy, the public institutions and the companies, in order to face these environmental problems in the industry; and, in the second part, to explore the degree of use of this collaborative framework and its possible connections with environmental performance of aviation companies.

To do so, a regression analysis, composed of 3 multiple regressions, and a later descriptive analysis, using combined tables, will be done.

Thus, this paper is structured as follows: the chapter 1 will shed light on the sustainability problem and the direct implications that the aviation sector has on it. Then it will be studied what have been done in each level of analysis and will identify needs for collaboration among them. And in the last section of the chapter, they will be highlighted some integrative solutions for the aviation-sustainability problem. In the second chapter, the methodology and the population and sample description are described, with the later analysis and the discussion of the results. Finally, chapter 3 will contain some conclusions, limitations and recommendations for future work.

CHAPTER 1. THEORETICAL BACKGROUND

The aim of this chapter is to introduce the problem of sustainability and the repercussion that the aviation sector has on it. Furthermore, different levels of analysis that, within the sector, have tried to tackle the environmental problems will be showed and also some managerial solutions will be posed in an attempt to contribute to the eradication of the aviation's sustainability effects.

1. Sustainability and Aviation's Detrimental Effects

The term sustainability has become a really widespread concept nowadays used in many forms and in almost all subjects, but this concept goes back to around 1972, when it was first verbalised by Ernst Friedrich "Fritz" Schumacher as "permanence", where "nothing makes economic sense unless its continuance for a long time can be projected without running into absurdities" (Schumacher, 1973, p. 19), and, according to Ashby and Hudson-Smith (2012), was recognised in key works such as "Limits to Growth" (Meadows et al., 1972) where the consequences of a fast growing world population and a finite number of natural resources were modeled.

Nevertheless, it was not until 1987 that the World Commission on Environment and Development (WCED) was established and defined sustainability on its Report "Our Common Future" (most known as "Brundtland Report") as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43). Since then, the idea of sustainability has also included the social and environmental dimensions, and not only the economic one, being widely interpreted as achieving the balance of social, economic and environmental imperatives, although when it is applied to aviation, however, this broad sustainability concept is often limited to mean "reduce environmental impact as much as possible" (ICAO, 2011a, p. 21).

It is true that aviation brings significant economic and social sustainability-related benefits, as we discussed above, but it is true as well that aviation also incurs environmental sustainability costs such as noise, atmospheric emissions that contribute to reduce local air quality and worsen climate change, the quality of water and land pollution, what does not contribute to an improvement of the overall environmental sustainability.

For example, the International Energy Agency (2014) has stated that throughout the past century, the concentrations in the atmosphere of CO_2 have been increasing significantly, being in 2013 about 40% higher than in the middle of 1800s (396 parts per million in volume, or ppmv), with an average growth of 2 ppmv/year in the last ten years. Similar increases have also been present in levels of methane (CH_4) and nitrous oxide (N_2O), all of this being clearly influenced by humans. Hence, it is not strange that geologists have introduced the concept of the Anthropocene as a way to mark a new geological era typified by the permanent and unprecedented mark left now by humans in the stratospheric record of the globe (Crutzen and Stoermer, 2000).

According to Zalasiewicz et al. (2010, p. 2231), the Anthropocene Era "represents a new phase in the history of both humankind and of the Earth, when natural forces and human forces

became intertwined, so that the fate of one determines the fate of the other", and it brings considerations for sustainability into a new orientation, one that recognises the limits set by the biosphere beyond which social systems should not go but already have, and not only one that requires an adjustment of social systems to the planetary boundaries (Hoffman and Devereaux Jennings, 2015).

As we have already surpassed all the limits and given that the CO_2 has a long lifetime in the atmosphere, "stabilizing concentrations of greenhouse gases at any level would require large reductions of global CO_2 emissions from current levels" (IEA, 2014, p. 7), despite sea level ascent and anthropogenic warming will continue for hundreds and hundreds of years due to the time scales associated with climate processes and repercussions.

Then, we now discuss the six negative effects that we have found aviation has on the environment and that threaten the sustainability of our surroundings.

Aircraft Noise

Aircraft noise is the most significant cause of adverse reactions from communities living in the vicinity of airports, disturbance that, in the opinion of Hooper and Greenall (2005), may constrain the growth of airports and thus the wider aviation industry.

The noise emanates from main aircraft engines, auxiliary power units (APUs) and airframes, and its perception depends on a number of factors including aircraft type, the overall number of daily take-offs and landings, general operating conditions, the timing and mode of operations, weather conditions, topography and other human factors (biological, psychological and sociological processes) (Daley and Thomas, 2011; ICAO Secretariat, 2013b).

In the end, the exposure of communities to aircraft noise can cause them diverse problems, such as, sleep deprivation, stress, communication obstruction, learning disruption and other cognitive and performance effects, then deteriorating physical, mental and social welfare (Hume and Watson, 2003), which convert this aviation environmental effect into a very controversial problem that has to be dealt with care due to the direct implication of communities.

Local Air Pollution

Local air quality has been affected mainly by emissions of NO_x and particulate matter (particles), and to a lesser extent by emissions of oxides of sulphur (SO_x), carbon monoxide (CO) and volatile organic compounds (VOCs), all coming from a variety of sources including main aircraft engines, APUs, apron vehicles, passenger ground transport vehicles, de-icing operations and refueling.

Aircraft NO_x emissions mainly include nitric oxide (NO), which is transformed immediately into NO_2 in the atmosphere, and these emissions perturb the chemical composition of the atmosphere resulting in enhancement of tropospheric ozone (O_3), a greenhouse gas, being both (NO_2 and O_3) regarded as critical local air pollutants owing to their effects on human health, i.e. human cardiovascular and respiratory systems, asthma and mortality (DETR, 2000).

The emission levels that contribute to local air pollution depend on several technological and operational factors, such as, the aircraft type, the use of thrust reversal, the degree of engine deterioration, the state of brakes and tyres or ambient conditions, among others (DfT, 2006), thus compromising the air transport operators in their activities and their use of the aircrafts.

Water Use and Pollution

Water is an always needed resource in all life facets and, in an airport ambient, water is needed to human consumption, the watering of green areas, cleaning activities, fire services, execution of works, definitely, to maintain airports' infrastructure and normal operation activities, and to provide appropriate services to customers.

Because of this, the quality of the water is threatened by a variety of aviation industry activities, such as, terminal services, aircraft de-icing, maintenance activities, engineering or refueling. Each one of these activities has the potential to cause substantial ground contamination, thus polluting surface and ground water, which can in the end affect drinking water supplies and agricultural land, with obvious implications for human health.

Waste Production

Airports and airlines generate great quantities of solid waste coming from different sources: office-based, engineering and maintenance activities, in-flight catering and cabin services, and terminal facilities, taking shape of organic waste, pruning waste, hazardous waste, fuel spill or electronic waste, among others.

This waste, if not handled with care, will pose a threat to environment and human health and also will spread disease among animals, due to the use of some available disposal routes, such as landfilling and incineration, polluting even when it is about relatively benign solid waste stream, like packaging, paper and food waste (Hooper and Greenall, 2005).

Ecological Modification

The construction of airports requires habitat modification and destruction, considering that airports (by their nature) demand great areas of land and create zones either aggressive to wildlife (i.e. pavements and buildings) or with ecological monocultures (i.e. mown grassland), as Daley and Thomas (2011) said. In fact, most of airports are located in a green belt in the surroundings of a major urban area.

It is not surprising then, that they have appeared policies in order to prevent or restrict airport development, especially in some parts of Europe, where there are sites protected by national and international conventions. And these constraints are likely to become stricter in the future because of the commitments made by nations at the UN Conference on Environment and Development in Rio de Janeiro (the Earth Summit) in 1992.

Climate Change

The main impacts of aviation that have global concern have their effects on climate change. Aircrafts release greenhouse gases (especially CO_2) that contribute to climate's radiative

forcing, and their emissions of NO_x produce O_3 (ozone), acting as a powerful greenhouse gas at the level at which civil aircraft usually cruise (lower stratosphere and upper troposphere).

Firstly, CO_2 emissions can be attributable to airports, as a consequence of ground support vehicles, stationary plant operations and passenger surface transport vehicles, and of course to aircrafts, emitting carbon dioxide in direct proportion to the amount of fuel burned. Thus, the quantity of CO_2 emitted depends upon the aircraft type, atmospheric conditions, flight duration, cruising levels, etc., definitely depending on the fuel efficiencies achieved by aircrafts.

Fleming and Ziegler (2013) estated that in 2010, international aviation consumed approximately 142 million metric tonnes (Mt) of fuel, resulting in approximately 448 Mt of CO_2 emissions, and estimated that by the year 2020, international aviation would consume 216-239 Mt of fuel per annum, resulting in 682-755 Mt of CO_2 emissions. This can be turned into an increase of fuel consumption by 2040 of 2.8-3.9 times the value of 2010, and extrapolating it to the year 2050, it will have increased from four to six times the 2010 value.

According to the data of the International Energy Agency (IEA) (2014), worldwide CO_2 emissions had an amazing growth of 52% within the 1990-2012 period, reaching in this last year levels of about 31734.3 million tonnes of CO_2, of which 1.5% approximately is from international aviation bunkers. Additionally, last year the IATA (2015, p. 36) has stated on its Annual Review that “air transport is responsible for only 2% of man-made carbon emissions annually”, which coincides with the beforehand said, and it could increase to about 10% by 2050 (Daley and Thomas, 2011). Furthermore, in comparison with the transport sector, aviation emissions account for around 12% of transport CO_2 emissions today, according to ICAO (2011a).

It only remains to add that CO_2 has a long life cycle in the atmosphere, so it has to be taken into account that the radiative effects of CO_2 emissions will endure for many decades.

Secondly, aircrafts have additional effects on climate that come from the emissions of oxides of nitrogen (NO_x), which bring to the generation of tropospheric ozone (O_3) and to the destruction of methane (CH_4), both operating as powerful greenhouse gases at cruise levels. Although the radiative effect of NO_x emissions varies, according to Lee (2004), the positive effect that can have the formation of O_3 does not cancel the negative effect of the CH_4 destruction because the ozone impact is concentrated in the Northern Hemisphere and that of methane happens globally.

In addition to this, aircrafts also affect climate change when producing cloudiness through the creation of condensation trails (contrails) and cirrus clouds, which are indistinguishable from naturally occurring cirrus (Lee, 2004; Stordal et al., 2005). And another impact comes from the aircraft emissions of aerosols and aerosol precursor gases, which yield to a large number of very small black carbon particles (soot particles) as a result of the incomplete combustion of the products with high vaporization temperatures (Daley and Thomas, 2011; Fahey et al., 2013), causing a local heating effect.

Despite operational and technological improvements have been made in the sector (for example, in modern aircrafts both local emissions and noise footprint are very much smaller than in the past (ICAO, 2011a)), the total environmental impacts of aviation are expected to increase. According to Horton (2006), the air transport sector is predicted to produce almost twice as much CO_2 in 2030 as in 2002.

In the end, the gamut of environmental impacts of air transport, together with the increasing public consciousness of environmental-related issues, has led to unprecedented levels of popular, politic and scientific concern about sustainability in general and the environmental influence of flying in particular.

2. Levels of Study and Previous Work

Due to the fact that sustainability has become of public concern and it is a problem with high visibility and that affects everyone, academies, public institutions and industry representatives have tried to face this challenge from many different manners and to give some solutions, and that is why we think that a collaboration between them would be necessary when trying to solve the problem our world is facing.

2.1. Academy Level

From the Academy sphere, it has always been a lot of interest in the problematic of sustainability and the way in which citizens, companies and states are dealing with it and how they could improve in their attempts to reach sustainability in all its dimensions.

To see if in academies there has been a really interest in this issue, we have made a search of this term in the ABI/INFORM Complete database, and that consist of important full-text journals and many sought-after titles from the business press as well as key trade publications, dissertations, conference proceedings and market reports.

When searching for the word “sustainability” inside the document title, the outcome was that there are 29.272 results between journals, business press releases, work documents, etc., and when restricting the search through adding the word “environment” inside the abstract (with the condition “AND”), we now have 2.337 results, what obviously continues confirming the assumption of importance of this theme among researchers.

For example, Van der Byl and Slawinski (2015) have studied the tensions created when companies try to reach the balance between the social, economic, and environmental goal of sustainability and they demonstrated that this problem could be approached through a win-win lens (by the alignment or optimization of the sustainability elements), a trade-off lens (with one sustainability element chosen over another), an integrative lens (shifting focus from economic to social and/or environmental element) or a paradox lens (acceptance and exploration of tensions rather than resolution), then giving the companies with different solutions to solve the problem.

Other authors, such as Seuring and Gold (2013) and Ashby et al. (2012) are centered in the idea of stakeholder integration to better manage corporate sustainability.

The thing is that in an increasingly interconnected world and in today's global market competition, single organizations cannot face sustainability challenges on their own and Seuring and Gold (2013) defend an improvement of sustainability performance along the supply chain as a key aspect to well manage sustainability, and it is that stakeholder management is key for driving sustainability performance (Asif et al., 2013).

In the same line, Ashby et al. (2012) propose a sustainable supply chain management (SSCM), a rapidly growing field that requires a widened approach to Supply Chain Management (SCM), incorporating not only the economic sustainability driver of SCM, but also the ecological and social aspects of business.

Supply Chains produce waste and emissions, which are considered the main sources of grave environmental problems and the most effective way to tackle these problems, according to Min and Galle (1997), is to focus on waste prevention and emissions control.

The use of Reverse Logistics (RL), for example, can help companies, when producing waste, in their attempt to contribute to the enhancement of the environmental dimension of sustainability, and it is defined by Carter and Ellram (1998, p. 85) as the "process whereby companies can become more environmentally efficient through recycling, reusing and reducing the amount of materials used". Reverse Logistics is about the products returned to the main company by the customer, and procures the maximum utilisation of used products, thus leading to cost savings and enhanced competitiveness (Rao and Holt, 2005).

Furthermore, the use of a green supply chain management (GSCM), which integrates environmental issues into SCM processes, in the opinion of Zhu et al. (2008), by identifying costs, benefits, risks, and opportunities, can help companies to manage and reduce waste production, and in general the company's environmental impact of its final product, with the eventual aim of waste elimination (Handfield et al., 2005).

Van Hoek (1999) identified on his work three different approaches with which companies can face environmental management: the reactive, characterized by "end of pipeline" pollution control; the proactive, where firms start to pre-empt new environmental legislation and to re-use and recycle products and materials within their supply chains; and the value-seeking, where environmental behaviour is incorporated into the business strategy with commitments along the supply network.

In addition to this, Ashby et al. (2012) provided on their work some ideas and solutions for the companies to use when dealing with environmental sustainability, such as using a Life cycle analysis (LCA), to evaluate environmental impacts at every level of the supply chain, or an Environmental Management System (EMS), to measure environmental performance and to allow external stakeholders to confirm whether environmental upgrade really occur.

Companies can also use:

- The Design for the environment (DfE), to design and develop new products and processes (Tsoulfas and Pappis, 2006), addressing at the same time the natural environment (Preuss, 2005).

- The Design for recycling (DfR) and design for disassembly (DfD): both complementary allow for more efficient and profitable re-use and disposal of product components.
- And Product stewardship, which is linked to DfE and use data to design products with a reduced impact in the environment (Angell and Klassen, 1999).

With this, it has been demonstrated that sustainability related issues have had and still have a lot of attention from the Academies spheres, above all, the environmental dimension of sustainability, what in fact cause most of people concern. From a theoretical lens, it is true that Academy has made a lot of contributions to the field and they have been very useful but, when translating it into practice, nobody discuss that Academy has to take into account the industry and the institutions responsible for this industry, thus collaborating with them to give appropriate solutions.

2.2. Institutional Level

Public Institutions have made lots of efforts in order to face the environmental challenge present nowadays and that we all have generated over the years. They have created policies, commitments, conventions, initiatives and tools, among others, to raise awareness between countries and to achieve a better world.

To start with, in 1992 the international community decided mutually to establish a framework for addressing global warming through the adoption of the United Nations Framework Convention on Climate Change (UNFCCC), whose ultimate objective is to stabilize greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system" (ICAO Secretariat, 2013a).

After, the Kyoto Protocol was adopted in 1997 but entered into force in 2005, and is an international agreement linked to the UNFCCC, which commits its Parties by setting internationally binding emission reduction targets. Other attempts to address climate change are the G8 2005 Gleneagles Plan of Action, the G20 Clean Energy and Energy Efficiency (C3E) Working Group, the Major Economies Forum on Energy and Climate (MEF) and Clean Energy Ministerial (CEM) processes, and also the International Renewable Energy Agency (IRENA), and the International Partnership for Energy Efficiency Co-operation (IPEEC).

The European Union Emissions Trading System (EU ETS) is an attempt to combat climate change and it is key tool for reducing industrial greenhouse gas emissions cost-effectively. It is the international system for trading greenhouse gas emission allowances and it covers more than 11,000 power stations and industrial plants in 31 countries, as well as airlines (EC, 2015).

When oriented these efforts to aviation, we have that the International Air Transport Association has elaborated the IATA Environmental Assessment (IEnvA) Program, whose aim is “to improve airline environmental management practices and efficiency performance at the company level by setting internal targets, implementing management programs, and providing access to best practices and information sharing among airlines” (IATA, 2013, p. 36).

What is more, the US Federal Aviation Administration (FAA), in collaboration with Transport Canada and the US National Aeronautics and Space Administration (NASA), has planned and implemented a suite of environmental modelling tools that would enable the interdependent

analysis of fuel burn, emissions and noise exposure, whose core component is the Aviation Environmental Design Tool (AEDT), which utilizes scenario-based schedule and operational data to predict environmental consequences (Roof and Grandi, 2013).

On the other hand, the International Civil Aviation Organization (ICAO) was created in 1944 as a specialized agency of the United Nations to promote the safe and thorough development of international civil aviation all over the world, and since the late 1960s it has been at the forefront of issues concerning the aviation's repercussion in the environment. From then on, the ICAO has provided diverse solutions for the problem of this sector and also leaded and proposed several initiatives, programmes, assemblies, tools, etc., in order to drive this issue.

Some of the solutions that have provided the ICAO are the use by aircrafts of sustainable biofuels and lightweight materials (ICAO, 2011a). In fact, airlines are already using some sustainable alternative fuels and it is proved that they do not require changes to aircraft design or fuel delivery systems, meaning that it is only needed to have them available for the airlines and at prices and quantities in line with the operators' needs.

This Organization has also establish some targets to control and reduce the industry's impacts, such as the global annual average fuel efficiency improvement of two percent until 2020 and an aspirational goal to continue improvement at this rate to 2050. The industry has agreed as well keeping a carbon neutral growth from 2020 and a 50 percent cut in emissions by 2050 relative to 2005 levels (ICAO, 2011a).

Furthermore, the ICAO Council established in 1983 the Committee on Aviation Environmental Protection (CAEP), replacing the Committee on Aircraft Noise (CAN) and the Committee on Aircraft Engine Emissions (CAEE), with the objective of assisting the ICAO Council in formulating new policies and adopting new Standards and Recommended Practices (SARPS) for aircraft noise and aircraft engine emissions.

According to Oh and Damar (2013, p. 45), "since 2009, Airports Council International (ACI) and ACI Europe have launched two important and complementary initiatives to assist member airports with the management of CO_2 and other greenhouse gas (GHG) emissions, and to measure progress made", which are the Airport Carbon Accreditation (ACA), a carbon mapping and carbon management standard specifically designed for the airport industry, and the Airport Carbon and Emissions Reporting Tool (ACERT), a tool with information data to allow airport operators to calculate their own greenhouse gas (GHG) emissions inventory.

Lastly, the European Organisation for the Safety of Air Navigation, most commonly known as EUROCONTROL, has developed some key environmental modelling tools, with the support of the European Commission and European Aviation Safety Agency (EASA), to assist with environmental impact assessments of Europe and the CAEP.

There is no doubt then that environmental sustainability and aviation environmental sustainability is a very important question, which public institutions do not put aside, but as well as it happens with the Academy, the Institutions need to collaborate with companies and the Academy in order to identify which are the concrete market necessities that require some regulation.

2.3. Company Level

Companies are really concerned about their behavior regarding sustainability and environmental matters, and public institutions do not let them forget these issues, above all because companies have also to comply with some policies and rules.

In order to increase their transparency, voluntary initiatives, such as the nonprofit Carbon Disclosure Project (CDP), have emerged and put pressure on companies to communicate their efforts and performance concerning greenhouse gas emissions (Hahn et al., 2015). This pressure to disclose emissions can bring to improved carbon management and, therefore, to reduced energy consumption and costs (Matisoff, 2013).

In addition, companies can improve their image, according to Sullivan and Gouldson (2012), by accomplishing proactive climate-related measures and carbon disclosures, as well as by developing climate-friendly products.

To improve their environmental behavior, companies can also make use of Industrial Symbiosis (IS), which is, in words of Walls and Paquin (2015, p. 1), "a collaborative environmental action whereby firms share or exchange by-products, materials, energy, or waste as a way to economically reduce aggregate environmental impact". But authors like Lombardi and Laybourn (2012) expanded this definition introducing intangible resource exchanges such as knowledge, experience, information, excess organizational capacity, etc.

Besides, companies can use an Employee Green Behavior (EGB) which constitute any measureable individual behaviour that contributes to environmental sustainability goals in the work context (Ones and Dilchert, 2012a). The employment of this, can lead, according to Norton et al. (2015), to competitive advantage, cost savings, environmental performance, energy use, leader effectiveness, positive social norms within a team, and intrinsic satisfaction of the own employee.

Despite companies are the entity who actually pollutes the environment and acts over it, they belong to a regulatory framework with which have to comply and also need a theoretical background to follow and translate to the real world.

I want to make clear that the aviation sector is not a homogeneous one. Apart from environmental concerns (which are the object of our study), aviation companies have other interests (managerial or those of the market, for example) that shape their ways of acting and how they understand business, what means different business models.

According to the Atmosfair's classification of business models, there are four different airline types (Atmosfair, 2012): net carrier, charter, low-cost and regional.

- Net carriers (also known as commercial airlines) are those that have scheduled flights. Departure and arrival flight times are planned along a large period of time, so these flights must be offered even if the plane is not complete.

- Charter airlines are those that do not have scheduled flights and these flights are offered only when a high demand is expected. As a result, charter airlines have no legal obligation to offer flights when the occupancy ratio of the aircraft is low.

- Low-cost airlines can be seen as a subgroup of airlines that offers cheaper flights thanks to a decrease in comfort, flexibility and a restriction to a few flight routes in the short-haul and middle-haul range.

- Regional airlines are those that carry out flights from small regional airports to hubs and vice versa.

The business model each company has is going to determine the company behaviour, and will therefore also affect its environmental performance.

In conclusion, environmental issues and sustainability are of great concern among individuals, companies and institutions and, above all, they increasingly constitute a meaningful business risk to aviation and could radically affect its growth and development. To contribute to the approach of these two -apparently- opposed forces (aviation and sustainability), from here, we propose that some kind of collaboration might be needed between these three fields in order to address from a different perspective than it has always be seen the problem of sustainability in the aviation sector.

3. Integrative Solutions to the Aviation & Sustainability Problem

When trying to face the challenge of sustainability aviation growth, lots of responses and solutions have arose and they have always been approched from the technological, operational and policy perspective, as it can have been discerned from the previous sections. These solutions vary from improvements in aircraft design and performance, with lighter structures and cleaner materials, and the development of more sustainable fuels (technological aspects), passing through the use of simpler processes of loading, manoeuvring, production and maintaining aircrafts, using improved air traffic management (ATM) procedures (operational aspects), and finishing with measures such as standards, emissions charges and carbon offsetting, among others (policy aspects).

All right then, in addition to using these responses, which all contribute to the reduction of the sustainability impact of aviation, we propose this dilemma to be conduced from a business management perspective, since it would be useful to connect airports, airlines, universities and private companies in order to collaborate and make possible a more sustainable aviation industry.

Therefore, keeping this in mind, we think that it would be necessary a reconfiguration of the companies (airlines and airports), engaging their stakeholders affected by the problem in their decission making processes and using open innovation and making alliances to give other solutions to the problem.

Since sustainability is a complex problem (without simple solutions) affecting multiple firms, groups and communities, we propose an analysis of the process of generation of shared

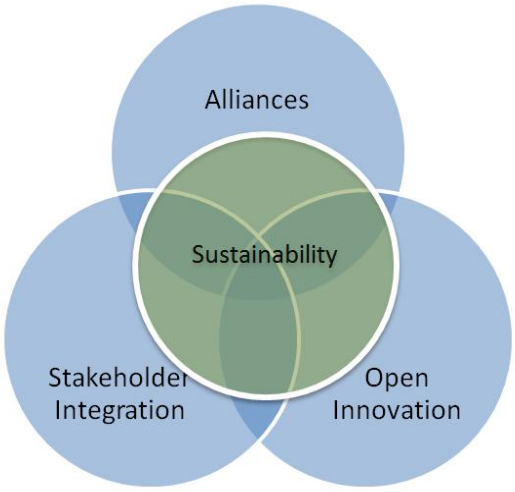
knowledge, which may lead to a better, greener and sustainable aviation industry, from 3 different perspectives that simultaneously interact (represented in Figure 1.1):

(1) The structural. This is how the organization of the firm and the embeddedness in alliances and networks may facilitate the generation and dissemination of best practices.

(2) The social. This is the analysis of how the engagement of stakeholders affects the setting, deployment and achievement of environmental goals.

(3) The procedural. This is the study of how firms may develop open innovation based processes to generate useful knowledge from the interaction with customers, suppliers and even competitors.

Figure 1.1: The generation of shared knowledge process



Source: Self-elaboration

With this, we want to face the challenge of analising the social and organizational aspects that help to develop a greener and more sustainable aviation industry through the close collaboration with universities, research centers and, in order to assure the development of a comprehensive approach for the sustainability of aviation, international oriented firms coming from some main subindustries such as Airports, Airlines an Suppliers. Through this integrative approach, innovative and effective proposals will be developed for helping aviation to develop greener business models based on the combination of insighs from three organizational fields: stakeholder engagement, alliances management and open innovation processes.

To start with, “stakeholder” is seen as an ‘essentially contested concept’ (Miles, 2015) due to the many different interpretations that it has, all of them equally acceptable. But in this work, a stakeholder will be viewed , according to Freeman (1984, p. 46), as ‘‘any group or individual who can affect or is affected by the achievements of the organization’s objectives’’. Thus, in Table 1.1, they are settled the main stakeholders that affect or are affected by the environmental problems created by aviation and that were described previously in the first section.

Table 1. 1: Aviation environmental problems' stakeholders

PROBLEMS	STAKEHOLDERS
Noise	Local communities, local authorities, employees, passengers, pressure groups, media, airlines and suppliers.
Local air pollution	Local communities, local authorities, pressure groups, media, Government, airlines and suppliers.
Water use and pollution	Passengers, employees, airports, airlines, suppliers (either materials or services), local communities and local authorities.
Waste production	Airports, airlines, employees, passengers, local communities, suppliers, retailers and local authorities.
Ecological modification	Local communities (i.e. fauna), pressure groups, local authorities, airports, suppliers and Government.
Climate Change	Pressure groups, Government, airports, airlines, suppliers (either materials or transport), passengers, employees and media.

Source: Self-elaboration

As Andriof *et al.* (2002, p. 9) wrote, "…in today's societies successful companies are those that recognise that they have responsibilities to a range of stakeholders that go beyond mere compliance with the law or meeting the fiduciary responsibility inherent in the phrase 'maximising returns to shareholders'", and we believe that companies should take advantage of the engagement of these groups, which will lead in the end to communication, satisfaction and a sense of belonging or compromise with the firm.

In this way, stakeholder engagement could be understood as "practices that the organization undertakes to involve stakeholders in a positive manner in organizational activities" (Greenwood, 2007, p. 318). Thus, Amaeshi and Crane (2006) stated that stakeholder engagement is a possible non-market and non-regulatory mechanism that could complement economic development and environmental degradation, and also that organizations can have a pro-active, accommodative, defensive or reactive attitude when dealing with its stakeholders.

An example of one of these behaviors, the reactive concretely, and of stakeholder integration are the Noise Insulation Plans of Aena, the manager of all Spanish airports and heliports, which is shown on its website (Aena, 2015). Nobody discusses that noise is the most important impact at the local level, considering that it is the most visible and which generates more disturbance to local communities, who are the main stakeholders of this problem along with local authorities, which are responsible for taking care of communities. Therefore, companies have to communicate in a direct and simple way, in order to give the better solution and to gain their confidence. It is for that reason that Aena listened to local communities and, as a response to their claim, it began to carry out the Noise Insulation Plans, which are executed in housing and sensitive use buildings included in the isophone area of the corresponding airport. As it has already been said, both the interested parties and the relevant administrations for the area actively participate in the procedure, what clearly supports the idea of stakeholder engagement in organizational activities.

In addition, integrating the different components of the supply chain in decision-making processes can reduce waste production and even water use and local air pollution, since resources are shared, better managed and not misused in the same activities from different areas, what ultimately will lead to a better business management and of the sustainability impact.

And it is that, as Accountability (1999, p. 107) affirmed, "meaningful engagement with stakeholders can anticipate and manage conflicts, improve decision-making from management, employees, investors and other external stakeholders, build consensus amongst diverse views, create stakeholder identification with the outcomes of the organization's activities and build trust in the organization".

Thus, airports and airlines should engage their most important stakeholders, such as local communities, local authorities and Government, suppliers, passengers and maybe pressure groups, in order to know their concerns and to be able to make up some important alliances with them to create an ambient where every single component is satisfied and, in this case, everyone pursues a single and common objective: contribute to the environment sustainability for their health and that of the company.

When talking about alliances in the aviation sector, they have always been seen as an act of formal multilateral collaboration between airlines (as they are the Star, Oneworld and SkyTeam) or formal bilateral alliances (such as that of Air France-KLM with Delta), with the aim of confronting and overcoming economic crisis and uncertainty, and for some airlines, to survive. In this sense, Parkhe (1991, p. 581) defined global strategic alliances as "the relatively enduring inter-firm cooperative arrangements, involving cross-border flows and linkages that utilize resources and/or governance structure (…), for the joint accomplishment of individual goals linked to the corporate mission of each sponsoring firm". More recently, following the same idea of authority, Clark (2010, p. 68) described a typical strategic alliance as "a formal association between two or more parties, with an aim to advance mutually beneficial and common interests", in which companies would experience an amelioration in traffic feed, development of complex itineraries, access to markets previously limited and travel opportunities through hubs and cost savings.

Having said that, besides these type of alliances characterised by being airline-airline and having some kind of authority or governance, we think that companies (airlines and airports in this case) should also build informal relations with suppliers and value-chain partners, as well as national and international public institutions, among others. These sort of alliances fit perfectly with the definition of Gulati (1998, p. 293), who stated that strategic alliances are "voluntary arrangements between firms involving exchange, sharing, or codevelopment of products, technologies, or services", providing companies with access to knowledge, resources, markets and technologies otherwise not attainable.

For example, where the water supplies are scarce or expensive and if airports do not possess treatment systems, there is a possibility for airports to make alliances or collaborations with suppliers of water or even with local authorities, and also to retire the use and contaminated water originated from the normal activities of airports and airlines. Furthermore, it would be beneficial to collaborate with local public institutions in order to eliminate the waste created

during all the processes of airports and airlines, and also to look for combinated solutions to reduce the impact of aircraft noise.

It could also be possible some sustainability-oriented collaboration activities and towards pollution reduction between airlines and air traffic controllers, since the way aircrafts move around airports directly influence de degree of gases emitted to the atmosphere, what could be controlled and diminished by the concurrent use of Air Traffic Management systems, for example.

Another type of collaboration present in this sector, is that created for example in the ACI (Airports Council International), where several organizations agree on different regulations and practices for airports. Definitely, international cooperation activities, allow for sharing important tools to guarantee good practices, human progress and air transport development, leading to improve transport infraestructures and its professionals' training.

Finally, open innovation is a more recent concept less studied and exploited than, for example, the stakeholder theory, but that has a lot of potential and has awakened researchers' interest, considering that thanks to this, they are generated new innovation processes otherwise not accessible.

According to Benner and Tushman (2015), during the past decade, innovation's focus and fundamental mechanisms have experienced a shift from the firm to community, and this is what open innovation consists in, an integration of internal and external competences. In words of Schwetzer et al. (2011, p. 1195), open innovation "involves such processes as broad-based investigations into technologies and markets by using external information sources and having market players actively participating in their innovation process", then implying cooperation in research and development processes rather than simple R&D outsourcing (Buganza and Verganti, 2009).

Thus, Rigby and Zook (2002) identified four key benefits of open innovation: innovation can be reached by the access to lateral and new ideas; the outflow of ideas may attract new talent and also generate revenues; firms can asses interest and gain important insights from the market with the early exposition of an idea to the market; and finally, with the inflow and outflow of ideas, companies can identify and focus on its core innovative assets.

Open innovation is about cooperating with what we think are the most important components of the aviation and of any company framework: clients, suppliers, competitors and universities and research centres, what partially coincide with what Schweitzer et al. (2011) stated that in technologically turbulent environments, as it is the case, it is also beneficial for companies to integrate their supply chain components in order to assure innovation success, considering that they have more direct contact with new technological knowledge and resources.

The thing is that universities are also a crucial component that we have inserted in the supply chain of airports' and airlines' companies as part of our knowledge co-creation process, because they are continuously creating knowledge and innovative ideas for them to be used and put in practice. Companies can closely cooperate with them and therefore produce innovative solutions for the technologic area, such as more light-weight structures and

materials, previously mentioned in the beginning of this section. In this sense Buganza and Verganti (2009, p. 319) concluded on their work that “the greater the number of technology switches, the bigger the benefit from collaboration with universities”, and nobody doubt that the aviation sector is one where technology changes every second.

With all the above, it can have been inferred that the three organizational fields that are part of our model, stakeholder engagement, alliances management and open innovation processes, are correlated at some extent, since to use open innovation, there is a need to engage with your stakeholders and, at the same time, to make and construct some alliances with them, in order to align all participants’ positions and reach, in this way, a better, greener and a more sustainable aviation industry.

CHAPTER 2. EMPIRICAL ANALYSIS

The aim of this chapter is to observe in the practice, in a first approach, how integrated are these three solutions proposed in the companies of the air transport sector and also if its use contribute to their environmental performance.

To do so, first, an overview of the population, the data sources and the sample will be provided, followed by a description of the variables used in the analysis and the analysis itself, which define the methodology. Secondly, the results and a discussion of them will be settled.

1. Methodology

1.1. Population and Sample Description

Before starting doing any analysis, it is required to have very well defined the population and the sample object of the study. Among all the aviation companies, in this analysis I will be focusing on airlines, which are responsible for the majority of the pollution that this sector releases to the environment, and that shape the population of the research.

The data used has been extracted from two different sources. The first one is Orbis, a database with information of companies worldwide (data updated to 2015). It provides very useful information: the description of the company and its history, its revenues, number of passengers, its assets and ROA and, of course, its mission and vision, among others. The second one is the Atmosfair Airline Index of 2015, which contribute to this analysis with the companies' business models, the number of passengers and form of measuring the environmental performance of the airlines, which is the most essential information for my study.

Therefore, the sample is a consequence of a mixture of the two sources. It is based on the airlines that appear in the Airline Index of Atmosfair (2015). There are 125 airlines in this index but it was not possible to select all of them because some financial data was lacking from the Orbis database for some of the airlines, leading to incomplete results, so those airlines were removed from the sample.

The final sample consists of 72 airlines from 3 different business models, different sizes and of course different environmental performance, which is pretty representative of the population.

1.2. Analysis

Before getting into the analysis itself, it becomes necessary to clarify and describe the variables utilized within the study.

Since I am trying to analyze the impact that alliances, stakeholder engagement and open innovation practices have on the environmental performance of aviation companies, the dependent variable used in this work will be the Efficiency Points (a way of measuring the environmental performance of companies) and the independent ones will be the business models (charter, net carrier and regional), which inevitably are going to affect direct or indirectly the environmental performance of the firm, the use of stakeholder integration and

open innovation processes, and the belonging to an alliance. Furthermore, two control variables will be introduced: the number of passengers, as a measure of the company size, and the Return on Assets, to estimate the profitability of the companies; both assumed to affect the model.

Efficiency Points (EP_2015)

The way Atmosfair (2015) measures environmental performance of companies is through the amount of Efficiency Points obtained by each airline in the sample and, since one of my databases of reference is the Atmosfair Airline Index, this is why I have chosen to use this variable. The methodology used by Atmosfair to calculate EP for every airline is the following.

For the calculation of the total emissions generated by each flight for a city-pair, the ICAO methodology was used, taking into account some variables like the type of aircraft, the occupancy rate, the number of seats, the efficiency of the engine and the co-loaded freight capacity. The results of this calculation are measured in equivalent CO_2 per payload kilometer.

The airline that obtains the best possible result—the lowest amount of emissions—for a given city-pair, gets 100 points for this flight, while the airline that obtains the worst possible result, gets 0 points. Taking this into account, the rest of the airlines receive a score through a process of linear interpolation between the worst and the best score.

Finally, the Efficiency Points for every flight of every company are averaged to give an overall score.

Business Models: Charter (CHARTER), Net Carrier (NETCARRIER) and Regional (REGIONAL)

The classification of the airlines by business model has been also extracted from the Atmosfair Airline Index of 2015 and following Atmosfair's methodology, there are three categories: charter, net carrier and regional airlines. It is important to highlight that in the Atmosfair Airline Index low-cost airlines are treated differently when estimating their environmental performance, preventing from the comparison of these type of airlines with those of the other business models. As a consequence, there is no accurate data on the environmental performance of low-cost airlines, so these types of airlines were not included in the sample of this study.

Since they are bivariant variables that describe if the airline has a concrete business model or not, they will just take the values 1 and 0 (1 if companies have the attribute and 0 if they don't).

Open Innovation (OI), Stakeholder Engagement (SE) and Alliances (AL)

These three variables OI, SE and AL are also bivariant variables, since they describe the practice or not of open innovation processes, the practice or not of stakeholder engagement and the belonging or not to an alliance, so they will be taking the values 1 and 0 (1 if they have the characteristic and 0 if they don't).

In order to give them those values, a content analysis with the software MAXQDA has been done over the objectives statements and the strategies companies outline and that are

exposed in the Orbis database. The rule used to give the variables the number 1 has been as follows:

I have sought for open innovation practices as processes of information exchange, coordination of the participation of diverse actors and the organization of solutions, apart from having agreed general rules of behavior (Huff, Möslein and Reichwald, 2015).

It was marked that an airline practiced Stakeholder engagement when it had into account any of its stakeholders, influencing then the company's decisions.

And lastly, it was settled that a company belonged to an alliance, when it is actually a member of one of the three leading alliances, Star Alliance, OneWorld and Sky Team.

So the keywords employed to carry out the content analysis and therefore to mark the variables are reflected in Table 2.1.

Table 2.1: Content analysis keywords

PRACTICE	KEYWORDS
Open innovation	Innovat-, creativity, coordination, new, flexibility, quality, information
Stakeholder Engagement	Customers, passengers, traveler, partner, third party, aircrew, social, employees, industry player, people
Alliances	Network, joint venture, alliance, membership, associat-, partnership, member, agreement, cooperation

Source: Self-elaboration

Control Variables: Number of passengers (PAX_2015) and ROA (ROA_2015)

It has been thought that the analysis could be affected by two variables that are important for any company: its size and its profitability, so it becomes necessary to include them in the study.

In order to measure the size of the sampled companies, the number of passengers carried out per year by each company was taken, and this data was obtained from Atmosfair Airline Index for 2015.

The profitability of the companies was assumed to be well represented by the Return on Assets (ROA), data expressed in percentage and coming from the Orbis database.

Going to the analysis itself, I have to say that it is composed of two analyses: a regression analysis and a descriptive one.

The regression analysis is in turn compound of 3 multiple regressions by blocks over the dependent variable EP_2015. In all of them, within the first model the control variables are introduced and in the second model, the independent variables CHARTER, NETCARRIER and REGIONAL are added. Now, it is in the third model where the differences between the three multiple regressions appear. In the first regression, the independent variables OI, SE and AL are introduced, whereas in the second, a combination 2 by 2 of these variables are added, resulting in SE_OI, SE_AL and AL_OI independent variables. Lastly, in the third regression, it has

been added an integrative variable of the first three, resulting in the variable PRACTICES, since this work is about a collaborative framework using the three practices in a combined way.

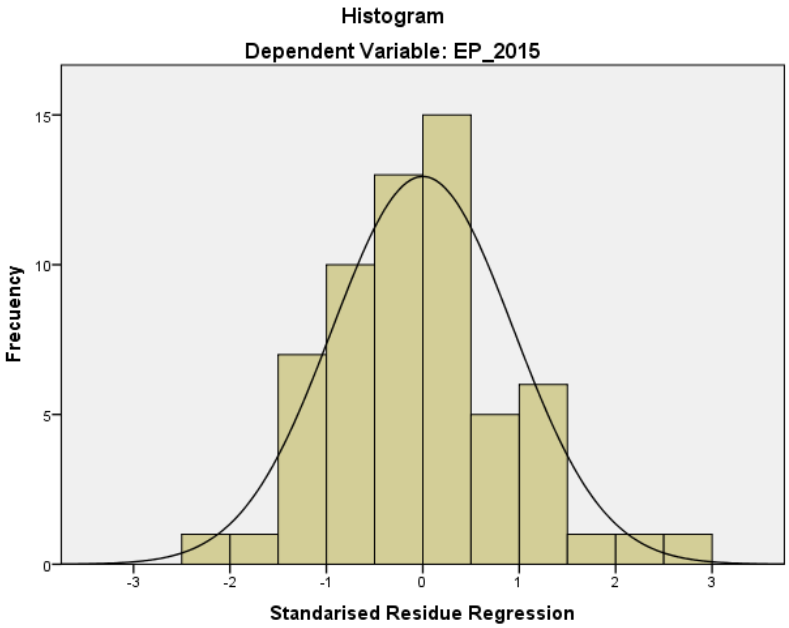
The results will be showed and discussed in the next section but after these regressions, a descriptive analysis becomes necessary in order to clarify some ideas. It will be made through the combined tables that the statistic program SPSS provides. They will show how the combination of the three practices with the business models affects the environmental performance of the airlines.

2. Results and Discussion

Once the variables have been established and the different analysis have been explained, in this section the results will be showed and a discussion of them will be made.

It is necessary to say that before the regressions, the assumptions of homocedasticity, normality and non-colinearity have been tested. The variances of the residues are uniform, they follow more or less a normal distribution as it can be seen in the Histogram (Figure 2.1), and the tolerances of the variables take values near 1, so there are no co-linearity problems, meaning that the sample matches the requirements to do the regressions (Kleimbaum et al., 1988).

Figure 2.1: Normal distribution of the sample



Source: Self-creation

As explained before, the first part of the analysis are 3 multiple regressions by blocks. In the next 3 tables, the variables introduced in each model are showed in the first column, as well as the non-standardized coefficients of each one of the variables (in bold which are significant) in the rest of the columns depending on the stage of the regression, the R^2 of the model and the increase of the R^2 regarding the previous model.

The results of the first multiple regression are showed in Table2.2. It must to be remembered that here the variables OI, SE and AL have been introduced separately.

Table 2.2: 1st Regression over the Variable "Efficiency Points" (EP_2015)

	NON-STANDARISED COEFFICIENTS VALUES		
VARIABLES	**MOD. 1**	**MOD. 2**	**MOD. 3**
PAX_2015	-0.019	0.012	0.007
ROA_2015	**0.074***	**0.084****	**0.083****
CHARTER		**10.595*****	**10.520*****
NETCARRIER †		base	base
REGIONAL		4.616	4.532
OI			1.131
SE			0.069
AL			1.067
R^2	0.056	0.278	0.283
ΔR^2		**0.222*****	0.006

* Significant at 0,10 ** Significant at 0,05 ***Significant at 0,01
†Net Carrier kept as reference

Source: Self-elaboration

In the model nº 1, the value of the R^2 indicates that the inclusion of the control variables explains just the 5.6% of the dependent variable's variance. In this model, regarding de significance level, only the control variable ROA_2015 is significant and positively related with the dependent variable at 10%.

When introducing as independent variables the business models of the companies (CHARTER, NETCARRIER and REGIONAL), the R^2 increases in 0.222, which means that this model 2 explains the variance of the dependent variable EP_2015 in a 27.8% with an error lower than 1%. In this case, the control variable ROA_2015 is still significant at 5% and it appears now that the independent variable CHARTER is significant and positively related with the EP_2015 at 1% of error. This high relation of the variable CHARTER with the environmental performance of the airlines could be due to charter airlines only offer flights when a high demand is expected, not wasting flights unless they are completed.

Within the model 3, the inclusion of the variables OI, SE and AL do not improve very much the value of the R^2, just 0.006 points and this is not significant. In this model the variables ROA_2015 and CHARTER remain significant at 5% and 1%, respectively, but none of the other variables is significant within the model. This means that the variables I am interested in for this project, these are OI, SE and AL, do not explain the environmental performance of the

airlines, it is just determined by their profitability and if they are Charter or not, in this regression.

In the second multiple regression, the independent variables OI, SE and Al are introduced in pairs, to see if a collaborative approach 2 by 2 actually affect the environmental performance of an airline. The variables resulting from this operation are the addition of the two they are talking about: SE_OI is the addition of Stakeholder Integration and Open Innovation, SE_AL is the addition of Stakeholder Integration and Alliances, and AL_OI is the addition of Alliances and Open Innovation. They will take the value 1 when the company puts into practice one of them and the value 2 if they used both (and of course the value 0 if they do not have them). The results are showed in Table 2.3.

Table 2.3: 2nd Regression over the Variable "Efficiency Points" (EP_2015)

NON-STANDARISED COEFFICIENTS VALUES			
VARIABLES	**MOD. 1**	**MOD. 2**	**MOD. 3**
PAX_2015	-0.019	0.012	0.007
ROA_2015	**0.074***	**0.084****	**0.083****
CHARTER		**10.595*****	**10.520*****
NETCARRIER †		base	base
REGIONAL		4.616	4.532
SE_OI			0.067
SE_AL			0.003
AL_OI			1.064
R^2	0.056	0.278	0.283
ΔR^2		**0.222*****	0.006

* Significant at 0,10 ** Significant at 0,05 *** Significant at 0,01
†Net Carrier kept as reference

Source: self-elaboration

The before said in the first regression, can also be stated for this second one. The values of the R^2 are the same and the independent variables that are significant are also de same for each one of the models. In the last model, the three new independent variables introduced, SE_OI, SE_AL and AL_OI, which are a combination two by two of the first ones, are still not significant, therefore, not explaining the environmental performance of the airlines.

In a last attempt to check the contribution of a combination of the three practices, I have introduced in the last multiple regression, the variable PRACTICES, which is the sum of the first three (OI, SE and AL). The results are expressed in the Table 2.4 below.

Table 2.4: 3rd Regression over the Variable "Efficiency Points" (EP_2015)

	NON-STANDARISED COEFFICIENTS VALUES		
VARIABLES	**MOD. 1**	**MOD. 2**	**MOD. 3**
PAX_2015	-0.019	0.012	0.010
ROA_2015	**0.074***	**0.084****	**0.086****
CHARTER		**10.595*****	**10.606*****
NETCARRIER †		base	base
REGIONAL		4.616	4.464
PRACTICES			0.643
R^2	0.056	0.278	0.283
ΔR^2		**0.222*****	0.006

* Significant at 0,10 ** Significant at 0,05 *** Significant at 0,01
†Net Carrier kept as reference

Source: Self-elaboration

Again, we have the same results for the R^2 values, varying a little bit the coefficients of the independent variables but not their significance. Here, the variable PRACTICES, which comprise the OI, SE and AL variables, is not significant as well, concluding that the environmental performance of an airline is not determined by its behavior regarding open innovation practices, stakeholder engagement and the belonging to an alliance.

Since the principal variables objects of the study are not significant within the model I have created, and with the control and independent variables I have taken into account, it becomes necessary to make now a descriptive analysis in order to extract some more clarifying ideas.

As stated in the previous chapter, business models directly and indirectly affect the way companies behave with their environment, which is why I have thought it would be interesting to analyze the variables object of my study classified by business model. In the aviation sector, the business model affects the environment mainly because of the definition of the flights. A Charter company just carry out the flights point to point and when has all (or almost all) the tickets sold, so the flight might be more efficient than the other traditional o regional companies, which have to operate the route whatever the number of passengers be.

Within the next tables, the average of Efficiency Points (EP_2015) will be showed for each one of these variables: OI, SE, AL, SE_OI, SE_AL, AL_OI and Practices, appearing for each business model. Besides, the number of airlines present in every category is also showed.

In the Table 2.5, it appears the information to know how Open innovation affects the environmental performance of the airlines. It must be remembered that 0 means that the airlines do not possess the characteristic and 1 means that it does.

Table 2.5: Average of Efficient Points by business model with Open Innovation

				EP_2015	
				Average	n. airlines
Charter	No	OI	No	62,3	58
			Yes	66,1	6
	Yes	OI	No	72,8	7
			Yes	**68,7**	**1**
Net Carrier	No	OI	No	69,8	10
			Yes	68,7	1
	Yes	OI	No	62,2	55
			Yes	**66,1**	6
Regional	No	OI	No	63,4	62
			Yes	66,5	7
	Yes	OI	No	62,9	3

Source: Self-elaboration

In the table we can see how, if the company is Charter, the Efficiency Point takes the value 72.8 if the airline does not have open innovation and 68.7 if the company does. This could mean that in this type of business model, the open innovation does not lead to a better environmental performance, which might be biased because this data only matches with one airline. But if we see it on the other way, when the company is not Charter, the environmental performance is better when it has open innovation processes. If the company is a Net Carrier, this issue changes. Now we have in the sample 6 airlines with the characteristic of being Net carrier and having open innovation practices and we can see that from not having open innovation to having it, the environmental performance raise almost 4 points from 62.2 to 66.1. This could be explained because the airlines with the most complex networks, this is more destinies, more flights and more connections, are those which benefit from open innovation. With a simpler structure, with point to point flights and without many tickets sale channels (as it is the case for Charter companies, which sell most of their places through tour operators), the open innovation does not have any effect over the environmental performance of the firm.

For the Regional companies, I cannot give any comment because there is no Regional airline that has open innovation practices in the sample.

When talking about Stakeholder engagement, as showed in Table 2.6, the issue does not change too much.

Table 2.6: Average of Efficient Points by business model with Stakeholder Engagement

				EP_2015	
				Average	n. airlines
Charter	No	SE	No	62,5	43
			Yes	62,9	21
	Yes	SE	No	74,2	6
			Yes	**66,4**	**2**
Net Carrier	No	SE	No	71,9	7
			Yes	65,9	4
	Yes	SE	No	**62,6**	42
			Yes	**62,7**	19
Regional	No	SE	No	64,1	48
			Yes	63,0	21
	Yes	SE	No	58,1	1
			Yes	**65,4**	**2**

Source: Self-elaboration

With Charter companies, the environmental performance goes down from 74.2 to 66.4 when the airlines actually does stakeholder engagement, but this is only for 2 companies of the sample, which does not give too much reliability. When talking about Net Carriers, the Efficiency Points are more or less stable when distinguishing between practicing stakeholder engagement or not. But with Regional companies, the environmental performance clearly is better when the airlines use stakeholder engagement; it passes from 58.1 to 65.4, although we should take these results cautiously given the simple size.

The results for Alliances are expressed in Table 2.7. Whether the company is Charter or Regional, the belonging to an alliance makes their environmental performance decrease, going from 74.6 to 68.4 and from 65.4 to 58.1, respectively. But when it is on the contrary, when the airlines are not Charter or Regional, the environmental performance increases when having alliances.

Table 2.7: Average of Efficient Points by business model with Alliances

				EP_2015	
				Average	n. airlines
Charter	No	AL	No	61,7	39
			Yes	64,1	25
	Yes	AL	No	74,6	5
			Yes	**68,4**	3
Net Carrier	No	AL	No	72,0	7
			Yes	65,8	4
	Yes	AL	No	61,5	37
			Yes	**64,3**	24
Regional	No	AL	No	63,1	42
			Yes	64,8	27
	Yes	AL	No	65,4	2
			Yes	**58,1**	1

Source: Self-elaboration

Concerning the Net Carriers, the fact of belonging to an alliance makes them to improve their environmental performance increasing the Efficiency Points in almost 3 points, being 24 companies which have alliances.

Going for the combined variables in pairs, we find that now they can take the values 0, 1 and 2. 1 is for the company that has one of the combined characteristics and 2 is if it has both at the same time.

When joining Stakeholder engagement and Open innovation, we can see (as it is showed in Table 2.8) that just 5 airlines have the combination of both practices and the 5 are Net Carriers.

Table 2.8: Average of Efficient Points by business model with Stakeholder Engagement and Open Innovation

				EP_2015	
				Average	n. airlines
Charter	No	SE_OI	No	62,4	42
			1	62,4	17
			2	65,7	5
	Yes	SE_OI	No	75,3	5
			1	67,1	3
Net Carrier	No	SE_OI	No	72,5	6
			1	66,4	5
	Yes	SE_OI	No	62,5	41
			1	62,0	15
			2	**65,7**	**5**
Regional	No	SE_OI	No	63,9	46
			1	62,9	18
			2	65,7	5
	Yes	SE_OI	No	58,1	1
			1	65,4	2

Source: Self-elaboration

It can be seen how for Net Carriers the environmental performance increases from 62.5 of not having them to 65.7 of having them both combined. It is also better having them combined to having just one of them (62.0).

The Table 2.9 contains the average of EP for the combination of Stakeholder engagement practices with the belonging to an alliance. In this case, just Regional companies do not have the combination of both.

Table 2.9: Average of Efficient Points by business model with Stakeholder Engagement and Alliances

				EP_2015	
				Average	n. airlines
Charter	No	SE_AL	No	61,3	26
			1	63,6	30
			2	63,5	8
	Yes	SE_AL	No	74,6	5
			1	72,4	1
			2	**66,4**	**2**
Net Carrier	No	SE_AL	No	74,6	5
			1	65,3	4
			2	66,4	2
	Yes	SE_AL	No	61,3	26
			1	63,6	27
			2	**63,5**	**8**
Regional	No	SE_AL	No	63,4	31
			1	63,9	28
			2	64,1	10
	Yes	SE_AL	1	62,9	3

Source: Self-elaboration

There are 2 Charter companies that have the combination SE and AL but that worsen their environmental performance. They have better Efficiency Points when using the practices separately. Centering the attention to Net Carriers, there are 8 of them that have the combination and that maintain their environmental performance in relation to having just one of them.

Almost finishing, the combination of Alliances with Open innovation is showed in Table 2.10.

Table 2.10: Average of Efficient Points by business model with Alliances and Open Innovation

				EP_2015	
				Average	n. airlines
Charter	No	AL_OI	No	61,0	34
			1	64,6	29
			2	62,1	1
	Yes	AL_OI	No	76,1	4
			1	68,5	4
Net Carrier	No	AL_OI	No	72,5	6
			1	66,4	5
	Yes	AL_OI	No	60,7	32
			1	64,9	28
			2	**62,1**	**1**
Regional	No	AL_OI	No	62,4	36
			1	65,3	32
			2	62,1	1
	Yes	AL_OI	No	65,4	2
			1	58,1	1

Source: Self-elaboration

As it can be seen in the table, there is just one company, which is Net Carrier, that has the combination of being part of an alliance and using open innovation practices, and its environmental performance increases from not having any practice to having it, 1.6 poins, not being better, for sure, than having one of these characteristics on its own.

Lastly, and to observe how the three practices at the same time affect to the environmental performance of airlines, the results with the variable PRACTICES are showed in Table 2.11. This variable is the result of the addition of the three practices and can take the values 0, 1, 2 or 3, depending on if the airline does not have any of the practices, has one of them, two or the three.

Table 2.11: Average of Efficient Points by business model with the three Practices

				EP_2015	
				Average	n. airlines
Charter	No	Practices	No	61,0	25
			1	63,3	27
			2	64,8	11
			3	62,1	1
	Yes	Practices	No	76,1	4
			1	70,6	2
			2	66,4	2
Net Carrier	No	Practices	No	76,1	4
			1	66,0	5
			2	66,4	2
	Yes	Practices	No	**61,0**	25
			1	63,3	24
			2	64,8	11
			3	**62,1**	**1**
Regional	No	Practices	No	63,1	29
			1	63,9	26
			2	65,0	13
			3	62,1	1
	Yes	Practices	1	62,9	3

Source: Self-elaboration

Analyzing this last table, it can be seen that there is just one company that has the three characteristics together and it is (again) a Net Carrier. It improves its environmental performance with the three practices from not having any (goes from 61.0 to 62.1), but it is not better than having just one or them or a combination 2 by 2.

After this analysis, it has been clear that the business model is going to determine the use of open innovation practices, stakeholder engagement processes and the belonging to an alliance in order to improve their environmental performance. Through the tables' analysis, it has been evidenced that the companies which use these practices and this actually contribute to improve their environmental performance, are Net Carriers.

Net Carriers are the so-called commercial airlines, those that have scheduled flights. Due to this issue and that are the ones which have more flights at a day, can be more aware of their environmental impacts and may have more care of their surroundings.

CHAPTER 3. CONCLUSIONS, LIMITATIONS AND FUTURE WORK

The air transport industry has always faced a sustainable development dilemma: how to deliver vital economic and social benefits while limiting or reducing its environmental impacts.

This sector has experienced an incessant increasing growth since the 1950s, with its consequent emissions increase and pollution of the environment which, although are modest compared with other sectors, are not expected to diminish in the coming years.

Despite the economic and social gain that the aviation sector provide, it also threaten the sustainability of our planet, with aircraft noise and by releasing several atmospheric emissions that reduce local air quality and deteriorate climate change, water quality and land pollution. All these effects have made this problem of high social visibility, placing this industry under the scope of analysis of policymakers, industry representatives and researchers, who have tried to face this challenge from many different ways.

From the academy level, these problems have been tackled by giving some technical improvements and solutions but those of the coordination and managerial world have been left secondly. Within the institutional sphere, the wide improvement in actions and meetings to solve environmental issues shows the need of developing their resolution not individually but through cooperation and alliances, this is, the model proposed in this final project. This is important since in security issues, for instance, they have resolved successfully the problem due to the ambient of collaboration in which it was made. Finally, from the company level, it is clear that they have done lots of efforts to achieve being more sustainable, but still remains a lot of work to do.

Environmental issues and sustainability increasingly constitute a meaningful business risk to aviation and could radically affect its growth and development. To contribute to the approach of these two -apparently- opposed forces (aviation and sustainability), I posit that some processes of collaboration and generation of shared knowledge between these three collectives may be developed in order to lead to a better, greener and sustainable aviation industry. And I think that these processes of knowledge co-creation can be approached from 3 different perspectives that simultaneously interact: the structural, that has to do with alliances and networks; the social, with the engagement of stakeholders and; the procedural, introducing the concept of open innovation.

It is important to make joint labours and sinergies to obtain environmental performance, this is alliances. Stakeholder engagement can provide a learning process among all the stakeholders of the company about environmental processes and the improvement of the evaluations. Lastly, open innovation is useful for the consolidation of environmental innovations within the value chains, where the generation of new ideas is key.

The empirical analysis of this final project have tried to check, in a first approach, if this model proposed is actually used and fits in the reality of aviation companies. Within the first part of the analysis, composed of 3 multiple regressions, it has be seen that our three practices were not significant in the model, therefore, not affecting the environmental performance of airlines. In the second part of the analysis, a descriptive study was done, deducing that the use of theses practices affects the environmental performance of the companies depending on the

kind of business model they have. After the analysis I can state that the business model which can profit the most of these practices concerning its environmental administration is Net Carrier, the most traditional business model and the most complex, with more connections and more flights.

As it has been highlighted during the project, the business model that a company has is going to mark its behaviour with its surroungings and, therefore, its environmental performance. So the level of complexity of the operations of a company determines its environmental impact and the benefit that can be obtained from the implementation of the practices proposed.

These results show the need to address the analysis of the theoretical contribution of this approach through qualitative studies on the managers responsible for environmental management in these companies. Stakeholders' relationships, the development of open innovation and the generation of alliances are new forms of management relatively innovative, and there are few companies that years ago have included these aspects in its key strategic issues as may be their vision's definition. The analysis of these practices should be approached with a qualitative approach to explore the management practices through scales empirically proven in literature.

At the same time, some limitations to this work are not having had into account all the variables that can be affecting the environmental performance of the airlines, or looking for facts of the real use of these practices in the mission and vision of the companies, as well. For this, a later survey and other field work should be made to be more accurate in the analysis. Tha sample size has been another handicap, since the regressions have been done with 72 cases, which leads to a future work: to broaden the database in order to make a more exhaustive analysis.

Another limitation of this work is its temporary nature. The analysis of business practices has been tested with success in literature when its study was conducted with longitudinal analysis observing the development of entrepreneurial skills and its effect on certain resultant variables such as environmental performance. That is why this work is a starting point for further work where the evolution of the capabilities of stakeholder integration, open innovation and alliances can be seen over different variables of business performance, especially the environmental performance and economic performance.

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