

Revisiting the Tourism- Growth Nexus in Asia: Evidence from Panel FMOLS and DOLS

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ABSTRACT

Tourism has emerged as an important driver of economic activity in Asia, yet its growth implications remain closely intertwined with energy use and environmental sustainability. This study examines the long-run and short-run relationships among tourism receipts, economic growth, energy consumption and carbon emissions across 19 Asian economies over the period 2000-2023. Using panel data framework, the analysis employs Fully Modified Ordinary Least Squares (FMOLS), Dynamic Ordinary Least Squares (DOLS) and Granger Causality techniques to capture both equilibrium dynamics and short-term interactions. The results provide robust evidence in support of Tourism-Led Growth Hypothesis indicating that tourism development and energy consumption exert significant positive effects on income growth in the long run. In contrast, short-run causal relationships between tourism and growth are weak, suggesting that tourism's macroeconomic benefits materialize gradually. Structural break analysis further reveals that the COVID-19 pandemic did not fundamentally alter the long-run tourism-growth relationship, highlighting the sector's resilience despite severe short-term disruptions. The findings emphasize the importance of sustainable tourism and energy policies in promoting long-term, inclusive economic growth.

Keywords: sustainable tourism, economic growth, environmental sustainability, panel data, Asia, FMOLS, DOLS

INTRODUCTION

Over the past few decades tourism has emerged as one of the most dynamic sectors of the global economy, contributing substantially to income generation, employment creation and regional development. In Asia, tourism has assumed a strategic role in economic transformation, offering emerging economies an alternative pathway to growth beyond traditional manufacturing and trade led models. At the same time, rapid expansion of tourism activities has intensified concerns regarding environmental degradation, rising carbon emissions and increasing pressures on natural resources.

Against this backdrop, the tourism-growth-environment nexus has attracted growing attention in the economic literature. The Tourism-Led Growth Hypothesis (TLGH) posits that tourism can stimulate economic expansion through foreign exchange earnings, investment flows and employment generation. However, an opposing strand of research cautions that unchecked tourism development may exacerbate environmental stress, particularly in regions characterized by rapid urbanization and rising tourist inflows. Striking a balance between economic growth and environmental sustainability has therefore become central policy challenge for Asian economies.

Motivated by these concerns, this study empirically examines the dynamic relationships between tourism development, economic growth and environmental sustainability in a panel of selected Asian economies over the period 2000-2023. Employing panel data econometric techniques, the analysis explores both long run equilibrium relationships and short run interactions among tourism receipts, income growth, energy use and carbon emission. The inclusion of the post COVID-19 period allows the study to assess whether the pandemic constituted a structural disruption or a transitory shock to the tourism-growth-environment relationship. By

integrating economic and environmental dimensions within a unified framework, the study aims to provide policy relevant insights into how tourism can be leveraged as a driver of growth in Asia, without compromising on environmental sustainability.

LITERATURE REVIEW

As international tourism has expanded in scale and economic relevance, scholars have increasingly examined whether tourism can act as an independent driver of long-term economic growth. In this context the Tourism-Led Growth (TLG) hypothesis suggests that tourism can be a significant driver of economic growth, particularly for developing countries. The evidence spans multiple countries and methodological approaches, showing a generally positive relationship between tourism and economic development (Tang, 2022). Studies have found support for the hypothesis in diverse geographical regions, including Balaguer & Cantavella-Jorda (2002) in Spain, Ertugrul & Mangir (2015) in Turkey, Katircioglu (2009) in Malta, Katircioglu (2010) in Singapore and Xia (2021) in 34 European countries. However, the impact is not uniform. Tang & Tan (2018) found that tourism's contribution to economic growth varies based on countries' income levels and institutional qualities.

Tourism demonstrates complex, context-dependent economic impacts that systematically differ between short-run and long-run dynamics. Empirical evidence reveals nuanced relationships: Çetintaş & Bektaş (2008) found no short-term relationship between tourism and economic growth in Turkey, but a significant long-term connection. Ridderstaat (2013) showed in Aruba that a 1% tourism revenue change would yield a 0.49% GDP increase long-term, with a slow correction speed of 0.25% requiring about 10.5 years to reach equilibrium. Zhai (2025) further confirmed tourism's positive impacts in Macao across both short and long terms, with physical capital, labor, and human capital playing critical roles. Brida & Pulina (2010) synthesized multiple studies, concluding that tourism consistently drives economic development, though the mechanisms and magnitudes vary significantly by context.

Energy consumption plays a complex, multidirectional role in tourism and economic growth, with studies revealing nuanced interconnections across different economies. The evidence spans multiple methodological approaches and geographical contexts. Rasool et al. (2023) found that energy consumption's impact on tourism is mixed but sensitive to econometric techniques, while economic growth consistently shows a positive tourism relationship. Khan (2020) demonstrated long-run relationships where energy consumption promotes economic growth and tourism stimulates economic expansion. Specific country studies provide granular insights: Jayasinghe & Selvanathan (2021) found in India that energy consumption and tourism positively contribute to economic metrics, while Avishek Khanal et al. (2021) in Australia confirmed that tourist arrivals, GDP, and financial development significantly relate to energy consumption. The evidence suggests a complex, context-dependent relationship requiring nuanced policy approaches to balance sustainable tourism development.

Tourism significantly contributes to CO₂ emissions, with varying impacts across different economic contexts. Multiple studies demonstrate that tourism increases carbon dioxide emissions, particularly in developing countries (Haseeb et al., 2018 & León, 2014). A comprehensive 32-country study found that tourism arrivals and revenues can both increase and potentially reduce environmental degradation, depending on specific conditions (Deb et al., 2023). The evidence suggests a complex relationship: tourism initially raises CO₂ emissions, but may eventually foster conditions for sustainable development (Bertsatos et al., 2025). Critically, the impact varies by economic development level, with developed countries showing faster emissions reduction (Paramati et al., 2017).

Researchers consistently recommend sustainable tourism practices, including adopting cleaner technologies and responsible consumption to mitigate environmental impacts (Cevik, 2023 & Deb et al., 2023).

Foreign Direct Investment (FDI) generally has a positive, mutually reinforcing relationship with tourism growth across multiple global contexts. Studies from diverse regions consistently demonstrate this connection. Rasit & Aralas (2019) found a positive bidirectional relationship between FDI and tourism arrivals in ASEAN

countries. Ağazade & Karasakaloğlu (2023) analyzed 135 countries and confirmed FDI positively affects tourism performance indicators, with the strongest impact on international tourism receipts. Specific regional evidence includes Antwi's (2022) finding that FDI positively affects tourism growth in Sub-Saharan African countries, and Chen's (2017) discovery that inbound tourism can promote FDI not just in tourism sectors, but across other economic sectors. However, the magnitude varies: Fauzel et al. (2017) noted tourism FDI's impact in Mauritius was smaller compared to non-tourism sectors. Mishra et al. (2020) even found no significant FDI impact in India's tourism sector.

The COVID-19 pandemic caused a dramatic, potentially transformative shock to the global tourism industry, fundamentally altering travel patterns, economic structures, and potentially opening pathways to more sustainable tourism models. Evidence shows the pandemic's impact was unprecedented: Škare et al. (2020) found recovery would take longer than the typical 10-month period for pandemic impacts, with tourism worldwide experiencing large adverse shocks. Jeon & Yang (2021) documented specific structural changes, such as tourists simplifying travel routes and concentrating on local destinations.

In a critical note, Ioannides & Gyimóthy (2020) argued the crisis presents a unique opportunity to redesign tourism towards a "greener and more balanced" approach. Mooney & Zegarra (2020) emphasized that governments must develop unparalleled policy responses to safeguard tourism-dependent economies.

Although a substantial body of literature explores the tourism-growth-environment nexus, comparative panel analysis covering multiple Asian economies over extended periods remain limited. Most prior studies have focussed on single country contexts or short time spans, restricting generalizability. Furthermore, the incorporation of environmental sustainability indicators, such as carbon emissions and energy use, into tourism growth models have been uneven and often methodologically weak. Few studies simultaneously analyse long run and short run relationship and structural stability, particularly in the post COVID context.

These study addresses these gaps by employing a comprehensive panel data framework for 19 Asian economies spanning period from 2000 to 2023, integrating both economic and environmental dimensions. By applying advanced econometric techniques like FMOLS, DOLS and panel causality analysis and incorporating a post-COVID structural break, this research provides a holistic and updated understanding of how tourism, energy and environmental factors interact to influence economic growth in Asia.

DATA AND METHODOLOGY

Data and Variables

This study is based on an unbalanced panel of 19 Asian economies- Bangladesh, Bhutan, China, Indonesia, India, Japan, Cambodia, South Korea, Kazakhstan, Sri Lanka, Myanmar, Mongolia, Malaysia, Nepal, the Philippines, Pakistan, Singapore, Thailand and Vietnam- spanning the period 2000 to 2023. The selection of countries was determined by data availability and their prominence in the Asia's tourism and economic landscape. Annual data is used which allows the analysis to capture long- run structural relationship rather than short- term fluctuations that are common in monthly or quarterly series.

The variables employed in the study reflect the multidimensional nature of the tourism-growth- environment nexus. The dependent variable, economic growth, is proxied by real GDP per capita (constant 2015 US\$). The main explanatory variable is tourism receipts which measures international tourism earnings in U. S. dollars and represents the economic contribution of the tourism sector. Foreign direct investment (FDI), expressed as a percentage of GDP, is included as a control for external capital flows that may influence growth. Energy use per capita (in kilograms of oil equivalent) serves as a proxy for production intensity and technological progress, while CO₂ emissions per capita (in metric tons) capture the environmental consequences associated with economic activity.

All monetary variables are expressed in constant U. S. dollars to eliminate inflationary effects and logarithmic transformation was applied to the variables- GDP per capita, tourism receipts, energy use and CO₂ emissions- to normalize distributions and interpret coefficients as elasticities. Accordingly, the main variables used in estimation are:

$\ln GDP_{PC}$ = natural logarithm of real Gross Domestic Product per capita (Proxy for economic growth)

$\ln TR$ = natural logarithm of international tourism receipts (in constant US dollar)

$\ln EN$ = natural logarithm of per capita energy use (measured in kilograms of oil equivalent per person)

$\ln CO_2$ = natural logarithm of per capita energy carbon dioxide emissions (metric tons per person)

FDI = foreign direct investment as percentage of GDP

Data for GDP per capita, tourism receipts, energy use and FDI were retrieved from the World Bank's World Development Indicators (WDI) while CO₂ emissions were obtained from Our World in Data (OWID). After aligning coverage across sources, the panel consists of 350 country- year observations, with individual countries contributing between 4 and 21 annual observations depending on data availability.

The dataset offers a broad and balanced representation of Asia's economic and environmental landscape over more than two decades, providing a solid base for examining how tourism activity, energy intensity and external investment interact to shape long- term economic growth.

Model Specification

Building on the variables described earlier, the empirical framework investigates the long- run and short- run relationships among tourism receipts, economic growth, foreign direct investment, energy use and carbon emissions across Asian economies. The analysis is grounded in the Tourism-Led Growth Hypothesis (TLGH), which posits that tourism expansion acts as a catalyst for long- term economic development.

The general panel model is expressed as:

$$\ln GDP_{PC(it)} = \alpha_i + \beta_1 \ln TR_{(it)} + \beta_2 FDI_{(it)} + \beta_3 \ln EN_{(it)} + \beta_4 \ln CO_{2(it)} + \varepsilon_{(it)} \quad (1)$$

where

$i = 1, \dots, 19$ denotes the country

$t = 2000, \dots, 2023$ denotes time

α_i captures country- specific fixed effects

$\varepsilon_{(it)}$ is the idiosyncratic error term.

$\ln GDP_{PC}$ represents the natural logarithm of real GDP per capita

$\ln TR$ is the logarithm of tourism receipts

FDI denotes foreign direct investment

$\ln EN$ is the logarithm of per- capita energy use

$\ln CO_2$ captures per- capita carbon emissions

This formulation allows the coefficients $\beta_1, \beta_2, \beta_3$ and β_4 to be interpreted as elasticities, measuring the percentage change in GDP per capita resulting from a one- percent change in the respective explanatory variables.

To assess the long- run equilibrium relationship, the study employs two complementary estimators

Fully Modified Ordinary Least Squares (FMOLS) which corrects for serial correlation and endogeneity by modifying the OLS estimator using semi- parametric adjustments (Phillips & Hansen, 1990).

Dynamic Ordinary Least Squares (DOLS) that augments the cointegrating regression with leads and lags of the differenced regressors to account for feedback effects and serial dependence (Stock & Watson, 1993).

The dynamics DOLS specification can be expressed as

$$\ln GDPpc_{(it)} = \alpha_i + \beta_1 \ln TR_{(it)} + \beta_2 FDI_{(it)} + \beta_3 \ln EN_{(it)} + \beta_4 \ln CO_{2(it)} + \sum_{(k=-1)}^{+1} \delta_k \Delta X_{(it-k)} + \varepsilon_{(it)} \quad (2)$$

The summation over $k= -1$ (lag) and $k=+1$ (lead) includes first-differenced values of the regressors, $\Delta X_{(it-k)}$, to control for short-run dynamics and to correct for potential endogeneity and serial correlation in the variables. This approach, standard in DOLS estimation, augments the cointegrating regression with leads and lags of the dependent variables' differences, ensuring that the estimated parameters are consistent and unbiased in the presence of such effects.

To complement the long- run analysis, country- specific Granger causality tests were applied to examine short-run interactions between tourism and economic growth. The test evaluates whether past values of tourism receipts help predict current GDP per capita and vice versa.

Finally, to determine whether the COVID-19 pandemic altered the tourism- growth relationship, a structural-break model incorporating a post- 2020 dummy variable was estimated.

$$\ln GDPpc_{(it)} = \alpha_i + \beta_1 \ln TR_{(it)} + \beta_2 FDI_{(it)} + \beta_3 \ln EN_{(it)} + \beta_4 \ln CO_{2(it)} + \gamma_1 D(COVID) + \gamma_2 (D(COVID) \times \ln TR_{(it)}) + \varepsilon_{(it)} \quad (3)$$

where $D(COVID)= 1$ for 2020-2023 and 0 otherwise.

This interaction term captures any shift in the elasticity of GDP with respect to tourism during the pandemic period. Altogether, this multi- stage specification enables a comprehensive examination of the long- run equilibrium, short- run dynamics and structural stability of the tourism- driven growth process in Asia over the period 2000-2023.

To ensure the reliability and robustness of the estimated models, several diagnostic tests were carried out after estimation. These tests validate key econometric assumptions and confirm that the results are statistically sound free from major specification errors.

First, multicollinearity among the explanatory variables was assessed using the Variance Inflation Factor (VIF). The compound VIF values were below the conventional threshold of 10, indicating that interdependence among regressors- particularly between energy use and CO₂ emissions- was moderate and within acceptable limits.

Second, heteroskedasticity was examined through the Breusch- Pagan test, which failed to reject the null hypothesis of constant variance ($p=0.22$). This confirms the homoscedastic nature of the residuals, implying consistent error variance across observations.

Third, the Wooldridge/ Breusch- Godfrey test was employed to detect serial correlation in the panel residuals. The test yielded a significant result ($p< 0.001$), suggesting the presence of autocorrelation- an expected feature in macro- panel data with persistent economic series. To address this issue, all models were estimated with

Arellano- type cluster- robust standard errors, clustered by country, thereby ensuring consistent inference even under serial dependence.

Finally, graphical analyses were used to visually inspect residual properties. The fitted- versus- actual plot showed a strong linear alignment, indicating good predictive accuracy. The autocorrelation function (ACF) of residuals revealed mild persistence, consistent with the statistical findings, while the Q- Q plot confirmed that residuals were approximately normally distributed. Together, these diagnostics reinforce the robustness of the model and validate its specification for analysing the tourism- growth relationship.

RESULTS AND DISCUSSION

Long- Run Relationship: FMOLS and DOLS Estimation

Table 1 presents the results of the Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimations examining the long- run relationships between economic growth ($\ln GDP_{PC}$), tourism receipts ($\ln TR$), foreign direct investment (FDI), energy consumption ($\ln EN$) and carbon emissions ($\ln CO_2$). Both estimators yield consistent results in sign and magnitude, validating the robustness of the findings.

Table 1: Long run estimation results (FMOLS and DOLS)

Variable	FMOLS Coefficient	FMOLS significance	DOLS Coefficient	DOLS significance
$\ln TR$	+0.11	***	+0.10	***
$\ln EN$	+1.09	***	+1.03	***
FDI	+0.004	ns	+0.005	ns
$\ln CO_2$	-0.045	ns	-0.052	ns
R^2	0.875		0.872	
Adj. R^2	0.873		0.870	
N	350		350	

*** denote statistically significant at 1% level

ns denotes not significant

Source: self-computed

Both estimators indicate that tourism receipts ($\ln TR$) and energy consumption ($\ln EN$) exert statistically significant positive effects on GDP per capita in the long run. Specifically, a 1% increase in tourism receipts is associated with approximately a 0.10- 0.11% rise in GDP per capita, holding other factors constant. Energy consumption exhibits an even larger elasticity ($\sim 1.1\%$), emphasizing the energy- dependent nature of economic activity across Asian economies.

FDI is expressed as a percentage of GDP and not log- transformed due to its possible negative or near- zero values; its coefficient therefore represents a marginal effect rather than an elasticity. Specifically, the FMOLS estimate indicates that one-percentage-point increase in FDI as a share of GDP is associated with an approximate 0.004% increase in GDP per capita, holding other factors constant. However, this effect is statistically insignificant suggesting that aggregate capital inflows do not independently drive long-run income growth once tourism development and energy consumption are accounted for. CO₂ emissions are similarly insignificant, reflecting weak direct environmental feedback effects on income levels. These results lend support to the Tourism- Led Growth Hypothesis (TLGH), consistent with panel evidence reported by Lee and Chang (2008) and Sequeira and Nunes (2008), which identifies tourism as a dominant long run driver of economic growth.

Short- Run Dynamics: Country- Level Granger Causality

To explore short- run interactions between tourism and economic growth, country- level Granger causality tests were estimated using annual data from 2000 to 2023 and these are reported in Table 2. Valid results were obtained for 17 of the 19 Asian economies; Bhutan and China were excluded due to insufficient time- series observations. The findings reveal no significant unidirectional or bidirectional causality between tourism and GDP at the 5% level. Only Indonesia and Myanmar displayed weak (10%) causality, suggesting marginal short- run interactions.

These results imply that tourism's contribution to economic growth materializes mainly over the long run, rather than through immediate short- term feedback effects. This interpretation is consistent with earlier evidence reported by Katircioglu (2009), who demonstrates that tourism led growth operates through long-run cointegrating relationships driven by infrastructure development and capital accumulation.

Table 2: Short-run dynamics: Country level Granger causality

Country	Tourism → GDP (p-value)	GDP → Tourism (p-value)	Causality Direction
Bangladesh	0.59	0.41	None
Bhutan	—	—	Data insufficient
China	—	—	Data insufficient
Indonesia	0.06	0.10	Weak (Tourism → GDP)
India	0.13	0.53	None
Japan	0.29	0.69	None
Cambodia	0.36	0.79	None
South Korea	0.14	0.38	None
Kazakhstan	0.40	0.19	None
Sri Lanka	0.23	0.53	None
Myanmar	0.68	0.08	Weak (GDP → Tourism)
Mongolia	0.96	0.88	None
Malaysia	0.81	0.21	None
Nepal	0.43	0.49	None

Philippines	0.65	0.36	None
Pakistan	0.94	0.24	None
Singapore	0.16	0.26	None
Thailand	0.88	0.94	None
Vietnam	0.45	0.90	None

Source: self-computed

Structural Break Analysis: COVID-19 Period

To assess whether the relationship between tourism and economic growth experienced a structural shift during the COVID-19 pandemic, a dummy- interaction regression model was estimated for the period 2020-2023. The interaction term captures potential changes in the elasticity of GDP with respect to tourism in the post- COVID years. Table 3 presents the results of the post- COVID regression estimated using cluster- robust (Arellano- type) standard errors.

Table 3: Post COVID structural break regression results

Variable	Coefficient	Robust Std. Error	p-value	Interpretation
$\ln TR_{(it)}$	0.106	0.063	0.095 *	Long-run positive elasticity of tourism on growth
$D(COVID)$	0.305	1.022	0.766 ^{ns}	Level shift in GDP post-2020 (insignificant)
$(D(COVID) \times \ln TR_{(it)})$	-0.006	0.046	0.896 ^{ns}	No structural change in tourism effect during COVID-19
$\ln EN_{(it)}$	1.096	0.283	0.000 ***	Energy consumption strongly drives growth
$\ln CO_{2(it)}$	-0.045	0.200	0.822 ^{ns}	Environmentally neutral in growth equation
$FDI_{(it)}$	0.004	0.015	0.802 ^{ns}	No significant FDI effect on GDP
Adjusted R ²	0.873	—	—	Model explains 87 % of variation in $\ln GDP_{pc}$
F-statistic (p-value)	401.27 (< 0.001)	—	—	Overall model highly significant

***, **, * denote significance at 1%, 5% and 10% level respectively

ns denotes not significant

Estimates are obtained from a pooled panel regression with Arellano-type robust errors clustered by country

$$\ln GDP_{pc(it)} = \alpha_i + \beta_1 \ln TR_{(it)} + \beta_2 FDI_{(it)} + \beta_3 \ln EN_{(it)} + \beta_4 \ln CO_{2(it)} + \gamma_1 D(COVID) + \gamma_2 (D(COVID) \times \ln TR_{(it)}) + \varepsilon_{(it)}$$

Source: self-computed

The results reveal that the interaction term $(D(COVID) \times \ln TR_{(it)})$, representing the change in tourism elasticity during the pandemic, is negative but statistically insignificant ($p = 0.896$). This indicates that the impact of tourism on economic growth remained structurally stable during the COVID- 19 period. Although the pandemic caused a temporary contraction in tourism flows, its effect on the long- run tourism- growth relationship was not transformative. The coefficient on $\ln TR_{(it)}$ remains positive and significant at the 10 percent level, implying that tourism continues to exert a pro- growth influence even under adverse global conditions. Energy use ($\ln EN_{(it)}$) retains a strong and highly significant positive coefficient, underscoring the energy- intensive nature of economic activity in the region. Other controls- FDI, CO2 emissions and the COVID dummy ($D(COVID)$)- are statistically insignificant, suggesting that the pandemic's influence was largely transitory and did not alter the structural dynamics of tourism- driven growth.

These findings confirms that while COVID-19 disrupted short- term tourism flows, the fundamental long- run relationship between tourism and economic growth in Asia remained resilient, reinforcing the robustness of the Tourism- Led Growth Hypothesis in the face of unprecedented global shocks.

Diagnostic and Robustness Tests

A series of diagnostic checks were conducted to ensure the robustness and validity of the estimated model. The results are summarized in Table 4.

Table 4: Diagnostic test summary

Diagnostic Test	Statistic	p-value
Variance Inflation Factor (max VIF)	8.7	—
Breusch–Pagan Test	BP = 8.21	0.22
Wooldridge Test (Serial Correlation)	$\chi^2 = 286.83$	< 0.001
Model Fit	Adj. $R^2 = 0.87$	—

Source: self-computed

These diagnostics confirm that the model is well- specified and statistically sound. There is no evidence of severe multicollinearity or heteroskedasticity. The presence of serial correlation is a common feature of macro panel data and has been appropriately corrected using robust clustered standard errors. The high adjusted R^2 value (0.87) further underscores the model's strong explanatory capacity.

Model Fit and Residual Diagnostics

The graphical diagnostics provide additional evidence of the model's reliability and goodness of fit.

Figure 1: Model fit: Tourism-growth relationship

The fitted-versus-actual plot exhibits a strong linear relationship, indicating a close correspondence between observed and predicted values of $\ln(\text{GDP}_{\text{PC}})$.

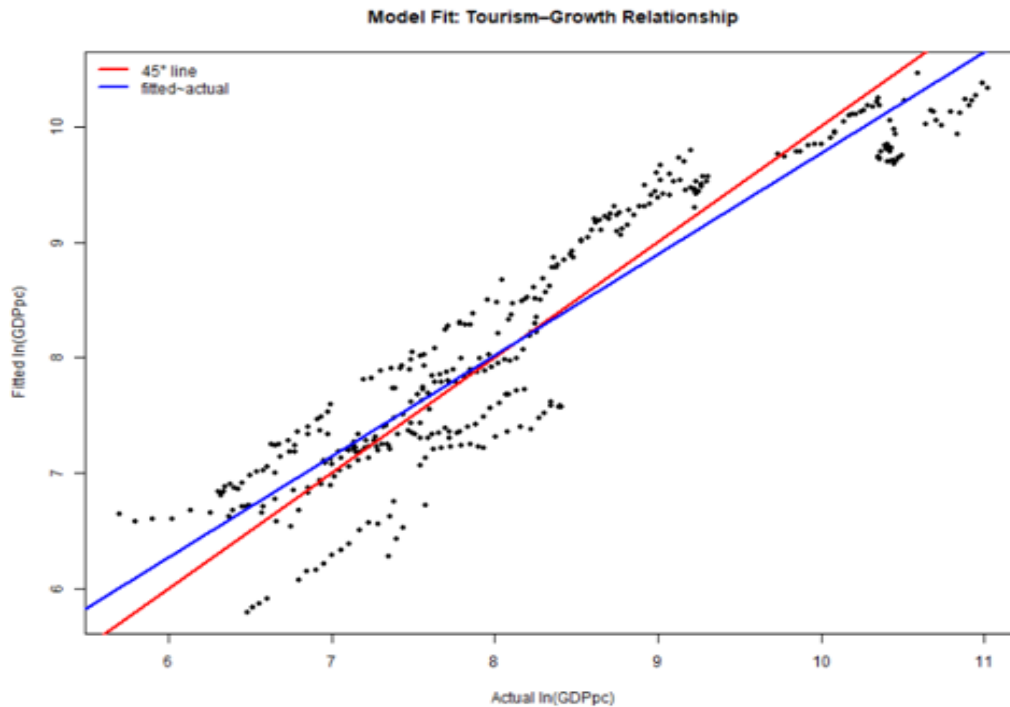
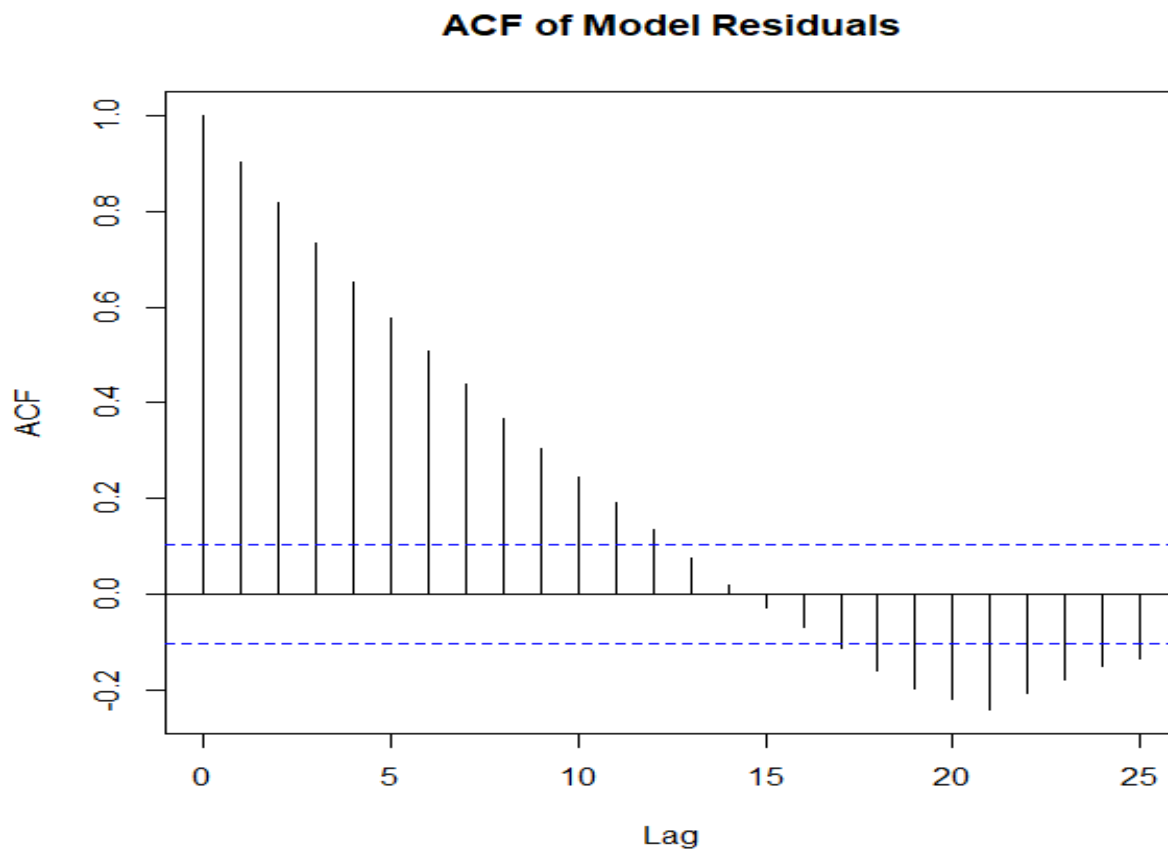
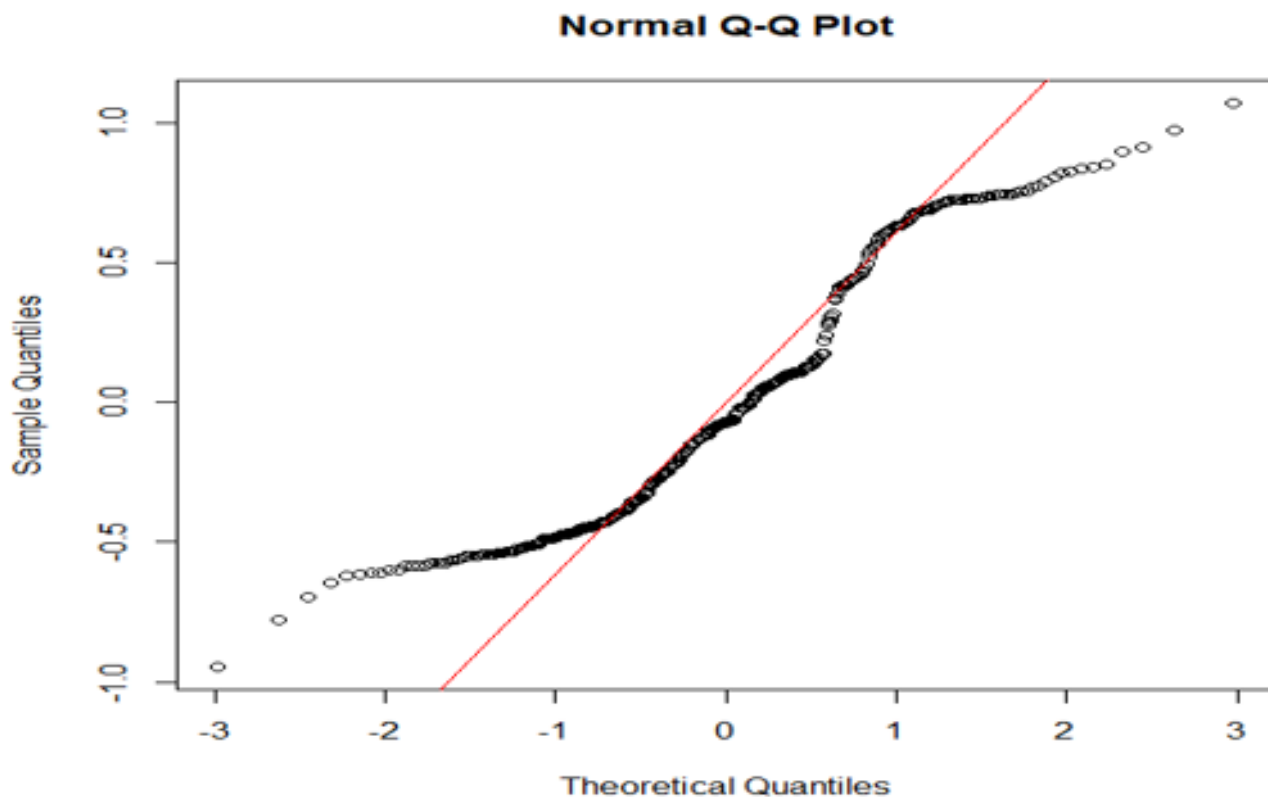


Figure 2: Autocorrelation Function (ACF) of Model Residuals



The ACF plot of residuals shows mild persistence, consistent with the serial correlation detected by the Wooldridge test. The use of clustered robust standard errors effectively mitigates this concern.

Figure 3: Q-Q plot of residuals



Residuals are approximately normally distributed, confirming that model assumptions regarding error normality and linear specification hold reasonably well.

Taken together, the diagnostic tests and residual plots reaffirm the stability, validity, and robustness of the estimated tourism- growth model.

DISCUSSION AND POLICY IMPLICATIONS

The findings from this study provides strong empirical support for the Tourism-Led Growth Hypothesis (TLGH) across Asian economies over the period 2000 to 2023. The results from FMOLS and DOLS estimations confirm a robust and positive long- run relationship between tourism receipts and economic growth, and energy consumption and economic growth, while short run Granger Causality remains insignificant. This pattern underscores that tourism's macroeconomic benefits in Asia are structural and long term, manifesting through channels such as capital formation, service diversification, employment generation and foreign exchange flows.

The FMOLS and DOLS estimation results not only confirm a robust and positive long-run relationship between tourism receipts and economic growth in Asia, but also closely align with established findings in the literature. Tang et al. (2016) demonstrate in the Indian context that tourism significantly elevates energy consumption in the long run, reflecting the sector's growing energy dependence alongside economic expansion. Similarly, Sarkhanov and Baghirov (2024) provide empirical evidence from Georgia, Ukraine, Azerbaijan and Moldova showing tourism revenues positively contribute to sustained economic growth through mechanisms such as capital formation and service diversification. These results reinforce the view that tourism's macro-economic benefits are structural and manifest via channels including employment generation and foreign exchange earnings. This long tern perspective is complemented by findings from Ohajionu et al. (2022), who document strong linkages between tourism activity, energy consumption and heterogeneous environmental effects across countries. Consistent with strand of literature, the weak short run Granger Causality observed in the present

study aligns with evidence from Hassoun et al. (2021) and Jiranyakul (2019), which suggest that tourism induced growth effects tend to emerge gradually rather than instantaneously.

However, literature also reports contrasting evidence. For instance, Wijesekara et al. (2022) and Zumba et al. (2019) provide empirical support for significant short run Granger causal relationships between tourism and economic growth, reflecting bidirectional or unidirectional causal effects in certain regional contexts. This divergence suggests that the temporal dynamics of tourism's economic impact may vary across countries and regions depending on structural factors, levels of development and sectoral composition. Hence, the evidence suggests that while tourism primarily delivers long-term structural gains, short-run effects may also arise under specific conditions.

The strong positive elasticity of energy consumption indicates that the economic expansion in Asia remains energy dependent. This finding is consistent with evidence from developing economies reported by Shahbaz et al. (2017) who document a close association between energy use and economic growth, highlighting the central role of energy as a production input. By contrast the insignificance of CO₂ emissions in the long run models suggests a potential weakening of the direct link between economic growth and environmental degradation. This outcome may reflect gradual improvements in energy efficiency, increased adoption of cleaner technologies or structural shifts towards less carbon intensive activities. Such evidence is partially consistent with the Environmental Kuznets Curve (EKC) framework proposed by Grossman and Krueger (1995) which posits that environmental pressures intensify during early stages of development but tend to decline as economies mature and adopt more sustainable technologies.

The structural break analysis provides additional insights. The COVID-19 dummy and its interaction with tourism receipts were statistically insignificant, implying that pandemic did not structurally alter the tourism-growth relationship. This resilience suggests that the long run fundamentals of tourism led growth remained intact despite severe short-term disruptions in global travel. This finding corroborates Yang et al. (2021) who document heterogeneous but adaptive responses of the tourism sector during the pandemic as well as and Gössling, Scott and Hall (2021), who highlight the role of domestic tourism substitution, digital transformation and adaptive recovery strategies in sustaining tourism activity during and after lockdown periods.

The lack of significant short run causality between tourism and GDP further implies that tourism's growth effects are not immediate but cumulative, requiring time to materialize through sustained investment and policy support. This lagged response is consistent with Katircioglu (2009) and Tang and Tan (2018), who argue that tourism-induced benefits diffuse gradually across sectors rather than producing instant macroeconomic shifts.

The finding from this study carries several important implications for policymakers in Asia. Firstly, governments should continue to invest in tourism infrastructure and marketing, as sustained tourism expansion enhances long run income growth and employment opportunities (Balaguer & Cantavella - Jordá, 2002; Brida & Pulina, 2010). Secondly, given the strong link between energy consumption and economic performance, integrating renewable energy and efficiency measures into tourism related activities is essential for sustaining growth while mitigating environmental pressures. This policy direction is consistent with evidence documenting the close tourism-energy-environment nexus (Alola, 2019; Shahbaz et al. 2018).

Third, the sector's structural resilience during COVID 19 emphasizes the need for institutionalized crisis management frameworks, including stabilization funds, domestic demand stimulation and real time digital platforms for communication and marketing (Yang et al., 2021; Gössling & Hall, 2020). In addition, fostering regional cooperation through mechanisms such as joint tourism initiatives and visa facilitation may help amplify spillover effects and improve short run responsiveness, particularly in regions with strong cross border tourism linkages (Tang & Tan, 2018). Finally, aligning Foreign Direct Investment (FDI) with sustainable tourism development, particularly in ecofriendly infrastructure and community-based projects will ensure that foreign capital supports inclusive growth while protecting environmental assets (Hewedi & Elmasry, 2019; Shahgerdi et al., 2016). Collectively, these strategies can strengthen the inclusiveness and sustainability of Asia's tourism sector leading to long term regional prosperity.

CONCLUSION

This study examined the dynamic interlinkages among tourism receipts, economic growth, energy consumption and carbon emissions across 19 Asian economies during the period 2000 to 2023, employing a comprehensive panel framework that integrates FMOLS, DOLS and Granger Causality techniques. The results affirm that the Tourism-Led Growth Hypothesis (TLGH) in the long run, demonstrating that tourism and energy use are significant and enduring drivers of income growth. The short run causality results, however, indicate limited immediate effects, consistent with the notion that tourism's macroeconomic impacts evolve gradually.

The COVID-19 pandemic did not cause a structural break in the tourism growth relationship, suggesting that the sector's foundational role in regional economies remains robust. Diagnostics confirmed that the estimated models are statistically sound, free from severe multicollinearity or heteroscedasticity and appropriately corrected for serial correlation.

From a policy standpoint, the findings advocate for continued tourism infrastructure investment, the promotion of renewable energy and regional cooperation to ensure that growth remains inclusive and environmentally sustainable. The tourism-energy-environment nexus highlighted here underscores the need for coordinated policy frameworks that integrate economic development, energy efficiency and ecological preservation. Future research could expand this analysis by incorporating renewable energy consumption, institutional quality indicators and digital tourism metrics or by employing nonlinear and spatial econometric models to capture complex interdependencies across countries. Such extensions would further enrich understanding of how tourism can serve as a engine of sustainable growth in the post-pandemic global economy.

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