Jomat

Journal of multidisciplinary academic tourism

ISSN: 2645-9078

2025, 10 (3): 297-313

https://doi.org/10.31822/jomat.2025-10-3-297

Interaction between air transportation, tourism and CO² emissions: The panel ARDL approach

Erkam Emin Ayvaz, Mevlüt Üzülmez, Didem Erşen, Hicran Ergen*

Keywords:
CO2 Emissions,
Air Transportation,
Tourism,
ARDL,
Mediterranean countries.

Article History:
Submitted: 24.09.2024
Revised:22.11.2024
Accepted: 31.08.2025
Published Online: 09.09.2025

ABSTRACT

The tourism sector is directly linked to air transportation, with air travel accounting for a large share of global travel demand. However, air transportation increases environmental impacts and poses a significant threat to sustainability due to its high carbon emissions. In this context, the relationship between tourism and air transportation is a critical area that requires the development of policies and practices to reduce the carbon footprint. This study investigates the dynamic link among tourism, air transportation and CO_2 emissions for the period 1995-2019 in 10 Mediterranean countries. To investigate the relationship between our variables, autoregressive distributed lag approach is used. According to ARDL long run estimations, it is stated that the increase air transportation increases the CO_2 emissions. Similar to air transportation, increase in tourism and economic growth results in an increase in CO_2 emissions. Finally, causality test of Dumitrescu and Hurlin is applied. Causality results stated 2 causalities between variables. There are unidirectional causalities from CO2 emissions to air transportation and from tourism to CO_2 emissions. Also, policy and further research implications are discussed regard to selected countries.

1. Introduction

The global community now seriously worries about climate change. It is commonly known that greenhouse gases (GHG), particularly the rising amount of CO_2, are the main cause of global warming (Rahaman et al., 2022). The last several decades have been witnessed a remarkable acceleration of economic activities, and there has been a rapid rise in greenhouse gas emissions along with this surge in global economic activity, (Wangzhou et al., 2022; Wei & Ullah, 2022). CO_2 emissions cause climate change by trapping heat in the atmosphere. Consequently, using or burning any fossil fuel produces some pollution. The extensive use of fossil fuels is having extremely harmful repercussions on the planet (Mohsin et al., 2022). Due to rising energy use and economic activity, carbon emissions worldwide grew until the year 2020. Because of a stronger economic growth and higher demand for heating and cooling in certain regions global energy consumption increased by 2.3% in 2018 according to the 2019 International Energy Agency report (IEA, 2019). Governments are currently being urged to present 2030 emission reduction targets at the latest UN Climate Change Conference in 2021, as they strive to achieve net-zero emissions by mid-century. To achieve the ambitious goals set forth by COP26 in 2021, countries must increase investment in renewable energy sources, hasten the transition to electric vehicles, decrease deforestation, and expedite the phase-out of coal (IEA, 2023).

Economic activities resulting environmental degradation generates pollution. These activities might be exemplified with tourism, transportation, and inbound and outbound trade. A trip taken for leisure, business, or other similar reasons that lasts no longer than a year is referred to as tourism. In the past century, the tourist sector has played a substantial role in fostering social and economic growth (Ozturk et al., 2022). Although tourism is a key driver of economic growth, empirical data also indicates that it plays a significant role in determining carbon emissions (León et al., 2014). Air travel, lodging, dining, and other tourism-related activities all require energy use and raise CO_2 emissions according to some studies such as Haseeb et al. (2018). Contrarily, some other studies thought that tourism can lead to improve environmental quality via better environmental investments such as renewable energies and green tourism policies.

As a key factor of tourism, air transportation gains importance in economic activities (Raihan et al., 2024). Especially after deregulation, air transportation has been grown implausibly. Air transportation business has been a

*Corresponding Author

Research Paper

Erkam Emin Ayvaz: Lec., Erciyes University, Kayseri, Türkiye, Email: erkameminayvaz@erciyes.edu.tr, Orcid ID: 0000-0001-8213-5117

Mevlüt Üzülmez: Res. Ass., Erciyes University, Kayseri, Türkiye, Email: mevlutuzulmez@erciyes.edu.tr, Orcid ID: 0000-0002-4606-7468

Didem Erşen: Res. Ass., Erciyes University, Kayseri, Türkiye, Email: didemover@erciyes.edu.tr, Orcid ID: 0000-0001-6349-7796

Hicran Ergen: Lec., Antalya Bilim University, Antalya, Türkiye, Email: hicran.ergen@antalya.edu.tr, Orcid ID: 0000-0003-2449-8918

*This work is licensed under a **Creative Commons Attribution (CC-BY) 4.0** License*

frequent target of criticism among experts and environmentalists for a very long time. It has experienced fast expansion and produces a sizable amount of CO_2 emissions. Between 2000 and 2020, its volume as indicated by air passenger numbers doubled (ATAG, 2020); as measured by air passenger kilometers (RPKs), it nearly doubled within a decade (IATA, 2020). Air transportation industry's abrupt growth and its transformation into an integrated industry bring environmental effects. Activities taking place at airports are an important cause of air pollution. Aircraft landing and take-off (LTO) cycles, APU, GPU and other apron vehicles, which operates 24 hours a day, constantly cause emissions (Masiol & Harrison, 2014). The main environmental effects of air transport can be listed as delays, traffic congestion, accidents, noise, and atmospheric pollution (Ekici et al., 2022; WHO, 2000).

Emissions related to air transport systems is one of the important environmental problems to be addressed (Song et al. 2023). While the share of aviation in the total emissions rate may not seem very large at first glance, it is expected that the strong growth in demand for air travel will cause this rate to increase significantly (Budd & Ison, 2017). If no action is taken, CO2 emissions from air transport are estimated to account for transport-related emissions by 23% and overall GHG emissions by 5% until 2050. In addition, the lack of a substitute method for air transportation strengthens the possibility that emissions from aviation will be a significant problem (Schlumberger, 2012; ATAG, 2022).

Besides these features, air transportation has numerous benefits such as speed, safety, reliability, comfort and easiness (Babetto et al., 2023). Air transportation also provides benefits in other sectors such as tourism, production, infrastructure and trade. Thanks to these advantages, it is preferred more than other transportation modes (Ekici et al., 2022). Between the modes of transportation, the share of land transportation has decreased from 49% to 35%, while the share of air transportation has increased from about 46% to 59% in 2000 and 2019, respectively (UNWTO, 2020).

Although each type of transportation has its own advantages and disadvantages, air transportation comes to the fore. In particular, it plays a key role for tourism in terms of converging long distances. Transport and tourism have strong relationships in tourism system. Air transportation facilitates the relocation of passengers between their place of origin and destination (Akkan and Cura, 2022). According to UNWTA (2020) report, the number of city pairs connected by air transportation has more than doubled at lower cost over the past two decades. Therefore, these two concepts are over-straightly bound each other.

Based on several reasons, the Mediterranean region is considered in this study. The Mediterranean region has a considerable impact on global tourism, air transportation, and the associated carbon dioxide (CO_2) emissions. As one of the most visited tourist destinations worldwide, the Mediterranean countries attract millions of visitors annually, thereby making a significant contribution to their economies through tourism-related activities (Hares et al., 2010). However, this influx of tourists predominantly relies on air travel, which is recognized as a significant contributor to greenhouse gas emissions. It is evident from the literature that air travel is a significant contributor to the carbon footprint of tourism, with estimates indicating that it is responsible for over 90% of emissions associated with tourism transport (Cohen & Higham, 2011). The aviation sector, particularly long-haul flights, is responsible for a disproportionate share of these emissions. Indeed, some studies have highlighted that long-distance travel can account for up to 64% of all travel emissions (Ben-Ari, 2024). The Mediterranean countries are crucial to global tourism and air transportation, but this comes with significant environmental costs in terms of CO2 emissions. Addressing these challenges requires a concerted effort to promote sustainable travel options and enhance awareness of the environmental impacts of air travel among tourists and stakeholders alike (Larsen & Guiver, 2013).

This study is unique from others in that it is the first of its kind to investigate the dynamics between CO2 emissions, air transport, economic growth, and tourism in Mediterranean countries using panel data of 10 countries (Turkiye, Spain, Italy, Egypt, Cyprus, Malta, Croatia, Morocco, Israel and Lebanon) covering the years 1995–2019. It does this by using panel Dumitrescu and Hurlin causality and the autoregressive distributed lag (ARDL) econometric methods. Primary contribution of this study has two parts. Model specification novelty of the study comes first and foremost. There is a lack of existing literature about air transportation and CO2 emissions. There is not much research in literature examining the dynamics among air transport and environmental contamination using econometric approaches. To the best of our knowledge, the dynamics among tourism, air transportation, and environmental pollution has never been directly investigated in the literature; therefore, this research is covered for the first time in this work. In this study, we use people who were transported by air. Secondly, our choice of proxy differs from other studies in literature. To gather much more reliable results, we selected tourist numbers rather than a tourism receipts or tourism revenue percentage. Also, selecting Mediterranean countries is vital for tourism related research because of charming environment and cultural richness of the region.

The study proceeds with a review of the literature, data, model specification, empirical findings, conclusions, and discussion.

2. Literature Review

Tourism and CO2 emissions

Tourism and CO2 emissions are frequently debated in the literature. Katircioglu et al. (2014) used tourism-induced models to establish a long-term causal connection in Cyprus. The simulations show that tourism significantly affects CO2 emissions. Al-Mulali et al. (2015) examined how transportation-related tourism affects CO2 emissions in 48 nations. Countries were grouped by region. Analysis showed that tourism arrivals had a major impact on CO2 emissions in all areas except Europe. Dogan & Aslan (2017) examined tourism, real income, carbon emissions, and energy consumption using heterogeneous panel estimate. The investigation showed a one-way link among CO2 and tourism. Paramati et al. (2018) examined tourist investment's influence on CO2 emissions and tourism development in 28 EU areas from 1990 to 2013. Evidence indicated tourist investment positively and negatively affected both factors. Balli et al. (2019) examined panel data on economic development, tourism, and CO2 emissions. Analysis showed a long-term link between variables. Tourism raised carbon dioxide and boosted economic expansion. Eyuboglu & Uzar (2020) used 3 cointegration to investigate energy consumption, CO2 emissions, economic growth, and tourist arrivals in Türkiye from 1960 to 2014. Long- and short-term connections were observed between factors. Koçak et al. (2020) examined how CO2 emissions affected tourism in the most visited nations from 1995 to 2014. For analysis, CUP-FM and CUP-BC estimators were utilized. tourist receipts had a decreasing influence on CO2 emissions, whereas tourist arrivals had a significant impact. Kumail et al. (2020) investigate Pakistani CO2 emissions and economic development, foreign tourism, and innovation from 1990 to 2017. This study found a bidirectional association between CO2 emissions and tourism. Selvanathan et al. (2020) used ARDL, VECM models to evaluate South Asian economic development, CO2 emissions, energy consumption, and tourism from 1990 to 2014. Tourism increased long-term CO2 emissions, according to the study. Uzuner et al. (2020) used non-linear ARDL model and Hatemi-J causality technique to study CO2 emissions-tourism asymmetry in Türkiye from 1970 to 2014. The findings show an unbalanced long-term association between the variables. Leitão & Lorente (2020) studied the correlation between tourism, CO2 emissions, economic growth, and renewable energy in 28 EU countries. We used FMOLS, DOLS, and GMM estimators. Results indicate tourism arrivals reduce CO2 emissions. This indicated that tourist sustainability studies helped the environment. Aslan et al. (2021) examined energy consumption, tourism, CO2 emissions, and economic development. Panel quantile regression was used in this investigation. This model found sustainable growth based on CO2 coefficient at modest growth levels. Zhang & Zhang (2021) used VECM to explore short- and long-term variable connections in 30 Chinese areas from 2000 to 2017. CO2 emissions and tourism had a long-term bidirectional link. Rahaman et al. (2022) examined Bangladesh's 1990–2019 CO2 emissions from tourism, economic development, foreign direct investment, and power use. Tourism had long-term positive and negative effects on CO2 emissions. Ozturk et al. (2022) used FMOLS and DOLS to study Saudi Arabia's economic development, pilgrimage tourism, CO2 emissions, and energy consumption from 1968 to 2017. The findings found unidirectional causation between pilgrimage tourism and CO2 emissions. Rahman et al. (2022) used ARDL and how tourism, foreign labor, and energy consumption affected Malaysian CO2 emissions. As a result, tourist arrivals had a favorable influence on CO2 emissions. Salahodjaev et al. (2022) examined the renewable tourism - CO2 emissions -energy nexus in Central Asia and Europe from 1990 to 2015. Tourism reduced CO2 emissions, the research found. Wangzhou et al. (2022) examined Asian CO2 emissions and tourism from 1995 to 2019 using NARDL-AMG panel models. Both positive and negative shocks boosted CO2 emissions in tourism. Wei & Ullah (2022) used FMOLS, DOLS models for Asian economies to study how digital infrastructure and tourism affect environmental quality. In the models, both factors improved environmental quality. Ravinthirakumaran & Ravinthirakumaran (2022) examined CO2 emissions and tourism in 20 APEC economies from 1995 to 2017 using heterogeneous panel estimate. Tourism reduced CO2 emissions, according to assessments. Fan et al. (2022) used ARDL to examine Mexico's 1996–2018 CO2 emissions, tourism, and health spending. Tourism increased CO2 emissions. Health costs soared as a result. Leito & Lorente (2020) examined tourism and CO2 emissions in EU member states from 1995 to 2014. They found that tourism increased CO2 emissions using FMOLS, DOLS, and GMM. Mehmood et al. (2021) found that tourism reduced CO2 emissions in Sri Lanka, Bangladesh, and Nepal from 1995 to 2016. Tourism decreased carbon dioxide emissions in 37 Asian nations between 1996 and 2019 utilizing POLS, FMOLS, and DOLS, according to Wei and Ullah (2022). Eyuboglu & Uzar (2020) discovered that tourism reduced CO2 emissions in Türkiye between 1960 and 2014 using ARDL, FMOLS, DOLS, and CCR methods. Another study, Kumail et al. (2020), found that tourism reduced Pakistan's CO2 emissions between 1990 and 2017. Tourism reduced carbon dioxide emissions in EU member states between 1990 and 2013, according to Paramati et al. (2018). In another study, Selvanathan et al. (2021) found that South Asian nations' CO2 emissions rose with tourist arrivals from 1990 to 2014. According to Uzuner et al. (2020), tourism in Türkiye increased with CO2 emissions from 1970 to 2014. Based on substantial 1995–2019 Asian data, Wangzhou et al. (2022) prove tourism reduces CO2 emissions. In the study of Wu et al. (2023) about tourism and energy related CO2 emissions in China between 2014 and 2019, shows that tourism activities cause increase in CO2 emissions via tourism related transportation activities.

Pata et al. (2023) indicates that an increase in tourism leads to an increase in CO2 emission in ASEAN countries between 1995 and 2018 by using panel ARDL and DH causality approaches. In their study of literature review, Segarra et al. (2024) indicates that there are different results based on the countries and variables used in the studies. This review study shows that there is a gap and the need for further studies about tourism-related emissions in different context with different approaches. Using LMDI and PVAR approaches, Yan and Phucharoen (2024) denotes that a decrease in tourism leads to a decrease in CO2 emissions in China. Bandyopadhyay et al. (2023) also indicates an increase in tourism lead to an increase in CO2 emissions in India by using ARDL approach.

Tourism and CO2 emissions are frequently debated in the literature. Katircioglu et al. (2014) used tourism-induced models to establish a long-term causal connection in Cyprus. The simulations show that tourism significantly affects CO2 emissions. Al-Mulali et al. (2015) examined how transportation-related tourism affects CO2 emissions in 48 nations. Countries were grouped by region. Analysis showed that tourism arrivals had a major impact on CO2 emissions in all areas except Europe. Dogan & Aslan (2017) examined tourism, real income, carbon emissions, and energy consumption using heterogeneous panel estimate. The investigation showed a one-way link among CO2 and tourism. Paramati et al. (2018) examined tourist investment's influence on CO2 emissions and tourism development in 28 EU areas from 1990 to 2013. Evidence indicated tourist investment positively and negatively affected both factors. Balli et al. (2019) examined panel data on economic development, tourism, and CO2 emissions. Analysis showed a long-term link between variables. Tourism raised carbon dioxide and boosted economic expansion. Eyuboglu & Uzar (2020) used 3 cointegration to investigate energy consumption, CO2 emissions, economic growth, and tourist arrivals in Türkiye from 1960 to 2014. Long- and short-term connections were observed between factors. Koçak et al. (2020) examined how CO2 emissions affected tourism in the most visited nations from 1995 to 2014. For analysis, CUP-FM and CUP-BC estimators were utilized. tourist receipts had a decreasing influence on CO2 emissions, whereas tourist arrivals had a significant impact. Kumail et al. (2020) investigate Pakistani CO2 emissions and economic development, foreign tourism, and innovation from 1990 to 2017. This study found a bidirectional association between CO2 emissions and tourism. Selvanathan et al. (2020) used ARDL, VECM models to evaluate South Asian economic development, CO2 emissions, energy consumption, and tourism from 1990 to 2014. Tourism increased long-term CO2 emissions, according to the study. Uzuner et al. (2020) used non-linear ARDL model and Hatemi-J causality technique to study CO2 emissions-tourism asymmetry in Türkiye from 1970 to 2014. The findings show an unbalanced long-term association between the variables. Leitão & Lorente (2020) studied the correlation between tourism, CO2 emissions, economic growth, and renewable energy in 28 EU countries. We used FMOLS, DOLS, and GMM estimators. Results indicate tourism arrivals reduce CO2 emissions. This indicated that tourist sustainability studies helped the environment. Aslan et al. (2021) examined energy consumption, tourism, CO2 emissions, and economic development. Panel quantile regression was used in this investigation. This model found sustainable growth based on CO2 coefficient at modest growth levels. Zhang & Zhang (2021) used VECM to explore short- and long-term variable connections in 30 Chinese areas from 2000 to 2017. CO2 emissions and tourism had a long-term bidirectional link. Rahaman et al. (2022) examined Bangladesh's 1990–2019 CO2 emissions from tourism, economic development, foreign direct investment, and power use. Tourism had long-term positive and negative effects on CO2 emissions. Ozturk et al. (2022) used FMOLS and DOLS to study Saudi Arabia's economic development, pilgrimage tourism, CO2 emissions, and energy consumption from 1968 to 2017. The findings found unidirectional causation between pilgrimage tourism and CO2 emissions. Rahman et al. (2022) used ARDL and how tourism, foreign labor, and energy consumption affected Malaysian CO2 emissions. As a result, tourist arrivals had a favorable influence on CO2 emissions. Salahodjaev et al. (2022) examined the renewable tourism - CO2 emissions -energy nexus in Central Asia and Europe from 1990 to 2015. Tourism reduced CO2 emissions, the research found. Wangzhou et al. (2022) examined Asian CO2 emissions and tourism from 1995 to 2019 using NARDL-AMG panel models. Both positive and negative shocks boosted CO2 emissions in tourism. Wei & Ullah (2022) used FMOLS, DOLS models for Asian economies to study how digital infrastructure and tourism affect environmental quality. In the models, both factors improved environmental quality. Ravinthirakumaran & Ravinthirakumaran (2022) examined CO2 emissions and tourism in 20 APEC economies from 1995 to 2017 using heterogeneous panel estimate. Tourism reduced CO2 emissions, according to assessments. Fan et al. (2022) used ARDL to examine Mexico's 1996–2018 CO2 emissions, tourism, and health spending. Tourism increased CO2 emissions. Health costs soared as a result. Leito & Lorente (2020) examined tourism and CO2 emissions in EU member states from 1995 to 2014. They found that tourism increased CO2 emissions using FMOLS, DOLS, and GMM. Mehmood et al. (2021) found that tourism reduced CO2 emissions in Sri Lanka, Bangladesh, and Nepal from 1995 to 2016. Tourism decreased carbon dioxide emissions in 37 Asian nations between 1996 and 2019 utilizing POLS, FMOLS, and DOLS, according to Wei and Ullah (2022). Eyuboglu & Uzar (2020) discovered that tourism reduced CO2 emissions in Türkiye between 1960 and 2014 using ARDL, FMOLS, DOLS, and CCR methods. Another study, Kumail et al. (2020), found that tourism reduced Pakistan's CO2 emissions between 1990 and 2017. Tourism reduced carbon dioxide emissions in EU member states between 1990 and 2013, according to Paramati et al. (2018). In another study, Selvanathan et al. (2021) found that South Asian nations' CO_2 emissions rose with tourist arrivals from 1990 to 2014. According to Uzuner et al. (2020), tourism in Türkiye increased with CO_2 emissions from 1970 to 2014. Based on substantial 1995–2019 Asian data, Wangzhou et al. (2022) prove tourism reduces CO_2 emissions. In the study of Wu et al. (2023) about tourism and energy related CO_2 emissions in China between 2014 and 2019, shows that tourism activities cause increase in CO_2 emissions via tourism related transportation activities. Pata et al. (2023) indicates that an increase in tourism leads to an increase in CO_2 emission in ASEAN countries between 1995 and 2018 by using panel ARDL and DH causality approaches. In their study of literature review, Segarra et al. (2024) indicates that there are different results based on the countries and variables used in the studies. This review study shows that there is a gap and the need for further studies about tourism-related emissions in different context with different approaches. Using LMDI and PVAR approaches, Yan and Phucharoen (2024) denotes that a decrease in tourism leads to a decrease in CO_2 emissions in China. Bandyopadhyay et al. (2023) also indicates an increase in tourism lead to an increase in CO_2 emissions in India by using ARDL approach.

Air transportation and CO2 emissions

Studies from all around the world such as Italy, China, Turkey, U.S., England, and Greece clearly point that there is a high amount of air pollution in and around the airport (Moussiopoulos et al., 1997). Air transportation significantly contributes to air pollution, as evidenced by emission calculations and quality control procedures on a per-flight basis (Hu, et al., 2009; Zhou, et al., 2019; Shirmohammadi, et al., 2017). In the study conducted in 2021, which analyzed air pollution between 2013 and 2019, Lin et al. (2021) observed that the rate of air pollution is higher in the winter period in many sectors, including the aviation sector. For the last few decades many studies examine air transport sector's impact on air pollution using different values (Gürçam et al., 2021; Schlenker & Walker, 2015; Stettler, Eastham, & Barrett, 2011; Grote, Williams, & Preston, 2014; Chen et al., 2021). Landing and take of (LTO) cycle, APU, GPU, apron vehicle traffic and ground handling activities are marked as main causes of air pollution during airline operations (Masiol & Harrison, 2014; Gürçam et al., 2021; Christodoulakis, et al., 2022; Vichi, et al., 2016; Hsu, et al., 2013). Number of aircraft in the air has increased with the reduction of aircraft sizes in order to increase the frequency of flights. Although individually, the emission rate is higher in wide-body aircraft compared to narrow-body aircraft, because of the number of flights increases, emission rate is getting higher (Givoni & Rietveld, 2010). Studies also indicate that the increase in flights increases the delay and taxi times, which triggers the increase in emissions (Schlenker & Walker, 2015). Furthermore, data obtained by toxic monitoring programs revealed that jet fuels cause a high amount of air pollution due to their physical and chemical contents (Tesseraux, 2004). It was also emphasized that this situation adversely affected the people's life quality who lives around the airport (Cohen et al., 2007). Report, sponsored by international aviation organizations, stated that there are many pollutants and air toxic criteria emitted by aircraft and other airport sources, and projects are developed to reduce them (Levy et al., 2008). Since emission rate is quite high in airline operation, some studies also recommended to develop special electric vehicles that will follow the aircraft after landing and until takeoff and use alternative transportation modes besides air transportation in order to reduce emission (Christodoulakis, et al., 2022; Corazza et al., 2022). Reducing the number of flights by regulations will also reduce the pollution, but sector stakeholders do not have a positive look on that (Grote et al., 2014). In another study, to reduce air pollution, more suitable flight times, taxation and altitude solutions were offered (Ekici et al., 2022). Jahanger et al. (2024) indicates that air transportation leads to an increase in environmental pollution in G7 countries using MMQR approach with data spanning from 1994 to 2020. Similarly, Song et al. (2023) indicates a causality from air transportation to CO_2 emissions in South Korea between 2010 and 2018 using Granger causality analysis. In their study on G7 countries, Erdogan et al. (2024) indicates that air transportation demand shows an incremental effect on CO_2 emission by 0,04-0,12% using FMOLS approach. Contrarily, Akbulut Yıldız and Yıldız (2024) reveals a negative relationship between air freight transportation and CO_2 emissions by 0,02% in G5 countries using AMG approach. These results also indicates the need for further studies in the context of different panel groups or time series across countries.

Air transport has a very important place for international tourism, which is very preferred for traveling long distances. Hussain (2023) has conducted a Granger causality test, which using data between 1996 and 2020, bidirectional relationship confirmed among outbound and inbound tourism and air transportation. So, developments in air transportation are directly affected by the development of tourism (Madurapperuma & Higgoda, 2022). The opposite is also possible (Dinu, 2018). Therefore, tourism and air transport are linked (Duval, 2013; Graham & Frederic, 2019; Robinson et al., 2020). Air transportation handles globally 58% of international tourists and impact economically including indirect and direct activities related to tourism was estimated at $3.5 trillion (ATAG, 2020). In addition, air transport increases the economic value of touristic destinations (Seetaram et al., 2013). So, it is quite fair to reach the conclusion that air transport is a necessity for the development of tourism (Balsalobre-Lorente et al., 2019). Since tourism is so vital for air transportation, even The International Air Transport Association (IATA) takes tourism impact of COVID-19 into consideration while making estimation on future air traffic (Pearce, 2020). In another study which investigating the social and economic effects of the air transportation on tourism observed that the aviation industry increased economic employment and had an induced impact on industrialization (Abdullahi et al., 2018). It has been also observed in many studies that the airline industry is effective in tourism policies (Liasidou et al. 2022). Moreover, while determining tourism policies, it is necessary to establish close ties with airline companies (Liasidou, 2017). Air transport and tourism are an area with different and relatively unexplored paths which should be explored perpetually (Papatheodorou, 2021).

3. Methodology

In this section, the data used in the study, model specification and methodologies are given. In the data section, brief information about data is given. In model specification section, function and econometric model are given. In the methodology section, methods and techniques used in the study are given respectively.

Table 1 – Sources of Data

Variables	Proxies	Sources
CO_2 Emissions	CO_2 emissions from liquid fuel consumption (kt)	Word Databank WDI
Air Transportation	Passengers carried	Word Databank WDI
Tourism	International tourism, number of arrivals	Word Databank WDI

Source: Authors' own elaboration

Data

In this study, which examines the dynamics between air transportation, carbon emissions, and tourism, we use data from 10 Mediterranean countries (Turkiye, Spain, Italy, Egypt, Cyprus, Malta, Croatia, Morocco, Israel and Lebanon) for the years 1995 to 2019. Independent and dependent variables are listed in Table 1. As an indicator of air transportation, passengers number carried via air transportation obtained from World Databank database.

Table 2 – Descriptive Statistics

	CO_2	AIR	TOUR
Mean	61587.40	13072317	23735907
Median	27157.80	4109489	6777000
Max	265006.8	1.00E+08	1.16E+08
Min	1342.122	644.1000	424000.0
Std. Deviation	70057.54	19096663	30276456
Skewness	1.339024	2.043195	1.255911
Kurtosis	3.808225	7.149665	3.346248
Jarque-Bera	70.75262	306.6780	58.13015
Probability	0.000000	0.000000	0.000000
Observations	217	217	217

Source: Authors' own elaboration

The World Bank database is also used to provide information on CO2 emissions and tourism. The fundamental analysis model includes each variable logarithmically. Descriptive statistics of the study is given in Table 2.

3.2. Model Specification

In this paper, the link between air transport, carbon emissions, economic growth, and tourism are considered for the first time to our knowledge, so we have also considered the similar studies (Shakouri et al., 2017; Katircioglu et al., 2014; Ozturk et al., 2022) in the definition of the model. The function used in this paper is comparable to that of Ozturk et al. (2022):

$$CO_2 = f(AIR, TOUR, GDP) \qquad (1)$$

The explanatory factors are, respectively, the number of tourists (TOUR) and air transportation (AIR), and the response variable is CO_2 (CO2). The primary hypothesis in the scope of the model chosen is that air travel, economic growth and tourism will affect air pollution in a positive direction. The following describes the econometric model created using Equation (1):

$$lnCO_{2t} = \beta_0 + \beta_1 lnAIR_t + \beta_2 lnTOUR_t + \beta_3 lnGDP_t + \mu_t \qquad (2)$$

where t stands for a time series (1995-2019). Later, μ_t denotes the estimation residual. Each β indicates the coefficient of slope of the respective variable. A logarithmic analysis is performed on each variable.

Methodology

The initial stage in our study is examining whether the series are stationary. The IPS and LLC tests, which were first presented by Im et al. (2003) and Levin et al. (2002), are utilized in this work in order to conduct an exhaustive investigation into the stationarity characteristics of the series. The most often used tests appear to be IPS and LLC, with LLC being the most popular method. Based on the ADF test, it is assumed as a homogenous group. Equation (3) below shows the basics of LLC test method:

$$Y_{it} = \rho_i Y_{it-1} + z_{it} Y + u_{it} Y = 1 \dots N; = 1 \dots T \qquad (3)$$

In this equation, z_{it} represents a constant such as zero or one, a fixed impact, or a time trend, u_{it} represents the stationary process, and Y_{it} represents the dependent variable. Residuals have a mean of zero and equal variance for all i values according to the LLC test. The variable which is dependent of lag' coefficient is assumed to be homogeneous in the entire panel cross-section. The null hypothesis, H0: ρ=1, states unit root in all series. The other hypothesis, H1: ρ<1, asserts that all series are stationary.

The IPS test, developed by Im et al. (2003), is a variant of the LLC test which accounts for heterogeneity in the autoregressive coefficients for all panel members, thereby relaxing the homogeneity assumption. This approach demonstrates a clear understanding of the complexities involved in panel data analysis and showcases the authors' expertise in the field. The following equation (4) is the fundamental formula for the IPS panel unit root tests:

$$\Delta Y_{it} = \alpha_i + \rho_i Y_{it-1} + \sum_{j=1}^{p} \varphi_{ij} \Delta Y_{it-j} + \varepsilon_{it} \quad i = 1,2 \ldots, N; t = 1,2, \ldots, N \tag{4}$$

Where p is chosen to make the residuals uncorrelated over time, Y_{it} stands for each variable being considered in our model, for all i and t, it is confidently assumed that ε_{it} is a random variable with a normal distribution. It is independent of each other, with zero means and finite heterogeneous variance. The individual fixed effect is confidently denoted by α_i. The alternative hypothesis suggests that $\rho_i < 0$ for some i=1,...,N1 and ρ_i=0 for i=N1+1,...,N, while the null hypothesis assumes that $\rho_i = 0$ for all i.

The Pedroni cointegration test (1999, 2004) is used to examine long-term variable cointegration. The series' stationary was tested using LLC and IPS unit root tests first. The Pedroni cointegration test has been used to identify long-term variable integration in several research (Khan et al., 2022; Musa, Safdar, Shah, 2022). Pedroni (1999, 2004) constructed seven test statistics to evaluate the null hypothesis that nonstationary panels contain no cointegration. The Pedroni cointegration test only works for stationary variables at first difference. The panel's seven test statistics account for short-run dynamics and long-run slope and intercept coefficient variations. Traditional time-series analysis considers normalization and cointegrating relationships, whereas this tool does not. The hypothesis test evaluates panel cointegration between variables.

The seven-test metrics are divided into statistics of group-mean, which sum up the outcomes for each nation, and panel measures, which aggregate the results for each aspect. This allows for a comprehensive assessment of the performance of different countries in various aspects. Both groups used parametric (ADF and v) and nonparametric (ρ and t) metrics. Pedroni panel cointegration test equation is given in the Equation 5 below:

$$\boldsymbol{lnCO_{2it} = \alpha_{it} + \delta_{it} + \beta_{1i} lnAIR_{it} + \beta_{2i} lnTOUR_{it} + \beta_{3i} lnGDP_{it} + \varepsilon_{it}} \tag{5}$$

where i=1,...,N denotes the panel's participants (10 Mediterranean nations), t=1,...,N denotes the time frame (1995-2019), CO_2 denotes CO_2 emissions, AIR denotes air transportation, TOUR denotes tourism, and $\boldsymbol{\beta}$ denotes the slope of the coefficients. The individual impacts are denoted by the parameter $\boldsymbol{\delta_i}$ which stands for the deterministic trend effects. Finally, $\boldsymbol{\alpha_i}$ is used to represent the predicted residual deflections from the long-term connection.

At the following stage, provided that the cointegration relation has been established, the coefficients are estimated. The ARDL bounds test method, developed by Pesaran et al. (2001), is utilized to investigate long-run and short-run equilibrium and the presence of co-integration in the time series data under consideration. The ARDL specification, which has a linear structure, has been widely used by academics to examine the relationship between variables (Korkut Pata & Balsalobre-Lorente, 2022; Avishek Khanal et al., 2022; Aydin, 2022; Bandyopadhyay et al., 2023; Fan et al., 2022; Mehmood et al., 2022). This passage highlights the importance of utilizing the ARDL approach to analyze the complex relationships between multiple variables. The ARDL model is used to estimate both the long- and short-term coefficients simultaneously. Compared to other single cointegration techniques, ARDL offers several advantages. Firstly, it is flexible in terms of variables' stationary properties, which can be a combination of stationary in level or in first difference. Secondly, despite the small sample size, the ARDL technique can produce more reliable and consistent data (Liu & Bae, 2018). Additionally, the technique allows for the simultaneous evaluation of long- and short-run coefficients of one variable on another (Sikder et al., 2022). The short-term coefficients depict the relationship between the dependent variable's divergence from its long-run trend. The ARDL method can be suitably employed to evaluate the impact of estimates derived from the long-run association of variables. This method carries the added advantage of incorporating a bootstrap bias-correction procedure. Moreover, it comprises functional elements of the conditional error correction model coefficients that exhibit nonlinearity. To identify a long-term relationship, we create the following equation:

$$\boldsymbol{\Delta lnCO_{2t} = \alpha_0 + \sum_{i=1}^{q} \alpha_1 \Delta lnCO_{2t-i} + \sum_{i=1}^{q} \alpha_2 \Delta lnAIR_{t-i} + \sum_{i=1}^{q} \alpha_3 \Delta lnTOUR_{t-i} + \sum_{i=1}^{q} \alpha_4 \Delta lnGDP_{t-i} + \varepsilon_t} \tag{6}$$

where the word for pure white noise $\boldsymbol{\varepsilon_t}$ and the first difference operator Δ are both present. The model's ARDL (3,3,3,3) model was estimated with a maximum lag duration of 3. The long-term and short-term coefficients based on the estimation results of the ARDL (3,3,3,3) model are shown in Table 5.

Finally, to determine the causal relationship between variables, the Dumitrescu and Hurlin causality analysis developed by Dumitrescu & Hurlin (2012) is used. This approach is advantageous because it accounts for the presence of sectional dependencies among the member countries of the panel (Dumitrescu and Hurlin, 2012).

4. Empirical Results

An analysis of stationary variables was first performed. The Table 3 presents the results of the Levin, Lin and Chu (LLC) and Im, Pesaran and Shin (IPS) unit root tests. The LLC test results indicate that the CO2 variable is non-stationary at the level but becomes stationary at the 1% significance level when the first difference is taken. Similarly, the AIR, TOUR and GDP variables are generally stationary at the level according to the LLC test. However, in some test conditions (in models with constant and trend), evidence of non-stationarity was also observed for these variables. The IPS test indicates that the CO2 and GDP variables are not stationary at the level. However, when first differences are taken, all variables (CO2, AIR, TOUR and GDP) become stationary at the 1% significance level. The results indicate that CO2 and GDP are integrated at first order (I(1)), whereas the remaining variables are stationary at level or first difference. Consequently, the first differences of the non-stationary variables were taken and included in the analysis during the modelling phase.

Unit root tests denotes that the coefficient and cointegration estimation techniques applied in the study satisfy the requirement that each of the three variables is stationary-at-first difference. The cointegration findings presented in the Table 4. Based on the Pedroni cointegration test results, nine out of the eleven discoveries had a significant probability at a level of 1%. The collected data was found to be cointegrated, and the null hypothesis was ruled out. The ARDL was then used to analyze the long-term association between the factors.

In order to analyze the factors that affect CO_2 emissions, we use the panel ARDL-PMG technique. The panel results are figured in Table 5. Based on the ARDL-PMG results, all computed coefficients are determined to be significantly statistically valid. Overall, long-term data show that the number of air transportation, tourism and economic growth are all pretend as a contributor to rising CO_2 emissions for the chosen panel of nations. The short-term analysis shows that the AIR coefficient is not statistically significant in the link among air transportation and the environmental degradation. However, at the 1% significant in the long term. An increase of 1% in air passengers leads to a 0.05% increase in carbon dioxide emissions in the long term. Our long-term result is in line with Demir (2022) on United Kingdom, Shirmohammadi et al. (2017) on United States, and Zhou et al. (2019) on China. As expected, tourist arrival's increase by 1% increase CO_2 emissions by 0.14%. The result is in line with Selvanathan et al. (2020) and Wangzhou et al. (2022).This long-term outcome is not consistent with ben Jebli et al. (2019) in South and Central America, Lee & Brahmasrene (2013) on nations in the European Union, and Katircioğlu (2014) on Singapore. Our findings, however, conflict with those of Koçak et al. (2020) for the most visited nations, Eyuboglu & Uzar (2020) about Turkiye, and Ozturk et al. (2022) regarding Saudi Arabia. Also, economic growth contributes to an increase in CO2 emissions by 0.71% in the long term. The result is in line with the literature (Işık et al., 2024; Zhang and Sharifi, 2024; Alam and Hossain, 2024)

The study continues by employing known as DH causality technique to examine the causal link between the variables, subsequent to coefficient estimation. The results are shown in Table 6. The Dumitrescu-Hurlin causality analysis offers significant advantages in econometric research, particularly in the context of heterogeneous panel data. This method allows for the examination of causal relationships across different cross-sectional units, accommodating variations in both the structure and behavior of the data. For instance, Kacemi and Hassan (2018) highlight that the Dumitrescu-Hurlin test accounts for heterogeneity in the panel, which enhances the robustness of the causal inference compared to traditional Granger causality tests that assume homogeneity across units. Similarly, Bozkurt et al. (2021) demonstrate its application in tourism economics, where the test effectively identifies causal links between demand and exchange rate shocks, revealing insights that are crucial for policymaking.

The estimates of probability in Table 6 demonstrate the presence of three causal relationships. Firstly, air transportation has a one-way causal relationship with carbon dioxide emissions. This result is in line with Arvin et al. (2015). On the other hand, our result is contrary to Saleem et al. (2018) which found no causality between air transportation and carbon dioxide emissions. Secondly, CO2 emissions cause a unidirectional increase in the number of tourist arrivals. This result is partly in line with Bandyopadhyay et al. (2023) which determined a bi-directional causality between tourism and CO_2 emissions. Also, Ozturk et al. (2022) supports our result of causality. It is contrary to results of Raihan & Tuspekova (2022), and Pata et al. (2023). Our result might be commented like that metropoles which produce carbon dioxide emissions pull more tourism activities to countries. Finally, tourism has been found to have a unidirectional causality with air transportation. As expected, number of tourist arrivals leads to air transportation because of transportation needs of tourism activities.

An analysis of stationary variables was first performed. The Table 3 presents the results of the Levin, Lin and Chu (LLC) and Im, Pesaran and Shin (IPS) unit root tests. The LLC test results indicate that the CO2 variable is non-stationary at the level but becomes stationary at the 1% significance level when the first difference is taken. Similarly, the AIR, TOUR and GDP variables are generally stationary at the level according to the LLC test. However, in some test conditions (in models with constant and trend), evidence of non-stationarity was also observed for these variables. The IPS test indicates that the CO2 and GDP variables are not stationary at the level. However, when

Table 3 – Unit root test results

Levin, Lin and Chu (LLC)				
	Level		***First Difference***	
Variables	***With Intercept***	***With Intercept and Trend***	***With Intercept***	***With Intercept and Trend***
CO_2	-1.26377	-0.03742	-9.47383 ***	-8.54686 ***
AIR	-6.30975***	-26.7124***	-63.4576***	-55.9271***
TOUR	-3.41271***	-2.28506**	-10.4372***	-9.66942***
GDP	-2.64750***	-1.54512*	-8.30553***	-6.21791***
Im, Pesaran and Shin (IPS)				
	Level		***First Difference***	
Variables	***With Intercept***	***With Intercept and Trend***	***With Intercept***	***With Intercept and Trend***
CO_2	1.38997	1.96996	-9.31675 ***	-8.26702 ***
AIR	-6.52289***	-13.7725***	-25.9048***	-23.9804***
TOUR	0.89162	-0.37221	-9.04320***	-8.14428***
GDP	0.55224	-0.67254	-8.98282***	-7.07981***

****, and **: Statistically significant at 1% and 5%, respectively.*
Source: Authors' own elaboration

first differences are taken, all variables (CO2, AIR, TOUR and GDP) become stationary at the 1% significance level. The results indicate that CO2 and GDP are integrated at first order (I(1)), whereas the remaining variables are stationary at level or first difference. Consequently, the first differences of the non-stationary variables were taken and included in the analysis during the modelling phase.

Unit root tests denotes that the coefficient and cointegration estimation techniques applied in the study satisfy the requirement that each of the three variables is stationary-at-first difference. The cointegration findings presented in the Table 4. Based on the Pedroni cointegration test results, nine out of the eleven discoveries had a significant probability at a level of 1%. The collected data was found to be cointegrated, and the null hypothesis was ruled out. The ARDL was then used to analyze the long-term association between the factors.

In order to analyze the factors that affect CO_2 emissions, we use the panel ARDL-PMG technique. The panel results are figured in Table 5. Based on the ARDL-PMG results, all computed coefficients are determined to be significantly statistically valid. Overall, long-term data show that the number of air transportation, tourism and economic growth are all pretend as a contributor to rising CO_2 emissions for the chosen panel of nations. The short-term analysis shows that the AIR coefficient is not statistically significant in the link among air transportation and the environmental degradation. However, at the 1% significant in the long term. An increase of 1% in air passengers leads to a 0.05% increase in carbon dioxide emissions in the long term. Our long-term result is in line with Demir (2022) on United Kingdom, Shirmohammadi et al. (2017) on United States, and Zhou et al. (2019) on China. As expected, tourist arrival's increase by 1% increase CO_2 emissions by 0.14%. The result is in line with Selvanathan et al. (2020) and Wangzhou et al. (2022). This long-term outcome is not consistent with ben Jebli et al. (2019) in South and Central America, Lee & Brahmasrene (2013) on nations in the European Union, and Katircioğlu (2014) on Singapore. Our findings, however, conflict with those of Koçak et al. (2020) for the most visited nations, Eyuboglu & Uzar (2020) about Turkiye, and Ozturk et al. (2022) regarding Saudi Arabia. Also, economic growth contributes to an increase in CO2 emissions by 0.71% in the long term. The result is in line with the literature (Işık et al., 2024; Zhang and Sharifi, 2024; Alam and Hossain, 2024)

The study continues by employing known as DH causality technique to examine the causal link between the variables, subsequent to coefficient estimation. The results are shown in Table 6. The Dumitrescu-Hurlin causality analysis offers significant advantages in econometric research, particularly in the context of heterogeneous panel data. This method allows for the examination of causal relationships across different cross-sectional units, accommodating variations in both the structure and behavior of the data. For instance, Kacemi and Hassan (2018) highlight that the Dumitrescu-Hurlin test accounts for heterogeneity in the panel, which enhances the robustness of the causal inference compared to traditional Granger causality tests that assume homogeneity across units. Similarly, Bozkurt et al. (2021) demonstrate its application in tourism economics, where the test effectively identifies causal links between demand and

Table 4 –Cointegration Test Results

Test	**Within Dimension**				**Test**	**Between Dimension**	
	Stat.	Prob.	*Weighted* Stat.	Prob.		Stat.	Prob.
Panel v-Statistic	-1.529104	0.9369	-2.022715	0.9977	Group rho-Statistic	-2.973427***	0.0015
Panel rho-Statistic	-3.665646***	0.0001	-3.885273***	0.0001	Group PP-Statistic	-10.21525***	0.0000
Panel PP-Statistic	-7.269410***	0.0000	-8.595635***	0.0000	Group ADF-Statistic	-9.520452***	0.0000
Panel ADF-Statistic	-7.294217***	0.0000	-8.531390***	0.0000			

**** indicates significant at 1%.*
Source: Authors' own elaboration

exchange rate shocks, revealing insights that are crucial for policymaking.

The estimates of probability in Table 6 demonstrate the presence of three causal relationships. Firstly, air transportation has a one-way causal relationship with carbon dioxide emissions. This result is in line with Arvin et al. (2015). On the other hand, our result is contrary to Saleem et al. (2018) which found no causality between air transportation and carbon dioxide emissions. Secondly, CO2 emissions cause a unidirectional increase in the number of tourist arrivals. This result is partly in line with Bandyopadhyay et al. (2023) which determined a bi-directional causality between tourism and CO_2 emissions. Also, Ozturk et al. (2022) supports our result of causality. It is contrary to results of Raihan & Tuspekova (2022), and Pata et al. (2023). Our result might be commented like that metropoles which produce carbon dioxide emissions pull more tourism activities to countries. Finally, tourism has been found to have a unidirectional causality with air transportation. As expected, number of tourist arrivals leads to air transportation because of transportation needs of tourism activities.

An analysis of stationary variables was first performed. The Table 3 presents the results of the Levin, Lin and Chu (LLC) and Im, Pesaran and Shin (IPS) unit root tests. The LLC test results indicate that the CO2 variable is non-stationary at the level but becomes stationary at the 1% significance level when the first difference is taken. Similarly, the AIR, TOUR and GDP variables are generally stationary at the level according to the LLC test. However, in some test conditions (in models with constant and trend), evidence of non-stationarity was also observed for these variables. The IPS test indicates that the CO2 and GDP variables are not stationary at the level. However, when first differences are taken, all variables (CO2, AIR, TOUR and GDP) become stationary at the 1% significance level. The results indicate that CO2 and GDP are integrated at first order (I(1)), whereas the remaining variables are stationary at level or first difference. Consequently, the first differences of the non-stationary variables were taken and included in the analysis during the modelling phase.

Unit root tests denotes that the coefficient and cointegration estimation techniques applied in the study satisfy the requirement that each of the three variables is stationary-at-first difference. The cointegration findings presented in the Table 4. Based on the Pedroni cointegration test results, nine out of the eleven discoveries had a significant probability at a level of 1%. The collected data was found to be cointegrated, and the null hypothesis was ruled out. The ARDL was then used to analyze the long-term association between the factors.

In order to analyze the factors that affect CO2 emissions, we use the panel ARDL-PMG technique. The panel results are figured in Table 5. Based on the ARDL-PMG results, all computed coefficients are determined to be significantly statistically valid. Overall, long-term data show that the

Table 5 –Long-term and short-term estimation results

Variables	Coefficients	Std. Error	t-statistics
Long-run results			
AIR	0.055126***	0.019827	2.780354
TOUR	0.141310***	0.021311	6.630964
GDP	0.714823***	0.050430	14.17464
Short-run results			
D(CO2(-1))	-0.115598	0.251457	-0.459712
D(CO2(-2))	-0.170752	0.189233	-0.902342
D(AIR)	-0.019151	0.057240	-0.334582
D(AIR(-1))	0.062119	0.060876	1.020423
D(AIR(-2))	0.100827	0.098173	1.027033
D(GDP)	-0.543840	0.354368	-1.534677
D(GDP(-1))	0.338836	0.373251	0.907798
D(GDP(-2))	-0.109006	0.342676	-0.318103
D(TOUR)	0.088408	0.100265	0.881739
D(TOUR(-1))	0.001204	0.100534	0.011980
D(TOUR(-2))	0.084549	0.096332	0.877681
ECM	-0.688362**	0.279614	-2.461835
C	-0.005150*	0.002938	-1.753137

*The symbols ***, **, and * denote 1%, 5%, and 10% level of significance, respectively.*

Source: Authors' own elaboration

Table 6 – Dumitrescu and Hurlin Causality Results

	Z-bar Statistics	P- value	Causality
AIR≠>CO2	1.28931	0.1973	CO2→AIR
CO2≠>AIR	1.90161*	0.0572	
TOUR≠>CO2	2.69924***	0.0069	TOUR → CO2
CO2≠>TOUR	0.58715	0.5571	
TOUR≠>AIR	1.63153	0.1028	No Causality
AIR≠>TOUR	1.44013	0.1498	
GDP≠>CO2	0.69852	0.4849	No Causality
CO2≠>GDP	-0.47271	0.6364	
GDP≠>TOUR	-0.21904	0.8266	No Causality
TOUR≠>GDP	0.99305	0.3207	
GDP≠>AIR	0.31023	0.7564	No Causality
AIR≠>GDP	0.74088	0.4588	

*The symbols ***, **, and * denote 1%, 5%, and 10% level of significance, respectively. →: Unidirectional Relationship*
Source: Authors' own elaboration

number of air transportation, tourism and economic growth are all pretend as a contributor to rising CO2 emissions for the chosen panel of nations. The short-term analysis shows that the AIR coefficient is not statistically significant in the link among air transportation and the environmental degradation. However, at the 1% significant in the long term. An increase of 1% in air passengers leads to a 0.05% increase in carbon dioxide emissions in the long term. Our long-term result is in line with Demir (2022) on United Kingdom, Shirmohammadi et al. (2017) on United States, and Zhou et al. (2019) on China. As expected, tourist arrival's increase by 1% increase CO2 emissions by 0.14%. The result is in line with Selvanathan et al. (2020) and Wangzhou et al. (2022). This long-term outcome is not consistent with ben Jebli et al. (2019) in South and Central America, Lee & Brahmasrene (2013) on nations in the European Union, and Katircioğlu (2014) on Singapore. Our findings, however, conflict with those of Koçak et al. (2020) for the most visited nations, Eyuboglu & Uzar (2020) about Turkiye, and Ozturk et al. (2022) regarding Saudi Arabia. Also, economic growth contributes to an increase in CO2 emissions by 0.71% in the long term. The result is in line with the literature (Işık et al., 2024; Zhang and Sharifi, 2024; Alam and Hossain, 2024)

The study continues by employing known as DH causality technique to examine the causal link between the variables, subsequent to coefficient estimation. The results are shown in Table 6. The Dumitrescu-Hurlin causality analysis offers significant advantages in econometric research, particularly in the context of heterogeneous panel data. This method allows for the examination of causal relationships across different cross-sectional units, accommodating variations in both the structure and behavior of the data. For instance, Kacemi and Hassan (2018) highlight that the Dumitrescu-Hurlin test accounts for heterogeneity in the panel, which enhances the robustness of the causal inference compared to traditional Granger causality tests that assume homogeneity across units. Similarly, Bozkurt et al. (2021) demonstrate its application in tourism economics, where the test effectively identifies causal links between demand and exchange rate shocks, revealing insights that are crucial for policymaking.

The estimates of probability in Table 6 demonstrate the presence of three causal relationships. Firstly, air transportation has a one-way causal relationship with carbon dioxide emissions. This result is in line with Arvin et al. (2015). On the other hand, our result is contrary to Saleem et al. (2018) which found no causality between air transportation and carbon dioxide emissions. Secondly, CO2 emissions cause a unidirectional increase in the number of tourist arrivals. This result is partly in line with Bandyopadhyay et al. (2023) which determined a bi-directional causality between tourism and CO2 emissions. Also, Ozturk et al. (2022) supports our result of causality. It is contrary to results of Raihan & Tuspekova (2022), and Pata et al. (2023). Our result might be commented like that metropoles which produce carbon dioxide emissions pull more tourism activities to countries. Finally, tourism has been found to have a unidirectional causality with air transportation. As expected, number of tourist arrivals leads to air transportation because of transportation needs of tourism activities.

5. Conclusion and Implications

The growth of social and economic activities since the Industrial Revolution has significantly increased atmospheric carbon dioxide emissions. The injection of carbon has accelerated over the last few decades. Global temperatures are increasing and natural disasters like food shortages, droughts, storms, extreme weather variations are occurring more frequently as a consequence. Moreover, the decline in environmental quality has caused major worry among international and environmental officers and leaders. As consistent point of this view, many studies have attempted to investigate the variables that can reduce the amount of pollution without affecting the process of economic growth.

This study investigates the causal direction and long-term dynamics among CO2 emissions tourism, and air transport in 10 Mediterranean countries, using data between 1995-2019. The aim of the study is to explore the significance of the tourism industry and air transportation on the environment. The study utilized the Autoregressive Distributive Lag (ARDL) technique. The results of the paper show that, using ARDL methodologies, CO2 emissions are affected in positive direction from the arrival of tourists in the fundamental model. Specifically, CO2 emissions are increasing by 0.14% with an increase in tourist arrivals of 1%. In the fundamental model with ARDL estimating technique, the number of passengers carried by air also affected CO2 emissions in a positive direction. A 1% increase in passengers carried by air leads to a 0.05% increase in CO2 emissions in the long term. Similar to tourism and air transportation, economic growth shows an incremental effect on CO2 emissions by 0.71% at an increase in 1% growth. The DH causality test confirms the presence of causal relationships among variables, with a unidirectional causality from air transportation to carbon dioxide emissions. This shows that air transportation causes air pollution through carbon dioxide emissions. The causality test confirms a unidirectional causality from CO2 emissions to tourism. Finally, there is a unidirectional causality from tourism to air transportation, which means that tourism activities lead to air transportation. The study's findings on the effect of tourism on the environment are not unanimous. However, studies by Leitão & Lorente (2020), Mehmood et al. (2021), and Wei & Ullah (2022) suggest that tourism can enhance environmental quality. Conversely, Eyuboglu & Uzar (2020), Kumail et al. (2020), Paramati et al. (2018), Selvanathan et al. (2021), Uzuner et al. (2020), and Wangzhou et al. (2022) indicate that tourism sector development has led to environmental degradation.

Some significant policy implications are recommended for the interested parties based on the findings. Policymakers in Mediterranean countries should prioritize strengthening ecotourism policies by promoting eco-friendly accommodations, sustainable tourist activities, and community-based tourism initiatives. Integrating green infrastructure, such as energy-efficient buildings and eco-friendly transportation, into the tourism sector is crucial for reducing environmental impacts. Additionally, the adoption of renewable energy sources like solar and wind should be incentivized, leveraging the region's favorable geological conditions to power tourism activities sustainably. Carbon reduction strategies, including energy-efficient practices, carbon offset programs, and retrofitting existing facilities, can further mitigate emissions. Regional cooperation should be enhanced to share best practices, protect shared ecosystems, and promote cross-border ecotourism programs. Finally, governments should invest in public awareness campaigns, capacity-building initiatives, and robust monitoring systems to ensure the effectiveness and adaptability of these measures, aligning tourism development with sustainable environmental goals.

Our research has some drawbacks. Ten nations from the Mediterranean are chosen for analysis due to a paucity of data. Additionally, analysis displayed only panel results, not individual country results, due to our approach. This opens the door for more investigation into the specific impacts that air transportation and tourism have on different nations. The impact can be examined by including green innovation variable in the models used in the subsequent research. Our study which does not reflect noise, water and soil pollution may be more comprehensive by using markers like ecological footprint instead of CO2 emissions, for further research. We excluded the post-2019 period from our study to prevent the extraordinary effects of the pandemic on tourism and air passenger transport from distorting the results. This is a limitation, but it allows us to evaluate the sudden and structural changes caused by the pandemic in line with the study's purpose. In the study, cross section dependence test has not been performed, and this is since the model assumptions assume of low dependence. This is considered as a limitation of the study, and it is suggested to be taken into consideration in future research.

References

Abdullahi, M., Adesogan, A., & Alhaji, A. (2018). The Economic and Social Benefits of Air Transportation to Tourism in Nigeria. People: International Journal of Social Sciences, 77-86.

Akbulut Yıldız, G., & Yıldız, B. (2024). CO2 Emisyonu, Hava Yolu Taşımacılığı, Yenilenebilir Enerji Tüketimi ve Ekonomik Büyüme Arasındaki İlişki: Beşli Grup (G5) Örneği. Alanya Akademik Bakış, 8(1), 48-63. https://doi.org/10.29023/alanyaakademik.1254086.

Akkan, M. M., & Cura, F. (2022). Turizmde Uluslararası Taşımacılık: Havayolu İşletmelerinde Markalaşma. Markalaşma, 231.

Alam, M. B., & Hossain, M. S. (2024). Investigating the connections between China's economic growth, use of renewable energy, and research and development concerning CO2 emissions: An ARDL Bound Test Approach. Technological Forecasting and Social Change, 201, 123220.

Al-Mulali, U., Fereidouni, H. G., & Mohammed, A. H. (2015). The effect of tourism arrival on CO2 emissions from transportation sector. Anatolia, 26(2), 230–243. https://doi.org/10.1080/13032917.2014.934701

Arvin, M. B., Pradhan, R. P., & Norman, N. R. (2015). Transportation intensity, urbanization, economic growth, and CO2 emissions in the G-20 countries. Utilities Policy, 35, 50–66. https://doi.org/10.1016/j.jup.2015.07.003

Aslan, A., Altinoz, B., & Özsolak, B. (2021). The nexus between economic growth, tourism development, energy consumption, and CO2 emissions in Mediterranean countries. Environmental Science and Pollution Research, 28(3), 3243–3252. https://doi.org/10.1007/s11356-020-10667-6

ATAG, (2020). Waypoint 2050: An Air Transport Action Group Project. Retrieved November 18, 2022, from https://aviationbenefits.org/environmental-efficiency/climate-action/waypoint-2050

ATAG. (2020). Full report (ENG) - Aviation: Benefits Beyond Borders. The Netherlands: ATAG.

ATAG. (2022). Air transport action group facts & figures. Air Transport Action Group, ATAG.

Avishek Khanal, Rahman, M. M., Khanam, R., & Velayutham, E. (2022). Does tourism contribute towards zero-carbon in Australia? Evidence from ARDL modelling approach. Energy Strategy Reviews, 43. https://doi.org/10.1016/j.esr.2022.100907

Aydin, M. (2022). The impacts of political stability, renewable energy consumption, and economic growth on tourism in Turkey: New evidence from Fourier Bootstrap ARDL approach. Renewable Energy, 190, 467–473. https://doi.org/10.1016/j.renene.2022.03.144

Babetto, L., Kirste, A., Deng, J., Husemann, M., & Stumpf, E. (2023). Adoption of the Urban Air Mobility System: Analysis of technical, legal and social aspects from a European perspective. Journal of the Air Transport Research Society, 1(1), 152-174.

Balli, E., Sigeze, C., Manga, M., Birdir, S., & Birdir, K. (2019). The relationship between tourism, CO 2 emissions and economic growth: a case of Mediterranean countries. Asia Pacific Journal of Tourism Research, 24(3), 219–232. https://doi.org/10.1080/10941665.2018.1557717

Balsalobre-Lorente, D., Driha, O., Bekun, F., & Adedoyin, F. (2019). The asymmetric impact of air transport on economic growth in Spain: fresh evidence from the tourism-led growth hypothesis. Current Issues in Tourism, 503-519.

Bandyopadhyay, A., Rej, S., Abbasi, K. R., & Awan, A. (2023). Nexus between tourism, hydropower, and CO2 emissions in India: fresh insights from ARDL and cumulative fourier frequency domain causality. Environment, Development and Sustainability, 25(10), 10903-10927. https://doi.org/10.1007/s10668-022-02511-3

ben Jebli, M., ben Youssef, S., & Apergis, N. (2019). The dynamic linkage between renewable energy, tourism, CO 2 emissions, economic growth, foreign direct investment, and trade. Latin American Economic Review, 28(1). https://doi.org/10.1186/s40503-019-0063-7

Ben-Ari, T. (2024). Flight quotas outperform focused mitigation strategies in reducing the carbon footprint of academic travel. Environmental Research Letters, 19(5), 054008. https://doi.org/10.1088/1748-9326/ad30a6

Bozkurt, K., Tekin, H., & Ergün, Z. (2021). An investigation of demand and exchange rate shocks in the tourism sector. Applied Economic Analysis, 29(86), 171-188. https://doi.org/10.1108/aea-05-2020-0051

Budd, L., & Ison, S. (2017). Air transport management: an international perspective. London: Routledge Taylor & Francis Group.

Chen, J., Hu, X., Razi, U., & Rexhepi, G. (2021). The sustainable potential of efficient air-transportation industry and green innovation in realising environmental sustainability in G7 countries. Economic Research-Ekonomska Istraživanja, 3814-3835.

Christodoulakis, J., Karinou, F., Kelemen, M., Kouremadas, G., Fotaki, E., & Varotsos, C. (2022). Assessment of air pollution from Athens International Airport and suggestions for adaptation to new aviation emissions restrictions. Atmospheric Pollution Research, 1-7.

Cohen, B., Bronzaft, A., Heikkinen, M., Goodman, J., & Nádas, A. (2007). Airport-Related Air Pollution and Noise. Journal of Occupational and Environmental Hygiene, 119-129.

Cohen, S. and Higham, J. (2011). Eyes wide shut? uk consumer perceptions on aviation climate impacts and travel decisions to new zealand. Current Issues in Tourism, 14(4), 323-335. https://doi.org/10.1080/13683501003653387

COP26 goals. UN Climate Change Conference (COP26) at the SEC – Glasgow 2021. (2021, October 26). Retrieved November 18, 2022, from https://ukcop26.org/cop26-goals/

Corazza, M., Mascio, P., & Esposito, G. (2022). Airports as Sensitive Areas to Mitigate Air Pollution: Evidence from a Case Study in Rome. Environments, 1-19.

Demir, A. S. (2022). Modeling and forecasting of CO2 emissions resulting from air transport with genetic algorithms: the United Kingdom case. Theoretical and Applied Climatology, 150(1–2), 777–785. https://doi.org/10.1007/s00704-022-04203-4

Dinu, A.-M. (2018). The importance of transportation to tourism development. Academic Journal of Economic Studies, 183-187.

Dogan, E., & Aslan, A. (2017). Exploring the relationship among CO2 emissions, real GDP, energy consumption and tourism in the EU and candidate countries: Evidence from panel models robust to heterogeneity and cross-sectional dependence. Renewable and Sustainable Energy Reviews, 77(February), 239–245. https://doi.org/10.1016/j.rser.2017.03.111

Dumitrescu, E. I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. Economic Modelling, 29(4), 1450–1460. https://doi.org/10.1016/j.econmod.2012.02.014

Duval, D. (2013). Critical Issues in Air Transport and Tourism. Tourism Geographies, 494-510.

Ekici, F., Orhan, G., Gümüş, Ö., & Bahce, A. B. (2022). A policy on the externality problem and solution suggestions in air transportation: The environment and sustainability. Energy, 258. https://doi.org/10.1016/j.energy.2022.124827

Erdogan, S., Sarkodie, S. A., Adedoyin, F. F., Bekun, F. V., & Owusu, P. A. (2024). Analyzing transport demand and environmental degradation: the case of G-7 countries. Environment, Development and Sustainability, 26(1), 711-734.

Eyuboglu, K., & Uzar, U. (2020). The impact of tourism on CO2 emission in Turkey. Current Issues in Tourism, 23(13), 1631–1645. https://doi.org/10.1080/13683500.2019.1636006

Fan, Y., Ullah, I., Rehman, A., Hussain, A., & Zeeshan, M. (2022). Does tourism increase CO2 emissions and health spending in Mexico? New evidence from nonlinear ARDL approach. International Journal of Health Planning and Management, 37(1), 242–257. https://doi.org/10.1002/hpm.3322

Givoni, M., & Rietveld, P. (2010). The environmental implications of airlines' choice of aircraft size. Journal of Air Transport Management, 159-167.

Graham, A., & Frederic, D. (2019). Air Transport – A Tourism Perspective. Amsterdam: Elsevier.

Grote, M., Williams, I., & Preston, J. (2014). Direct carbon dioxide emissions from civil aircraft. Atmospheric Environment, 214-224.

Gürçam, S., Konuralp, E., & Ekici, S. (2021). Determining the effect of air transportation on air pollution in the most polluted city in Turkey. Aircraft Engineering and Aerospace Technology, 93(2), 354-362.

Hares, A., Dickinson, J., & Wilkes, K. (2010). Climate change and the air travel decisions of uk tourists. Journal of Transport Geography, 18(3), 466-473. https://doi.org/10.1016/j.jtrangeo.2009.06.018

Haseeb, M., Hassan, S., Azam, M., & Suryanto, T. (2018). The dynamics of governance, tourism and environmental degradation: The world evidence. International Journal of Global Environmental Issues, 17(4), 340–363. https://doi.org/10.1504/IJGENVI.2018.095155

Hsu, H.-H., Adamkiewicz, G., Houseman, E., Zarubiak, D., Spengler, J., & Levy, J. (2013). Contributions of aircraft arrivals and departures to ultrafine particle counts near Los Angeles International Airport. Science of The Total Environment, 347-355.

Hu, S., Fruin, S., Kozawa, K., Mara, S., Winer, A., & Paulson, S. (2009). Aircraft Emission Impacts in a Neighborhood Adjacent to a General Aviation Airport in Southern California. Environ. Sci. Technol, 8039-8045.

Hussain, M. (2023). Evaluating the impact of air transportation, railway transportation, and trade openness on inbound and outbound tourism in BRI countries. Journal of Air Transport Management, 102307.

IATA, (2020). Air passenger market analysis January 2021. IATA Econ. Anal.. https://www.iata.org/en/publications/economics/.

IEA. (2019). Global Energy Review 2019 – analysis. IEA. Retrieved November 18, 2022, from https://www.iea.org/reports/global-energy-review-2019

IEA. (2023). The Breakthrough Agenda Report 2023. IEA.

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. Journal of Econometrics, 115(1), 53–74. https://doi.org/10.1016/S0304-4076(03)00092-7

Işık, C., Bulut, U., Ongan, S., Islam, H., & Irfan, M. (2024). Exploring how economic growth, renewable energy, internet usage, and mineral rents influence CO2 emissions: A panel quantile regression analysis for 27 OECD countries. Resources Policy, 92, 105025.

Jahanger, A., Ozturk, I., Onwe, J. C., Ogwu, S. O., Hossain, M. R., & Abdallah, A. A. (2024). Do pro-environmental interventions matter in restoring environmental sustainability? Unveiling the role of environmental tax, green innovation and air transport in G-7 nations. Gondwana Research, 127, 165-181.

Kacemi, T. and Hassan, S. (2018). Causal linkage between inflation and unemployment: an evidence from the selected mena countries. Pakistan Journal of Humanities and Social Sciences, 6(1), 121-131. https://doi.org/10.52131/pjhss.2018.0601.0037

Katircioğlu, S. T. (2014). Testing the tourism-induced EKC hypothesis: The case of Singapore. Economic Modelling, 41, 383–391. https://doi.org/10.1016/j.econmod.2014.05.028

Katircioglu, S. T., Feridun, M., & Kilinc, C. (2014). Estimating tourism-induced energy consumption and CO2 emissions: The case of Cyprus. In Renewable and Sustainable Energy Reviews (Vol. 29, pp. 634–640). https://doi.org/10.1016/j.rser.2013.09.004

Khan, S., Yahong, W., & Chandio, A. A. (2022). How does economic complexity affect ecological footprint in G-7 economies: the role of renewable and non-renewable energy consumptions and testing EKC hypothesis. Environmental Science and Pollution Research, 29(31), 47647–47660. https://doi.org/10.1007/s11356-022-19094-1

Koçak, E., Ulucak, R., & Ulucak, Z. Ş. (2020). The impact of tourism developments on CO2 emissions: An advanced panel data estimation. Tourism Management Perspectives, 33. https://doi.org/10.1016/j.tmp.2019.100611

Korkut Pata, U., & Balsalobre-Lorente, D. (2022). Exploring the impact of tourism and energy consumption on the load capacity factor in Turkey: a novel dynamic ARDL approach. Environmental Science and Pollution Research , 29, 13491–13503. https://doi.org/10.1007/s11356-021-16675-4/Published

Kumail, T., Ali, W., Sadiq, F., Wu, D., & Aburumman, A. (2020). Dynamic linkages between tourism, technology and CO2 emissions in Pakistan. Anatolia, 31(3), 436–448. https://doi.org/10.1080/13032917.2020.1742169

Larsen, G. and Guiver, J. (2013). Understanding tourists' perceptions of distance: a key to reducing the environmental impacts of tourism mobility. Journal of Sustainable Tourism, 21(7), 968-981. https://doi.org/10.1080/09669582.2013.819878

Lee, J. W., & Brahmasrene, T. (2013). Investigating the influence of tourism on economic growth and carbon emissions: Evidence from panel analysis of the European Union. Tourism Management, 38, 69–76. https://doi.org/10.1016/j.tourman.2013.02.016

Leitão, N. C., & Lorente, D. B. (2020). The linkage between economic growth, renewable energy, tourism, CO2 emissions, and international trade: The evidence for the

European Union. Energies, 13(18). https://doi.org/10.3390/en13184838

León, C. J., Arana, J. E., & Hernández Alemán, A. (2014). CO2 Emissions and tourism in developed and less developed countries. Applied Economics Letters, 21(16), 1169–1173. https://doi.org/10.1080/13504851.2014.916376

Levin, A., Lin, C.-F., & James Chu, C.-S. (2002). Unit root tests in panel data: asymptotic and ÿnite-sample properties. In Journal of Econometrics (Vol. 108). www.elsevier.com/locate/econbase

Levy, J., Hsu, H.-H., & Melly, S. (2008). High-Priority Compounds Associated with Aircraft Emissions. Cambrigde: Partne-Coe.

Liasidou, S. (2017). Drafting a realistic tourism policy: the airlines' strategic influence. Tourism Review, 28-44.

Liasidou, S., Garanti, Z., & Pipyros, K. (2022). Air transportation and tourism interactions and actions for competitive destinations: the case of Cyprus. Worldwide Hospitality and Tourism Themes, 470-480.

Lin, W., He, Q., & Yu, H. (2021). The convergence of PM2.5 concentration in Chinese cities: A distribution dynamic approach. Economic Research-Ekonomska Istraživanja, 2555-2573.

Liu, X., & Bae, J. (2018). Urbanization and industrialization impact of CO2 emissions in China. Journal of Cleaner Production, 172, 178–186. https://doi.org/10.1016/j.jclepro.2017.10.156

Madurapperuma, W., & Higgoda, R. (2022). AIR-TRANSPORTATION, TOURISM AND ECONOMIC GROWTH INTERACTIONS IN SRI LANKA: COINTEGRATION AND CAUSALITY ANALYSIS. International Journal of Business and Management, 85-107.

Masiol, M., & Harrison, R. (2014). Aircraft engine exhaust emissions and other airport-related contributions to ambient air pollution: A review. Atmospheric Environment, 409-455.

Mehmood, U., Mansoor, A., Tariq, S., & Ul-Haq, Z. (2021). The interactional role of globalization in tourism-CO 2 nexus in South Asian countries. Environmental Science and Pollution Research, 28, 26441–26448. https://doi.org/10.1007/s11356-021-12473-0/Published

Mehmood, U., Tariq, S., Ul Haq, Z., Azhar, A., & Mariam, A. (2022). The role of tourism and renewable energy towards EKC in South Asian countries: fresh insights from the ARDL approach. Cogent Social Sciences, 8(1). https://doi.org/10.1080/23311886.2022.2073669

Mohsin, M., Naseem, S., Sarfraz, M., & Azam, T. (2022). Assessing the effects of fuel energy consumption, foreign direct investment and GDP on CO2 emission: New data science evidence from Europe & Central Asia. Fuel, 314. https://doi.org/10.1016/j.fuel.2021.123098

Moussiopoulos, N., Sahm, P., Karatzas, K., Papalexiou, S., & Karagiannidis, A. (1997). Assessing the impact of the New Athens airport to urban air quality with contemporary air pollution models. Atmospheric Environment, 1497-1511.

Musa, M., Yi, L., Rahman, P., Ali, M. A. S., & Yang, L. (2022). Do anthropogenic and natural factors elevate the haze pollution in the South Asian countries? Evidence from long-term cointegration and VECM causality estimation. Environmental Science and Pollution Research. https://doi.org/10.1 007/s11356-022-21759-w

Ozturk, I., Aslan, A., & Altinoz, B. (2022). Investigating the nexus between CO2 emissions, economic growth, energy consumption and pilgrimage tourism in Saudi Arabia. Economic Research-Ekonomska Istrazivanja , 35(1), 3083–3098. https://doi.org/10.1080/1331677X.2021.1985577

Papatheodorou, A. (2021). A review of research into air transport and tourism: Launching the Annals of Tourism Research Curated Collection on Air Transport and Tourism. Annals of Tourism Research, 103-151.

Paramati, S. R., Alam, M. S., & Lau, C. K. M. (2018). The effect of tourism investment on tourism development and CO2 emissions: empirical evidence from the EU nations. Journal of Sustainable Tourism, 26(9), 1587–1607. https://doi.org/10.1080/09669582.2018.1489398

Pata, U. K., Dam, M. M., & Kaya, F. (2023). How effective are renewable energy, tourism, trade openness, and foreign direct investment on CO2 emissions? An EKC analysis for ASEAN countries. Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-022-23160-z

Pearce, B. (2020). COVID-19: June Data and Revised Air Travel Outlook. Montreal, Canada: IATA presentation.

Pedroni, P. (1999). Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors. Oxford Bulletin of Economics and Statistics, 61(s1), 653–670. https://doi.org/10.1111/1468-0084.0610s1653

Pedroni, P. (2004). PANEL COINTEGRATION: ASYMPTOTIC AND FINITE SAMPLE PROPERTIES OF POOLED TIME SERIES TESTS WITH AN APPLICATION TO THE PPP HYPOTHESIS. Econometric Theory, 20(03), 597–625. https://doi.org/10.1017/S0266466604203073

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16(3), 289–326. https://doi.org/10.1002/jae.616

Rahaman, M. A., Hossain, M. A., & Chen, S. (2022). The impact of foreign direct investment, tourism, electricity consumption, and economic development on CO2 emissions in Bangladesh. Environmental Science and Pollution Research, 29(25), 37344–37358. https://doi.org/10.1007/s11356-021-18061-6

Rahman, A. R. A., Shaari, M. S., Masnan, F., & Esquivias, M. A. (2022). The Impacts of Energy Use, Tourism and Foreign Workers on CO2 Emissions in Malaysia. Sustainability (Switzerland), 14(4), 1–14. https://doi.org/10.3390/su14042461

Raihan, A., & Tuspekova, A. (2022). Dynamic impacts of economic growth, energy use, urbanization, tourism, agricultural value-added, and forested area on carbon dioxide emissions in Brazil. Journal of Environmental

Studies and Sciences. https://doi.org/10.1007/s13412-022-00782-w

Raihan, A., Voumik, L. C., Akter, S., Ridzuan, A. R., Fahlevi, M., Aljuaid, M., & Saniuk, S. (2024). Taking flight: Exploring the relationship between air transport and Malaysian economic growth. Journal of Air Transport Management, 115, 102540.

Ravinthirakumaran, K., & Ravinthirakumaran, N. (2022). Examining the relationship between tourism and CO2 emissions: evidence from APEC region. Anatolia, 00(00), 1–15. https://doi.org/10.1080/13032917.2021.2021430

Robinson, P., Lück, M., & Smith, S. (2020). Air transportation. In CABI Books. CABI International.

Safdar, S., Khan, A., & Andlib, Z. (2022). Impact of good governance and natural resource rent on economic and environmental sustainability: an empirical analysis for South Asian economies. Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-022-21401-9

Salahodjaev, R., Sharipov, K., Rakhmanov, N., & Khabirov, D. (2022). Tourism, renewable energy and CO2 emissions: evidence from Europe and Central Asia. Environment, Development and Sustainability, 24(11), 13282–13293. https://doi.org/10.1007/s10668-021-01993-x

Saleem, H., Jiandong, W., Zaman, K., Elsherbini Elashkar, E., & Mohamd Shoukry, A. (2018). The impact of air-railways transportation, energy demand, bilateral aid flows, and population density on environmental degradation: Evidence from a panel of next-11 countries. Transportation Research Part D: Transport and Environment, 62, 152–168. https://doi.org/10.1016/j.trd.2018.02.016

Schlenker, W., & Walker, W. (2015). Airports, Air Pollution, and Contemporaneous Health. The Review of Economic Studies, 768-809.

Schlumberger, C. E. (2012). The World Bank. Air transport and energy efficiency. Washington: Transport Papers.

Seetaram, N., Song, H., & Page, S. (2013). Air Passenger Duty and Outbound Tourism Demand from the United Kingdom. Journal of Travel Research, 476–487.

Segarra, V., Brida, J. G., & Cárdenas-García, P. J. (2024). On the relationships between tourism demand, carbon dioxide emissions and economic growth: a literature review. Journal of Policy Research in Tourism, Leisure and Events, 1-42.

Selvanathan, E. A., Jayasinghe, M., & Selvanathan, S. (2021). Dynamic modelling of inter-relationship between tourism, energy consumption, CO2 emissions and economic growth in South Asia. International Journal of Tourism Research, 23(4), 597–610. https://doi.org/10.1002/jtr.2429

Shah, M. I., AbdulKareem, H. K. K., Zulfiqar khan, & Abbas, S. (2022). Examining the agriculture induced Environmental Kuznets Curve hypothesis in BRICS economies: The role of renewable energy as a moderator. Renewable Energy, 198, 343–351. https://doi.org/10.1016/j.renene.2022.08.052

Shakouri, B., Khoshnevis Yazdi, S., & Ghorchebigi, E. (2017). Does tourism development promote CO2 emissions? Anatolia, 28(3), 444–452. https://doi.org/10.1080/13032917.2017.1335648

Shirmohammadi, F., Sowlat, M., Hasheminassab, S., Saffari, A., Ban-Weiss, G., & Sioutas, C. (2017). Emission rates of particle number, mass and black carbon by the Los Angeles International Airport (LAX) and its impact on air quality in Los Angeles. Atmospheric Environment, 82-93.

Sikder, M., Wang, C., Yao, X., Huai, X., Wu, L., KwameYeboah, F., Wood, J., Zhao, Y., & Dou, X. (2022). The integrated impact of GDP growth, industrialization, energy use, and urbanization on CO2 emissions in developing countries: Evidence from the panel ARDL approach. Science of the Total Environment, 837. https://doi.org/10.1016/j.scitotenv.2022.155795

Song, M. J., Seo, Y. J., & Lee, H. Y. (2023). The dynamic relationship between industrialization, urbanization, CO2 emissions, and transportation modes in Korea: empirical evidence from maritime and air transport. Transportation, 50(6), 2111-2137.

Stettler, M., Eastham, S., & Barrett, S. (2011). Air quality and public health impacts of UK airports. Part I: Emissions. Atmospheric Environment, 5415-5424.

Tesseraux, I. (2004). Risk factors of jet fuel combustion products. Toxicology Letter, 295-300.

UNWTO. (2020). International Tourism Highlights International tourism trends, 2019. Unwto, 1–24.

Uzuner, G., Akadiri, S. Saint, & Lasisi, T. T. (2020). The asymmetric relationship between globalization, tourism, CO2 emissions, and economic growth in Turkey: implications for environmental policy making. Environmental Science and Pollution Research, 27(26), 32742–32753. https://doi.org/10.1007/s11356-020-09190-5

Vichi, F., Frattoni, M., Imperiali, A., Balducci, C., Cecinato, A., Perilli, M., & Romagnoli, P. (2016). Civil aviation impacts on local air quality: A survey inside two international airports in central Italy. Atmospheric Environment, 393-345.

Wangzhou, K., Wen, J. J., Wang, Z., Wang, H., Hao, C., & Andlib, Z. (2022). Revealing the nexus between tourism development and CO2 emissions in Asia: does asymmetry matter? Environmental Science and Pollution Research, 79016–79024. https://doi.org/10.1007/s11356-022-21339-y

Wei, L., & Ullah, S. (2022). International tourism, digital infrastructure, and CO2 emissions: fresh evidence from panel quantile regression approach. Environmental Science and Pollution Research, 29(24), 36273–36280. https://doi.org/10.1007/s11356-021-18138-2

WHO. (2000). Transport, environment and health. Europe: WHO Regional Office Europe.

Wu, J.; Wang, S.; Liu, Y.; Xie, X.; Wang, S.; Lv, L.; Luo, H. (2023). Measurement of Tourism-Related CO2 Emission and the Factors Influencing Low-Carbon Behavior of

Tourists: Evidence from Protected Areas in China. Int. J. Environ. Res. Public Health, 20, 1277. https://doi.org/10.3390/ijerph20021277.

Yan, Y., & Phucharoen, C. (2024). Tourism Transport-Related CO2 Emissions and Economic Growth: A Deeper Perspective from Decomposing Driving Effects. Sustainability, 16(8), 3135.

Zhang, J., & Zhang, Y. (2021). Tourism, economic growth, energy consumption, and CO2 emissions in China. Tourism Economics, 27(5), 1060–1080. https://doi.org/10.1177/1354816620918458

Zhang, Z., & Sharifi, A. (2024). Analysis of decoupling between CO2 emissions and economic growth in China's provincial capital cities: A Tapio model approach. Urban Climate, 55, 101885.

Zhou, Y., Jiao, Y., Lang, J., Chen, D., Huang, C., Wei, P., . . . Cheng, S. (2019). Improved estimation of air pollutant emissions from landing and takeoff cycles of civil aircraft in China. Environmental Pollution, 463-471.

Jomat

Journal of multidisciplinary academic tourism

ISSN: 2645-9078

2010, 10 (3): 297-313

https://doi.org/10.31822/jomat.2010-10-3-297

INFO PAGE

Interaction between air transportation, tourism and CO2 emissions: The panel ARDL approach

Abstract

The tourism sector is directly linked to air transportation, with air travel accounting for a large share of global travel demand. However, air transportation increases environmental impacts and poses a significant threat to sustainability due to its high carbon emissions. In this context, the relationship between tourism and air transportation is a critical area that requires the development of policies and practices to reduce the carbon footprint. This study investigates the dynamic link among tourism, air transportation and CO2 emissions for the period 1995-2019 in 10 Mediterranean countries. To investigate the relationship between our variables, autoregressive distributed lag approach is used. According to ARDL long run estimations, it is stated that the increase air transportation increases the CO2 emissions. Similar to air transportation, increase in tourism and economic growth results in an increase in CO2 emissions. Finally, causality test of Dumitrescu and Hurlin is applied. Causality results stated 2 causalities between variables. There are unidirectional causalities from CO2 emissions to air transportation and from tourism to CO2 emissions. Also, policy and further research implications are discussed regard to selected countries.

Keywords: *CO2 emissions, air transportation, tourism, ARDL, Mediterranean countries.*

Authors

Full Name	Author contribution roles	Contribution rate
Erkam Emin Ayvaz:	*Methodology, Software, Formal Analysis, Writing - Original Draft*	*25%*
Mevlüt Üzülmez:	*Writing - Original Draft, Writing - Review & Editing*	*25%*
Didem Erşen:	*Data Curation, Writing - Original Draft*	*25%*
Hicran Ergen:	*Data Curation, Writing - Original Draft*	*25%*

Author statement: *Author(s) declare(s) that All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.* ***Declaration of Conflicting Interests:*** *The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article*

This paper does not required ethics committee report

Justification: The methodology of this study does not require an ethics committee report.