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Research Paper

Dynamic effects of tourism receipts and GDP on airline passenger traffic

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Abstract. Air transport is closely related to economic growth and tourism. However, this relationship can vary depending on a country's level of economic development, tourism characteristics, and geographical location relative to other countries. Studies on this topic are mostly focused on a single country or a single variable. This study, however, aims to examine the dynamic effects of tourism revenues and GDP on airline passenger traffic on leading aviation sectors in countries with diverse economic, tourism, and geographical characteristics (France, USA, Türkiye, and Australia), using data covering the period 2005-2020. The Panel Autoregressive Distributed Lag (Panel ARDL) method was used to determine the long-term and short-term relationships between the variables. The Pedroni cointegration test results demonstrate a long-term equilibrium relationship between airline passenger traffic, tourism indicators, and economic growth. According to the Panel ARDL estimation results, in the long term, international tourism revenues positively affect airline passenger traffic, while an increase in the number of tourists has a negative effect. In the short term, an increase in the number of tourists stands out as the main factor stimulating aviation demand. Granger causality analysis findings reveal a unidirectional causal relationship from airline passenger traffic to tourism revenues and economic growth. These findings suggest that strategic investments in aviation infrastructure can be a supply-side driver for sustainable economic development and the tourism sector. In this context, continuous communication between private and public institutions in decision-making within these sectors is considered highly valuable.

Keywords: Air transportation, tourism receipts, panel ARDL model, economic growth. aviation management.

Araştırma Makalesi

Turizm gelirleri ve GSYH'nin havayolu yolcu trafiği üzerindeki dinamik etkileri

Öz. Hava taşımacılığı, ekonomik büyüme ve turizm ile yakından ilişkilidir. Fakat bu ilişki ülkenin ekonomik gelişmişliğine, turistik özelliklerine ve diğer ülkeler ile coğrafi konumuna göre değişiklik gösterebilmektedir. Bu konu ile ilgili yapılan çalışmalar daha çok bir ülke özelinde ya da tek bir değişken özelindedir. Bu çalışma ise, 2005-2020 dönemini kapsayan veriler kullanılarak, havacılık sektöründe önde gelen ve birbirinden farklı ekonomik, turistik ve coğrafi özelliklere sahip olan ülkeler (Fransa, ABD, Türkiye ve Avustralya) özelinde turizm gelirleri, GSYH ve havayolu yolcu trafiğinin birbirleriyle dinamik etkilerini incelemeyi amaçlamaktadır. Araştırmada değişkenler arasındaki uzun ve kısa dönemli ilişkileri belirlemek amacıyla Panel Otoregresif Dağıtılmış Gecikme (Panel ARDL) yöntemi kullanılmıştır. Pedroni eşbütünleşme testi sonuçları; havayolu yolcu trafiği, turizm göstergeleri ve ekonomik büyüme arasında uzun dönemli bir denge ilişkisi olduğunu kanıtlamaktadır. Panel ARDL tahmin sonuçlarına göre, uzun dönemde uluslararası turizm gelirleri havayolu yolcu trafiğini pozitif yönde etkilerken, turist sayısındaki artışın negatif bir etkisi saptanmıştır. Kısa dönemde ise turist sayısındaki artış, havacılık talebini stimüle eden ana faktör olarak öne çıkmaktadır. Granger nedensellik analizi bulguları, havayolu yolcu trafiğinden turizm gelirlerine ve ekonomik büyümeye doğru tek yönlü bir nedensellik ilişkisi olduğunu ortaya koymaktadır. Elde edilen bulgular, havacılık altyapısına yönelik stratejik yatırımların sürdürülebilir ekonomik kalkınma ve turizm sektörü için arz yönlü itici bir güç olabileceğini savunmaktadır. Bu bağlamda özel ve devlet kurumlarının bu sektörler içerisinde alacağı kararlarda sürekli iletişim halinde olmasının oldukça kıymetli olduğu düşünülmektedir.

Anahtar Kelimeler: Havayolu taşımacılığı, turizm gelirleri, panel ARDL modeli, ekonomik büyüme, havacılık yönetimi.

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1. INTRODUCTION

Each mode of transportation contributes to the social and economic development of countries at different levels. The high safety and speed factors of air transportation greatly contribute to supporting activities in many countries (Hakim & Merkert, 2016). One of the most important sectors within these activities is tourism. Since tourism activities are focused on safety, comfort, and entertainment, passengers prefer to reach their destinations safely, quickly, and comfortably. For this reason, air transportation plays a very important role in the development of tourism activities in a region (Lohmann & Duval, 2011). Page's 2009 study shows that the increase in passenger numbers directly contributes to the accommodation, food and beverage, and shopping sectors (Page, 2009). This relationship between aviation and tourism is not one-sided. On the contrary, just as air transportation contributes to tourism, the development of tourism also contributes to the development of the aviation sector in the relevant region (Button & Taylor, 2000; Brida et al., 2016; Zhang & Graham, 2020). Private and corporate companies in the region know that increasing demand depends on improving transportation infrastructure. Spending on transportation infrastructure directly and indirectly increases foreign currency inflow to the region and, more importantly, boosts tourism revenue (Holloway & Humphreys, 2016). Improving transportation infrastructure both increases transportation activities to the region and allows for new routes from different points. This leads to a more developed and diversified transportation network, making it possible to gain market share in new markets.

Another area where the aviation sector is influential is economic growth and employment. The ATAG 2025 report states that the aviation sector provides direct and indirect income to 86.5 million people. Furthermore, its impact on the global economy is approximately $4.1 trillion (ATAG, 2025). To understand that this sector will remain a significant factor in the future, it is sufficient to look at its recovery from the sharp decline during the COVID-19 pandemic, showing a 94.1% improvement a few years later (World Bank, 2024; International Air Transport Association, 2024). Many economic activities are now significantly depend on air transportation. To illustrate this, a review of existing literature clearly shows a predominantly positive correlation between air transportation and economic growth (Button & Taylor, 2000; Hakim & Merkert, 2016; Brida et al., 2016; Zhang & Graham, 2020; Çelik et al., 2025). Furthermore, Adedoyin et al. (2020) discovered a unidirectional relationship between air transportation and tourism. Raihan et al. (2024) revealed a significant relationship between passenger numbers and a country's economic growth. Considering all this, Çelik et al. (2025) state that the relationship between air transportation and economic growth can vary depending on time, the data used, and the country.

This study will examine the impact of tourism and economic growth on air passenger traffic using data from France, the USA, Türkiye, and Australia, prominent countries in the aviation sector, for the years 2005-2020. The reason for selecting these countries is to utilize country data that reflects diverse economic and geographical frameworks, rather than analyzing a narrow profile as seen in previous literature studies. These markets are heterogeneous in terms of both development level and geographical characteristics. This approach allows for a more comprehensive and valid relationship to be established by considering factors such as the political influence of the USA, the isolated status of Australia, and the tourism advantages of Türkiye and France. Although the cross-sectional dimension is relatively small (N=4), this deliberate selection focuses on structurally diverse, leading global aviation markets to capture heterogeneous dynamics. Utilizing a panel framework rather than separate country-based ARDL models allows for the exploitation of pooled variations, thereby increasing the degrees of freedom and statistical power while preventing the loss of country-specific short-run insights.

The introduction explains the purpose and scope of the research, while the second part presents the literature on economic growth, tourism and ARDL methodology. The methods section then describes the research data sources and analysis methodology. The findings section discusses the analysis results in comparison with the literature. The final section concludes the study with a discussion of the empirical findings and relevant policy implications.

2. LITERATURE

An examination of the literature exploring the nexus between air transportation, tourism, and economic growth indicates that the subject has been analyzed through various methodologies that have evolved significantly over the years. In this context, the prominent studies in literature are summarized chronologically in Table 1, highlighting the methodologies employed and the empirical findings obtained, ranging from foundational research to contemporary analyses.

Table 1. Summary of Relevant Literature

Publication	Data & Time Period	Methodology	Dependent Variables	Independent Variables	Key Findings
(Çelik et al., 2025)	1970-2021 Top 10 countries with highest air transport volume	Bootstrap & Fourier Causality Tests	Economic Growth	Passenger and Freight Transport	Unidirectional causality found except for Brazil and Russia; bidirectional causality found for Japan and China.
(Günbay & Eyüboğlu, 2025)	1970-2020 Türkiye	NARDL	Economic Growth	Air Transportation and Energy Consumption	The impact of a decrease in air transport is greater than an increase. Tourism-led growth is empirically evidenced.
(Aydın & Oğuztimur, 2025)	2007-2023 12 Major Provinces	Panel Data, Cointegration	Economic Growth	Air Transportation Activities	A positive relationship was identified between airports and GDP per capita.
(Kılıç et al., 2024)	1960-2022 Türkiye	Cointegration Method	Economic Growth	Air Passenger and Freight Transport	GDP is positively affected by both passenger and freight transport.
(Nguyen, 2023)	1975-2019 Asian Regions	Granger Causality, Cointegration	Air Passenger and Freight Traffic	Economic Growth	Bidirectional in Asia; unidirectional from growth to transport in South, Central, and West Asia.
(İnci, 2022)	1970-2020 G7 Countries	Causality Test	Economic Growth	Number of Flights	No causality from flights to GDP; positive causality from GDP to flights was found.
(Özbey & Akan, 2022)	1981-2021 Türkiye	Regression and Cointegration	Economic Growth	Passenger and Aircraft Traffic	Passenger and aircraft traffic affect GDP positively and significantly.
(Mazzola et al., 2022)	Southern European Islands	Panel Data Analysis	Tourism Arrivals	Air Transportation Indicators	Air transport is not the sole determinant in increasing tourism receipts.
(Özkurt & Bilgir, 2022)	1980-2020 Türkiye	ARDL	Economic Growth	Tourism Receipts	Tourism receipts positively affect economic growth in

					both the short and long run.
(İslamoğlu, 2021)	1960-2019 Türkiye	Cointegration Test	Economic Growth	Air Transportation	Air transport and economic growth were found to move together in the long run (*co-movement*).
(Chassard et al., 2021)	2020 France	Descriptive Statistical Analysis	Accommodation and Air Transportation	Tourist Visits	The decline in tourists directly and negatively affected accommodation and air transport.
(Eren et al., 2020)	1980-2018 Türkiye	Causality and Cointegration	Number of Air Passengers	Economic Growth	A positive long-term relationship and unidirectional causality from growth to passenger demand were found.
(Gümüş Akar et al., 2019)	1980-2015 Türkiye	Causality Test	Economic Growth	Air Transport Liberalization	Causality was identified from liberalization toward economic growth.
(Kızılkaya et al., 2016)	1980-2014 Türkiye	ARDL	Economic Growth	Tourism Receipts, Number of Tourist Arrivals	Tourism receipts were found to have an impact on economic growth in both the short and long run.
(Çoban & Özcan, 2013)	1963-2010 Türkiye	Cointegration and Causality Test	Economic Growth	Tourism Receipts	A bidirectional causality was identified between tourism and economic growth in the long run.

Table 1 above shows that studies on the relationship between air transport, economic growth, and tourism have been conducted from quite different perspectives and comprehensively. While sometimes only economic growth is linked to aviation, in recent years, the one-way and two-way relationships between the two variables have been examined significantly. Studies by Çoban and Özcan (2013) and Kızılkaya et al. (2016) reveal a close and clear relationship between tourism and economic growth in the Turkish market. Akar et al. (2019) revealed the impact of aviation on economic growth, while Eren et al. (2020) explored the opposite, revealing the impact of economic growth on aviation. İslamoğlu (2021) showed a two-way relationship between these variables.

In a study conducted in France by Chassard et al. (2021), the events were examined from a downward perspective, revealing the negative impact of the decrease in tourist numbers on the aviation sector. Similar studies also reinforce this relationship (İnci, 2022; Özbey & Akan, 2022; Özkurt & Bilgir, 2022; Mazzola et al., 2022). Nguyen's (2023) study focusing on the Asian region also clarifies that the situation does not change from region to region. In addition, in studies conducted from 2025 onwards, Çelik et al. (2025) identified causal relationships such as tourism and economy in a sample of the top ten countries with the highest air transport volume; Günbay and

Eyüboğlu (2025) detected asymmetric effects in aviation; and Aydın et al. (2025) revealed the positive contribution of local-level airport activities to economic growth. Since the Panel Autoregressive Distributed Lag (ARDL) method will be used in this study, its suitability for examining similar relationships is explained through a literature review. It would not be wrong to say that the panel ARDL method is widely and effectively used in modeling macroeconomic and sectoral variables in various research fields. For example, Altay and Kayıkçı (2025) and İşcan and Demirel (2021) applied this method to model the connections between economic growth and social indicators. Similarly, Barış and Barış (2024) used this method to identify the long-term effects of geopolitical risks and the relationships between environmental factors (Barış & Barış, 2024; Kurt, 2024; Yıldız, 2021). The methodological flexibility and analytical power of the panel ARDL approach in economic evaluations have been further validated by studies conducted by Aktop (2024) and Yaşar (2022) on foreign trade and income distribution, by Kalkan and Pala (2022) and Ünlü (2021) on technological innovations, and by Özşahin (2016) and Çadırcı and Güner (2020) on energy economics. Furthermore, the effectiveness of the Panel ARDL method in decomposing short-term and long-term dynamics has been highlighted by Sarıhan and Bayır (2023) in protectionist policy assessments, by Çoban (2020) in inflation dynamics, by Dam et al. (2019) in the role of economic freedoms, and by Özgür (2019) in financial market analyses.

3. METHODOLOGY

The selection of variables for the analysis was determined based on common practices in the literature and academically accepted studies. In this context, the number of passengers carried in air transport was defined as the dependent variable, while Gross Domestic Product (GDP), the number of international tourists, and tourism revenues were defined as independent variables. The dependent and independent variables, along with their relevant references and data sources, are presented in Table 2. The Panel ARDL model was chosen for the analysis via the EViews software package. The Panel ARDL model can sometimes yield unsuccessful results when measuring the elasticity relationships of values from raw data. To overcome this drawback, the available datasets were converted to natural logarithms. The country data used in the analysis was obtained from the World Bank (World Development Indicators - WDI) database. To minimize potential deviations caused by the unusual decrease in data due to the COVID-19 impact in 2020, structural breaks and outliers were considered during the econometric analysis to maintain the reliability of the model. To determine the cointegration relationships and dynamic interactions between variables in the analysis process, the Panel Autoregressive Distributed Lag (ARDL) method developed by Pesaran (Pesaran et al., 2001) was used. This method allows for different levels of integration of the data set. Furthermore, this method has the feature of presenting both short-term and long-term coefficients simultaneously in the study. Optimal lag lengths for the variables in the model were determined by selecting the lag level that minimizes the Akaike Information Criterion (AIC) or the Schwarz Information Criterion (SIC) to prevent potential autocorrelation problems within the model. In the analysis process, the analytical process, cross-sectional dependence test, unit root tests, and then long-term coefficient estimations were performed first. Subsequently, Pesaran's (2004) CD (Cross-sectional Dependence) test was applied to account for economic and sectoral dependencies between the relevant countries. To determine whether these coefficients were similar across countries, the model's structure was validated using Swamy's (1970) slope homogeneity test.

Table 2. Data and Variables Used in Research

Variable	Referenced Publication(s)	Data Source
GDP (Gross Domestic Product)	(Aydın & Oğuztimur, 2025; Günbay & Eyüboğlu, 2025; Kılıç et al., 2024)	World Bank (WDI)
Air Transport, Passengers Carried	(Günbay & Eyüboğlu, 2025; İslamoğlu, 2021; Eren et al., 2020)	World Bank (WDI)
International Tourist Arrivals	(Chassard et al., 2021; Mazzola et al., 2022)	World Bank (WDI)
International Tourism Receipts	(Kılıç et al., 2024; Özkurt & Bilgir, 2022)	World Bank (WDI)

The Panel ARDL method is specifically designed for scenarios where the stationarity levels of the fundamental explanatory variables, whether trend-stationary or integrated of order one $I(1)$, are not definitively established. This

approach facilitates the robust identification of long-term relationships (Pesaran et al., 2001). Furthermore, the capacity to incorporate an Unrestricted Error Correction Mechanism (UECM) within the ARDL framework renders this methodology more flexible and reliable compared to alternative cointegration tests. By virtue of the Error Correction Term (ECT), both the short-run speed of adjustment and the long-run equilibrium of the variables can be analyzed concurrently within a unified model (Akel & Gazel, 2015). To determine the appropriate model between the Pooled Mean Group (PMG) estimator, which assumes that long-term coefficients are homogeneous across countries, and the Mean Group (MG) estimator, which accounts for heterogeneity, the Hausman test was performed. Based on the test results, the PMG estimator was found to produce more efficient and consistent results; accordingly, the findings have been reported following this procedure. Crucially, the Panel ARDL approach, specifically the PMG estimator, is well-documented to possess superior performance and robust small-sample properties, mitigating potential small-sample biases when N is small and T is moderate. Furthermore, to eliminate any concerns regarding estimator-specific bias and to cross-verify the long-term relationships, this study does not rely solely on the Panel ARDL method; it explicitly employs Panel Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) frameworks as rigorous robustness checks. The functional form of the model is specified in equation 1.

$$ln\ YO = \beta_0 + \beta_1 ln\ GSY\dot{I}H + \beta_2 ln\ TU + \beta_3 ln\ GE. \quad (1)$$

The variable definitions are given below:

- YO: (Air Passengers): Total number of passengers carried in air transport annually.
- GSYİH: Annual Gross Domestic Product (in current USD).
- TU: Total annual international tourist arrivals.
- GE: Annual total international tourism receipts (in current USD).

4. FINDINGS

This section is organized into five systematic subsections. It begins with descriptive statistics and essential pre-estimation diagnostics, including cross-sectional dependence, slope homogeneity, and panel unit root tests. Next, the long-run co-movement is verified through panel cointegration tests, followed by the primary Panel ARDL estimation results. Finally, long-run robustness checks via FMOLS/DOLS and dynamic directional pathways via Granger causality analysis are presented.

4.1. Descriptive Statistics and Pre-Estimation Diagnostics

Table 3, which includes findings on passenger traffic, international tourism revenues, international tourist numbers, and economic growth, is a descriptive statistics table summarizing the information from the datasets. This information is used to understand how the data is distributed, the mean and degree of variability, and to identify outliers, if any (Gujarati & Porter, 2009).

Table 3. Descriptive Statistics

Statistic	Air Transport Passengers	International Tourism Receipts	International Tourist Arrivals	Economic Growth
Mean	-0.122775	-0.172216	-0.128780	-0.197116
Median	0.012531	0.018482	0.004691	0.016019
Maximum	1.460482	0.578089	1.065781	0.692344
Minimum	-7.368217	-10.41886	-6.261976	-12.12333
Std. Dev.	0.984960	1.355870	0.838400	1.581979
Skewness	-6.740599	-7.370198	-6.660607	-7.325712
Kurtosis	50.59373	56.22504	49.45301	55.68458

Jarque-Bera	6117.265	7625.461	5838.343	7475.824
Probability	0.000000	0.000000	0.000000	0.000000
Sum	-7.366512	-10.33294	-7.726791	-11.82698
Sum Sq. Dev.	57.23865	108.4646	41.47197	147.6568
Observations	60	60	60	60

Table 3 presents the descriptive statistics for the variables under study. Although the Jarque-Bera test results indicate a departure from normality ($p < 0.01$), the validity of the empirical findings remains robust. The Panel ARDL framework and FMOLS estimators are inherently resilient to distributional characteristics, ensuring consistent and unbiased estimates even in the presence of non-normality, endogeneity, and mixed integration orders (I(0) and I(1)). Furthermore, it is crucial to clarify that the descriptive statistics reported in Table 3 were calculated on the first-differenced logarithmic series (i.e., growth rates) rather than their baseline level forms. This deliberate methodological approach directly corresponds to the unit root findings presented subsequently in Table 5. Because 'Air Transport Passengers' and 'Economic Growth (GDP)' are mathematically non-stationary at their levels—containing unit roots, meaning their means and variances are time-dependent—calculating descriptive statistics on their differenced forms ensures that the reported distributional metrics remain time-invariant and statistically reliable. This perfectly harmonizes the preliminary data diagnostics with the mixed integration structure required for the Panel ARDL model.

Before proceeding to unit root testing, it is methodologically imperative to examine the presence of cross-sectional dependence (CD) and slope homogeneity across the panel. Testing for CD determines whether shocks occurring in one country transition to others, which dictates the choice between first-generation and second-generation unit root tests. Additionally, slope homogeneity testing verifies whether the long-run coefficients are uniform across cross-sections. The empirical findings for Pesaran's (2004) CD test and Swamy's (1970) slope homogeneity test are reported in Table 4.

Table 4. Cross-Sectional Dependence and Slope Homogeneity Test Results

Test / Variable	Statistic	p-value	Decision
Pesaran (2004) CD Test (H_0: No CD)			
Air Transport Passengers	1.124	0.261	Fail to Reject H_0
International Tourism Receipts	0.852	0.394	Fail to Reject H_0
International Tourist Arrivals	1.411	0.158	Fail to Reject H_0
Economic Growth (GDP)	0.946	0.344	Fail to Reject H_0
Swamy (1970) Test (H_0: Homogeneous Slopes)			
Δ Statistic	1.157	0.247	Fail to Reject H_0
$\tilde{\Delta}_{adj}$ Statistic	1.283	0.199	Fail to Reject H_0

The results of the Pesaran (2004) CD test indicate that the null hypothesis of no cross-sectional dependence cannot be rejected at any conventional significance level ($p > 0.05$) for all variables. This cross-sectional independence justifies the application of first-generation panel unit root tests, such as the Phillips-Perron (PP) test, and standard panel cointegration techniques. Furthermore, the Swamy (1970) test results confirm that the null hypothesis of slope homogeneity cannot be rejected ($p > 0.05$). This confirms that the long-run parameters are homogeneous across the sampled nations, strongly validating the suitability of the Pooled Mean Group (PMG) estimator within the Panel ARDL framework.

In econometric analysis, the stationarity of a time series means that its statistical moments, such as the mean and variance, remain constant over time and are independent of time (Gujarati & Porter, 2009). To examine the stationarity properties of the series, the Phillips-Perron (PP) test, developed by Phillips and Perron (1988), is used. This method is chosen because it provides more reliable results than the Augmented Dickey-Fuller (ADF) test when the variance is time-dependent and the error terms do not follow a normal distribution (Enders, 2014). The Phillips-Perron (PP) unit root test was utilized to determine whether the variables in the panel dataset contain unit roots, and the findings are summarized in Table 5.

Table 5. Phillips-Perron (PP) Unit Root Test Results

Variables	At Level [I(0)]: Intercept	At Level [I(0)]: Trend and Intercept	At First Difference [I(1)]: Intercept	At First Difference [I(1)]: Trend and Intercept	Integration Order
Air Transport Passengers	0.3542	0.1285	0.0001***	0.0003***	I(1)
International Tourism Receipts	0.0125**	0.0084***	0.0000***	0.0000***	I(0)
International Tourist Arrivals	0.0341**	0.0152**	0.0000***	0.0001***	I(0)
GDP	0.6421	0.2158	0.0000***	0.0000***	I(1)

Note: *** and ** indicate statistical significance at the 1% and 5% levels, respectively. The values in the table represent p-values.

The Phillips-Perron (PP) unit root test results demonstrate a mixed integration profile among the variables, which is visually and structurally ideal for panel autoregressive distributed lag modeling. Specifically, "Air Transport Passengers" and "GDP" contain unit roots at their levels ($p > 0.05$) but become strictly stationary after taking their first differences ($p < 0.01$), identifying them as I(1) processes. Conversely, "International Tourism Receipts" and "International Tourist Arrivals" are statistically significant at their baseline levels ($p < 0.05$), confirming that they follow an I(0) stationary process. Crucially, none of the variables exhibit an I(2) integration order. This explicit mixture of I(0) and I(1) variables mathematically rejects the use of traditional panel cointegration methods (like Johansen) and provides a powerful, textbook-perfect justification for employing the Panel ARDL methodology, as developed by Pesaran et al. (2001).

4.2. Panel Cointegration Test Results

The Pedroni (2001) cointegration test presented in Table 6 is a methodology used to examine whether there is a long-term equilibrium relationship between variables. This test is conducted to identify long-term relationships, prevent misleading regression, ensure appropriate model selection, account for heterogeneity in panel data, and establish the necessary preconditions for causality analysis. Statistical significance across test statistics is considered sufficient evidence for the existence of cointegration (Pedroni, 2001). The results of the Pedroni cointegration test for air passenger traffic, international tourism revenues, international tourist arrivals, and economic growth are summarized in Table 6.

Table 6. Pedroni Cointegration Test Results

	Intercept (Without Trend)		**Trend and Intercept**	
Test Statistics	Statistic	Probability	Statistic	Probability
Panel v-Statistic	-0.793098	0.7861	-1.579527	0.9420
Panel rho-Statistic	0.348479	0.6363	1.184893	0.8820
Panel PP-Statistic	-2.667654	0.0038*	-3.254453	0.0006*
Panel ADF-Statistic	-2.213692	0.0134*	0.0015	0.0015*
Group rho-Statistic	1.177898	0.8806	1.688464	0.9543
Group PP-Statistic	-3.080445	0.0010*	-3.262228	0.0006*
Group ADF-Statistic	-1.820321	0.0344*	-1.207107	0.1137

As shown in Table 6, Panel PP, Panel ADF, Group PP, and Group ADF statistics were found to be statistically significant ($p < 0.05$). These results indicate the existence of a long-term cointegration relationship between the variables. According to the findings of the trend-incorporating model, the cointegration relationship remains robust

when a deterministic trend is included. The resulting table supports the aim of the study. The results provide significant evidence that air transport, international tourism indicators, and economic growth move together in the long term. In light of these findings, Fully Modified Least Squares (FMOLS) and Dynamic Least Squares (DOLS) methods, along with the Panel ARDL approach, are considered appropriate to explain the nature of long-term relationships between variables. While the Pedroni cointegration test investigates whether variables move together in the long term, it does not provide information about the direction, magnitude, or statistical strength of the relationship. Consequently, it is necessary to use FMOLS and DOLS methods to estimate long-term coefficients. Since this study aims to measure both the short-term and long-term dynamic effects of the relevant variables, the Panel ARDL approach has also become usable for the simultaneous analysis of the available data.

4.3. Panel ARDL Estimation Results

The Autoregressive Distributed Lag (ARDL) model employs the "Bounds Test" procedure developed by Pesaran, Shin, and Smith (2001) to investigate the existence of a long-term relationship between variables. Therefore, the ARDL bounds test is capable of accommodating variables with varying degrees of integration. This feature allows for the simultaneous analysis of series with I(0) or I(1). Before evaluating the empirical model, the Hausman specification test was performed to determine the optimal estimator between the Pooled Mean Group (PMG) and Mean Group (MG) models. The null hypothesis (H_0) posits that long-run parameters are homogeneous across cross-sections, meaning that the PMG estimator is more efficient and consistent than the heterogeneous MG estimator. The Hausman test yielded a Chi-square statistic of 2.38 with 3 degrees of freedom, resulting in a p-value of 0.497. Since the p-value is significantly greater than the 0.05 threshold, the null hypothesis cannot be rejected. This result provides robust statistical evidence that long-run homogeneity holds across the panel, confirming that the PMG estimator is the most efficient choice for this study. Consequent to this model selection procedure, the Panel ARDL estimation results based on the PMG framework are detailed in Table 7.

Table 7. Panel ARDL Estimation Results

Variables	Coefficient	Std. Error	t-Statistic	Prob.
Long-Run Coefficients				
International Tourist Arrivals	-0.718647	0.173685	-4.137644	0.0002
International Tourism Receipts	0.351408	0.090678	3.875359	0.0004
Economic Growth (GDP)	-0.098415	0.065515	-1.502181	0.1415
Short-Run Coefficients				
COINTEQ01 (ECT)	-0.675671***	0.143215	-4.717878	0.0001
Δ (International Tourist Arrivals)	1.195513	0.652622	1.831861	0.0750
Δ (International Tourism Receipts)	-0.055231	0.198504	-0.278235	0.7824
Δ (Economic Growth)	0.074772	0.060188	1.242295	0.2219
Constant (C)	-0.005464	0.017364	-0.314666	0.7548

Note: Prob. values indicate statistical significance. Δ denotes the first difference operator.

When examining the data in Table 7, it is observed that in the long term, an increase in the number of international tourists has a diminishing effect on air passenger traffic. Contrary to previous studies, this long-term negative effect means that a quantitative increase in the number of tourists, usually associated with mass tourism, may not always lead to a linear increase in aviation demand in every country. This is particularly evident in developed economies like the USA, where passengers arrive for other purposes despite appearing to be tourism-based. This also highlights the fact that tourists with low spending capacity are forced to choose alternative modes of transportation, or that groups wishing to engage in tourism activities may increasingly opt for short-distance destinations that do not require air travel, such as yacht trips or long-sleeper train journeys. Therefore, these findings suggest that the

relationship between the two variables is not always based on the absolute numerical value of tourists, but rather on their spending potential and desires, and the tourism revenues obtained. Similar results are also found in existing literature. Papatheodorou (2021) argues that long-term growth in tourism revenues, rather than the number of tourists, positively affects air passenger traffic. Furthermore, Graham and Zhang (2020) similarly show that tourists with higher economic budgets tend to travel by air. This inevitably forces passengers with lower economic levels to prefer other modes of transportation. Because, especially for flights to tourist areas, if there is sufficient demand, airlines do not lower ticket prices, and sometimes even increase them. Regarding the economic growth variable, the results were found to be statistically insignificant ($p > 0.05$). One of the most important reasons for this result is that economic growth is a phenomenon with many broad sub-categories. It does not seem possible for any single sub-item (air transport or tourism) to directly affect economic growth at a similar rate for every country. This finding is also confirmed by Brida et al. (2016), who, conversely, argue that economic growth does not always lead to a direct increase in air passenger demand. This is because sometimes the level of economic growth can be caused by developments or declines in areas not directly related to civil air transport, such as the defense industry and agriculture. When short-term results are examined, the increase in the number of international tourists has a positive impact on air passenger traffic. Indeed, seaside tourism, especially during the summer season, or activities such as religious trips, skiing, and tournaments at certain times of the year, are largely carried out by air because they are international travel. Otherwise, the attractiveness of these activities in terms of comfort and safety would decrease. This finding is consistent with the literature suggesting that the increase in tourism demand stimulates short-term aviation demand and that air transport serves as the primary mode of transport for international travel in many areas (Brida et al., 2016; Zhang & Graham, 2020). However, no statistically significant relationship was found between international tourism revenues and economic growth in the short term ($p > 0.05$). Similarly, it was concluded that neither tourism revenues nor economic growth have a statistically significant effect on the number of air transport passengers in the short term ($p > 0.05$). This result highlights that it is quite difficult for factors such as tourism or economic growth, whether short-term or immediate, to directly affect aviation. Developments in these sectors can only have a significant impact on the aviation sector in the long term. Indeed, studies on this subject indicate that the relevant variables do not produce effective results on the aviation sector in the short term (Balaguer & Cantavella-Jorda, 2002; Lee & Chang, 2008). Another crucial econometric finding displayed in Table 7 is that the error correction term (COINTEQ01) is negative (-0.675671) and statistically highly significant at the 1% level ($p < 0.01$). This negative and highly significant parameter provides robust and definitive empirical validation for the existence of a stable, long-run cointegrated equilibrium relationship among air transport passengers, international tourism indicators, and economic growth. The coefficient value of -0.6756 implies that approximately 67.5% of the short-run deviations and imbalances resulting from economic or external shocks in one year are automatically corrected and adjusted back toward the long-run steady-state equilibrium in the following year. This indicates a relatively rapid speed of adjustment, confirming that despite major global structural shocks within the 2005–2020 observation period, the aviation passenger traffic framework across the sampled nations possesses a highly resilient self-correcting mechanism.

To evaluate the comprehensive reliability of the reported Panel ARDL framework, the statistical and macroeconomic implications of the coefficients warrant a deeper structural discussion. Econometrically, the reliability of these estimators is tightly anchored to the pre-estimation diagnostics established in Sections 4.2 and 4.3. The verified absence of cross-sectional dependence guarantees that the long-run parameters are not contaminated by unobserved transboundary shocks across the sampled nations, while the Hausman test mathematically ensures that the pooled consistency of the PMG estimator is superior to heterogeneous alternatives. Macroeconomically, the contrasting signs of international tourist arrivals between the short run (1.1955) and the long run (-0.7186) provide a highly sophisticated and reliable reflection of aviation market dynamics. In the short run, a surge in tourist volume functions as an immediate demand shock that directly stimulates airline capacity utilization. In the long run, however, nominal increases in tourist arrivals without equivalent high spending potential indicate the onset of mass tourism. This phenomenon often leads to airport infrastructure saturation, slot constraints, and environmental regulations in advanced aviation hubs like the USA and France, ultimately exerting a diminishing long-term effect on passenger traffic. Conversely, international tourism receipts exhibit a robust, consistently positive long-run coefficient (0.3514). This underscores that high-yield, premium-spending tourism represents the genuine long-term structural catalyst for sustainable airline passenger demand. The statistical insignificance of GDP further validates that within these prominent and highly institutionalized aviation sectors, passenger traffic has become partially decoupled from

baseline aggregate economic growth, moving instead on an intrinsic trajectory dictated by targeted tourism revenues. This multi-layered alignment between rigorous diagnostic robustness and structural economic theory confirms the high explanatory reliability of our empirical results.

4.4. Long-Run Coefficient Estimation (FMOLS and DOLS)

The Fully Modified Ordinary Least Squares (FMOLS) method is an approach used to estimate long-term coefficients between cointegrated variables in panel datasets such as firms, countries, or sectors (Pedroni, 2001). FMOLS analysis is performed to measure long-term relationships, estimate coefficients after determining cointegration, facilitate policy analysis, and address methodological limitations where the standard Least Squares (OLS) method is insufficient. The Dynamic Least Squares (DOLS) method is a dynamic regression approach developed to estimate long-term relationship coefficients between cointegrated time series and panel datasets. The DOLS method is specifically designed to reduce series correlation. Furthermore, DOLS is used to estimate long-term coefficients under cointegration frameworks, eliminate endogeneity problems, and obtain more robust and reliable long-term estimates (Stock & Watson, 1993). This part of the analysis involved coefficient estimation for international tourist arrivals, international tourism revenues, and economic growth, and the empirical results are presented in Table 8.

Table 8. Long-Run Coefficient Estimation Results (FMOLS and DOLS)

Variables	FMOLS Coefficient	t-Statistic	Prob.	DOLS Coefficient	t-Statistic	Prob.
International Tourist Arrivals	-0.257844*	-1.955844	0.0562	0.508686	0.453523	0.6692
International Tourism Receipts	0.575962***	3.134975	0.0029	0.988448	0.952687	0.3845
Economic Growth (GDP)	0.252502*	1.944860	0.0575	0.070847	0.128380	0.9029

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

As seen in the FMOLS estimation presented in Table 8, it was concluded that air transport passenger numbers increase significantly as international tourism revenues increase. In contrast, in the DOLS estimations, the effect of both tourism revenues and economic growth on air passenger traffic is seen as insignificant. This difference may have arisen due to the heterogeneity in the economic structures of the countries sampled in the study and the technical differences in how these models address endogeneity issues. This situation reinforces the idea that the effect of economic growth on aviation traffic is not a uniform effect, but rather a dynamic phenomenon that varies in different national contexts. Furthermore, the lack of statistical significance in the DOLS results may also be due to the fact that the dynamic nature of the model requires significant lag lengths.

4.5. Granger Causality Analysis

Granger causality analysis is performed to determine the direction of causality, test its predictive power, derive policy and investment implications, analyze short-term dynamics, and examine causality after cointegration has been identified (Granger, 1969). At this stage, the table presented in Table 9 is used to understand in what direction the variables included in the study influence each other and which variable causes which.

Table 9. Granger Causality Test Results

Null Hypothesis (H0)	Probability (p-value)	Decision
International Tourist Arrivals → Air Transport Passengers	8×10^{-7}*	Reject H_0
Air Transport Passengers → International Tourist Arrivals	0.4799	Fail to Reject H_0
International Tourism Receipts → Air Transport Passengers	0.9202	Fail to Reject H_0

Air Transport Passengers → International Tourism Receipts	0.0000*	Reject H_0
Economic Growth → Air Transport Passengers	0.8816	Fail to Reject H_0
Air Transport Passengers → Economic Growth	0.0000*	Reject H_0
International Tourism Receipts → International Tourist Arrivals	0.6637	Fail to Reject H_0
International Tourist Arrivals → International Tourism Receipts	0.0000*	Reject H_0
Economic Growth → International Tourist Arrivals	0.6435	Fail to Reject H_0
International Tourist Arrivals → Economic Growth	0.0000*	Reject H_0
Economic Growth → International Tourism Receipts	0.2835	Fail to Reject H_0
International Tourism Receipts → Economic Growth	0.0000*	Reject H_0

Note: A probability value (p-value) of less than 0.05 indicates the presence of a statistically significant causality relationship between the respective variables.

The empirical results of the Granger causality test reveal a complex network of interactions among the variables. A unidirectional causality was identified running from international tourist arrivals to air transport passengers. Furthermore, the findings indicate that air transport passengers Granger-cause both international tourism receipts and economic growth. In addition, international tourist arrivals were found to have a significant causal impact on both tourism receipts and economic growth. Finally, a unidirectional causality was detected from tourism receipts toward economic growth ($p = 0.00$). The fact that causality flows from air transport toward tourism receipts confirm that aviation infrastructure and accessibility serve as a fundamental "supply-side" driver that nourishes the tourism sector. This finding is consistent with the theoretical expectation that strategic investments in aviation directly stimulate the tourism economy by facilitating easier access and increasing destination competitiveness.

5. CONCLUSION AND POLICY RECOMMENDATIONS

This study, aiming to explore the relationship and direction of variables among countries with different economic, social, and tourism characteristics, differs from other studies in the literature, even though similar studies have been conducted at the country and regional levels, because it attempts to determine whether there is a broader and more valid relationship between variables by bringing together different profiles. Using the Panel ARDL method to examine long-term and short-term changes and relationships, this research included total number of passengers carried in air transport, GDP, total number of international tourists, and annual international tourism revenues as unique variables in the analysis. Main analyses were performed after meeting the relevant prerequisites to ensure methodological reliability of the study. This aimed to understand whether variables in countries with different profiles would yield common results.

The analysis results show a significant long-term relationship between the variables listed above. In particular, the significant results of the Panel PP statistic (0.0006) and the Panel ADF statistic (0.0015) revealed a synchronized and long-term link between air transport, tourism, and economic growth. Furthermore, the findings are consistent with similar studies in literature. The results of FMOLS and Panel ARDL analyses show that an increase in international tourism revenue directly and statistically significantly leads to an increase in the number of air passengers. Tourism revenue is divided into two parts: revenue from low- and medium-level spending tourists, and revenue from high-level spending tourists. These findings primarily indicate that an increase in tourism revenue generated by tourists with higher spending potential directly stimulates aviation demand. This is explained by the fact that low-spending tourists do not always prefer air travel, and airfare prices are high, especially during peak tourist seasons. Furthermore, according to the FMOLS analysis results, while economic growth has a positive effect on air traffic, this effect was not statistically significant in ARDL and DOLS estimations. This situation is closely related to the level of economic development of countries. In economically developed countries, an increase in air traffic may not directly or at least significantly affect economic growth. Conversely, for economically developing countries like

Türkiye, this relationship is sharper and more significant. The Granger Causality Analysis results reveal an intricate network of unidirectional causal interactions among the variables. For example, unidirectional causal relationships have been identified from the number of international tourists to air transport passengers, from air transport passengers to both tourism revenue and economic growth, from tourist numbers to tourism revenue and GDP, and finally from tourism revenue to economic growth. Based on these empirical findings, it would not be wrong to say that each variable is both an influencer and an influenced factor.

In light of these results, it would be highly appropriate for policymakers and industry stakeholders in countries with similar profiles, not just those mentioned, to prioritize expanding airport capacities and airline networks to trigger sustainable economic growth. Strategic investments in aviation infrastructure will not be limited to tourism but will also enable the creation of new economic sectors and flight networks. Furthermore, instead of pursuing policies focused solely on increasing tourist numbers, authorities should implement high-value (niche) tourism policies designed to attract high-spending visitors. These visitors contribute more to the economy and aviation sector of their host country than other mid- and low-level visitors. In addition, high-income tourists are more inclined to choose air travel due to its comfort, safety, and speed features. An increase in this number could create a positive multiplier effect for the aviation sector. As this study demonstrates, there is a deep, structural, and mutually beneficial relationship between the tourism and aviation sectors. Therefore, integrating airline flight planning and tourism activities would be much more beneficial for both sectors. For example, planning direct flights to destinations with high tourism revenue potential, or increasing existing flight traffic, would revitalize both the aviation sector and tourism, simultaneously strengthening the regional economy. The main limitation of this study is that the analysis period ends in 2020, when the COVID-19 pandemic peaked. For future research, it is recommended to include data from after 2022 to observe the long-term structural effects of the pandemic more clearly. Furthermore, including the levels of aviation liberalization in the relevant countries in the model could provide deeper insights into the regulatory dynamics of the sector.

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This article meets the standards of research and publication ethics.

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During the preparation of this manuscript, Gemini was used for translation purposes. All AI-generated translations were reviewed and verified by the author(s).

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The authors declare that they have no competing interests.

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