



Research Article

A Study on the Relationship between ANSP Financial Profitability and Emission Gas Values

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Abstract

During the initial quarter of the 21st century, the planet experienced a substantial shift in its climate, with the onset of a process of global heating that began to disrupt the environmental equilibrium. While a multitude of factors have contributed to this phenomenon, a significant contributing element is the substantial increase in the emission of pollutants on a national, regional and international scale. This phenomenon poses a significant challenge for nations worldwide. This paper proposes a novel econometric approach to describe European airspace with regard to emission production. To this end, the model utilises a panel regression approach incorporating variables (as GRA methodology based profitability ratios, emission values, GDP, population, labour, cargo volume, number of passengers and emission values) of Air Navigation Service Providers in continental Europe. The findings indicate a positive relationship between the formed-profitability index values and carbon dioxide and nitrogen oxide values. Specifically, a one percent increase in carbon dioxide (CO₂) emissions is associated with a 0.442 percent increase in profitability (index), while a one percent increase in nitrogen oxide (NO) is linked to a 0.174 percent increase in profitability (index) for the 2017-2020 (pre-Covid 19) period. The analysis indicates that the busiest routes or countries are those where the production of carbon dioxide and nitrogen oxide is highest. In addition to this, a conceptual map is formulated, drawing upon extant literature.



1. Introduction

The "Paris Agreement", the key outcome of the 21st meeting of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), sets out an ambitious emissions reduction path. The long-term objective of maintaining average warming well below the 20°C threshold necessitates considerable reductions in anthropogenic greenhouse gases (GHG) by mid-century (Becken & Mackey, 2017). As Larsson et al. (2018) and Şöhret (2019) note, global civil aviation accounts for 3-5% of total greenhouse gas emissions, which are increasing. According to Macintosh and Wallace (2009), international aviation carbon dioxide (CO₂) emissions are projected to rise by more than 110 per cent between 2005 and 2025. It is implausible that these emissions could be stabilised at levels consistent with risk-averse climate targets without restrictions on demand. Prussi et al. (2021) attribute this negativity to fuel or petroleum-derived jet fuel, as is the case in every industrial structure of the producing world, such as marine transportation (McCollum et al., 2010) and tourism (Scott et al., 2010). Consequently, the decarbonisation of civil aviation and the transition to petroleum-derived fuel have garnered significant attention, as corroborated by Tian et al. (2020). In addition to the aforementioned elements, Cai et al. (2019) contribute to this body of research by examining the impact of carbon dioxide, methane, nitrous oxide and fluorinated Greenhouse Gases on air pollution in China. However, the impact of these gases is not limited to the atmosphere; they also contribute to soil and water contamination. Consequently, they exert a detrimental effect on the environment and its habitats. Furthermore, according to Harrison et al. (2015), human health is adversely impacted by airport-related emissions, including those emanating from ground service equipment and road traffic. In this context, Khalili et al. (2019) propose the concept of a "climate-constrained world," a term that aligns with the work of Işık et al. (2024a). These researchers categorise environmental dimension measures as follows: renewable energy consumption, combustible renewable energy, renewable electricity output, forest area, control of air pollution, natural resources depletion, access to clean fuels and technologies for cooking and wastewater treatment. In this context, the present research can be positioned to control air pollution. Conversely, the undertaking of sustainability and air pollution research by countries and regions has been well-documented in the extant literature (Işık et al., 2024b; Mannucci & Franchini, 2017; Emberson et al., 2001). This study undertakes such analyses for European countries. The relationship between energy transformations and the economy is a subject that has been explored in various studies. For instance, Taghavi and Lee (2025) examined the relationship between exergy and economics in novel hydrogen liquefaction structures.

In an effort to address the issue of greenhouse gas emissions, national, regional and international organizations have embarked on the development of various scenarios and regulations, with the aim of establishing more stringent emission targets. For instance, Lyle (2018) has voiced criticism of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), while Ahmad (2015) has highlighted the European Union Emissions Trading System (EU ETS) and its implications for both European and aviation governance structures. Additionally, Lindenthal (2014) has underscored the European Union's leadership role in the International Civil Aviation Organization (ICAO) managerial structure with regard to environmental matters. Guo et al. (2023) categorise the Greenhouse Gas Emissions (GHGE) under various titles (e.g. CO₂ and other air pollutants) and according to their detrimental impacts on the environment in China. Tsai and Petsonk (1999) also emphasise the efforts made by international authorities to eliminate GHGE or at least their impacts on the civil aviation industry. Furthermore, Barrett (1996) asserts that the incorporation of aviation environmental charges within the context of a development process serves as a sustainability metric for GHGE. Miller (1997) emphasises the importance of technical and technological expertise in the design of aircraft and engine systems and in the conduct of civil aviation activities. The use and utilisation of new sustainable fuels are also important in the solution scheme (Stratton et al., 2010). The literature also includes regional studies. For instance, Harris et al. (2012) developed a framework for Hong Kong, which has one of the densest GHGE rates in the world. The authors argue that diminishing the negatives sourced from the aviation and shipping industries should be an aim for Hong Kong state management and governance structure. Another regional study was conducted by Ryerson et al. (2015), who asserted that effective and efficient policies from ANSPs could serve as a solution to reduce GHGE emissions in the United States' airspace. Grabar et al. (2011) and Dmitrieva (2014) designed an analysis for Russia to show the negatives sourced from GHGE as externalities of aviation activities by stating the strategic implications of emission allowance in trade credits. De Azevedo et al. (2018) conducted research in Brazil, proposing a redesign of industrial activities to achieve optimal solutions to the GHGE problem.

The present paper aims to map European airspace concerning emission values in an area where there is a paucity of research and papers on ANSPs. It will address this lacuna by investigating the relationship between gas emission and ANSP profitability. Moreover, the research develops an econometric model to explain the relationship

between the profitability values of Air Navigation Service Providers (ANSPs) in European countries and emission gases. The analysis will address the question of whether the densest airspace has the highest emission values in European airspace. This will be answered by considering the profitability to be an indicator of air space density. The initial section of the analysis will entail a comprehensive review of the extant literature. The subsequent section will encompass the data and methodology, while the conclusions, policy implications and recommendations will be outlined in the final section.

The study is subject to two limitations. The primary data resource for this analysis, EUROCONTROL, commenced the issuance of the dataset in 2017. The second restriction pertains to the acceptance of ANSP profitability as a direct measure of airspace utilisation. The second assumption is that the most financially profitable country has the densest airspace. The dataset utilised in the research is notable for its high validity and reliability. The paucity of literature on the subject of ANSP on a regional basis lends further support to the paper's value.

2. Literature review

Air Navigation Systems (ANS) are considered to be fundamental elements of modern aviation. These systems have been developed for the purpose of ensuring that aircraft are able to navigate both safely and efficiently (Bourgeois et al., 2018). Air Navigation Service Providers (ANSPs) have been identified as key contributors to enhancing aviation safety and efficiency through the provision of airspace management, flight guidance and control services (Efthymiou, 2023; Adler et al., 2020). However, as air travel, with its convenient and rapid transportation, has become increasingly popular, it has led to a rise in emissions. This increase in emissions has raised environmental concerns (Bergero et al., 2023). This situation has drawn the attention of both airlines and institutions that carry out ANSP activities. Moreover, the impact of air travel on global warming, climate change and human health (Klenner et al., 2022) has led to it becoming a matter of public concern, as evidenced by the activities of environmental activists (Elessawy et al., 2013). ANSPs are vital for aviation safety and efficiency. A balance must be struck between air traffic management and environmental sustainability goals. ANSPs should develop methods that enhance operational efficiency to reduce carbon emissions (Castelli et al., 2013; Buyle et al., 2021). For instance, the National Air Traffic Services (NATS) of the United Kingdom, as the ANSP, is set to have a positive impact on the reduction of CO₂ consumption and the deceleration of climate change through its 3Di (3-Dimensional Inefficiency Score) method (Elessawy et al., 2013). However, it should be noted that flight operations can be adversely affected by meteorological conditions. While a shorter route is typically required, various adverse conditions can change this situation. This has been shown to result in increased fuel consumption and CO₂ emissions (Klenner et al., 2022; Efthymiou, 2023). Furthermore, an increase in the number of seats and passengers on board results in a greater demand for fuel during take-off, thereby reducing the aircraft's efficiency and increasing its emission rates (Drews, 2011; Dempsey-Brench & Volta, 2018).

The following Air Navigation Service Providers (ANSP) can be listed: National Air Traffic Services (NATS), The Federal Aviation Administration (FAA), Deutsche Flugsicherung GmbH (DFS), Direction des Services de la Navigation Aérienne (DSNA), Ente Nazionale per l'Aviazione Civile (ENAV), State Airports Authority (DHMI), NAV CANADA, Departamento de Controle do Espaço Aéreo (DECEA), Japan Civil Aviation Bureau (JCAB), Civil Aviation Administration of China (CAAC), ENAIRE, AIRSERVICES AUSTRALIA et al. The optimisation of flight processes by ANSPs in countries situated along significant flight routes is projected to result in a reduction in CO₂ emissions in the future. The transportation sector is responsible for approximately 14% of global CO₂ emissions (IPCC, n.d.). In addition, the aviation sector has been responsible for approximately 2% of these emissions (Terrenoire et al., 2019; Klenner et al., 2022).

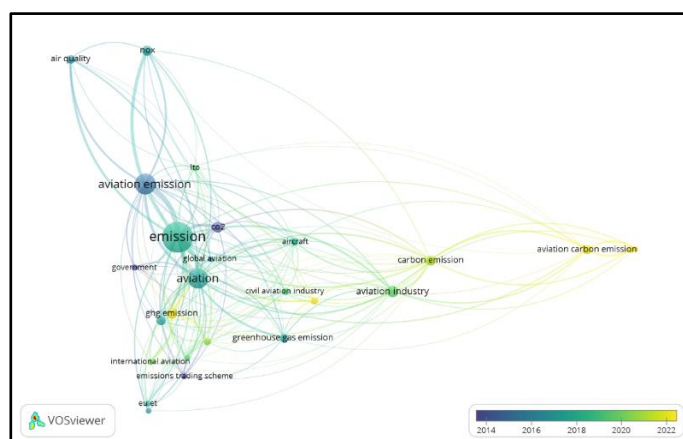


Fig. 1. Studies on Aviation and Emissions

A study was conducted using the keywords "Aviation" and "Emissions" in the Web of Science (WOS) database. Thereafter, the analysis software VOSviewer was utilised to obtain the output. The results of this study are presented in Fig. 1. The analysis revealed a notable increase in the frequency of research publications concerning aviation, carbon emissions and other emissions in recent years.

However, in the context of contemporary global conflicts, it is plausible that airlines have been compelled to select available routes rather than optimal ones, resulting in an escalation in CO₂ emissions. For instance, the Ukrainian airspace is not usable for east-west transitions. This predicament, akin to the broader context of transportation corridor routes, necessitates the identification of alternative routes, which in turn engenders augmented fuel consumption, elevated CO₂ emissions and escalating costs, factors that are of particular concern to business enterprises (Ranasinghe et al., 2019; Toraman, 2023).

3. Data and methodology

The research data were collected from the Eurocontrol website and worldbank.com between the years 2017 and 2020 for 36 European Air Navigation Service Providers (see Appendix 1). The GRA-based index values employed in the econometric analysis are drawn from Ölçen and Alnıpak (2023).

Following a comprehensive review of the extant literature, the research model is formed by the following variables. The utilisation of panel data is predicated on its superiority over time series or cross-sectional data concerning the quantity of information, variability and efficiency it contains (Baltagi, 2008; Wooldridge, 2002). The selection of variables was informed by extant literature, encompassing the population (Bartlett, 1994; Daily & Ehrlich, 1992), Gross Domestic Product (Fleurbaey & Blanchet, 2013; Liu et al., 2024) and passenger and cargo numbers (Aparicio, 2016; Song & Choi, 2020).

$$Indexvalue_{ij} = \beta_0 + \beta_1 \log_Population_{ij} + \beta_2 \log_GDP_{ij} + \beta_3 \log_Labor_{ij} + \beta_4 \log_Passenger_{ij} + \beta_4 \log_Cargo_{ij} + \beta_5 \log CO_{2ij} + \beta_4 \log NO_{ij} + \beta_4 \log METH_{ij} + \varepsilon_{ij} \quad (1)$$

Where,

Index value - the GRA results of the air navigation service providers.

Log_population - population of the country with logarithmic transformation.

Log_GDP - gross domestic production of the country with logarithmic transformation.

Log_LABOR - the active labour force of the country with logarithmic transformation.

Log_passenger - the yearly passenger number of the country with logarithmic transformation.

Log_cargo - the yearly cargo amounts with logarithmic transformation.

Log_CO₂ - carbon dioxide emissions (metric tons) with logarithmic transformation.

Log_N₂O - nitrous oxide emissions (metric tons) with logarithmic transformation.

Log_METH - methane emissions (metric tons) with logarithmic transformation.

4. Findings

Subsequent to the establishment of the research model, data pertaining to Gross Domestic Product (GDP), population, labour, cargo (in terms of volume in kilometres), passenger (in terms of head number in kilometres) and emission values (carbon dioxide, nitrous oxide and methane) are retrieved from the World Bank database. The presence of individual effects or time effects on the data is determined by conducting F-tests on the data set. The detection of these two important effects results in the selection of the two-way fixed effect regression model. However, it is acknowledged that the data may be subject to temporal constraints. The research model is subject to data limitations. Consequently, the time effect was disregarded. To this end, a range of statistical estimations have been employed, including fixed effect (FE) estimation, random effect (RE) estimation and maximum likelihood (MLE) estimation, utilising the Stata program (Yerdelen Tatoğlu, 2020). The selection between RE and FE is made using a Hausman test. The results can be found in Table 1.

Table 1. Model selection results

	Fixed effect estimation	Random effect estimation	Maximum likelihood effect estimation
F test value	5.307		
Score test			125.636
LR test (chi2_c)			14.934
Breusch Pagan LM test		20.621	
Hausman test score		40.213	
p values	0.000***	0.001***	0.000***

Pursuant to the outcomes of the model selection process, it is postulated that the fixed effect estimation results are commensurate with the continuation of the analytical process. The fixed estimation results are presented in Table 2.

Table 2. Fixed estimation results of the model

INDEX VALUE GRA	Coefficient	Std. err	T	P value
<i>Log Population</i>	-2.653	0.790	-3.36	0.001
<i>Log GDP</i>	-0.176	0.090	4.03	0.000
<i>Log Labor</i>	1.499	0.372	3.29	0.001
<i>Log Cargo</i>	-0.004	0.005	-0.87	0.387
<i>Log Passenger</i>	0.023	0.089	2.66	0.009
<i>Log CO₂ emission</i>	0.238	0.738	3.23	0.002
<i>Log NO emission</i>	0.104	0.053	1.97	0.052
Log MET	-0.066	0.062	-1.08	0.284
<i>cons</i>	10.590	4.498	2.35	0.021
R Squared values		F test Results		
<i>Within</i>	0.410	F (8,81)=7.05		prob=0.0000***
<i>Between</i>	0.028			
<i>Overall</i>	0.016			

The research model can be described and formed using the following equation:

$$\begin{aligned}
 \text{Indexvalue}_{ij} = & 10.590 + -2.653 \log_Population_{ij} - 0.293 \log_GDP_{ij} + 2.002 \log_Labor_{ij} \\
 & + 0.023 \log_Passenger_{ij} + 0.442 \log CO_{2ij} + 0.174 \log NO_{ij} + \beta_4 \log METH_{ij} + \varepsilon_{ij}
 \end{aligned}
 \tag{2}$$

According to the findings of the FRE analysis, in the absence of fluctuations in other variables, a one-percent increase in population results in a three-fourth of a percent decrease in profitability (index) values. Similarly, a one-percent rise in GDP leads to a zero-tenths of a percent decrease in profitability (index). Furthermore, a one-percent rise in labour results in a one-percent increase. The data also reveals a 499% increase in profitability (index) for every 1% increase in passenger numbers, a 0.023% increase in profitability (index) for every 1% increase in carbon dioxide (CO₂) emissions and a 0.104% increase in profitability (index) for every 1% increase in nitrogen oxide (NO) emissions, for the 2017-2020 (pre-Covid 19) period. The R-squared value was found to be 0.440 and the F-test value was found to be statistically significant. The statistical analysis indicates an absence of a significant relationship between cargo volume and methane values and GRA-based index values.

5. Discussion, conclusions and suggestions

The findings indicate that the results are consistent with the European continent's norms with respect to industrial development and development level. It can be concluded that the most profitable routes (countries) have relatively low population density, low GDP values, high labour force values, relatively high passenger values and high CO₂ and NO_x values for the research period. Consequently, if we consider the positive relationship between ANSPs (Air Navigation Service Providers) profitabilities and utilization of airspace, it can be inferred that the densest airspaces have these values. It is important to note that the research findings may be influenced by the impact of the pandemic on air traffic indicators, such as passenger and cargo numbers and emission values.

The present findings are consistent with those reported in the extant literature. Li et al. (2024) emphasise the significance of energy production and clean energy markets in this context for countries with elevated CO₂ and NO_x emissions. In a similar vein Andrejiová et al. (2020) assert that the transportation sector, encompassing air transport, constitutes a primary contributor to air pollution. This emphasis is also realised by Moffat (2010) for the shipping industry. In a detailed analysis of China, Wang et al. (2022) states that nations should have a national emissions inventory that includes information on transportation-related activities and emissions. A similar analysis of Seymore et al. (2014) for South Africa corroborates the effective and efficient use and utilisation of national emissions inventory. The utilisation of sustainable fuels and measures to decarbonise can be regarded as other significant measures (Jing et al., 2022). Another significant step in the Clean Development Mechanisms (CDM) in transportation, particularly in civil air transportation, is on the research and development agenda of the International Civil Aviation Organization (ICAO) and international authorities (Warnecke et al., 2019). Concurrent with these developments, Wang et al. (2014) posit that new generations of aircraft and engine designs incorporating sustainable components are emerging. The industry's efforts to harmonise profit and sustainability across nations, as exemplified by the SESAR (Single European Sky ATM Research) initiative, underscore the need for comprehensive air traffic optimization. The EU ETS (The European Union Emissions Trading System) has also brought the European continent to the verge of more strict and comprehensive amendments regarding the sustainability of air. Concurrently, the provisions of Annex 16 and its overarching vision, embodied by CORSIA (the Carbon Offsetting and Reduction Scheme for International Aviation), are poised to exert a profound influence on the evolution of aviation in the post-pandemic era. It is premature to draw any conclusions about the impact of this development on air quality.

It is reasonable to hypothesise that the government will be unable to reduce its transportation activities. Nevertheless, it is recommended that the government focus on enhancing its technological, technical and legal foundations to achieve sustainable objectives. The economic development of the country will be another challenge to be faced. Future research endeavours should take into account these significant factors, incorporating the impact of civil aviation at the national, regional and international levels, utilising a specialised econometric model and techniques.

Nomenclature

ANSP	: Air Navigation Service Providers
CO ₂	: Carbon dioxide
NO	: Nitrogen Oxide
MET	: Methane
EBITDA	: Earnings before Interests, Taxes, Depreciation and Amortization

OPEX	: Operational Expenditures
CAPEX	: Capital Expenditures
POPEX	: Profit per operational expenditure
PAPEX	: Profit per capital expenditure
ROA	: Return on Assets
ROD	: Return on Debts,
ROE	: Return on Equity
FCF	: Free Cash Flow
SE	: Shareholder Equity
RONOA	: Return on Operational Activity
RONIA	: Return on Investment Activity
EU ETS	: The European Union Emissions Trading System
CORSIA	: Carbon Offsetting and Reducing Scheme for International Aviation

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APPENDIX 1.

ANSP COMPANY	COUNTRY
Albcontrol	Albania
ANS CR	Czech
Fintraffic	Finland
ARMATS	Armenia
Austro Control	Austria
Avinor Flysikring	Norway
BULATSA	Bulgaria
Croatia Control	Croatia
DFS	Germany
DHMI	Türkiye
DSNA	France
EANS	Estonia
ENAIRE	Spain
ENAV	Italy
Hungaro Control	Hungary
IAA	Ireland
LFV	Sweden
LGS	Latvia
LPS	Slovak republic
LVNL	Netherlands
MATS	Malta
M-NAV	North Macedonia
MOLDATSA	Moldova
NATS	United Kingdom
NAV Portugal	Portugal
NAVIAIR	Denmark
Oro Navigacija	Lithuania
PANSA	Poland
ROMATSA	Romania
Skyguide	Switzerland
Slovenia Control	Slovenia
SMATSA	Serbia and Montenegro