

## Article

# Tourism Growth Trap and Environmental Sustainability: How Tourism Dependence Shapes Development Pathways and Carbon Emissions in Asia

Leena Ajit Kaushal 

Economics & Public Policy, Management Development Institute Gurgaon, Gurugram 122007, India;  
leena.kaushal@mdi.ac.in

## Abstract

Tourism is widely regarded as an engine of economic growth, yet its environmental consequences remain contested. Existing studies largely treat tourism as a homogeneous activity, overlooking whether alternative tourism development pathways yield distinct environmental outcomes. Drawing on Ecological Modernisation Theory and Resource Dependence Theory, the study develops the Tourism Growth Trap (TGT) framework to examine how tourism dependence conditions the environmental effects of tourism development. Specifically, the study distinguishes between tourism expansion, measured by tourist arrivals, and tourism upgrading, measured by tourism yield. Using panel data for 20 leading Asian tourism destinations from 2002 to 2023, the analysis employs Driscoll–Kraay fixed-effects estimation, with Augmented Mean Group (AMG) and Dynamic Common Correlated Effects (DCCE) estimators for robustness checks. The findings reveal that tourism dependence amplifies the environmental costs of visitor-volume growth. However, it strengthens the emission-reduction effects of tourism upgrading. Marginal-effects analysis further identifies a threshold beyond which tourism expansion becomes environmentally harmful. The findings suggest that destinations generating greater value from existing tourism activity are better positioned to balance tourism growth with environmental sustainability. The study highlights value-based tourism development as a pathway for achieving sustainable tourism transitions.

**Keywords:** tourism growth trap framework; tourism dependence; tourism expansion; tourism upgrading; carbon emissions; environmental sustainability



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## 1. Introduction

Tourism has rapidly become one of the world's leading engines for economic growth. Across developing and emerging economies, governments have increasingly turned to tourism as a pathway toward economic development [1,2]. Tourism generates employment, foreign exchange earnings, infrastructure investment, and opportunities for regional development [3,4]. Consequently, many countries across Asia and elsewhere have adopted policies to promote tourism to support long-term economic growth.

At the same time, tourism growth has important environmental implications. Tourism activity relies on transportation networks, accommodation services, infrastructure development, energy consumption, and resource utilisation, all of which contribute to greenhouse gas emissions and environmental pressure [5,6]. As countries seek to meet climate mitigation commitments and Sustainable Development Goal 13, increasing attention has been

directed towards the environmental sustainability of tourism-led development [7–9]. This raises a fundamental question: can economies continue to pursue tourism-led growth while simultaneously achieving environmental sustainability?

Current evidence does not offer a definitive answer. Some studies conclude that tourism contributes to environmental degradation through increased transportation demand, construction activity, accommodation provision, and resource consumption [10,11]. Other studies suggest that tourism can improve environmental outcomes by encouraging technological innovation, supporting investments in sustainable infrastructure, and generating resources for environmental protection [12–14]. These contrasting findings suggest that the environmental consequences of tourism development are neither uniform nor straightforward.

One reason for these mixed findings is that most studies treat tourism growth as a homogeneous process and rely on aggregate indicators such as tourist arrivals, tourism receipts, or tourism expenditure [15]. Consequently, limited attention has been paid to whether different forms of tourism development generate distinct environmental outcomes. In particular, little is known about whether tourism growth achieved by increasing visitor numbers has different sustainability implications from growth achieved by generating greater economic value per visitor.

To address this gap, the present study introduces two conceptual distinctions. First, it distinguishes between tourism expansion and tourism upgrading as alternative pathways for tourism development. Tourism expansion occurs when tourism grows by increasing visitor arrivals, whereas tourism upgrading occurs when tourism grows by increasing the economic value created per tourist. Second, the study examines whether the environmental consequences of these pathways vary according to the degree of tourism dependence. While existing research generally assumes that tourism affects environmental outcomes similarly across destinations, economies that rely heavily on tourism revenues may face different incentives and constraints when balancing economic growth and environmental sustainability [16]. Understanding tourism sustainability, therefore, requires consideration of both how tourism grows and the extent to which economies depend on tourism activity.

Drawing on insights from the scale-effect literature, Ecological Modernisation Theory, and Resource Dependence Theory, this study argues that the environmental consequences of tourism development depend on the interaction between tourism development pathways and tourism dependence [17–19]. These insights form the basis of the Tourism Growth Trap framework, which explains how tourism dependence conditions the environmental consequences of alternative tourism development pathways. The framework proposes that tourism-dependent economies may become locked into visitor-volume-based growth strategies despite rising environmental costs, thereby amplifying the environmental pressures associated with tourism expansion. At the same time, tourism dependence may increase incentives for tourism upgrading by encouraging destinations to generate greater economic value from existing tourism activity rather than relying on continual increases in visitor numbers.

Accordingly, this study addresses three research questions:

RQ1: How do tourism expansion and tourism upgrading affect carbon emissions in Asian economies?

RQ2: Does tourism dependence moderate the relationship between tourism expansion and carbon emissions?

RQ3: Does tourism dependence moderate the relationship between tourism upgrading and carbon emissions?

To investigate these questions, a panel dataset covering 20 leading Asian tourism destinations between 2002 and 2023 is analysed using fixed-effects models with Driscoll–Kraay

standard errors. Tourism expansion is measured by international tourist arrivals, tourism upgrading by tourism yield, and tourism dependence is included as a moderating variable.

The study contributes to the tourism sustainability literature in three ways. First, it distinguishes between tourism expansion and tourism upgrading as alternative pathways of tourism development, thereby moving beyond aggregate measures of tourism activity. Second, it identifies tourism dependence as a critical conditioning factor shaping tourism–environment relationships. Third, it develops and empirically supports the Tourism Growth Trap Framework, providing a theoretical explanation for how tourism dependence interacts with tourism development pathways to influence environmental sustainability outcomes.

The remainder of the paper is organised as follows. Section 2 reviews the relevant literature and develops the hypotheses underpinning the Tourism Growth Trap Framework. Section 3 describes the data, variables, and methodology. Section 4 presents the empirical results, while Section 5 reports robustness analyses. Section 6 examines heterogeneity across tourism dependence regimes and tourism development pathways. Section 7 discusses the findings, Section 8 outlines policy implications, and Section 9 concludes.

## 2. Literature Review and Hypothesis Development

### 2.1. Tourism Development and Environmental Sustainability

Tourism is widely recognised as an important contributor to economic development, generating employment opportunities, foreign exchange earnings, infrastructure investment, and regional growth. The Tourism-Led Growth Hypothesis (TLGH) posits that tourism stimulates economic activity through multiplier effects across transportation, accommodation, construction, retail, and related service sectors. Consequently, many countries have actively promoted tourism as a strategy for economic development and poverty reduction [3,4].

Despite these economic benefits, tourism also generates environmental pressures. Tourism development relies on transportation networks, accommodation facilities, supporting infrastructure, and resource-intensive consumption, all of which contribute to energy use, greenhouse gas emissions, and environmental degradation [5,6]. As tourism continues to expand globally, concerns regarding its environmental sustainability have become increasingly prominent.

The relationship between tourism and environmental quality remains highly contested. One strand of literature argues that tourism contributes to environmental degradation through increased transportation demand, energy consumption, and tourism-related development activities [6,10,20]. In contrast, another suggests that tourism can improve environmental outcomes by encouraging investment in greener infrastructure, technological innovation, renewable energy adoption, and environmental protection initiatives [12,13]. Consequently, empirical evidence remains mixed, with some studies documenting tourism-induced environmental degradation and others highlighting opportunities for sustainable tourism transitions [21–25].

A key limitation of the existing literature is its tendency to treat tourism as a homogeneous activity [18,26,27]. These contrasting findings suggest that the environmental consequences of tourism may depend on how tourism develops, thereby motivating a closer examination of alternative tourism development pathways. This limitation motivates the distinction between tourism expansion and tourism upgrading, which forms the foundation of the TGT framework developed in this study.

## 2.2. *Tourism Expansion, Tourism Upgrading and Environmental Sustainability*

Although the tourism-sustainability literature has expanded considerably, limited attention has been paid to whether alternative forms of tourism development generate distinct environmental consequences [15,28,29]. To address this limitation, this study distinguishes between tourism expansion and tourism upgrading as two alternative tourism development pathways, thereby shifting attention from the quantity of tourism activity to the nature of tourism development and providing a more nuanced framework for understanding tourism–environment relationships.

Tourism expansion refers to growth achieved by increasing visitor arrivals, whereas tourism upgrading refers to growth achieved by increasing tourism yield (tourism receipts per tourist), thereby generating greater economic value from each visitor. Tourism expansion is associated with a scale effect because higher visitor volumes increase demand for transportation, accommodation, tourism services, and supporting infrastructure, thereby increasing resource use and environmental pressure [14,30,31]. Existing evidence suggests that tourism growth driven by visitor-volume expansion can generate significant environmental costs [11].

By contrast, tourism upgrading is associated with an efficiency effect because it enables destinations to generate greater economic value without a proportionate increase in visitor volumes or resource use. Tourism upgrading focuses on generating greater economic returns from existing tourism activity rather than continually increasing visitor numbers. Higher tourism yield may arise from longer visitor stays, higher per-tourist expenditure, business tourism, medical tourism, educational tourism, cultural tourism, and other higher-value tourism segments. Because tourism upgrading generates more economic value per visitor, destinations may achieve tourism income objectives without relying on continual increases in tourist arrivals [15,32]. Higher tourism yield also allows destinations to generate additional revenue without proportional increases in transportation demand, accommodation capacity, and resource-intensive infrastructure expansion. Consequently, tourism upgrading may reduce the environmental intensity of tourism development.

## 2.3. *Tourism Dependence and the Tourism Growth Trap Framework*

The environmental consequences of tourism development may depend not only on how tourism grows but also on the extent to which economies rely on tourism activity. Tourism dependence reflects the degree to which economic performance is supported by tourism revenues, including their contributions to income generation, employment, and external earnings [33,34]. In highly tourism-dependent economies, governments, firms, and other tourism stakeholders often have strong incentives to sustain and expand tourism activity because of its strategic importance to economic stability and development [35].

From a Resource Dependence Theory perspective, increasing reliance on tourism revenues creates incentives to prioritize activities that maintain and expand tourism demand [19]. As a result, tourism-dependent economies may continue to prioritise tourism expansion as a development strategy, even when the associated environmental costs become increasingly evident [18,29,36]. Under such conditions, the environmental pressures associated with tourism expansion may become increasingly pronounced, particularly where tourism constitutes a major source of income and employment [33,34].

At the same time, tourism dependence can strengthen incentives for tourism upgrading. By increasing the economic value generated per visitor, destinations can expand tourism revenues without relying exclusively on continual increases in tourist arrivals. Such strategies are consistent with emerging approaches to tourism development that emphasize value creation, destination well-being, and long-term sustainability rather than

visitor growth alone [29,32]. Tourism upgrading may therefore provide a pathway for destinations to reconcile economic objectives with environmental sustainability.

The central proposition of the proposed Tourism Growth Trap framework is that tourism dependence acts as a reinforcing, rather than merely additive, condition. From a Resource Dependence Theory perspective, increasing reliance on tourism revenues strengthens the economic and political incentives to sustain visitor growth because tourism contributes progressively more to employment, government revenues, foreign exchange earnings, and regional development. As tourism dependence deepens, destinations become increasingly committed to maintaining visitor growth, even when environmental pressures intensify. Consequently, tourism dependence does not simply increase the environmental consequences of tourism expansion; rather, it amplifies them by reinforcing development strategies centred on continually increasing visitor numbers. In this way, each additional increase in tourist arrivals occurs within an economy that is progressively more dependent on tourism, causing the environmental consequences of tourism expansion to become stronger rather than merely additive.

Ecological Modernisation Theory provides a complementary explanation for why tourism dependence can also strengthen the environmental benefits of tourism upgrading. Destinations whose economies rely heavily on tourism have stronger incentives to preserve the environmental quality upon which their long-term competitiveness depends. Consequently, they are more likely to invest in cleaner infrastructure, renewable energy, resource-efficient technologies, sustainable destination management, environmental certification, and higher-value tourism products that generate greater economic returns without proportional increases in visitor numbers. These complementary technological and institutional adjustments enhance the environmental efficiency of tourism development, enabling tourism upgrading to produce progressively larger environmental gains as tourism dependence increases rather than following a simple linear relationship.

Drawing on insights from the Tourism-Led Growth Hypothesis, sustainable tourism literature, Ecological Modernisation Theory, and Resource Dependence Theory, this study develops the TGT framework. Unlike conventional tourism–environment models that treat tourism dependence primarily as a statistical moderator, the proposed Tourism Growth Trap framework conceptualises tourism dependence as a reinforcing structural condition that fundamentally shapes tourism development pathways and their environmental consequences. The framework integrates three complementary mechanisms. First, the scale effect suggests that tourism expansion may increase environmental pressure through higher visitor volumes and associated resource consumption. Second, the efficiency effect suggests that tourism upgrading may reduce the environmental intensity of tourism development by generating greater value from existing tourism activity. Third, the dependence effect conceptualises tourism dependence as a reinforcing mechanism that amplifies the environmental costs of tourism expansion while strengthening the environmental benefits of tourism upgrading. Accordingly, tourism dependence is theorised to be a critical conditioning factor influencing whether tourism development follows environmentally intensive or environmentally sustainable pathways.

The interaction of these mechanisms gives rise to the Tourism Growth Trap. Tourism-dependent economies may become locked into visitor-volume-based growth strategies despite rising environmental pressures because tourism revenues remain economically important [18]. However, tourism upgrading offers an alternative pathway by enabling destinations to generate greater economic value from tourism while reducing reliance on continual increases in visitor numbers. The TGT framework, therefore, provides an analytical lens for understanding how tourism development pathways and tourism dependence jointly shape environmental sustainability outcomes. In doing so, it shifts attention

from whether tourism affects the environment to the conditions under which tourism development becomes environmentally intensive or environmentally sustainable.

#### 2.4. Hypotheses Development

According to the TGT framework, tourism expansion primarily operates through a scale effect. As visitor numbers increase, demand for transportation, accommodation, supporting infrastructure, and tourism-related services expands, leading to higher energy consumption and resource use. These activities are often associated with higher carbon emissions, particularly when tourism growth is driven by increased visitor volumes rather than efficiency improvements [11]. Accordingly:

**H1.** *Tourism expansion is positively associated with carbon emissions.*

Tourism upgrading operates through an efficiency effect. By generating greater economic value from each visitor, destinations can increase tourism revenues without proportionate increases in visitor volumes, transportation demand, or resource-intensive infrastructure expansion. As a result, tourism upgrading may reduce the environmental intensity of tourism development and lower associated carbon emissions. Accordingly:

**H2.** *Tourism upgrading is negatively associated with carbon emissions.*

The TGT framework further proposes that tourism dependence conditions the environmental consequences of tourism development pathways. In economies that rely heavily on tourism revenues, employment, and economic activity, maintaining tourism growth becomes a strategic priority. Under such conditions, governments and businesses may continue to support visitor-volume expansion despite increasing environmental pressures, thereby reinforcing the scale effect associated with tourism expansion. Consistent with the Resource Dependence Theory mechanism developed in Section 2.3, increasing tourism dependence progressively strengthens the economic and institutional incentives to prioritise visitor-volume growth. Consequently, the environmental consequences of additional tourist arrivals are amplified rather than merely increased, as each increment in tourism expansion occurs within an economy increasingly committed to tourism-led development. Accordingly:

**H3.** *TD strengthens the positive relationship between tourism expansion and carbon emissions.*

Conversely, tourism-dependent economies also have strong incentives to maximise the economic returns generated by tourism. Tourism upgrading enables destinations to increase tourism revenues by increasing value per visitor rather than by continual growth in visitor numbers. Drawing on Ecological Modernisation Theory, destinations with greater tourism dependence are expected to invest more heavily in cleaner infrastructure, resource-efficient technologies, and sustainable destination management to safeguard the long-term competitiveness of the tourism sector. These complementary investments enhance the environmental efficiency of tourism upgrading, implying that its emission-reducing benefits become progressively stronger as tourism dependence increases rather than following a simple linear relationship. Accordingly:

**H4.** *TD strengthens the negative relationship between tourism upgrading and carbon emissions.*

Figure 1 illustrates the theoretical logic of the Tourism Growth Trap framework. Tourism development can follow two alternative pathways: tourism expansion, which increases visitor volumes, and tourism upgrading, which increases the economic value

generated per tourist. Tourism dependence conditions the environmental consequences of both pathways. As dependence increases, destinations become increasingly reliant on tourism revenues, reinforcing incentives to sustain visitor-volume growth despite rising environmental costs. Conversely, greater dependence also increases incentives to improve tourism efficiency through higher-value tourism products and sustainable destination management. The framework therefore predicts that tourism dependence strengthens the scale effect associated with tourism expansion while simultaneously reinforcing the efficiency effect associated with tourism upgrading, resulting in contrasting environmental outcomes across tourism development pathways.

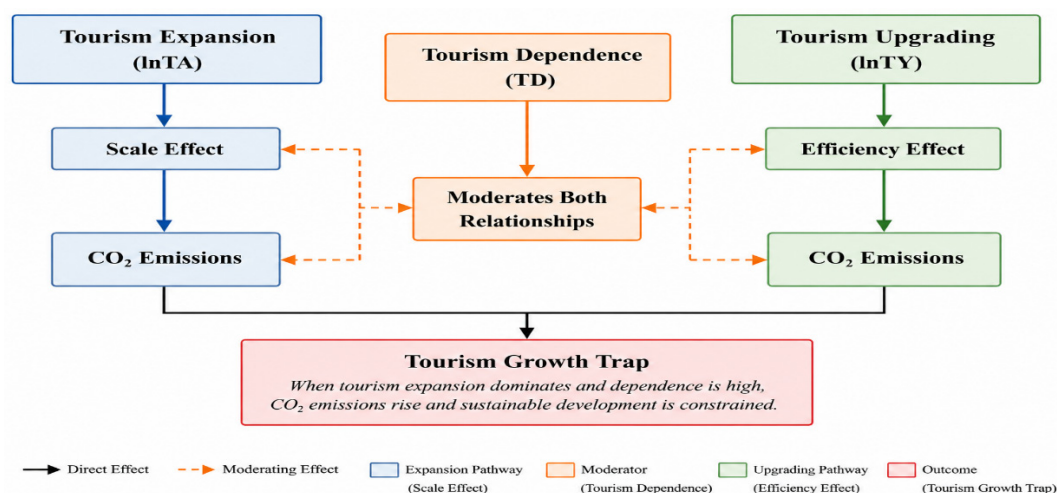


Figure 1. Conceptual model of the Tourism Growth Trap Framework.

### 3. Data, Variables and Methodology

#### 3.1. Data and Sample

The sample comprises 20 leading Asian tourism destinations. Countries were selected based on their average international tourist arrivals over the most recent decade (2014–2023), ensuring that the sample reflects the region’s contemporary major tourism destinations, while the empirical analysis covers the period 2002–2023 to maximise the use of consistent historical data across all study variables. Countries were ranked by average annual arrivals, and the top 20 destinations were retained for analysis (see Appendix A Table A1). This selection strategy ensures that the sample captures the region’s leading tourism markets while providing substantial variation in TD, economic structure, and environmental performance. The focus on major tourism destinations aligns with the study’s objective of examining tourism-dependent development pathways, which are most evident in economies with significant tourism activity. In addition, restricting the sample to these destinations ensured the availability of consistent and comparable data for all variables included in the analysis over the study period, particularly tourism yield, tourism dependence, institutional quality, renewable energy consumption, and energy intensity. Consequently, several small island developing states and other highly tourism-dependent economies were excluded because comparable long-term data for the full set of study variables were not consistently available. Accordingly, the findings should be interpreted primarily in the context of medium- and large-scale Asian tourism economies and should not be directly generalised to smaller tourism-dependent economies with substantially different tourism and economic structures.

The dataset consists of annual observations spanning 2002–2023. Environmental sustainability is measured by per capita carbon dioxide (CO<sub>2</sub>) emissions. Tourism development is captured through two complementary indicators: tourism expansion, measured by

international tourist arrivals, and tourism upgrading, measured by tourism yield (tourism receipts per tourist). Tourism upgrading is measured using tourism yield (tourism receipts per tourist), which captures the economic value generated per visitor and is widely employed in the tourism economics literature to distinguish value creation from visitor-volume growth. Unlike aggregate tourism receipts or tourist arrivals, tourism yield reflects the economic return generated from each visitor and therefore aligns closely with the concept of tourism upgrading developed in this study. Nevertheless, this proxy does not fully capture other dimensions of tourism upgrading, such as visitor composition, average length of stay, expenditure patterns, tourism quality, or visitor experiences. These dimensions remain important aspects of tourism upgrading and should be explored as more comprehensive and internationally comparable data become available. TD is measured as tourism receipts as a share of GDP. GDP per capita, renewable energy consumption, institutional quality, and energy intensity are included as control variables. Table 1 summarises the definitions, measurement, and data sources for all variables employed in the empirical analysis.

**Table 1.** Variable Definitions and Sources.

| Variable | Definition                                 | Source     |
|----------|--------------------------------------------|------------|
| lnCO2pc  | CO <sub>2</sub> emissions per capita (log) | WDI        |
| lnTA     | International tourist arrivals (log)       | UNWTO      |
| lnTY     | Tourism yield (receipts per tourist) (log) | Calculated |
| TD       | Tourism dependence (receipts/GDP)          | Calculated |
| lnTR     | Tourism receipts (log)                     | UNWTO      |
| RE       | Renewable energy share (%)                 | WDI        |
| IQ       | Institutional quality index                | WGI        |
| lnEI     | Energy intensity (log)                     | WDI        |
| lnGDPpc  | GDP per capita (log)                       | WDI        |

Institutional quality (IQ) is included as a control variable and is measured using a composite index constructed from four Worldwide Governance Indicators: Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. The index was generated using Principal Component Analysis (PCA), with higher values indicating stronger institutional quality. Details of the PCA procedure are reported in Appendix A Tables A2 and A3.

### 3.2. Preliminary Analysis

The descriptive statistics presented in Table 2 indicate considerable heterogeneity across countries. TD varies from less than 1% to more than 20% of GDP, indicating considerable cross-country differences in tourism specialisation. Likewise, shares of renewable energy production vary from 0% to 81%. This suggests tourism will not have homogeneous environmental effects across countries. Furthermore, such variation justifies using a panel framework, which can account for this heterogeneity. Moreover, the correlation matrix in Table 3 provides an initial indication that expanding tourism and improving its quality might lead to distinct environmental consequences. While tourist arrivals correlate positively with emissions, tourism yield correlates negatively with emissions. Renewable energy correlates strongly and negatively with emissions, while GDP per capita correlates strongly and positively with emissions. Most importantly, none of the bivariate correlations suggest concerning levels of multicollinearity.

**Table 2.** Descriptive Statistics.

| Variable | Obs | Mean   | SD     | Min    | Max    |
|----------|-----|--------|--------|--------|--------|
| lnCO2pc  | 440 | 1.580  | 1.171  | −1.727 | 3.500  |
| lnTA     | 440 | 8.943  | 1.173  | 5.056  | 11.999 |
| lnTY     | 440 | 13.516 | 1.039  | 11.019 | 18.143 |
| TD       | 440 | 0.045  | 0.043  | 0.001  | 0.201  |
| lnGDPpc  | 440 | 8.837  | 1.358  | 5.774  | 11.390 |
| RE       | 440 | 16.971 | 17.870 | 0.000  | 81.000 |
| IQ       | 440 | 0.000  | 1.000  | −1.695 | 2.698  |
| lnEI     | 405 | 1.623  | 0.326  | 0.820  | 2.386  |

**Table 3.** Correlation Matrix.

| Variables | lnCO2pc    | lnTA       | lnTY       | TD         | lnGDPpc    | RE         | IQ    | lnEI  |
|-----------|------------|------------|------------|------------|------------|------------|-------|-------|
| lnCO2pc   | 1.000      |            |            |            |            |            |       |       |
| lnTA      | 0.360 ***  | 1.000      |            |            |            |            |       |       |
| lnTY      | −0.153 *** | −0.130 *** | 1.000      |            |            |            |       |       |
| TD        | −0.280 *** | −0.077     | −0.070     | 1.000      |            |            |       |       |
| lnGDPpc   | 0.885 ***  | 0.325 ***  | 0.097 **   | −0.236 *** | 1.000      |            |       |       |
| RE        | −0.899 *** | −0.359 *** | 0.133 ***  | 0.164 ***  | −0.798 *** | 1.000      |       |       |
| IQ        | 0.576 ***  | 0.216 ***  | 0.315 ***  | −0.047     | 0.791 ***  | −0.590 *** | 1.000 |       |
| lnEI      | 0.447 ***  | 0.095 *    | −0.426 *** | −0.071     | 0.172 ***  | −0.277 *** | 0.001 | 1.000 |

Notes: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

### 3.3. Diagnostic Tests

A series of diagnostic tests was conducted prior to estimation. Variance Inflation Factors (VIFs) indicate no multicollinearity concerns, with all values below 2.45 after mean-centering the interaction terms (see Appendix A Table A4). Cross-sectional dependence was assessed using the Breusch–Pagan LM and Pesaran CD tests. As reported in Table 4, both tests reject the null hypothesis of cross-sectional independence, indicating the presence of common shocks and interdependencies across Asian economies. Stationarity was examined using Pesaran’s [37] Cross-Sectionally Augmented Dickey–Fuller (CADF) panel unit root test. The results reported in Table 5 indicate that all variables are integrated of order zero or one, with none exceeding I(1). These results support the use of panel estimators that accommodate cross-sectional dependence and mixed orders of integration.

**Table 4.** Cross-Sectional Dependence Tests.

| Test             | Statistic | $p$ -Value |
|------------------|-----------|------------|
| Breusch–Pagan LM | 910.337   | 0.000      |
| Pesaran CD       | 2.277     | 0.023      |

**Table 5.** Pesaran CADF Panel Unit Root Test Results.

| Variable | Level      | First Difference | Order of Integration |
|----------|------------|------------------|----------------------|
| lnCO2pc  | −1.949     | −2.857 ***       | I(1)                 |
| lnTA     | −2.283 *** | −                | I(0)                 |
| lnTY     | −1.726     | −2.866 ***       | I(1)                 |
| TD       | −2.113 **  | −                | I(0)                 |
| lnGDPpc  | −2.359 *** | −                | I(0)                 |
| RE       | −1.301     | −2.742 ***       | I(1)                 |
| IQ       | −1.701     | −2.735 ***       | I(1)                 |
| lnEI     | −1.895 **  | −                | I(0)                 |

Notes: Pesaran [37] Cross-Sectionally Augmented Dickey–Fuller (CADF) panel unit root test. \*\*\*, \*\* denote significance at the 1% and 5% levels, respectively.

### 3.4. Estimation Technique

The diagnostic results indicate the presence of cross-sectional dependence, while the variables exhibit a mixture of  $I(0)$  and  $I(1)$  properties. Accordingly, the study employs the Driscoll–Kraay fixed-effects (DK-FE) estimator, which yields standard errors that are robust to heteroskedasticity, autocorrelation, and cross-sectional dependence [38,39]. The estimator is particularly suitable for panels with moderate cross-sectional and time dimensions and has been widely applied in environmental and sustainability research. All estimations include country and year fixed effects. Country fixed effects control for time-invariant unobserved heterogeneity across countries, while year fixed effects capture common time-specific shocks affecting all economies, including global economic crises, the COVID-19 pandemic, technological changes, and other unobserved temporal influences.

Although DK-FE provides robust inference, concerns regarding persistence and unobserved common factors may remain. Therefore, robustness checks are conducted using the Augmented Mean Group (AMG) estimator [40,41] and the Dynamic Common Correlated Effects (DCCE) estimator [42,43]. While AMG accounts for unobserved common dynamic processes, DCCE additionally controls for dynamic persistence and multifactor error structures. Consistency across estimators enhances confidence in the robustness of the findings.

All continuous variables entering interaction terms were mean-centred following Aiken and West [44]. Mean-centring does not affect model fit or interaction coefficients but facilitates the interpretation of lower-order terms and reduces potential multicollinearity. The empirical analysis proceeds in four stages. First, baseline models examine the direct effects of tourism expansion and tourism upgrading on carbon emissions. Second, TD is introduced through interaction terms to test the TGT framework. Third, robustness checks employ alternative tourism measures and estimation techniques. Finally, heterogeneity analyses investigate whether tourism–environment relationships differ across tourism dependence regimes and tourism development pathways.

The baseline empirical model is as follows:

$$CO_{2it} = \alpha + \beta_1 TA_{it} + \beta_2 TY_{it} + \beta_3 GDP_{pcit} + \beta_4 RE_{it} + \beta_5 IQ_{it} + \beta_6 EI_{it} + \mu_i + \varepsilon_{it}$$

where  $CO_2$  represents carbon emissions per capita,  $TA$  denotes tourist arrivals,  $TY$  represents tourism yield,  $GDP_{pc}$  measures income per capita,  $RE$  captures renewable energy consumption,  $IQ$  represents institutional quality,  $EI$  represents energy intensity,  $\mu_i$  captures country-specific effects, and  $\varepsilon_{it}$  is the error term.

To examine whether TD conditions the environmental consequences of tourism development, the following interaction model is estimated:

$$CO_{2it} = \alpha + \beta_1 TA_{it} + \beta_2 TY_{it} + \beta_3 (TA \times TD)_{it} + \beta_4 (TY \times TD)_{it} + \beta_5 GDP_{pcit} + \beta_6 RE_{it} + \beta_7 IQ_{it} + \beta_8 EI_{it} + \mu_i + \varepsilon_{it}$$

where  $TD$  denotes tourism dependence, measured as tourism receipts as a share of GDP. A positive coefficient for  $TA \times TD$  indicates that increased tourism dependence heightens the environmental costs associated with higher visitor numbers. Conversely, a negative coefficient for  $TY \times TD$  indicates that tourism dependence enhances the environmental benefits of tourism upgrading.

While the estimation strategy employs country and year fixed effects together with Driscoll–Kraay standard errors and complementary robustness checks using AMG and DCCE estimators to mitigate several econometric concerns, the analysis remains observational in nature and cannot completely eliminate potential endogeneity arising from reverse causality, omitted variables, or measurement error. Although instrumental variable estimation could potentially address such concerns, identifying valid and theoretically defensible

external instruments for tourism dependence and tourism upgrading is challenging. Similarly, System GMM is primarily designed for panels characterised by a large cross-sectional dimension and a relatively short time dimension, whereas the present dataset comprises a relatively small number of countries observed over a longer period. Likewise, panel VAR is primarily intended to analyse dynamic interactions among endogenous variables rather than to test the theoretically specified moderation framework developed in this study. Accordingly, the findings should be interpreted as robust statistical associations rather than definitive causal relationships.

### 3.5. Construction of Tourism Development Pathways

To complement the econometric analysis, a tourism development pathway framework was developed to classify tourism systems according to two dimensions: tourism scale and tourism value creation. Tourism scale was measured using average international tourist arrivals (TA), while tourism value creation was measured using tourism yield (TY), defined as tourism receipts per tourist arrival.

Countries were classified by comparing their average tourist arrivals and tourism yield with the sample median over the study period. The use of median thresholds provides an objective, distribution-independent classification while ensuring balanced separation of countries across the two dimensions. This approach yields four tourism development pathways (Table 6). Emerging tourism economies exhibit low tourism scale and low value creation. Volume-led tourism economies combine high visitor volumes with relatively low tourism yield. Value-led tourism economies generate high value per tourist despite lower visitor numbers. Hybrid tourism economies combine both high tourism scale and high value creation.

**Table 6.** Tourism development pathways Framework.

|                       | Low Tourism Yield            | High Tourism Yield          |
|-----------------------|------------------------------|-----------------------------|
| Low Tourist Arrivals  | Emerging Tourism Economies   | Value-Led Tourism Economies |
| High Tourist Arrivals | Volume-Led Tourism Economies | Hybrid Tourism Economies    |

The framework operationalises the distinction between tourism expansion and tourism upgrading that underpins the TGT framework. While tourism expansion emphasises visitor growth, tourism upgrading emphasises value creation per tourist. The classification is descriptive rather than causal and complements the econometric analysis by illustrating heterogeneity in tourism development patterns across Asian economies.

## 4. Baseline Results

### 4.1. Tourism Expansion and Tourism Upgrading

Table 7 presents the baseline estimates of tourism development and carbon emissions before controlling for tourism dependence. The objective is to assess the direct environmental effects of tourism expansion and tourism upgrading and to establish a benchmark for the subsequent interaction models.

Model 1 considers tourism expansion, measured by international tourist arrivals. Tourist arrivals do not exert a statistically significant influence on carbon emissions ( $\beta = 0.006$ ,  $p > 0.10$ ), suggesting that visitor growth alone is not systematically associated with environmental pressure in Asian economies. Model 2 examines tourism upgrading, measured by tourism yield. Although the coefficient is negative ( $\beta = -0.028$ ), it is not statistically significant. Model 3 includes both tourism dimensions simultaneously. Tourism yield becomes negative and statistically significant ( $\beta = -0.052$ ,  $p < 0.05$ ), while tourist arrivals exhibit a weak negative effect ( $\beta = -0.027$ ,  $p < 0.10$ ). These results suggest that

the environmental consequences of tourism depend not only on visitor volumes but also on the value generated per tourist. Higher-value tourism development may therefore be associated with lower environmental pressure.

**Table 7.** Baseline Tourism–Environment Models. **Dependent variable:  $\ln\text{CO}_2\text{pc}$ .**

| Variables         | Model 1<br>Tourism Expansion | Model 2<br>Tourism Upgrading | Model 3<br>Combined Model |
|-------------------|------------------------------|------------------------------|---------------------------|
| $\ln\text{TA}$    | 0.006 (0.010)                | -                            | −0.027 * (0.016)          |
| $\ln\text{TY}$    | -                            | −0.028 (0.022)               | −0.052 ** (0.019)         |
| $\ln\text{GDPpc}$ | 0.233 *** (0.031)            | 0.248 *** (0.030)            | 0.274 *** (0.020)         |
| RE                | −0.029 *** (0.003)           | −0.028 *** (0.003)           | −0.028 *** (0.003)        |
| IQ                | −0.008 (0.043)               | −0.002 (0.043)               | 0.002 (0.044)             |
| $\ln\text{EI}$    | 0.155 * (0.091)              | 0.153 * (0.069)              | 0.173 * (0.093)           |
| Constant          | −0.292 (0.451)               | −0.004 (0.488)               | 0.294 (0.558)             |
| Observations      | 405                          | 405                          | 405                       |
| Countries         | 20                           | 20                           | 20                        |
| Within $R^2$      | 0.771                        | 0.776                        | 0.778                     |

Notes: Standard errors are reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

Among the control variables, GDP per capita has a positive and highly significant effect on emissions across all specifications, whereas renewable energy consumption has a significant negative effect. Energy intensity is positively associated with emissions and is significant across specifications, indicating that energy-intensive economies generate higher carbon emissions. Institutional quality does not exhibit a statistically significant direct effect.

Overall, the baseline results suggest that the environmental consequences of tourism development are not uniform. Neither tourism expansion nor tourism upgrading is significantly associated with emissions when considered independently. However, tourism upgrading becomes environmentally beneficial when both dimensions of tourism development are considered together. These findings suggest that the tourism–environment relationship may depend on broader structural conditions, a possibility examined in the following section through the moderating role of tourism dependence (TD).

#### 4.2. Tourism Growth Trap Model

Table 8 provides the first direct test of the TGT framework. Tourist arrivals exhibit a significant negative correlation with carbon emissions ( $\beta = -0.093$ ,  $p < 0.01$ ), and tourism yield similarly demonstrates an inverse association with emissions ( $\beta = -0.057$ ,  $p < 0.10$ ). More importantly, both interaction terms are statistically significant. The positive coefficient observed in the  $\text{TA} \times \text{TD}$  interaction ( $\beta = 1.181$ ,  $p < 0.01$ ) indicates that reliance on tourism amplifies the environmental impact associated with increased visitor numbers. On the other hand, the negative coefficient on  $\text{TY} \times \text{TD}$  ( $\beta = -0.719$ ,  $p < 0.01$ ) implies tourism dependence reinforces tourism upgrading’s emission-reducing power. These findings provide initial support for the central proposition of the TGT framework that the environmental consequences of tourism development depend on both the pathway of tourism growth and the degree of tourism dependence.

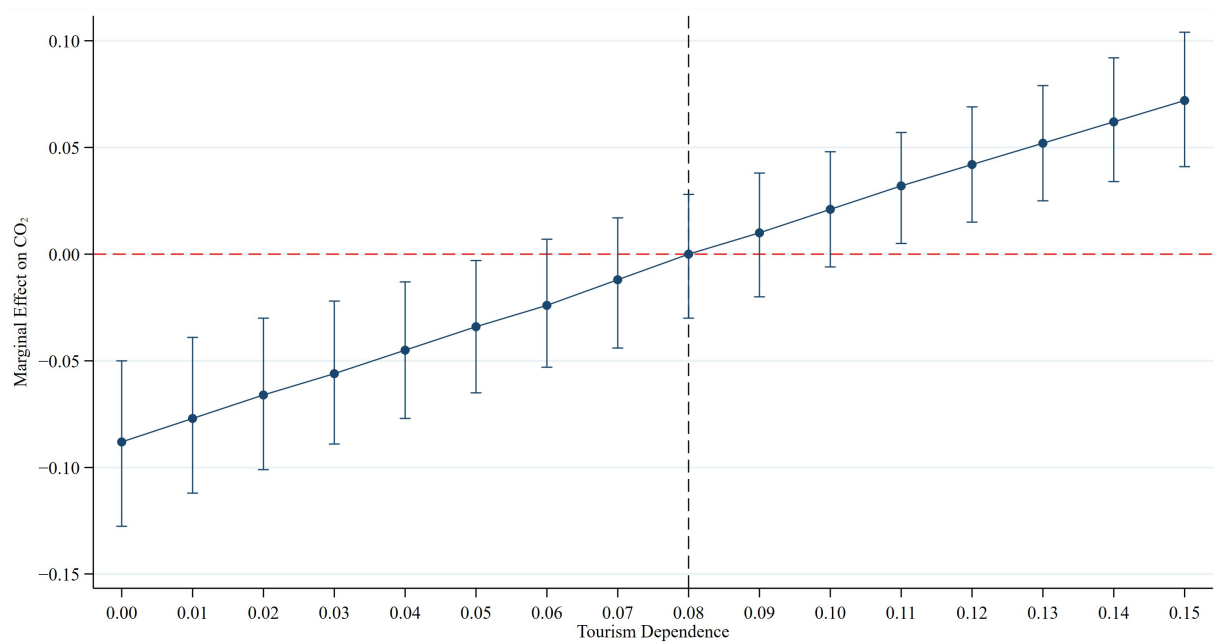
**Table 8.** Tourism Growth Trap Model. Dependent variable:  $\ln\text{CO}_2\text{pc}$ .

|                              |                    |
|------------------------------|--------------------|
| $\ln\text{TA}$               | −0.093 *** (0.030) |
| $\ln\text{TY}$               | −0.057 * (0.028)   |
| $\text{TA} \times \text{TD}$ | 1.181 *** (0.295)  |
| $\text{TY} \times \text{TD}$ | −0.719 *** (0.164) |
| $\ln\text{GDPpc}$            | 0.311 *** (0.016)  |
| RE                           | −0.026 *** (0.003) |
| IQ                           | −0.013 (0.039)     |
| $\ln\text{EI}$               | 0.181 ** (0.077)   |
| Constant                     | 0.548 (0.665)      |
| Observations                 | 405                |
| Countries                    | 20                 |
| Within $R^2$                 | 0.803              |
| F-statistic                  | 288.97 ***         |

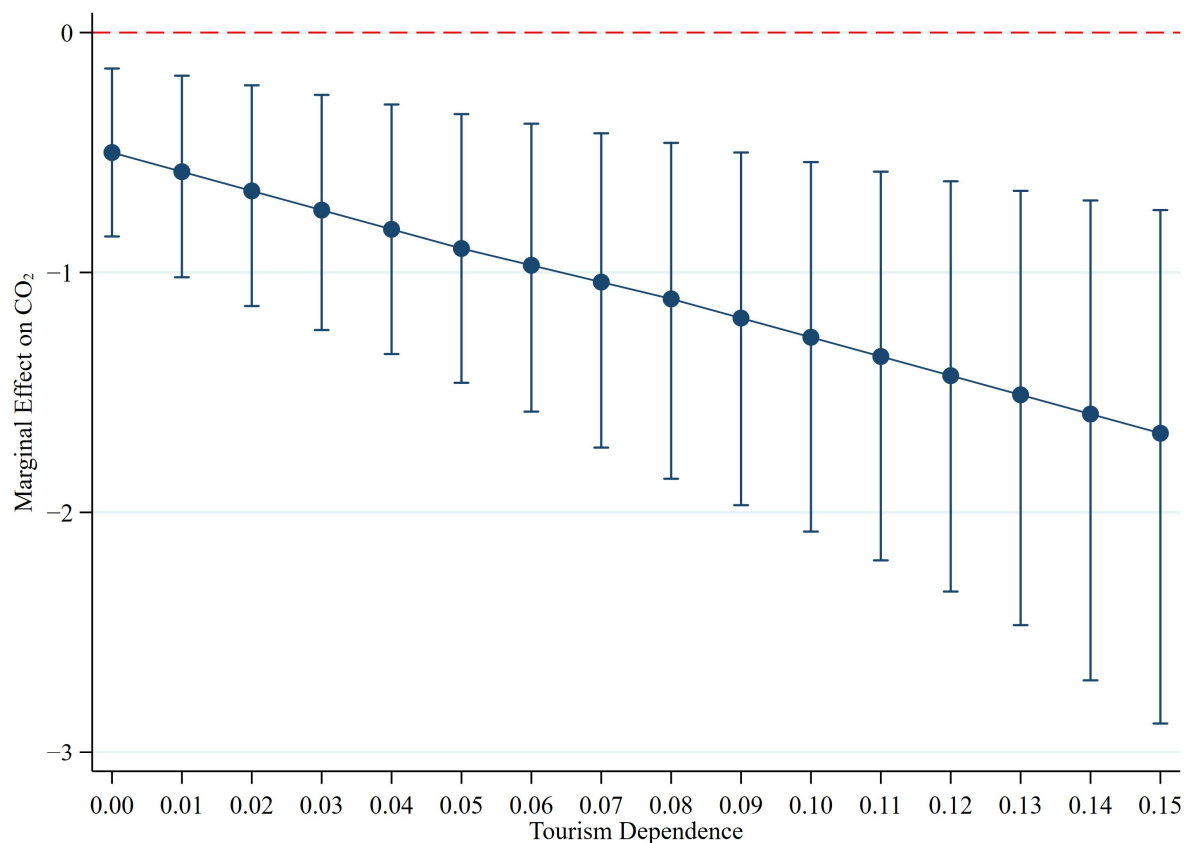
Notes: Standard errors are reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

Figures 2 and 3 illustrate the marginal effects of tourism expansion and upgrading at various levels of tourism dependence (TD). Figure 2 reveals that the marginal effect of tourism expansion increases with tourism dependence (TD) and becomes positive when TD reaches approximately 8% (i.e., tourism receipts account for about 8% of GDP), suggesting that visitor growth begins to have a positive association with carbon emissions beyond this point. It is important to note that the reported threshold of approximately 8% tourism dependence is not a statistically estimated threshold obtained from a panel threshold model. Rather, it is derived from the estimated interaction model and represents the point at which the estimated marginal effect of tourism expansion on carbon emissions changes sign (i.e., where the marginal effect equals zero). Accordingly, this value should be interpreted as an indicative empirical benchmark specific to the present sample and model specification rather than as a universal policy threshold applicable across all tourism-dependent economies. By contrast, Figure 3 shows that tourism upgrading remains negatively associated with emissions across all levels of TD, with its emission-reducing effect becoming stronger as tourism dependence increases. Together, these results provide direct support for the dependence effect proposed by the TGT framework and suggest that tourism dependence conditions whether tourism development follows environmentally intensive or environmentally sustainable pathways.

Among the control variables, GDPpc and energy intensity have positive and significant effects on emissions, whereas renewable energy consumption has a significant negative effect. Institutional quality does not exhibit a statistically significant direct effect. Overall, the findings provide strong support for the TGT framework. The environmental consequences of tourism depend not only on tourism growth but also on how it grows and on the extent to which economies rely on tourism revenues. TD increases the environmental costs of visitor-volume expansion while strengthening the environmental benefits of higher-value tourism development.



**Figure 2.** Marginal Effect of Tourism Expansion on CO<sub>2</sub> Emissions Across Levels of Tourism Dependence.



**Figure 3.** Marginal Effect of Tourism Upgrading on CO<sub>2</sub> Emissions Across Levels of Tourism Dependence.

## 5. Robustness Analysis

Several robustness checks are performed to assess the stability of the baseline findings. First, tourism expansion and tourism upgrading are replaced with aggregate tourism

receipts to evaluate whether the results are sensitive to the measurement of tourism development. Second, the baseline Driscoll–Kraay estimator is replaced with clustered fixed-effects estimation. Third, the Augmented Mean Group (AMG) estimator is employed to account for cross-sectional dependence and unobserved common factors by including a common dynamic process. Finally, the Dynamic Common Correlated Effects (DCCE) estimator is used as an additional robustness check to address dynamic persistence and cross-sectional dependence. Consistent findings across these alternative specifications provide greater confidence in the robustness of the empirical results.

### 5.1. Alternative Tourism Measure

Table 9 presents robustness results using aggregate tourism receipts in place of the separate measures of tourism expansion and tourism upgrading. The findings are broadly consistent with the baseline results. TR are negatively associated with carbon emissions ( $\beta = -0.083$ ,  $p < 0.01$ ), suggesting that higher tourism revenue is associated with lower environmental pressure. The interaction between tourism receipts and TD is positive and statistically significant ( $\beta = 0.069$ ,  $p < 0.05$ ), indicating that the emissions-reducing effect of TR weakens as economies become more dependent on tourism. This finding suggests that excessive reliance on tourism may diminish the environmental benefits associated with higher tourism revenue. Overall, the signs and significance of the key coefficients remain consistent with the baseline results, providing additional support for the robustness of the TGT framework.

**Table 9.** Tourism Receipts Robustness. Dependent variable:  $\ln\text{CO}_2\text{pc}$ .

|                              |                        |
|------------------------------|------------------------|
| $\ln\text{TR}$               | $-0.083^{***} (0.025)$ |
| $\text{TR} \times \text{TD}$ | $0.069^{**} (0.033)$   |
| $\ln\text{GDPpc}$            | $0.319^{***} (0.019)$  |
| RE                           | $-0.028^{***} (0.003)$ |
| IQ                           | $-0.022 (0.043)$       |
| $\ln\text{EI}$               | $0.178^{**} (0.086)$   |
| Constant                     | $0.751(0.626)$         |
| Observations                 | 405                    |
| Countries                    | 20                     |
| Within $R^2$                 | 0.784                  |
| F-statistic                  | 252.80 <sup>***</sup>  |

Notes: Standard errors are reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ .

### 5.2. Alternative Estimator

Table 10 reports estimates obtained using a standard FE estimator with clustered standard errors. The results remain broadly consistent with the baseline specification. The interaction between TA and TD remains positive and statistically significant ( $\beta = 1.181$ ,  $p < 0.05$ ), while the interaction between tourism yield and TD remains negative and statistically significant ( $\beta = -0.719$ ,  $p < 0.05$ ). Although the statistical significance of some direct tourism variables weakens under clustered standard errors, the coefficient signs and magnitudes remain largely unchanged. These findings indicate that the central predictions of the TGT framework are not sensitive to the choice of estimator and continue to hold under an alternative estimation approach.

**Table 10.** Clustered Fixed-Effects Robustness. Dependent variable:  $\ln\text{CO}_2\text{pc}$ .

|                              |                    |
|------------------------------|--------------------|
| $\ln\text{TA}$               | −0.093 * (0.047)   |
| $\ln\text{TY}$               | −0.057 (0.059)     |
| $\text{TA} \times \text{TD}$ | 1.181 ** (0.429)   |
| $\text{TY} \times \text{TD}$ | −0.719 ** (0.330)  |
| $\ln\text{GDPpc}$            | 0.311 *** (0.050)  |
| RE                           | −0.026 *** (0.007) |
| IQ                           | −0.013 (0.074)     |
| $\ln\text{EI}$               | 0.181 (0.127)      |
| Constant                     | 0.548 (0.968)      |
| Observations                 | 405                |
| Countries                    | 20                 |
| Within $R^2$                 | 0.803              |
| F-statistic                  | 41.91 ***          |

Notes: Standard errors are reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

### 5.3. Augmented Mean Group (AMG) Estimation

To further assess the robustness of the findings, the baseline model is re-estimated using the Augmented Mean Group (AMG) estimator proposed by Eberhardt and Bond [40], and Eberhardt and Teal [41]. The AMG estimator accounts for cross-sectional dependence and unobserved common factors by incorporating a common dynamic process into the estimation procedure. Given that Asian economies are exposed to common shocks such as fluctuations in global tourism demand, energy prices, technological change, and international environmental initiatives, AMG provides a useful robustness check for the baseline Driscoll–Kraay estimates.

The AMG results, reported in Appendix A Table A5, are broadly consistent with the baseline findings. In particular, the interaction between tourism expansion and TD remains positive and statistically significant. Although the direct coefficients for tourism expansion and tourism upgrading differ from those obtained using the Driscoll–Kraay estimator, such differences are expected because AMG explicitly accounts for unobserved common dynamic processes and heterogeneous cross-sectional responses. Importantly, the key interaction effects remain stable in both sign and significance across estimators, indicating that the main relationships identified in the baseline analysis are not driven by estimator choice, cross-sectional dependence, or unobserved common shocks. These results provide additional evidence for the robustness of the study’s core findings.

### 5.4. Dynamic Common Correlated Effects (DCCE) Estimation

As an additional robustness check, the Dynamic Common Correlated Effects (DCCE) estimator is employed to account for dynamic persistence and unobserved common factors. The specification incorporates cross-sectional averages of the dependent variable to mitigate cross-sectional dependence across countries [42,43].

The DCCE results, reported in Appendix A Table A6, are broadly consistent with the baseline findings. Tourism upgrading remains negatively associated with carbon emissions, while the interaction between tourism upgrading and TD remains negative and statistically significant. Although the interaction between tourism expansion and TD is not statistically significant under the dynamic specification, its coefficient retains the predicted positive sign. Some coefficients are estimated with less precision under this specification; however, the principal relationships remain largely consistent with the baseline results. Taken together,

the DCCE estimates suggest that the key mechanisms associated with tourism upgrading are robust to dynamic modelling and cross-sectional dependence. In contrast, the evidence for tourism expansion is somewhat weaker under the dynamic specification. Overall, the DCCE estimates provide broad support for the principal conclusions of the TGT framework and suggest that the main findings are not solely driven by unobserved common factors or dynamic persistence.

Although some differences emerge across the robustness estimators, these should be interpreted in light of their distinct econometric properties. The AMG estimator primarily accounts for unobserved common dynamic processes and heterogeneous slope coefficients, whereas the DCCE estimator additionally controls for dynamic persistence and multifactor error structures. Consequently, some variation in coefficient magnitudes and statistical significance is expected. Importantly, despite differences in the statistical significance of individual coefficients, the overall pattern of results remains broadly consistent across estimators. The evidence continues to support the central proposition of the Tourism Growth Trap framework that tourism development pathways exhibit different environmental consequences and that tourism dependence conditions these relationships. Accordingly, the robustness analysis should be interpreted as providing broad support for the principal findings rather than identical results across alternative estimation approaches.

## 6. Heterogeneity Analysis

### 6.1. High Versus Low Tourism Dependence Economies

To examine whether the environmental consequences of tourism development vary with the degree of tourism dependence, the sample was divided into high- and low-tourism-dependence economies. TD was measured as tourism receipts as a share of GDP. Countries were ranked by their average TD over the study period. The five countries with the highest values were classified as high-tourism-dependence economies, while the remaining 15 were classified as low-tourism-dependence economies (Table 11). This classification is descriptive and intended to assess whether the environmental implications of tourism development pathways differ across economies with varying levels of tourism reliance.

**Table 11.** High- and Low-Tourism-Dependence Economies.

| High Tourism Dependence Economies            | Low Tourism Dependence Economies                                                                                                                                           |
|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Jordan, Cambodia, Bahrain, Thailand, Georgia | China, India, Japan, Republic of Korea, Indonesia, Malaysia, Saudi Arabia, Singapore, United Arab Emirates, Türkiye, Viet Nam, Philippines, Kazakhstan, Kuwait, Kyrgyzstan |

Table 12 highlights clear differences between high- and low-tourism-dependence economies. The positive effect of tourism expansion on emissions is substantially larger in highly tourism-dependent economies ( $\beta = 1.536$ ) than in low-dependence economies ( $\beta = 0.371$ ). A similar pattern emerges for tourism upgrading. The emission-reducing effect of tourism upgrading is considerably stronger in highly tourism-dependent economies ( $\beta = -0.890$ ) than in low-dependence economies ( $\beta = -0.249$ ). These results suggest that greater reliance on tourism intensifies both the environmental costs of visitor-volume growth and the environmental benefits of tourism upgrading. The findings are consistent with the central proposition of the TGT framework, indicating that tourism development pathways become increasingly important as economies depend more heavily on tourism revenues.

**Table 12.** Tourism Dependence Heterogeneity. Dependent variable:  $\ln\text{CO}_2\text{pc}$ .

| Variable              | Low Tourism Dependence | High Tourism Dependence |
|-----------------------|------------------------|-------------------------|
| TA $\times$ TD        | 0.371 ** (0.140)       | 1.536 *** (0.449)       |
| TY $\times$ TD        | −0.249 ** (0.091)      | −0.890 ** (0.324)       |
| Observations          | 305                    | 100                     |
| Countries             | 15                     | 5                       |
| Within R <sup>2</sup> | 0.759                  | 0.839                   |

Notes: Standard errors are reported in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ .

Although the high-tourism-dependence group includes several relatively lower-income economies, all heterogeneity specifications control for GDP per capita. Accordingly, the reported differences should be interpreted as tourism-dependence-based heterogeneity after accounting for differences in economic development, rather than as unconditional differences between richer and poorer economies. Future research could further investigate how tourism dependence and income levels jointly shape environmental sustainability in tourism-dependent economies.

### 6.2. Descriptive Tourism Development Pathways

Countries were grouped using the tourism development pathway framework introduced in Section 3.5. The classification is based on two dimensions of tourism activity: tourism scale, measured by tourist arrivals, and tourism value creation, measured by tourism yield. Combining these dimensions produces four tourism development pathways: Emerging (low scale–low value), Value-led (low scale–high value), Volume-led (high scale–low value), and Hybrid (high scale–high value). Table 13 reports the resulting classification.

**Table 13.** Tourism Development Pathways.

| Pathway                                        | Countries                                                                    |
|------------------------------------------------|------------------------------------------------------------------------------|
| Emerging (Low arrivals, low value creation)    | Kazakhstan, Kuwait, Georgia, Kyrgyzstan, Jordan, Cambodia                    |
| Value-led (Low arrivals, high value creation)  | India, Indonesia, Viet Nam, Philippines                                      |
| Volume-led (High arrivals, low value creation) | China, Malaysia, Saudi Arabia, Bahrain                                       |
| Hybrid (High arrivals, high value creation)    | Thailand, Japan, United Arab Emirates, Singapore, Republic of Korea, Türkiye |

The classification is intended as a descriptive supplement to the econometric analysis rather than a causal test. Volume-led economies rely primarily on visitor numbers to generate tourism revenues. Value-driven economies produce significant economic benefits even with a smaller tourism sector. Hybrid economies combine scale with value creation, while emerging economies remain characterised by comparatively low levels of both. These pathways illustrate the diverse tourism development patterns observed across Asian economies.

### 6.3. Descriptive Characteristics of Tourism Development Pathways

Table 14 shows clear differences across the four tourism development pathways. Value-led economies record the lowest average carbon emissions despite generating relatively high tourism value. By contrast, volume-led economies combine the largest visitor volumes with the highest emissions. Hybrid economies achieve both scale and value creation but continue to exhibit relatively high emissions, while emerging economies remain characterised by comparatively low tourism activity and value creation. Although descriptive, these patterns are consistent with the regression results and suggest that value-based

tourism development is associated with more favourable environmental outcomes than visitor-volume-driven growth.

**Table 14.** Tourism characteristics across tourism development pathways.

| Pathway    | lnTA | lnTY  | TD    | lnCO <sub>2</sub> pc | Countries ( <i>n</i> ) |
|------------|------|-------|-------|----------------------|------------------------|
| Emerging   | 8.07 | 12.72 | 0.068 | 1.18                 | 6                      |
| Value-led  | 8.56 | 14.16 | 0.019 | 0.43                 | 4                      |
| Volume-led | 9.95 | 13.08 | 0.043 | 2.47                 | 4                      |
| Hybrid     | 9.40 | 14.17 | 0.040 | 2.15                 | 6                      |

These descriptive patterns should not be interpreted as causal evidence. Instead, they provide illustrative support for the econometric findings and are broadly consistent with the central proposition of the TGT framework. Specifically, the pathway analysis suggests that value-based tourism development is associated with more favourable environmental outcomes than visitor-volume-driven growth.

## 7. Discussion

The findings suggest that the environmental consequences of tourism development depend not only on the scale of tourism activity but also on the pathway through which tourism grows. This challenges the common assumption that tourism exerts a uniform environmental impact and highlights the importance of distinguishing between tourism expansion and tourism upgrading. More importantly, the findings extend prior tourism–environment research by demonstrating that tourism dependence is a critical conditioning factor shaping environmental outcomes and the sustainability implications of alternative tourism development pathways.

The positive interaction between tourism expansion and tourism dependence indicates that the environmental costs of tourism become increasingly pronounced as economies rely more heavily on tourism revenues. In destinations that rely heavily on tourism, growth is typically achieved by drawing in more visitors. This leads to increased demand for transportation, lodging, infrastructure, and other tourism-related services. As visitor numbers rise, resource use and environmental pressures tend to increase as well. These findings are consistent with earlier studies showing that tourism growth driven primarily by visitor expansion and carbon-intensive activities can contribute to higher emissions and environmental degradation [10,11]. The results suggest that strong reliance on tourism revenues may encourage development strategies centred on visitor growth, increasing the environmental costs associated with tourism expansion.

A different picture emerges for tourism upgrading. In economies that depend heavily on tourism, higher-value tourism is linked to better environmental outcomes. Destinations can increase tourism revenues through longer stays, specialised tourism segments, higher-quality products, and richer visitor experiences rather than through continual increases in visitor numbers. This allows tourism value added to grow without a comparable increase in visitor volumes and the environmental pressures that accompany them.

Higher-value tourism may also make sustainability investments more viable. Higher tourism value can promote cleaner technologies, encourage the use of renewable energy, support environmental certification, enhance waste management, and develop low-impact transportation systems. These findings largely align with Ecological Modernisation Theory, which underscores the importance of efficiency improvements, technological advancements, and institutional changes in mitigating environmental impacts [17]. They also align with recent tourism research that emphasises value creation, destination well-being, and the overall quality of tourism development rather than continuous growth in visitor

numbers [32]. An additional finding is that institutional quality does not have a statistically significant direct effect on carbon emissions once tourism development pathways and other structural factors are accounted for. Although stronger institutions are generally associated with improved environmental performance, this result suggests that institutional quality alone may not be sufficient to reduce emissions in tourism-dependent economies. Rather, its contribution appears to be indirect, operating through the extent to which institutions facilitate effective environmental regulation, sustainable destination governance, cleaner technologies, and green tourism investments. This finding suggests that institutional quality serves as an enabling condition for environmentally sustainable tourism development when complemented by appropriate tourism development strategies, rather than as an independent driver of environmental improvement. This interpretation is consistent with the Tourism Growth Trap (TGT) framework, which emphasises that the environmental consequences of tourism depend primarily on the pathways through which tourism develops. At the same time, institutional conditions shape the effectiveness of those pathways rather than directly determining environmental outcomes.

The heterogeneity analysis offers additional insights into these relationships. The environmental costs associated with tourism expansion are greater in highly tourism-dependent economies. At the same time, the environmental benefits of tourism upgrading are also more pronounced. The pathway analysis points in the same direction. Value-led destinations record lower emissions than volume-led destinations despite generating substantial tourism income. These patterns suggest that tourism dependence shapes the environmental consequences of tourism development and that value-based tourism may offer a more sustainable alternative to visitor-volume growth.

The results are broadly consistent with the central proposition of the Tourism Growth Trap framework. In highly tourism-dependent economies, development strategies centred on visitor growth can increase environmental pressures and reinforce the long-standing tension between tourism expansion and sustainability [18]. However, the findings also point to an alternative trajectory. Destinations can generate greater economic benefits through tourism upgrading rather than through continual increases in visitor numbers. In doing so, they may reduce some of the environmental pressures associated with volume-driven growth. Sustainable tourism development, therefore, depends not only on the scale of tourism activity but also on the way tourism value is created.

## 8. Policy Implications

The findings offer important implications for tourism policy and sustainable development strategies, particularly in economies that rely heavily on tourism revenues.

First, policymakers should move beyond visitor-arrival targets as the primary indicator of tourism performance. The results suggest that tourism dependence amplifies the environmental costs associated with visitor-volume growth. Consequently, development strategies centred on continually increasing tourist arrivals may generate mounting environmental pressures, particularly in highly tourism-dependent economies. Second, tourism authorities should place greater emphasis on tourism upgrading rather than visitor numbers alone. The findings suggest that the environmental benefits of tourism upgrading become stronger as tourism dependence increases. Performance should therefore be assessed using a broader set of indicators, including tourism yield, tourism value added, average length of stay, visitor engagement, and the quality of tourism experiences. Policymakers should also promote higher-value tourism segments, such as business, educational, cultural, heritage, wellness, and nature-based tourism, which can generate greater economic value without relying on continual increases in visitor numbers.

Beyond improving environmental sustainability, these tourism segments may also strengthen local economic capabilities by creating demand for specialised services, skilled employment, and knowledge-intensive activities, thereby contributing to broader economic development through human capital accumulation and productivity enhancement [45,46].

Third, destinations with high levels of tourism dependence should integrate environmental sustainability directly into tourism development strategies. The results suggest that tourism-dependent economies face greater environmental costs when growth is driven primarily by visitor expansion. Long-term tourism planning needs to place greater emphasis on resource efficiency, sustainable destination management, renewable energy, low-carbon transport, and environmentally responsible infrastructure. Fourth, tourism policy should be consistent with broader energy-transition and innovation policies. The results show that renewable energy consumption is associated with lower carbon emissions, suggesting that investments in clean energy infrastructure can improve the environmental sustainability of tourism development. Technological innovation, environmental certification systems, circular-economy approaches, and sustainable infrastructure investments can also support the transition towards lower-carbon tourism systems.

In sum, the results suggest that the sustainability of tourism depends on more than growth alone. The way tourism develops also matters. Policies that encourage tourism upgrading, value creation, and sustainable destination development may help economies capture the benefits of tourism while limiting environmental pressures, particularly where tourism plays a major economic role.

## 9. Conclusions

This study examined how different tourism development pathways affect environmental sustainability across 20 leading Asian tourism destinations between 2002 and 2023. It distinguishes between tourism expansion, measured by international tourist arrivals, and tourism upgrading, measured by tourism yield. The analysis also considers the role of tourism dependence in shaping environmental outcomes.

The results show that the environmental consequences of tourism depend not only on the level of tourism activity but also on the way tourism develops. In economies that rely heavily on tourism, growth driven primarily by increasing visitor numbers is associated with greater environmental pressures. A different pattern emerges for tourism upgrading. The environmental benefits of higher-value tourism become stronger as tourism dependence increases. These findings indicate that tourism dependence plays an important role in shaping the sustainability outcomes of tourism development.

The findings point to a broader challenge for tourism-dependent economies. The issue is not whether tourism should grow, but how that growth is achieved. Destinations can improve environmental outcomes by shifting from visitor-volume-based growth towards tourism upgrading. This involves generating greater economic value through longer stays, higher-value tourism products, specialised tourism segments, and richer visitor experiences rather than continual increases in visitor numbers. Such an approach may help reduce some of the environmental pressures associated with volume-driven growth. More broadly, the results suggest that sustainable tourism development depends not only on the scale of tourism growth but also on the way tourism value is created.

Several limitations should be acknowledged. First, the analysis focuses on the leading tourism destinations in Asia, reflecting both the study's objective and the availability of consistent long-term data for all variables included. Consequently, the findings may not be directly generalisable to small island developing states or other highly tourism-dependent economies whose tourism structures differ substantially from those examined in this study. Second, environmental sustainability is measured by per capita CO<sub>2</sub> emissions,

which provide a consistent and internationally comparable indicator but do not capture tourism-specific emissions or indirect environmental impacts from aviation, accommodation, tourism infrastructure, and other tourism-related activities. Similarly, tourism upgrading is measured by tourism yield (tourism receipts per tourist), which reflects value creation per visitor but does not fully capture other dimensions of tourism upgrading, such as visitor composition, length of stay, expenditure patterns, or tourism quality. Future research could examine other regions and consider broader environmental outcomes, including ecological footprints, biodiversity loss, water stress, and waste generation. Future studies may also employ richer indicators of tourism upgrading and tourism-specific environmental performance, such as tourism carbon intensity or carbon emissions per unit of tourism value added, where comparable cross-country data are available. Further work could explore how institutional quality, technological innovation, renewable energy adoption, and destination governance influence the relationship between tourism development and environmental sustainability. Non-linear effects and alternative forms of tourism upgrading also warrant further investigation. Finally, although the study employs several estimation strategies and robustness checks to mitigate econometric concerns, the observational nature of the data limits definitive causal inference. Future research could employ instrumental variables, natural experiments, quasi-experimental designs, or other causal identification strategies to establish stronger causal evidence regarding the relationships proposed in the Tourism Growth Trap framework.

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**Conflicts of Interest:** The author declares no conflict of interest.

## Appendix A

**Table A1.** Sample Economies Included in the Study (2002–2023).

|                                                                                                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Jordan, Cambodia, Bahrain, Thailand, Georgia, China, India, Japan, Republic of Korea, Indonesia, Malaysia, Saudi Arabia, Singapore, United Arab Emirates, Türkiye, Viet Nam, Philippines, Kazakhstan, Kuwait, Kyrgyzstan. |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

**Table A2.** Principal Component Analysis Results.

| Component | Eigenvalue | Variance Explained (%) | Cumulative Variance (%) |
|-----------|------------|------------------------|-------------------------|
| PC1       | 3.752      | 93.79                  | 93.79                   |
| PC2       | 0.106      | 2.65                   | 96.45                   |
| PC3       | 0.083      | 2.08                   | 98.53                   |
| PC4       | 0.059      | 1.47                   | 100.00                  |

Notes: PCA based on Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption. The first principal component was retained as the composite institutional quality index.

**Table A3.** Factor Loadings and Sampling Adequacy.

| Variable                      | Factor Loading | Uniqueness | KMO   |
|-------------------------------|----------------|------------|-------|
| Government Effectiveness (GE) | 0.968          | 0.062      | 0.894 |
| Regulatory Quality (RQ)       | 0.962          | 0.075      | 0.901 |
| Rule of Law (RL)              | 0.968          | 0.063      | 0.873 |
| Control of Corruption (CC)    | 0.976          | 0.048      | 0.848 |
| Overall KMO                   |                |            | 0.878 |

Notes: Factor loadings are obtained from principal-component factor analysis. Higher loadings indicate a stronger contribution to the latent construct of institutional quality. KMO values above 0.80 indicate excellent sampling adequacy.

**Table A4.** Multicollinearity Diagnostics.

| Variable | VIF  |
|----------|------|
| lnGDPpc  | 5.29 |
| RE       | 3.69 |
| IQ       | 3.43 |
| c_lnTY   | 1.76 |
| c_lnTA   | 1.42 |
| cTA_TD   | 1.39 |
| lnEI     | 1.33 |
| cTY_TD   | 1.31 |
| Mean VIF | 2.45 |

**Table A5.** AMG Robustness Estimates.

|                        |                    |
|------------------------|--------------------|
| lnTA                   | 0.154 (0.102)      |
| lnTY                   | 0.271 *** (0.099)  |
| TA × TD                | 7.062 *** (2.347)  |
| TY × TD                | −5.744 *** (1.860) |
| lnGDPpc                | −0.098 (0.102)     |
| RE                     | −0.111 * (0.062)   |
| IQ                     | 0.005 (0.045)      |
| lnEI                   | 0.045 (0.072)      |
| Common Dynamic Process | −0.325 (0.367)     |
| Constant               | −2.191 (1.405)     |
| Observations           | 374                |
| Countries              | 20                 |
| Wald $\chi^2$          | 26.20 ***          |

Notes: Dependent variable: lnCO<sub>2</sub> per capita. Standard errors are reported in parentheses. \*\*\*  $p < 0.01$ , \*  $p < 0.10$ .

**Table A6.** Dynamic Common Correlated Effects (DCCE) Robustness Estimates.

| Variables              | DCCE Estimates     |
|------------------------|--------------------|
| L.lnCO <sub>2</sub> pc | 0.492 *** (0.078)  |
| c_lnTA                 | 0.118 * (0.070)    |
| c_lnTY                 | −0.128 * (0.074)   |
| cTA × TD               | 0.565 (2.233)      |
| cTY × TD               | −6.850 *** (2.396) |
| c_IQ                   | 0.045 (0.030)      |
| lnGDPpc                | 0.030 (0.068)      |
| Observations           | 420                |
| Countries              | 20                 |
| CD Statistic           | −0.41              |
| $p$ -value (CD test)   | 0.680              |
| R <sup>2</sup> (MG)    | 0.96               |

Notes: Dependent variable: lnCO<sub>2</sub> per capita. Variables prefixed by c\_ denote mean-centered variables. Standard errors are reported in parentheses. \*\*\*  $p < 0.01$ , \*  $p < 0.10$ .

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