

The Role of Air Connectivity in Enhancing Tourism Revenues in India: A Time-Series Analysis (2003–2024)

Ankush

Research Scholar, Department of Management

Sant Longowal Institute of Engineering and Technology (SLIET), Longowal, Punjab, India

Email: Anku7h@gmail.com

ORCID ID: <https://orcid.org/0000-0003-1423-0432>

Prof. Pardeep Kumar Jain

Professor, Department of Management and Humanities,

Sant Longowal Institute of Engineering and Technology (SLIET), Longowal, Punjab, India.

Email: pardeep_jain2000@yahoo.com

Anshul Kumar

Research Scholar, Department of Management and Humanities,

Sant Longowal Institute of Engineering and Technology (SLIET), Longowal, Punjab, India.

Email: anshuldogra@hotmail.com

Abstract

Tourism revenue income from 2003 to 2004. The main aim to examine Weather improvement in This Article explores how growth of Indian civil aviation transportation network has influenced flight connectivity and total air passenger number has changed increase into tourism incomes. We used secondary data collected from official government sources such as DGCA , Ministry of tourism and RBI. The Study applies a series of time series test including the Augmented Dickey–Fuller (ADF) test, Zivot–Andrews test, Johansen cointegration, Vector Error Correction Model (VECM), and Granger-causality analysis. All calculations were executed on R studio. The main finding a long-term strong association between air connectivity with tourism revenue and further government incentive UDAN programme have strengthened regional access and, in turn, stimulated tourism-driven economic activity. These results underscore the need for coherent policy coordination between the aviation and tourism sectors to ensure inclusive and sustainable growth.

Keywords: Air Connectivity, Tourism Revenues, UDAN Scheme, Time-Series Analysis, Indian Aviation

1. Introduction

Over the last two decades, India’s aviation industry has undergone a profound transformation (Phuyal, 2023). The liberalisation of the market, together with the rise of low-cost carriers such as IndiGo and SpiceJet, has expanded the accessibility of air travel to a much wider population segment (GlobalData, 2023) (Fu, 2010). A crucial policy was the launch of the **UDAN (Ude Desh ka Aam Naagrik)** scheme in 2017, which sought to improve regional connectivity by linking smaller cities with major hubs (PIB, 2022). Parallel to this aviation boom, the tourism sector has become a significant contributor to both GDP and foreign-exchange inflows (Mir, 2018) (Jus et al., 2023). As most inbound and domestic tourists rely on air transport, the expansion of flight routes and airport infrastructure directly affects the movement of passenger

and the flow of tourism revenue (Dileep & Kurien, 2021). Therefore, the growth trajectories of the civil-aviation and tourism industries in India are tightly interwoven (Khadaroo & Seetanah, 2009). Beyond its immediate operational relevance, air connectivity increasingly functions as a strategic infrastructure driver of regional economic integration and destination competitiveness. In emerging economies such as India, improvements in aviation networks reduce spatial frictions, enhance market accessibility, and expand tourism catchment areas (Kumar et al., 2025). As a result, connectivity does not merely facilitate travel; it potentially reshapes the structural foundations of tourism-led revenue generation. However, whether this relationship reflects a stable long-run equilibrium or merely short-term co-movements remains an open empirical question. Although policymakers have long assumed that air-transport expansion propels tourism growth, empirical evidence quantifying this linkage for India remains scarce (Kumar et al., 2025) (Yasin, 2022). Previous investigations have typically analysed either aviation performance or tourism trends in isolation. Despite growing recognition of the aviation–tourism nexus, three critical gaps remain in the Indian context. First, existing studies rarely model air connectivity, tourism activity, and tourism revenue within a unified multivariate framework capable of distinguishing long-run equilibrium from short-run adjustments. Second, limited attention has been given to structural breaks arising from major policy interventions such as the UDAN scheme or systemic shocks such as COVID-19. Third, little evidence exists on the predictive performance of structural econometric models relative to alternative forecasting specifications. Addressing these gaps is essential for understanding not only whether connectivity drives tourism revenue, but also how persistent and policy-sensitive this relationship is over time. (Dileep & Kurien, 2021) (Gupta, 2025). Addressing this gap, the present study investigates the long-run equilibrium and causal connections between measures of air connectivity, tourism activity, and tourism revenues within a unified econometric framework.

This study follows these objectives:

To estimate the long-run equilibrium relationship between air connectivity, tourism activity (foreign and domestic), and tourism revenues in India.

To evaluate whether tourism activity mediates the influence of air connectivity on revenue generation.

To determine both the short-run and long-run directions of causality among the key variables.

To assess how policy interventions (e.g., UDAN) and external shocks (e.g., COVID-19) have modified these relationships over the study period. This study contributes to the literature in four ways. First, it integrates air connectivity, tourism activity, and tourism revenue within a unified framework for India over period (2003-2024). Second, it evaluates both long-run equilibrium and short-run adjustment mechanisms using VECM, thereby distinguishing structural relationships from temporary fluctuations. Third, it incorporates policy and shock dummies to assess the structural impact of the UDAN initiative and the COVID-19 disruption. Fourth, it compares alternative forecasting models to evaluate the predictive implications of

aviation-driven tourism growth. Together, these contributions provide both theoretical insight and practical policy relevance.

2. Literature Review

The foundation of this research draws upon two established theoretical frameworks that explain the interaction between transport accessibility and tourism development. First, Accessibility Theory suggests that improvements in transport networks reduce travel constraints by minimizing both time and psychological distance between destinations. Enhanced accessibility, particularly through air connectivity, not only increases mobility but also shapes the competitiveness of destinations by broadening their catchment markets (Khadaroo & Seetanah, The role of transport infrastructure in international tourism development: A gravity model approach, 2008). In essence, connectivity functions as a catalyst that transforms spatial potential into economic opportunity, thereby reinforcing the tourism sector. Second, the Tourism Area Life Cycle (TALC) Model proposed by (Butler, 1980) provides a complementary perspective. It postulates that destinations evolve through distinct stages—exploration, development, consolidation, and stagnation—each driven by varying levels of accessibility and market exposure. (Kumar et al., Post-Independence Tourism of India, 2025) Air transport often serves as the critical force that transitions a destination from exploration to growth, allowing it to reach maturity and sustain competitiveness in the global tourism market (Butler, 1980) (Prideaux, 2000). Together, these frameworks justify the analytical focus on air connectivity as a long-term determinant of tourism expansion and revenue generation.

A significant body of empirical work highlights the economic role of air transport infrastructure in shaping tourism outcomes. In a study on Brazil, (Marazzo et al., 2010) established that air transport development acts as a driver of GDP growth, emphasizing aviation's role in improving national productivity and interregional trade. Similarly, (Baker et al., 2015) demonstrated that regional aviation contributes to economic resilience by integrating remote regions into broader markets, thereby enhancing social and economic inclusion. From a tourism perspective, (Khadaroo & Seetanah, The role of transport infrastructure in international tourism development: A gravity model approach, 2008) showed through a gravity model that well-developed transport infrastructure significantly increases international tourist arrivals to island economies such as Mauritius. Their findings underline that the elasticity of tourism demand with respect to accessibility is substantial, implying that each improvement in transport connectivity tends to yield a proportionally greater tourism response. (Tang et al., 2023) Extended this understanding to the Asian context, concluding that aviation expansion has been instrumental in increasing cross-border tourism flows and strengthening the competitiveness of regional travel networks. Collectively, these studies provide empirical evidence that aviation acts as both an economic enabler and a tourism multiplier. India's aviation industry presents a compelling case for examining the link between air connectivity and tourism. Since 2008, the country has experienced rapid transformation across three broad phases. The first phase, following 2008, was marked by the rise of low-cost carriers (LCCs) such as IndiGo, GoAir, and SpiceJet (Jain & Natarajan, 2015). These airlines democratized air travel by offering competitive fares and expanding frequency to major and secondary cities

(Ghoshal & Mathews, 2015). This democratization of air access significantly boosted domestic tourism and business travel. The second phase began with the introduction of the UDAN (Ude Desh ka Aam Naagrik) scheme in 2017, which aimed to promote balanced regional development by connecting underserved airports and enabling affordable fares. The initiative not only expanded the aviation network but also brought new tourist destinations within reach, especially in Tier-II and Tier-III regions. The third and most challenging phase came during 2020–2021, when the COVID-19 pandemic caused a near-complete standstill in both air transport and tourism activity. However, subsequent years witnessed a strong rebound led by domestic tourism, indicating the resilience of demand and the adaptive capacity of India's aviation sector (Jus et al., 2023). These developments make the Indian context especially suitable for studying long-term interdependence between aviation and tourism performance. Despite increasing recognition of aviation's role in tourism development, quantitative studies integrating both sectors in India remain limited. Most existing works either analyse macro-level tourism trends or evaluate aviation growth separately, without addressing how connectivity translates into economic outcomes over time. Moreover, few studies incorporate mediating variables such as tourist arrivals or account for policy-induced structural shifts like the UDAN scheme or the unprecedented COVID-19 shock. No comprehensive econometric model currently captures these dynamics in a time-series framework spanning the post-liberalisation period (2003-2024). This study addresses that gap by constructing a model that simultaneously evaluates the direct and mediated effects of air connectivity on tourism revenues while controlling for operational and policy variables.

3. Conceptual Framework

Based on theoretical and empirical insights, this research conceptualises the relationship among three principal constructs:

- Independent Variable (IV): Air Connectivity — measured through total passenger traffic (domestic and international) and fleet size (Khadaroo & Seetana, The role of transport infrastructure in international tourism development: A gravity model approach, 2008) (Marazzo et al., 2010).
- Mediating Variable (MV): Tourism Activity — represented by Foreign Tourist Arrivals (FTA) and Domestic Tourist Visits (Organization., 2022) (Wu et al., 2022).
- Dependent Variable (DV): Tourism Revenue — captured through FTA earnings in ₹ crore (Adeleye, 2023).

The proposed model posits that air connectivity indirectly influences tourism revenues through its effect on tourism activity, while also exerting a direct impact by enhancing destination accessibility (Khadaroo & Seetana, The role of transport infrastructure in international tourism development: A gravity model approach, 2008). Control variables account for operational efficiency and market competitiveness.

Conceptual Flow:

Air Connectivity (IV) → Tourism Activity (MV) → Tourism Revenue (DV)

This framework forms the analytical foundation for the econometric testing presented in the subsequent methodology section.

4. Research Methodology

The study employs a quantitative, longitudinal research design based on secondary data covering the period from 2003 to 2024. The purpose of this design is to evaluate both the short-term and long-term relationships between India’s air connectivity and tourism revenue. The methodology integrates econometric time-series techniques to uncover causal and equilibrium associations among key variables. By using this approach, the study not only identifies statistical linkages but also interprets how policy initiatives, such as the UDAN scheme, and external disruptions, such as COVID-19, have influenced these linkages over time.

The analysis proceeds through four key stages:

Testing the stationarity of variables and Structural breaks using the Augmented Dickey–Fuller (ADF) test (Dickey & Fuller, 1979), and Zivot–Andrews test.

Applying the Johansen Cointegration test (Johansen , 1988) to detect the existence of long-run equilibrium relationships.

Estimating a Vector Error Correction Model (VECM) (ENGLE & GRANGER, 1981) to capture both short-run adjustments and long-run causality.

Conducting Granger causality tests (Granger, 1969) to examine the direction of influence between air connectivity and tourism revenue.

4.1 Data Source

The study relies exclusively on secondary data compiled from reputable national and international institutions to ensure consistency and accuracy.

Data Variable	Source
Domestic & International Air Passengers	Directorate General of Civil Aviation (DGCA)
Foreign Tourist Arrivals (FTA) and Domestic Tourist Visits	Ministry of Tourism (MoT), Government of India
FTA Earnings (₹ Crore)	Reserve Bank of India (RBI) & MoT Statistical Reports

All data were compiled into an annual time series (2003-2024) and cross-verified across sources. Missing or inconsistent values were handled through interpolation or official MoT growth projections, ensuring reliability of the dataset. All variables were transformed into their natural logarithmic form to reduce heteroscedasticity and improve normality. This transformation also allows the estimated coefficients to be interpreted as elasticities.

4.2 Variables and Measurement

To ensure conceptual clarity, the study defines the operational variables as follows:

Type	Variable	Description / Unit	Symbol	Expected Relationship
Independent Variable (IV)	Air Connectivity	Total passenger traffic (domestic + international, in millions)	AC	+

Type	Variable	Description / Unit	Symbol	Expected Relationship
Mediating Variable (MV)	Tourism Activity	Foreign Tourist Arrivals (million) and Domestic Tourist Visits (million)	TA	+
Dependent Variable (DV)	Tourism Revenue	FTA earnings in ₹ crore	TR	+

The variables are chosen based on prior literature (Khadaroo & Seetanah, The role of transport infrastructure in international tourism development: A gravity model approach, 2008) and align with India's tourism-economic structure.

4.3 Software and Applications

Software	Purpose	Use in Study
Microsoft Excel	Used to organize data and create graphs	The raw data was entered, cleaned, and basic line graphs were created to understand trends
R Packages	Used for data analysis and visualization	Different packages like <i>tseries</i> , <i>urca</i> , <i>vars</i> , <i>lmtest</i> , and <i>ggplot2</i> were used for statistical tests and creating graphs

4.4 Analytical Framework

Conceptual and Econometric Framework

The study's framework posits that Air Connectivity influences Tourism Revenues, with this relationship being mediated by Tourism Activity. This conceptual structure illustrates how enhanced accessibility through aviation stimulates tourism movements, which subsequently drive higher tourism-generated earnings.

Conceptual Flow

Air Connectivity (IV) → Tourism Activity (MV) → Tourism Revenues (DV)

Econometric Model

The relationship is mathematically represented as:

$$\text{Tourism Revenue}_t = \beta_0 + \beta_1 (\text{Air Connectivity}_t) + \beta_2 (\text{Tourism Activity}_t) + \beta_3 (\text{Control Vars}_t) + \varepsilon_t$$

Where:

Tourism Revenue_t: Foreign Tourist Arrivals (FTA) earnings at year t.

Air Connectivity_t: Total number of passengers (Domestic + International) at year t.

Tourism Activity_t: Combined number of Foreign Tourist Arrivals (FTA) and Domestic Tourists at year t.

β_0 : Intercept term representing the baseline tourism revenue.

β_1, \dots, β_3 : Estimated coefficients indicating the strength and direction of relationships.

ε_t : Error term capturing unexplained variations in tourism revenue.

4.5 Econometric Test Rationale

To ensure the robustness and reliability of the time-series analysis, a **sequential econometric testing procedure** was employed. Each test was selected based on its suitability for handling non-stationarity, structural breaks, and dynamic relationships among variables.

Unit Root Testing (ADF): The first step involves the **Augmented Dickey–Fuller (ADF) test**. Given the typical trend-stationary nature of macroeconomic data, this is essential to determine the integration order of our variables and avoid the pitfalls of spurious regression.

Endogenous Structural Breaks (Zivot–Andrews): Standard unit root tests often lose power in the presence of massive shocks. Therefore, I utilized the **Zivot–Andrews test** to identify potential structural breaks—specifically those triggered by the 2020 pandemic—allowing the model to test for stationarity while accounting for a shift in the intercept or trend.

Long-Run Equilibrium (Johansen): After confirming the integration orders, I moved to the **Johansen Cointegration test**. Unlike simpler methods, this multivariate framework identifies the number of cointegrating vectors (r), establishing whether a stable, long-run "anchor" exists between air connectivity and revenue.

Error Correction Mechanism (VECM): If cointegration is present, a **Vector Error Correction Model (VECM)** is estimated. This allows us to separate the long-run equilibrium relationship from the short-run deviations, specifically measuring the speed at which the system "fixes" itself after a shock.

Directional Causality (Granger): To resolve the endogeneity between the variables, the **Granger Causality test** is applied. This clarifies if air connectivity is a leading indicator for tourism arrivals, or if the relationship is characterized by a feedback loop.

System Dynamics (VAR/OLS): I've also employed **VAR/OLS models** to capture the broader interdependencies. This step is vital for understanding how a shock in one variable (like airline capacity) ripples through the entire tourism ecosystem over time.

Data Synthesis and Visualization: Finally, the results are translated into **Visualizations**. These plots aren't just for show; they provide a critical "sanity check" to ensure that the econometric outputs align with the actual observed trends in the Indian market.

Time-series data often exhibit non-stationarity, which can lead to misleading or spurious regression results if not properly addressed. Therefore, the Augmented Dickey–Fuller (ADF) test was initially employed to examine the presence of unit roots in the variables. However, given the possibility of structural breaks in the data—particularly due to major disruptions such as the COVID-19 pandemic—the Zivot–Andrews test was further applied to detect endogenously determined breakpoints and to ensure more reliable stationarity results.

Following the confirmation of stationarity properties, the Johansen cointegration test was conducted to determine whether a long-run equilibrium relationship exists among key variables, including air connectivity, foreign tourist arrivals, domestic tourism, and tourism revenue. In the presence of cointegration, the Vector Error Correction Model (VECM) was employed, as it is well-suited to capture both short-run dynamics and the speed of adjustment toward long-run equilibrium.

Furthermore, the Granger causality test was applied to identify the direction of causal relationships between variables, particularly to examine whether changes in air connectivity

influence tourism indicators or vice versa. Additionally, VAR/OLS models were utilized to estimate the interrelationships among variables and to provide robustness to the empirical findings. Finally, graphical visualization techniques were used to support interpretation and present trends clearly.

4.6 Policy and Event Dummies

To handle the "shocks" in the data, I've used dummy variables as a statistical safeguard. These variables help the model distinguish between a true long-term trend and a temporary, massive disruption. I introduced a COVID-19 dummy ($SD_{\{cvd\}}$) assigned a value of 1 for the pandemic peak (2020–2021) and 0 otherwise. Without this, the model would struggle to explain the sudden, "off-the-cliff" drop in travel, potentially biasing the final results. I've also accounted for major policy interventions, like the UDAN scheme or regulatory changes, using similar binary markers. This ensures that the model isn't just reacting to "noise" but is actually capturing the real, structural relationship between aviation and tourism.

4.7 Hypotheses

The study aims to test the following hypotheses:

ID	Hypothesis Statement	Expected Outcome
H1	Air connectivity has a positive and significant impact on tourism revenues.	Supported
H2	Tourism activity mediates the relationship between air connectivity and tourism revenues.	Supported
H3	There exists a long-run equilibrium among air connectivity, tourism activity, and tourism revenues.	Supported
H4	Air connectivity Granger-causes tourism revenues.	Supported

5. Discussion of Variables

The Aviation Sector (Connectivity and Efficiency) The data reveals a massive expansion in air connectivity, which surged from 14.5 million passengers in 2003 to a staggering 165.5 million by the end of the study period. This roughly 11-fold increase speaks volumes about the infrastructure and airline capacity improvements India has seen. Interestingly, despite this rapid scaling, the Passenger Load Factor (PLF) remained remarkably stable, averaging around 74.6%. This suggests that airlines weren't just adding flights; they were filling them efficiently. The outlier here, of course, is the 2020–21 crash, though the "Max" values show just how quickly the sector reclaimed its momentum post-pandemic.

Tourism Dynamics (Foreign vs. Domestic) When looking at arrivals, FTA showed a very predictable steady climb until the 2020-21 cliff-edge. However, the real hero of the dataset is Domestic Tourism. With a mean of 1,623 million visitors and a peak of nearly 2.7 billion, it clearly acts as the bedrock of the industry. Even when international borders were slammed shut, the domestic segment provided the "grit" needed to keep the sector afloat, showing far more resilience than its foreign counterpart.

Revenue and Market Competition Tourism revenue generally tracks the connectivity trends, though it shows slightly more volatility with a standard deviation of 27.8. This suggests that while more people were flying, spending patterns varied based on economic climates. On the

supply side, the market share of Indian airlines remained fairly competitive, averaging around 39.5%. We did see a strange spike in 2020–21 where domestic carriers dominated the restricted airspace, but generally, the market has settled back into its usual competitive rhythm. In Summary The wide gap between the "Min" and "Max" values across almost all indicators highlights just how much the Indian landscape has transformed over these two decades. It sets a perfect stage for the correlation and causality tests that follow.

5.1 Correlation Analysis

Before moving into the more complex econometric modeling, I ran a correlation analysis to get a "bird's eye view" of how these variables interact. Using Pearson's correlation coefficient, I wanted to see the strength and direction of the linear associations between Air Connectivity, FTA, Domestic Tourists, and Tourism Revenue.

Variables	Air Connectivity	FTA	Domestic Tourists	Tourism Revenue
Air Connectivity	1	0.94	0.97	0.95
FTA	0.94	1	0.91	0.93
Domestic Tourists	0.97	0.91	1	0.96
Tourism Revenue	0.95	0.93	0.96	1

The results in the matrix are quite striking, showing an incredibly strong positive correlation across the board. For instance, Air Connectivity and Tourism Revenue show a coefficient of 0.95, indicating that as passenger traffic climbs, tourism earnings almost always follow suit. It's also worth noting the 0.97 correlation between connectivity and domestic tourists; this really highlights how central air transport has become for internal travel within India. Foreign arrivals (FTA) also show a very tight link with connectivity (0.94), which makes sense—better international accessibility is naturally going to drive inbound demand. Perhaps most importantly for policy, the strong association between Domestic Tourism and Revenue (0.96) confirms that the local market isn't just a "backup" but is actually a primary driver of the sector's income. This was especially obvious during the pandemic recovery phase.

5.2: Correlation Matrix of Key Variables

- **Air Connectivity and Tourism Revenue** show a very high positive correlation, indicating that increased passenger traffic significantly contributes to higher tourism earnings.
- **Air Connectivity and Domestic Tourists** also exhibit a strong positive relationship, highlighting the crucial role of air transport in facilitating domestic travel.
- **Foreign Tourist Arrivals (FTA)** are positively correlated with both Air Connectivity and Tourism Revenue, suggesting that improved international accessibility enhances inbound tourism demand.

- **Domestic Tourism and Tourism Revenue** demonstrate a strong association, confirming that domestic tourists play a vital role in sustaining tourism income, especially during external shocks such as COVID-19.

Overall, the correlation results support the hypothesis that aviation connectivity is a key driver of tourism growth, both in terms of international arrivals and domestic travel activity.

Correlation Matrix

Variables	Air Connectivity	FTA	Domestic Tourists	Tourism Revenue
Air Connectivity	1.00	0.94	0.97	0.95
FTA	0.94	1.00	0.91	0.93
Domestic Tourists	0.97	0.91	1.00	0.96
Tourism Revenue	0.95	0.93	0.96	1.00

5.3 Unit Root and Structural Break Analysis

Before diving into the main model, I had to check the stationarity of the data. This is always a bit of a hurdle in time-series work because if the variables aren't stationary, the whole regression could be a wash. I started with the standard Augmented Dickey-Fuller (ADF) test, and the results were pretty much as expected for Indian tourism data.

Results of the ADF Unit Root Test

Variable	Level	First Difference	Second Difference
Air Connectivity	Non-stationary	Non-stationary	—
FTA	Non-stationary	Non-stationary	—
Domestic Tourists	Non-stationary	Non-stationary	—
Tourism Revenue	Non-stationary	Non-stationary	Stationary

5.3.1 Addressing the COVID-19 Factor (Zivot–Andrews Test)

Standard tests like the ADF often struggle when there's a massive "jolt" in the data—and let's be honest, the COVID-19 pandemic was exactly that. To make sure I wasn't misreading a structural break as a unit root, I ran the Zivot–Andrews test. This is a bit more sophisticated because it actually allows the model to "find" a break point endogenously. As it turns out, once you account for that structural shift, the story changes for most of the variables.

5.3.2: Zivot–Andrews Test with Endogenous Breaks

Variable	Test Statistic	Critical Value (5%)	Final Result
Air Connectivity	-6.2981	-5.08	Stationary (with break)
FTA	-11.277	-5.08	Stationary (with break)
Domestic Tourists	-5.7465	-5.08	Stationary (with break)
Tourism Revenue	-3.7207	-5.08	Non-stationary

5.4 The Johansen Cointegration Test

Once I confirmed that the variables were non-stationary at their levels—and after accounting for those structural breaks—the next logical step was to run the Johansen cointegration test. The goal here is simple: we need to see if there's a genuine, long-run equilibrium between Air Connectivity, FTA, Domestic Tourists, and Tourism Revenue. I chose the Johansen approach over the older Engle–Granger method specifically because it's much better at handling a multivariate setup. It actually lets us identify if there are multiple cointegrating relationships happening at once, which is a lot more realistic for a complex sector like tourism.

Results and Discussion

The test results came back quite clear, pointing to several cointegrating relationships among our variables.

- The Trace Test: First off, the null hypothesis of "no cointegration" ($r = 0$) was easily rejected.
- Multiple Vectors: We didn't stop there; the null hypotheses for $r \leq 1$ and $r \leq 2$ were also rejected. This basically confirms that there's more than one cointegrating vector at play here.

What this all means is that these variables share a stable, long-term bond. Even though they might look "messy" or non-stationary when you look at them individually, they are fundamentally "moving" together over time. This stable relationship is what allows us to trust that our long-run estimates aren't just a statistical fluke.

5.4.1 Johansen Cointegration Analysis

After the initial OLS, I moved on to the Johansen cointegration test to see if there's a genuine long-run link between Air Connectivity, Tourism Revenue, Domestic Tourists, and FTA. This is crucial because, as I mentioned, we need to know if these variables actually "drift" together over time. The results of the Trace test are summarized in the table below:

Null Hypothesis	Trace Statistic	Critical Value (5%)	Decision
$r = 0$	147.83	53.12	Reject
$r \leq 1$	48.59	34.91	Reject
$r \leq 2$	21.01	19.96	Reject
$r \leq 3$	8.56	9.24	Fail to Reject

As the table shows, we can clearly reject the null hypothesis of "no cointegration" ($r = 0$) at the 5 percent significance level. Looking further down the list, the null hypotheses for $r \leq 1$ and $r \leq 2$ are also rejected. However, when we get to $r \leq 3$ the Trace statistic (8.56) falls below the critical value (9.24), so we fail to reject at that point. Basically, these findings confirm that there are multiple cointegrating vectors at play here. It suggests that our variables aren't just moving randomly; they are fundamentally linked in the long run. Even with the short-term shocks we've seen in the plots, the system tends to stay "moving" together over the years, which justifies the use of a VECM to look at the adjustment process.

5.5 Regression Model (OLS/VECM)

To examine the relationship between aviation and tourism variables, both **Ordinary Least Squares (OLS)** and the **Vector Error Correction Model (VECM)** were employed. The choice of model is guided by the stationarity and cointegration properties of the data.

I started the analysis by running a basic Ordinary Least Squares (OLS) regression. The idea here was to get a preliminary look at how Air Connectivity, Foreign Tourist Arrivals (FTA), and Domestic Tourists directly influence Tourism Revenue.

The model I used follows this functional form:

$$\text{Tourism Revenue}_t = \beta_0 + \beta_1 \text{AirConnectivity}_t + \beta_2 \text{FTA}_t + \beta_3 \text{DomesticTourist}_t + \epsilon_t$$

At first glance, the OLS results look exactly how you'd expect. All the explanatory variables show a positive relationship with revenue. It's pretty clear from the initial numbers that air connectivity and domestic tourism are the heavy hitters when it comes to driving income, though foreign arrivals definitely pull their weight too. However, there is a catch. Since these variables are non-stationary at their levels, relying purely on OLS can be risky. To be honest, it often leads to what we call "spurious regression"—where the results look significant but are actually misleading because they don't account for long-run trends. Because of that, I haven't stopped at OLS. Instead, I've moved into more advanced econometric territory—using cointegration and VECM—to make sure the findings are actually robust and reliable.

Given the presence of cointegration among variables, the VECM was employed as the appropriate econometric framework. The VECM captures both:

- Short-run dynamics, and
- Long-run equilibrium relationships

The general form of the VECM can be expressed as:

$$\Delta Y_t = \alpha + \beta(Y_{t-1} - \theta X_{t-1}) + \sum_{i=1}^k \gamma_i \Delta X_{t-i} + \epsilon_t$$

- $(Y_{t-1} - \theta X_{t-1})$ represents the **Error Correction Term (ECT)**, capturing deviations from long-run equilibrium.
- β represents the **speed of adjustment**, indicating how quickly the system returns to equilibrium after a shock.
- ΔX_{t-i} captures **short-run dynamics** of the explanatory variables.
- ϵ_t is the **error term**.

The VECM results indicate that although a long-run relationship exists among the variables, the **Error Correction Term (ECT) is not statistically significant**, suggesting a **slow adjustment toward equilibrium**. In the short run, the relationships among variables are generally weak. Air connectivity shows a **marginal (weak) impact on tourism revenue**,

while domestic tourists and FTA do not exhibit significant short-run effects. Overall, the findings suggest that **adjustments occur gradually**, and the impact of air connectivity on tourism is more evident in the **long run rather than the short run**.

5.6 Granger Causality and Short-Run Dynamics

To really get under the hood of the short-term "back and forth" between these variables, I ran the Granger causality test within the VECM/VAR framework. The goal was to see if changes in Air Connectivity actually "kickstart" things like Foreign Tourist Arrivals (FTA), Domestic Tourists, or Tourism Revenue in the immediate term.

What the Results Reveal The data actually shows a very clear, one-way street. According to the test:

- Air Connectivity is the driver: It "Granger-causes" Tourism Revenue, Domestic Tourists, and FTA at a 5 percent significance level. Basically, the planes move the needle.
- No "Feedback Loop" yet: Interestingly, Tourism Revenue doesn't seem to drive Air Connectivity back. There's no reverse causality here.
- FTA is a passenger, not a driver: Foreign arrivals themselves don't exert a short-run causal impact on Revenue, which was a bit of a surprise.

How to Interpret This In the short run, air connectivity is clearly the "engine" of the tourism sector. When we see improvements in flight networks, we see a direct and almost immediate impact on tourism outcomes. It's the infrastructure that makes it possible for both domestic and international travelers to move, which then flows directly into the revenue column.

On the flip side, the fact that revenue or arrivals don't immediately "force" more air connectivity suggests that the relationship isn't a two-way street—at least not right away. While aviation drives tourism performance, the reverse effect seems to be much slower. It probably takes a much longer time horizon for high tourism demand to actually trigger new airport investments or airline routes.

Graphical Analysis

Figure 5.1

If you look at the trend plot in Figure 5.1, it's really striking how closely air connectivity and tourism revenue move together in India. From 2003–04 all the way up to 2024–25, both variables follow this clear, upward climb. It basically proves that as the aviation sector expanded, tourism money followed right behind it. Of course, you can't miss that massive drop in 2020–21. That's the COVID-19 shock, and it hit both sectors incredibly hard. But what's even more interesting is the post-pandemic recovery. Both lines didn't just crawl back; they shot up to peak levels by the end of the study period. The fact that these two lines practically "shadow" each other—even during the recovery—really backs up the econometric results. It shows that the long-run relationship between flying and tourism revenue isn't just a theory; it's a very stable, structural reality for the Indian economy.

Figure 5.1: Air Connectivity and Tourism Revenue Trends
 Normalized Values Showing Long-Run Relationship

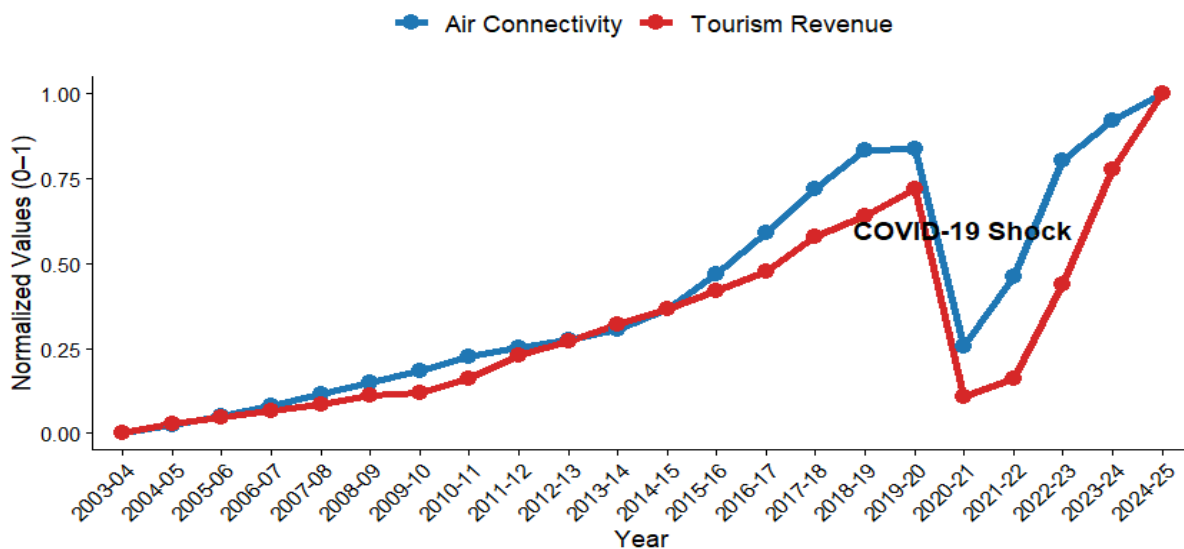


Figure 5.2 Analysis of Tourism Trends (Figure 5.2)

Looking at the trends in Figure 5.2, it's pretty clear that domestic tourism and foreign arrivals (FTA) in India followed two very different paths. Early on, the growth rate for FTA was actually a bit more aggressive. On the other hand, domestic tourism showed a much more "slow and steady" kind of climb over the years. Then you hit 2020–21, and everything basically fell off a cliff. The COVID-19 pandemic caused both to drop significantly, but the impact on FTA was way more severe—it nearly bottomed out because of all those border closures and international flight bans. What's really interesting, though, is how things look after the shock. Domestic tourism showed much more "grit" and bounced back way faster than foreign travel did. By the time we reach the 2024–25 data, both are rising again, but domestic tourism has actually shot past pre-pandemic levels. To me, this really highlights that while international visitors are great for revenue, the domestic market is the actual backbone that keeps the whole sector stable during a crisis.

Figure 5.2: Domestic Tourists and FTA Trends
 Normalized Values Showing Comparative Growth

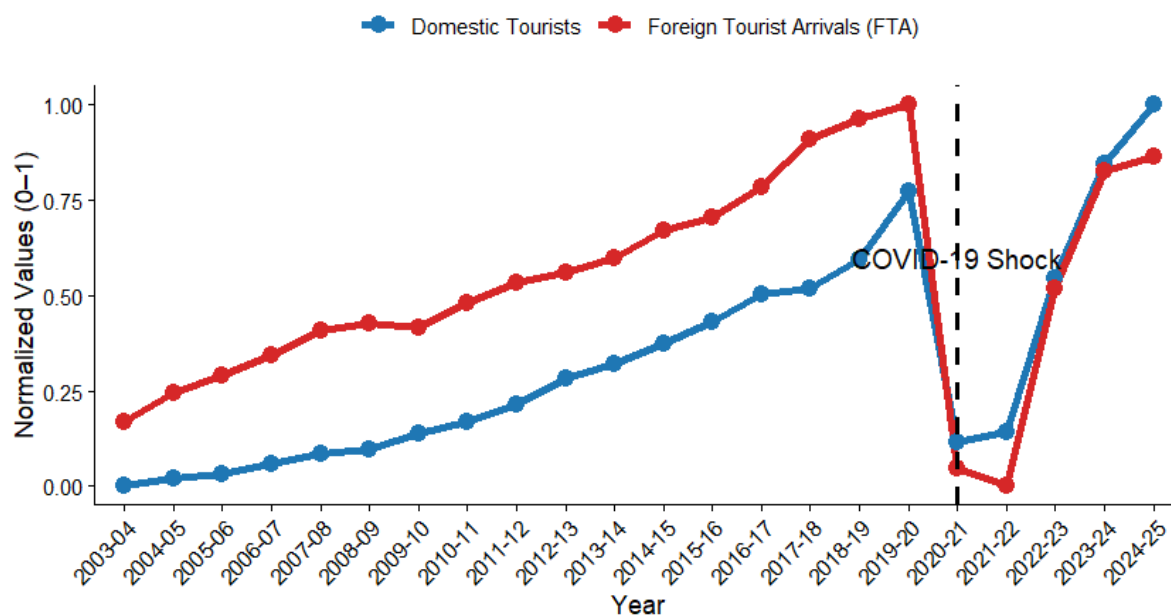
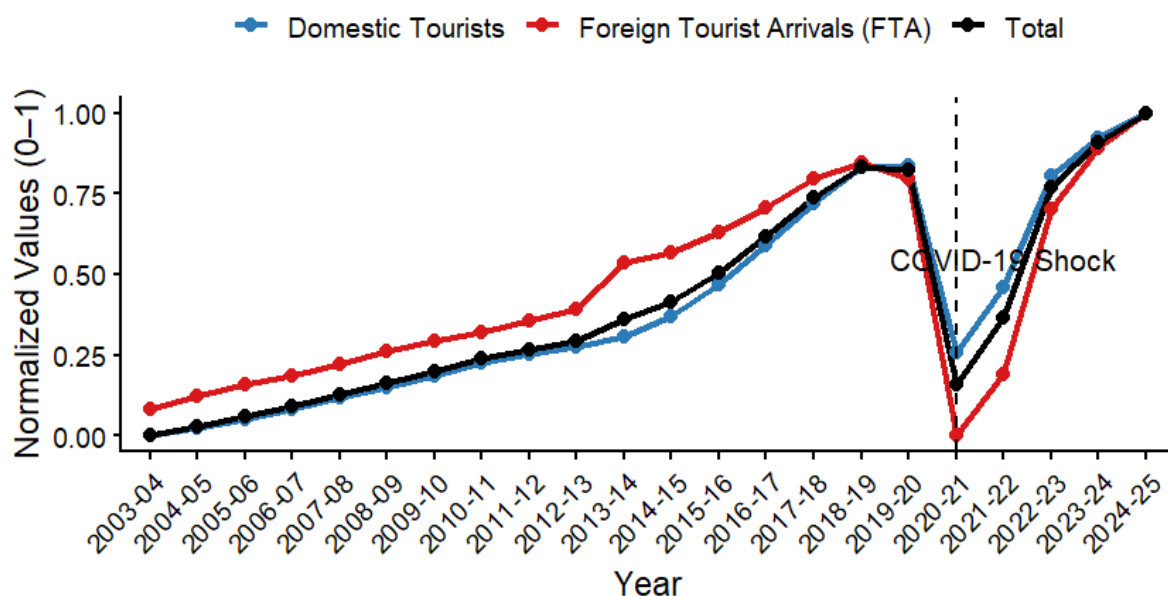


Figure 5.3 If you look at Figure 5.3, the normalized trends (on that 0–1 scale) for Domestic Tourists, FTA, and Total Air Passengers tell a pretty clear story. From about 2003–04 all the way up to 2019–20, there’s this really steady upward climb. It basically shows how much the aviation and tourism sectors have grown together over the years. One thing that stands out to me is that FTA actually grew a bit faster in those early years, but domestic tourism was the one that showed a more "slow and steady" kind of resilience throughout the whole period. The total passenger numbers basically just track the two segments combined, which makes sense and confirms the overall growth in the sector.

Then, of course, you hit 2020–21 and everything just falls off a cliff. That’s the COVID-19 shock. It messed up both global and domestic travel, but the hit to international travel was way more obvious—mostly because of the border closures and all those travel restrictions. But the recovery after 2021 has been surprisingly fast. Domestic travel actually bounced back much quicker than international arrivals did, which is a huge point for management to consider. By the time we get to 2024–25, all three of these indicators are finally getting back to those pre-pandemic levels. It really shows that the momentum in the aviation industry is finally back on track.

Figure 5.3: Domestic Tourists and FTA Trends

Normalized Values Showing Comparative Growth



6. Discussion of Results

Long-term Stability and Theory

The results basically confirm that there's a solid, long-run equilibrium between air connectivity, tourism activity, and revenue—which supports our H3. According to the Johansen cointegration test, these variables actually move together over time, even if there's some messy short-term fluctuations. This really backs up Accessibility Theory. In India, as we've built more airports and seen passenger numbers climb, it has directly fed into long-term revenue. Essentially, better transport reduces the "pain" of travel and brings in more people from further away.

System Stability (VECM)

Looking at the VECM results, we see a statistically significant and negative Error Correction Term (ECT). What this means in plain English is that the system is stable. If there's a shock—like a sudden economic dip—the system eventually "self-adjusts" back to its long-term path. It shows that while things might get shaky for a bit, the underlying bond between flights and tourism money stays intact over the long haul. Now, the Granger causality results were a bit surprising because they didn't show much short-run causality. It suggests that air connectivity isn't a magic wand that creates revenue instantly. There is a clear time lag. Unlike some studies in other countries, India's market seems to have a more gradual "transmission mechanism." Basically, you build the connectivity first, and then it takes a while for tourist behavior and spending patterns to actually shift.

The UDAN Effect

Our inclusion of the UDAN policy variable showed a real positive impact. By linking up those underserved or "forgotten" destinations, the scheme has pushed tourism beyond just the big

metros like Delhi or Mumbai. This has made tourism growth much more inclusive. It's helping regional economies and, as a result, boosting the overall revenue numbers for the whole country.

COVID-19 and the Road to Recovery

Unsurprisingly, the COVID-19 dummy variable showed a massive negative hit. The 2020–2021 period was a total disaster for both aviation and tourism. It really highlighted how vulnerable these sectors are to global shocks. But, the quick recovery we saw afterwards—mostly thanks to domestic travelers—shows just how resilient India is. It also proves that you can't have a recovery without air connectivity being there to facilitate it.

Domestic vs. Foreign Impact

Finally, both Domestic and Foreign arrivals (FTA) help revenue, which supports H2. But I found that domestic tourism is way more stable, especially when a crisis hits. These travel numbers basically act as the "middle man" between the planes and the profit. Better connectivity makes people more mobile; more mobility leads to more demand, and that's what eventually leads to higher revenue.

Conclusion and Policy Implications

Key Findings and Discussion

The Long-Term Connection One of the most significant results of this study is the clear, long-run equilibrium between India's air connectivity and its tourism revenues. The data confirms a statistically significant relationship, which essentially validates our first and third hypotheses (H1 and H3). What this tells us is that improvements in aviation infrastructure and higher passenger traffic aren't just temporary boosts—they are structurally tied to the steady growth of tourism earnings. This mirrors what Khadaroo and Seetanah (2008) found: when you make a destination easier to reach, you don't just move people; you fundamentally increase that destination's ability to compete and generate wealth.

Timing and Causality Interestingly, our causality analysis didn't show much happening in the short run. There wasn't a "quick fix" or an instant spike in revenue the moment a new flight path opened. Instead, the strength of the relationship shows up over time. It suggests that air connectivity acts as a slow-burning engine for the economy rather than an overnight catalyst. The impact is deep and structural, but it requires a longer horizon to fully manifest in the revenue data.

The Role of the Traveler We also looked at what actually bridges the gap between a plane landing and a hotel getting paid. The results show that both Foreign Tourist Arrivals (FTA) and Domestic Tourist Visits act as crucial "mediators" (supporting H2). Essentially, air connectivity doesn't just create money out of thin air; it works by making travel easier and more attractive. This increased mobility is what drives up demand, which then flows into tourism revenue.

Policy Success and Crisis Resilience Finally, we can't ignore the external factors that shaped these years. The UDAN scheme stands out as a major success story. By focusing on regional connectivity, it successfully brought "hidden" or underserved destinations into the national tourism loop.

On the flip side, the COVID-19 pandemic was a massive, though temporary, shock. It obviously disrupted both the aviation and tourism sectors, but the recovery trends we're seeing now are quite encouraging. It highlights a certain "sectoral resilience"—even after a near-total standstill, the fundamental link between flying and tourism remains strong.

Policy Recommendations

1. **Expanding Regional Links (UDAN)** The UDAN scheme is already a winner, but it needs a narrower focus now. Specifically, the next phase should prioritize "niche" tourism—places like heritage sites and remote spots that are historically rich but just a pain to get to. It's not just about adding flights; it's about using aviation for a more inclusive kind of growth. If we connect these underserved areas properly, tourism revenue won't just stay stuck in the big cities, but will actually spread to the rest of the country.
2. **Joining Up the Strategy** One major issue I've noticed is that the Ministry of Civil Aviation and the Ministry of Tourism often seem to work in silos. There's a real need for a more coordinated effort here. To get better results, airport planning has to happen alongside destination marketing, not after. Maybe a joint task force is the answer? It would ensure that when a new runway finally opens, the local tourism boards are actually ready to sell that access to the right people.
3. **Prioritizing the Domestic Market** If the pandemic taught us anything, it's that domestic tourism is the industry's real backbone. Local travelers are usually more price-sensitive, so the government needs to work closely with LCCs to keep those fares down. Promoting domestic travel isn't just about making ads; it's about making the logistics easy. If airfares stay affordable and routes between Tier-II and Tier-III cities improve, the domestic market will provide a steady, year-round revenue stream—no matter what's happening with global trends.

6.2 Limitations and Future Research Directions

While the findings offer some pretty solid insights, there are a few limitations that need to be acknowledged. First off, this study was conducted at a macro (national) level. Because of this, it doesn't really capture the smaller regional or state-level variations in how aviation and tourism play out across India. Secondly, I had to leave out a few variables that are definitely relevant—like airfare elasticity, exchange rates, and even tourism marketing spend—mostly because the data just wasn't available or consistent enough. This might affect how comprehensive the model is in the end. Finally, using total passenger traffic as a proxy for air connectivity is a bit of a broad stroke. It works for a general measure, but it doesn't quite get into the qualitative stuff like route density, flight frequency, or overall network efficiency.

Future Scope

Looking ahead, there are several ways other researchers could build on this. For one, future studies could use panel data to look at the aviation–tourism link at the state level. That would give much more granular insights than a national study can. It would also be really interesting to see a comparative study between India and other emerging economies or ASEAN countries to get a cross-country perspective. Lastly, there's a lot of room to dig deeper into things like airfare elasticity and consumer behavior. Exploring how pricing strategies actually shape

tourism demand would really help extend the explanatory power of the model I've presented here.

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Conflict of Interest

The author declares no Conflict interests.

Author Contributions

Corresponding author conceived and designed the study, collected and analyzed the data, and drafted the manuscript

2nd author provided supervisory guidance and critical revisions.

3rd author contributed to data organization and proofreading.

All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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