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Tourism, Economic Growth, and Environmental Pollution in APEC Economies, 1995–2020: An Econometric Analysis of the Kuznets Hypothesis

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Abstract: Tourism plays an important role in fostering economic growth within the Asia-Pacific Economic Cooperation (APEC) forum member countries. Nevertheless, the development of this sector has resulted in significant depletion of natural resources and pollution. This research aims to determine the relationship between tourism, economic growth, and environmental pollution in both developing and developed APEC economies from 1995 to 2020. By adopting the Environmental Kuznets Curve (EKC) framework, two dynamic panel data models are estimated employing Dynamic Ordinary Least Squares (DOLS), and causal relationships are established using the Dumitrescu–Hurlin test. The results indicate that tourism and economic growth have had a positive influence on the rise of environmental pollution in both groups of economies during the specified period. This research offers new insights by analyzing twelve developing and nine developed APEC economies over a span of 25 years, estimating two DOLS models, conducting Dumitrescu–Hurlin causality tests, and presenting evidence of EKC for both types of economies. Consequently, the implementation of policies that foster the preservation of natural areas, the utilization of renewable energies, and the promotion of sustainable tourism practices is recommended.

Keywords: tourism; economic growth; environmental pollution; APEC

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1. Introduction

Tourism serves as a generator of economic growth in both developing and developed economies. It produces resources that contribute to economic development through various means such as foreign currency revenues, international investments, tax collection, and job creation (Alam and Paramati 2016). Recognizing this potential, in 1969 the World Bank (WB) took the initiative to promote tourism by providing loans for the preservation of archaeological sites, and the construction of roads, airports, basic infrastructure, and hotels (De Kadt 1991).

These tourism projects proved highly successful, and the countries involved established themselves as international tourist destinations (Mendoza and Hernández 2018). However, multiple studies highlight the negative consequences arising from the inadequate implementation of policies to mitigate the social and environmental impacts on tourist destinations (Álvarez and González 2015; Brenner 1999; Guerrero 2018; Hidalgo 2018; Marín 2012; Márquez and Sánchez 2007; Muñoz et al. 2012; Palafox et al. 2016; Rivas 1998; Solano-Báez et al. 2017; Velázquez-Torres and Castillo 2015).

Recognizing the need for sustainable practices, the World Bank began showing greater interest in a sustainable tourism model in 1990, emphasizing social development, preservation of cultural heritage, and environmental protection. They reemphasized the principles of Agenda 21 (1992), which increased understanding of the environmental crisis and fostered a better interpretation of sustainability. Subsequently, the United Nations World

Tourism Organization (UNWTO) has recommended the adoption of a sustainable tourism approach from an ecological perspective since 2002 (Bertoni 2008).

The Asia-Pacific Economic Cooperation (APEC), established in 1989, comprises 21 economies, including Australia, Brunei, Canada, Chile, China, Hong Kong, Indonesia, Japan, South Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, the Philippines, Russia, Singapore, Taiwan, Thailand, the United States, and Vietnam. APEC recognized the tourism sector as an area of cooperation in the 1994 Bogor Goals Declaration, aiming to achieve sustainable economic growth in APEC economies. During the inaugural APEC Tourism Ministerial Meeting (TMM1) in Seoul, Korea, in July 2000, tourism ministers agreed to enhance efforts to improve the environmental well-being of member economies through tourism. Following the aforementioned efforts, the APEC Tourism Charter was proposed, emphasizing the sustainable management of tourism as a key policy objective (APEC 1994).

Over the period from 1995 to 2020, the tourism sector within APEC experienced significant growth rates across various indicators, including Gross Domestic Product (GDP) (140%), tourist arrivals (136%), tourist expenditure (116%), private investment (220%), and public spending (446%), and this contributed to 9.4% of total employment in the region (WTTC 2023). These statistics indicate the substantial impact of tourism on the economic growth of APEC. Notably, the developing economies within APEC (Brunei, Chile, China, Indonesia, Malaysia, Mexico, Papua New Guinea, Peru, The Philippines, Russia, Thailand, and Vietnam) significantly increased their contribution to the region's tourism GDP during the period from 1995 to 2020, with a growth rate of 401%. This growth was driven by increases in tourist arrivals (145%), tourism exports (140%), private tourism investment (508%), government spending (632%), and the generation of 39.5 million direct jobs annually. Similarly, the developed economies within the region (Australia, Canada, The United States, Hong Kong, Japan, New Zealand, The Republic of Korea or South Korea, Singapore, and Taiwan) observed a 62% increase in tourism GDP during the same period. This growth was a result of increased tourist arrivals (126%), international visitor expenditure (106%), tourism investment (130%), government spending (376%), and the creation of 9 million direct annual jobs. Despite the developed countries' economic dynamism, it is noteworthy that their contribution to the region's tourism output has decreased from 79% to 53% due to the greater tourism activity in the developing economies (WTTC 2023).

The economic growth observed in the region and its economies has been heavily reliant on the consumption of fossil fuels, extensive exploitation of natural resources, and environmental pollution. It is important to highlight that the region is responsible for approximately 60% of global greenhouse gas (GHG) emissions (WB 2023; Martínez et al. 2016). In the case of the developing economies within APEC, CO_2 emissions from energy consumption underwent a significant increase of 138% during the period of 1995–2020. Conversely, the developed economies experienced a slight reduction of 1.3% in their CO_2 emissions from energy consumption during the same period (EIA 2023).

The effects of climate change represent a threat to the tourism sector, especially due to extreme weather events which can increase insurance costs and create security problems, but also due to water scarcity, loss of biodiversity, and degradation of destination tourism assets (UNWTO and ITF 2020). Ongoing environmental degradation due to climate change will impact the tourism sector, diminishing the attractiveness of destinations and reducing economic opportunities for local communities (Koçak et al. 2020).

Grossman and Krueger (1991) analyzed the link between economic growth and pollution, based on Kuznets' (1955) research, which led to the formulation of the Environmental Kuznets Curve (EKC). The EKC hypothesis suggests that as an economy reaches a certain level of economic growth, higher growth can lead to a reduction in environmental pollution (Kaika and Zervas 2013). Various factors contribute to the observed EKC pattern, including income distribution equity, institutional and governance frameworks that enforce environmental regulations, trade openness, structural change, technical progress, energy intensity, and CO_2 emissions (Bouvier 2004; Chontanawat et al. 2008; Dasgupta et al. 2006;

Dinda 2004; Kaika and Zervas 2013; Kearsley and Riddel 2010; Panayotou 2016; Panayotou et al. 2000).

In the framework of the EKC, this research aims to determine the relationship between tourism, economic growth, and environmental pollution in both developing and developed economies within APEC from 1995 to 2020. To achieve this goal, two dynamic panel data models were estimated employing Dynamic Ordinary Least Squares (DOLS), and Dumitrescu–Hurlin causality tests were conducted. The methods employed in this study were selected based on their effectiveness in producing accurate estimators and identifying causality between variables. The DOLS model is specifically chosen for its ability to produce highly efficient and unbiased long-run estimates in small panels (Stock and Watson 1993; Masih and Masih 1996; Kao and Chiang 2000; Pedroni 2001; Dogan et al. 2017; Dogan and Seker 2016; Naradda et al. 2017; Danish et al. 2020). Additionally, the Dumitrescu–Hurlin test is selected for its robustness in conducting causality analysis (Dumitrescu and Hurlin 2012). The first model is integrated by twelve APEC developing economies (Brunei, Chile, China, Indonesia, Malaysia, Mexico, Papua New Guinea, Peru, The Philippines, Russia, Thailand, and Vietnam), and the second by nine developed economies (Australia, Canada, the United States, Hong Kong, Japan, New Zealand, South Korea, Singapore, and Taiwan). In these models, environmental pollution is the dependent variable, while economic growth, tourism activity, fossil energy consumption, and trade openness serve as explanatory variables.

In recent years, the relationship between tourism, growth, and pollution has been the subject of extensive research. This research contributes to the existing literature in several aspects: (a) examining all economies within APEC over a 25-year period and classifying them based on their level of economic development; (b) estimating two DOLS models along with Dumitrescu–Hurlin second-generation causality tests; (c) analyzing energy use and trade openness in addition to the variables of tourism, pollution, and economic growth, which has not been previously done for the APEC region; (d) providing evidence that an economy's economic growth has an impact on the levels of pollution it emits; (e) contributing to the understanding of the negative impacts of environmental pollution on the tourism sector; (f) identifying long-term causalities between tourism and environmental pollution for developing and developed economies by comparing both groups; (g) establishing evidence of the EKC phenomenon for developing and developed APEC economies; and (h) highlighting the need for policies aimed at preserving natural areas, promoting the use of renewable energies, and encouraging sustainable tourism practices, especially in developing economies.

The remaining sections of the paper are structured as follows: Section 2 presents a literature review, followed by a description of the methodology used in Section 3. The analysis and discussion of the results are presented in Section 4, while the conclusions and recommendations are presented in Section 5.

2. Theoretical and Empirical Review of the Literature

Contamination is defined as the addition of an external factor, be it a chemical product, a form of energy, a biological entity, or a pictorial entity, to an environment suitable for man or chosen by man, altering it, and diminishing its qualities (Chávez and Icaza 1992). Carbon dioxide (CO_2) is not commonly considered an atmospheric pollutant since it is a natural part of the air. However, the use of fossil fuels, deforestation, industrial processes, electricity generation, and transportation have led to increased concentrations of CO_2, in addition to other gases, generating a greenhouse effect and a gradual change in the state of the climate that affects the atmospheric composition, better known as climate change (Inche 2004; Puerto and García 1986).

Climate change represents a threat to tourism as it increases weather hazards, water scarcity, loss of biodiversity, and degradation of natural resources, affecting the attractiveness of tourism destinations (Koçak et al. 2020; UNWTO and ITF 2020). The UNWTO (1994, 1995), based on the findings of Mathieson and Wall (1982), defines tourism as the activities carried out by people during their trips and stays in places other than their usual environment for a consecutive period of time of less than one year for leisure, business, and other purposes (Panosso 2007). The concept of sustainable tourism was developed with the purpose of maintaining the viability and quality of natural and cultural resources and achieving a more productive and harmonious relationship between the visitor and the local community, which avoids the undermining of natural and cultural resources (Álvarez and González 2015). Sustainable tourism is defined as tourism that meets the needs of tourists and the host regions while protecting and promoting opportunities for the future (Bertoni 2008; Blancas et al. 2010; Cordero 2006; García and Sotelo 2011; UNWTO 1999).

Beyond its theoretical implications, tourism is an activity that contributes to economic growth through foreign currency revenues that positively impact balances of payments, thereby attracting international investments, increasing tax revenues, and generating jobs (Alam and Paramati 2016; Ren et al. 2019). There are four approaches in the literature to examine the relationship between tourism and economic growth: 1. The tourism-led growth hypothesis, 2. The growth-led tourism hypothesis, 3. The feedback hypothesis, and 4. The neutrality hypothesis (Antonakakis et al. 2016; Balli et al. 2019; Brida et al. 2011, 2016, 2020; Nunkoo et al. 2019). From these, it is established that for tourism to generate the necessary impact, it must fulfill a specific purpose, whether economic, social, or environmental, and there must be an explicit strategy to achieve any development objective. In this sense, the tourism industry must be integrated with the rest of the economy, so that the tourism product is innovative and exclusive to the destination (Boxill 2000; Singh et al. 2010).

The relationship between economic growth and environmental degradation, based on the Environmental Kuznets Curve (EKC) hypothesis of Grossman and Krueger (1991), has laid the groundwork for multiple studies analyzing the sustainability of tourism development worldwide. For Becken and Simmons (2002), tourism imposes pressure on the use of natural resources and contributes to climate change. Some of the authors who identified the effect of tourism on the increase in CO_2 emissions are Balli et al. (2019); Ben Jebli and Hadhri (2018); Gövdeli (2019); Shi et al. (2019); Zhang and Zhang (2020). Whereas for Huiyue and Meng (2019) and Ren et al. (2019), tourism activity presents a negative correlation with CO_2 in certain cases, research works such as those of Ben Jebli et al. (2019) and Lu et al. (2019), by incorporating variables such as renewable energies, established that tourism has a significant impact on environmental pollution.

Reviewing the relationships between tourism, growth, and environmental degradation in the EKC framework allows us to determine whether environmental conservation policies are well balanced with the macroeconomic objectives of the economies analyzed (Katircioğlu 2014). Some of the studies that support the EKC hypothesis are those conducted by Fethi and Senyucel (2021), and Sghaier et al. (2019). Other studies that contain evidence of the existing EKC pattern induced by tourism are those of Tabash et al. (2023), Martial et al. (2023), Kongbuamai et al. (2023), Alam and Paramati (2016), De Vita and Kyaw (2016), Dinda (2004), Fethi and Senyucel (2021), Katircioğlu (2014), Ozturk et al. (2016), Paramati et al. (2017), Shakouri et al. (2017), Stern (2004), and Zaman et al. (2016) (Table 1).

Table 1. Studies on the tourism–growth–pollution relationship within the framework of the EKC.

Authors	Variables	Methodology	Destination and Time	EKC	Results
Tabash et al. (2023)	GDP per capita, international tourism, foreign direct investment, personal remittances, exported goods, and labor force.	Fixed Effect Model (FE), and Fully Modified Least Squares (FMOLS)	Bangladesh, China, India, Pakistan, and Sri Lanka (2001–2019)	N.A.	International tourism activities have a positive and significant effect on the GDP growth. GDP per capita has been positively and significantly influenced by international tourism activities.
Martial et al. (2023)	CO_2 emission, population, international tourism arrivals, GDP per capita, GDP per capita squared, renewable energy, and access to electricity (% of the population).	Fixed Effects (FE), Random Effects (RE), Differenced Generalized Method of Moments (D-GMM), and System Generalized Method of Moments (S-GMM)	26 low-income countries: Afghanistan, Mozambique, Chad, Guinea-Bissau, Ethiopia, Malawi, Burundi, Burkina Faso, Sierra Leone, Congo, Central African Republic, Somalia, Eritrea, Guinea, Gambia, Liberia, Madagascar, Mali, Niger, Rwanda, and The Central African Republic (2001 to 2020)	∩	CO_2 emissions are rising because per capita income, electricity consumption, and population are growing. CO_2 emissions can be lowered by using more renewable energy and growing the economy faster. EKC is valid in low-income countries. Increasing tourism, renewable energy, and rising GDP per capita benefit low-income countries.
Kongbuamai et al. (2023)	GDP, GDP^2, energy consumption, ENU, air transportation, and globalization.	FMOLS, Dynamic Ordinary Least Squares (DOLS), and Feasible Generalized Least Squares (FGLS)	17 APEC countries: Australia, Canada, Chile, China, Indonesia, Japan, Korea Rep., Malaysia, Mexico, New Zealand, Peru, Philippines, Russia, Singapore, Thailand, The United States, and Vietnam (1992–2015)	∩	Air transportation increases CO_2 emissions. There is a unidirectional causality between air transportation and CO_2 emissions. There is a one-way causality relationship running from globalization to CO_2.
Ravinthirakumaran and Ravinthirakumaran (2022)	Tourism, energy consumption, trade openness, GDP per capita, GDP per capita squared, and CO_2 emissions	FMOLS/Dumitrescu and Hurlin non-causality test	20 economies of the APEC region (1995–2017)	N.A.	Tourism and trade openness have positive effects on CO_2 emissions, while economic growth and energy consumption adversely affect CO_2 emissions in the long run. There is a one-way causality running from tourism to CO_2 emissions and economic growth to CO_2 emissions.

Table 1. *Cont.*

Authors	Variables	Methodology	Destination and Time	EKC	Results
Fethi and Senyucel (2021)	CO_2 emissions, GDP per capita, GDP per capita squared, international tourists, and energy use.	Dynamic Seemingly Unrelated Regression (DSUR)/Dumitrescu and Hurlin causality test	Top 50 tourist countries (1996–2016)	∩	Tourism positively impacts CO_2 emissions over time. Increasing the level of tourism development can reduce the level of CO_2 and the level of energy consumption by the exponential level of income growth.
Sghaier et al. (2019)	CO_2 emissions, GDP per capita, GDP per capita squared, energy consumption per capita, and international tourists.	ARDL Model	Tunisia, Egypt, and, Morocco (1980–2014)	∩ U	Tourism has a negative effect on environmental quality in Egypt, a positive effect in Tunisia, and a neutral effect in Morocco. The EKC is confirmed for Morocco and Egypt, but not for Tunisia.
Mikayilov et al. (2019)	Ecological footprint, international tourism revenues, trade openness, energy consumption, urban population, government effectiveness, urbanization, institutional quality, and regulatory quality.	FMOLS	Azerbaijan (1996–2014)	U	Tourism and energy consumption have a statistically significant and positive impact on the ecological footprint.
Işik et al. (2017)	GDP, energy consumption, tourist arrivals, and tourism receipts.	Emirmahmutoglu–Kose Bootstrap Granger non-causality test	10 most visited countries (1995–2013)	N.A.	Using the data for tourist arrivals, a tourism-led growth hypothesis is present in China and Turkey; a growth-led tourism hypothesis is found in Russia and Spain; bidirectional causality exists between growth and tourism in Germany; and no causality occurs between the variables in France, Italy, Mexico, the UK, and the USA.

Table 1. *Cont.*

Authors	Variables	Methodology	Destination and Time	EKC	Results
Naradda et al. (2017)	CO_2 emissions, GDP per capita, GDP per capita squared, energy consumption per capita, and tourism income per capita.	Vector error correction model (VECM) and DOLS	Sri Lanka (1974–2013)	U	There is unidirectional causality from economic growth, energy consumption, and environmental degradation to tourism development. The hypothesis of tourism-driven economic growth (HTICE) is supported.
Shakouri et al. (2017)	CO_2 emissions, GDP is real income, GDP^2 is the square of real income, energy consumption, and international tourism arrivals.	Generalized Method of Moments (GMM)/Bootstrap Panel Granger causality test	12 Asia-Pacific countries (1995–2013)	∩	Tourist arrivals have positive effects on CO_2 levels in the long run. Unidirectional causality from energy consumption to tourism arrivals, and unidirectional causality from CO_2 emissions to tourism arrivals. The results confirm the validity of the tourism-induced EKC hypothesis.
Paramati et al. (2017)	GDP per capita, GDP per capita squared, GFCF per capita, number of tourism jobs, energy efficiency, and international tourism income.	FMOLS/Dumitrescu and Hurlin non-causality test	26 developed and 18 developing economies (1995–2012)	∩	Inbound tourism has positive effects on the economies of both developed and developing countries. Tourism increases CO_2 emissions in both developed and developing countries until a threshold is reached at which CO_2 emissions will be significantly reduced, especially in developed economies.
Dogan and Seker (2016)	CO_2 emissions, GDP, energy consumption, international tourists, and the ratio of merchandise trade to GDP.	DOLS/Dumitrescu–Hurlin causality tests	OECD countries (1995–2010)	U	Tourism and energy consumption have a statistically significant and positive impact on CO_2 emissions.

Table 1. *Cont.*

Authors	Variables	Methodology	Destination and Time	EKC	Results
Zhang and Gao (2016)	Tourist arrivals, energy consumed per tourist, CO_2 emissions, climate change index (IPCC)	FMOLS/Granger causality tests	Chinese regions (1995–2011)	U	Tourism has a negative impact on CO_2 emissions in the eastern region. Tourism increases economic growth and CO_2 emissions in the long term. The tourism-led growth hypothesis is accepted.
Alam and Paramati (2016)	Income inequality (Gini coefficient), gross domestic product per capita, foreign direct investment as a percentage of GDP, trade openness, and tourism revenue.	FMOLS	49 developing economies (1991–2012)	∩	Results from long-run elasticities indicate that tourism increases income inequality significantly. The long-run elasticities on squared tourism revenue confirm the existence of the Kuznets curve hypothesis between tourism revenue and income inequalities.
Ozturk et al. (2016)	Ecological footprint, tourism GDP, urban population, fossil energy consumption, and trade openness (exports + imports of goods and services).	GMM	144 countries (1988–2008)	∩	There is a negative relationship between the ecological footprint and its determinants: GDP growth from tourism, energy consumption, trade openness, and urbanization. EKC is present in middle- and high-income countries.
Zaman et al. (2016)	Tourism development index, CO_2 emissions, GDP per capita, tourism expenditures, FBKF, health expenditures, energy use.	Two-stage Least Square Regression	East Asia and Pacific regions, the European Union, and high-income OECD and non-OECD countries (2005–2013).	∩	Causal relationships: (i) tourism-induced carbon emissions; (ii) energy-induced emissions; (iii) investment-induced emissions; (iv) growth-driven tourism; (v) investment-driven tourism; and (vi) health-driven tourism development.

Table 1. *Cont.*

Authors	Variables	Methodology	Destination and Time	EKC	Results
De Vita et al. (2015)	GDP, energy consumption, tourist arrivals, and CO_2 emissions	DOLS	Turkey (1970–2014)	∩	The development of tourism leads to an increase in CO_2 emissions.
Katircioğlu (2014)	CO_2 emissions, energy consumption, GDP, and the total number of international tourists	DOLS	Singapore (1971–2010)	∩	There is a unidirectional causality running from tourism development to economic growth and long-term carbon emissions' growth. Tourism development and GDP^2 would lead to a decrease in CO_2 emissions in the long term. Short-term causality extends from tourism development to energy consumption.

Note: ∩ implies the existence of the functional form of the Environmental Kuznets Curve (EKC), U indicates the presence of the inverted functional form of the EKC, and N.A. represents a lack of evidence of EKC. Source: Authors' design.

As shown in Table 1, the most commonly used pollution indicators to measure the sustainability of the tourism sector in the framework of the EKC are CO_2 emissions and the ecological footprint. Likewise, tourism development is mainly represented by three indicators: international tourist arrivals, tourism revenues, and international tourist expenditures. Economic growth, in turn, is indicated by GDP and GDP per capita. On the other hand, the most commonly applied methodologies in these kinds of studies are: FMOLS, panel data-ARDL, time series-TVC, panel GMM, GMM time series, and two-stage OLS. However, the results are subject to the indicator representing environmental deterioration, the period considered, the type of observation (cross-section or panel), the estimation technique, and the level of income considered.

3. Methodology

3.1. Methodological Description of the DOLS Models

In economic analysis, panel data are a valuable tool for studying the dynamics of change in the dependent variable (Baltagi 2011, 2021; Novales 1993; Stock and Watson 2012). The estimation techniques used in panel data consider the heterogeneity of the units, which reduces collinearity between variables and increases the efficiency of the estimators. In addition, they allow the modeling of more complex and sophisticated behaviors with less restrictive assumptions (Stock and Watson 2012). It is important to keep in mind that the relative size of the cross-sectional and longitudinal dimensions of the panel data influences how they will be treated (Novales 1993). Thus, panel data enrich the empirical analysis and are essential for the estimation of econometric models with time samples from similar units of analysis (Gujarati and Porter 2010).

Linear dynamic panel data models are a useful tool for analyzing the relationship between dependent variables and exogenous regressors. These models include lagged dependent variables as covariates, which allows modeling of a partial adjustment mechanism. In general, these models are a valuable tool for analyzing both the long-run equilibrium relationship and the short-run dynamics between dependent variables and exogenous regressors in a panel context (Das 2019; Stock and Watson 2012; Wang and Wang 2020; Andrews and Monahan 1992)

Dynamic Ordinary Least Squares (DOLS) is a long-run estimation method developed by Stock and Watson (1993) which consists of regressing the dependent variable on the independent variables using lags and leads of the differentiated independent variables. By means of DOLS, it is possible to perform fully efficient estimations, thus eliminating the bias by adding a set of lags with the purpose of correcting the problems derived from the cross-correlation between the error term of the cointegration equation and the innovations of the stochastic estimators, whereas with Ordinary Least Squares, (OLS) asymptotically biased and asymmetrically non-scalar parameters would be obtained (Wang and Wang 2020). In this way, DOLS eliminates the second order problem that could arise due to the long-run correlation through the error and the first difference of the regressors. This semi-parametric correction to the OLS estimator eliminates the second order bias induced by the endogeneity of the regressors (Saikkonen 1992; Stock and Watson 1993).

Through the parametric approach, DOLS methods allow estimating and testing hypotheses for cointegrating vectors in dynamic panels in a way that is consistent with the degree of cross-sectional heterogeneity. Therefore, they are highly efficient in dealing with the issue of endogeneity between regressors and serial correlations in the error terms (Kao and Chiang 2000; Pedroni 1999).

The DOLS regression model is represented by the following equation:

$$Y_{it} = a_{it} + \beta_i X_{it} + \sum_{i=-p_i}^{p_i} c_{ip} \Delta X_{it-p} + \mu_{it} \quad (1)$$

where Y_{it} and X_{it} are I(1) processes (i.e., of order of integration in first differences) of dimension m-th dimension, a_{it} is the constant of the equation; β_i is the vector of parameters to be estimated; $\sum_{i=-p_i}^{p_i} c_{ip}$ represents the operator of advances and lags of the variable

ΔX_{it} through which the possibility of bias due to endogeneity or serial correlation is asymptotically eliminated; and, μ_{it} is the error term with the appropriate properties.

In the case of small samples, like in this research, the DOLS method produces efficient and unbiased long-run estimates (Dogan and Seker 2016; Dogan et al. 2017; Kao and Chiang 2000; Pedroni 2001; Danish et al. 2020). In particular, the DOLS technique enables the correction of autocorrelation, endogeneity, simultaneity bias, and serial correlation in small samples (Masih and Masih 1996; Pedroni 2001; Naradda et al. 2017).

Statistical Tests

(a) Cross-section dependence test and homogeneity test.

Panel data models may exhibit cross-sectional dependence in idiosyncratic errors, which may arise due to the presence of common shocks and unobserved components, which eventually become part of the error term (Baltagi 2021; Pesaran 2004, 2021). The cross-sectional independence test has as its null hypothesis that u_{it} is independent and identically distributed across periods and cross-sectional units. Under the alternative hypothesis, u_{it} may be correlated across cross-sections, but the assumption of no serial correlation is maintained.

Pesaran (2004) proposed the following cross-section dependence test:

$$CD = \sqrt{\frac{2t}{N\ (N-1)} \left(\sum_{i=j}^{N-1} \sum_{j=i+1}^{N} \hat{p}_{ij} \right)} \tag{2}$$

where N is equal to the number of cross-sectional units of the panel, and $\hat{p}_{ij}$ is the product-moment correlation coefficient of the disturbances, establishing that under the null hypothesis of no cross-sectional dependence $CD \rightarrow N\ (0,\ 1)$ for $N \rightarrow \infty$ and T sufficiently large.

(b) Homogeneity test of the slope coefficients.

Pesaran and Yamagata (2008) proposed a standardized version of the slope homogeneity test of Swamy (1970). The proposal takes up the cross-sectional dispersion of individual weighted slopes for its relative accuracy. The statistical test is given by:

$$\overset{\sim}{\Delta} = \frac{1}{\sqrt{N}} \left(\frac{\sum_{i=1}^{N} \tilde{d}_i - k_2}{\sqrt{2k_2}} \right) \tag{3}$$

where N is equal to the number of cross-sectional units in the panel, k represents the independent variables, the $\tilde{d}_i$ is defined as the weighted difference between the cross-sectional unit specific estimate and the pooled estimate, and the $\overset{\sim}{\Delta}$, under the null hypothesis of homogeneity of the coefficients, is asymptotically like N (0,1) (Bersvendsen and Ditzen 2020).

(c) Unit root test

Pesaran (2007) proposed the CIPS unit root test, which considers the lack of independence of the units and the presence of unobservable common factors (Breitung and Pesaran 2008). Pesaran (2007) assumes that both individual specific regressors and common unobservable factors are stationary and exogenous. If the unobservable factor exhibits (I(1)) behavior (i.e., reveals a unit root), then the possibility that this factor may cointegrate within each unit and also between units must be considered.

(d) Westerlund cointegration test.

Westerlund (2007) developed four new panel cointegration tests that rely on structural dynamics instead of residuals. The idea is to test the null hypothesis of no cointegration by inferring whether the error correction term in a conditional panel error correction model is equal to zero. The new tests have a normal distribution and are general enough to accommodate unit specific short-run dynamics, unit specific trend and slope parameters, and cross-sectional dependence. Two tests are designed to test the alternative hypothesis that the panel is cointegrated as a whole, while the other two test the alternative that at least one unit is cointegrated.

The long-run equilibrium relationship between the variables is examined using the panel error correction cointegration test of Westerlund (2007) which assumes cross-sectional dependence. This panel error correction cointegration methodology is based on four statistics. Two of them, $G\vartheta$ and $G\Psi$, are group statistics that do not exploit information from the error correlation mechanism. Alternatively, the other two $P\vartheta$ and $P\Psi$ are panel statistics based on the combination of error correction information along the cross-sectional units. For the group mean statistics, the null hypothesis is that there is no cointegrating relationship for at least one of the cross-sectional units. The alternative hypothesis is that a cointegrating relationship exists for one or more cross-sectional units. In contrast, for panel statistics, the null hypothesis postulates the absence of a cointegrating relationship for the panel as a whole. The alternative hypothesis states that a cointegrating relationship exists for all cross-sectional units (Westerlund 2007).

(e) Causality test.

The dynamic causal relationship between the variables is explored using the heterogeneous panel non-causality test developed by Dumitrescu and Hurlin (2012). This approach is significantly different from conventional causality tests, as it allows all coefficients to be different across cross-sections. Therefore, the findings from this model will be more robust and reliable. The implication of this approach is that it takes a different logarithmic structure and equally heterogeneous measurements along the cross-section under both assumptions. First, the null hypothesis that there is no causal relationship is tested, and then the alternative hypothesis is tested to prove the causal relationship, at least for some cross-sections. Finally, the Wald test is calculated for each of the cross-sections individually to check for non-causality (Dumitrescu and Hurlin 2012).

3.2. Model Specification

To determine the relationship between tourism, economic growth, and environmental pollution in developing and developed APEC economies during the period 1995–2020, two DOLS models were estimated using the following equation:

$$\begin{aligned} \mathrm{lnCO}_{2\mathrm{it}} = \alpha_{\mathrm{it}} + \beta_1 \mathrm{lnGDPp}_{\mathrm{it}} + \beta_2 \mathrm{lnGDPp}^2_{\mathrm{it}} + \beta_3 \ln \mathrm{EC}_{\mathrm{it}} + \\ \beta_4 \ln \mathrm{ITA}_{\mathrm{it}} + \beta_5 \ln \mathrm{TO}_{\mathrm{it}} + \mathrm{u}_{\mathrm{it}} \end{aligned} \quad (4)$$

where CO_2 represents environmental pollution, GDPp represents economic growth, $GDPp^2$ represents an increase in the economic growth, EC represents energy intensity, ITA represents tourism performance, and TO represents trade openness. Thus, equation 4 estimates the effect of the explanatory variables on the volume of CO_2 emissions. The symbol ln indicates natural logarithm, i is the cross-section identifier, and t is the identifier of the time section from 1995 to 2020. Finally, u_{it} represents the stochastic error term of the equation.

The data for the calculation of the models were obtained from the statistical databases of the WB (2023), the APEC (2023a, 2023b), the World Travel and Tourism Council (WTTC 2023), and the U.S. Energy Information Administration Agency (EIA 2023) (Table 2). According to the classification of the International Monetary Fund (IMF 2019, p. 413), the group of developing economies consists of Brunei, Chile, China, Indonesia, Malaysia, Mexico, Papua New Guinea, Peru, The Philippines, Russia, Thailand, and Vietnam, and the developed economies consist of Australia, Canada, The United States, Hong Kong, Japan, New Zealand, South Korea, Singapore, and Taiwan. The study period covers the years 1995 to 2020, because the databases that record tourism activity start their time series from 1995 and the databases on CO_2 emissions are updated up to 2020.

Table 2. Variables Description.

Variable	Indicator	Description	Source
Environmental pollution	CO_2	CO_2 emissions in million metric tons	WB/APEC
Economic growth	GDPp	GDP per capita (US dollars, PPP) in constant 2015 prices	WB/APEC
An increase in the economic growth	$GDPp^2$	Squared GDP per capita (US dollars, PPP) in constant 2015 prices	WB/APEC
Energy intensity	EC	Fossil energy consumption in kilograms of equivalent petroleum	EIA
Tourism performance	ITA	International tourist arrivals	WTTC
Trade openness	TO	Trade openness, ratio of merchandise trade to GDP for each economy	APEC

Source: Authors' design based on WB (2023), APEC (2023a), WTTC (2023), and EIA (2023).

Empirical Framework

The method followed in this research consists of six stages. The first stage involved conducting a cross-sectional dependence test to determine the independence of the transversal units of the panel (Baltagi 2021; Pesaran 2004, 2021). The second stage applied the homogeneity test of the slope coefficients to identify the presence of homogeneity in the slope of the coefficients of the panel data (Pesaran and Yamagata 2008). In the third stage, the unit root test was performed on the variables to determine their level of integration (Pesaran 2007). The fourth stage implemented the Westerlund cointegration test to establish the cointegration relationship between the variables (Westerlund 2007). The fifth stage estimated the DOLS models to identify the relationship between the independent and dependent variables (Stock and Watson 1993). Finally, in the sixth stage, the causality analysis between the variables was carried out using the Dumitrescu–Hurlin test (Dumitrescu and Hurlin 2012).

4. Analysis and Discussion of the Results

4.1. Descriptive Analysis of the Data

The descriptive statistics of the variables used in the research are presented in Table 3, in which the mean of the dependent variable CO_2 is 885.041 million metric tons, and the standard deviation is 1860.125. The means of the independent variables GDPp, EC, ITA, and TO were 20,177; 5; 24,498; and 85, respectively, and the standard deviations were 17,703; 8; 38,901; and 76, respectively. Likewise, the variables CO_2, GDPp, EC, ITA, and TO show asymmetric behavior or positive skewness and excessive kurtosis, indicating that the variables do not have a normal distribution.

Table 3. Descriptive statistics of the variables.

Stats	CO_2	GDPp	EC	ITA	TO
Mean	885,041	20,177	5	24,498	85
Median	258,337	11,174	2	7268	57
Max	10,700,000	61,374	41	183,178	420
Min	2130	892	0	34	14
SD	1,860,125	17,703	8	38,901	76
Skewness	3	1	3	2	2
Kurtosis	14	2	12	8	7
Sum	483,000,000	11,000,000	2561	13,400,000	46,456

Source: Authors' design based on WB (2023), APEC (2023a), WTTC (2023), and EIA (2023).

4.2. Data Correlation Coefficient

The results in Table 4 show a strong correlation between CO_2 emissions and EC (0.85), and ITA (0.77). There is also a significant correlation between EC and ITA (0.75). The correlation between CO_2 emissions and GDPp was 0.11, while it was −0.25 with TO. This behavior, generalized for the 21 APEC economies, has as a background the heterogeneity of the members of the Forum and the behavior of their macroeconomic variables.

Table 4. Correlation matrix of the variables.

	CO_2	GDPp	EC	ITA	TO
CO_2	1	0.1114	0.8467	0.766	−0.25
GDPp	0.1114	1	0.3444	0.1657	0.1525
EC	0.8467	0.3444	1	0.7557	−0.2924
ITA	0.766	0.1657	0.7557	1	−0.1186
TO	−0.25	0.1525	−0.2924	−0.1186	1

Source: Authors' design based on WB (2023), APEC (2023a), WTTC (2023), and EIA (2023).

4.3. Statistical Tests

4.3.1. Cross-Sectional Dependence Test

To identify the cross-sectional dependence of the panel, the CD cross-sectional dependence test of Pesaran (2004, 2021) is applied. The hypotheses of the test are: Ho: Cross-sectional independence, and Hi: Cross-sectional dependence.

P-values close to zero indicate that there is cross-correlation between the panel groups. In accordance with Table 5, the alternative hypothesis of the existence of cross-section dependence in the panel of developing and developed economies is accepted. Therefore, the existence of cross-section dependence is approved for the variables $lnCO_2$, lnGDPp, $lnGDPp^2$, lnEC, lnITA, and lnTO, of the panel of developing and developed economies.

Table 5. Cross-sectional dependence test.

	Developing Economies		Developed Economies	
Variable	**CD-Test**	***p*-Value**	**CD-Test**	***p*-Value**
$lnCO_2$	33.77 *	0.000	13.88 *	0.000
lnGDPp	25.89 *	0.000	29.38 *	0.000
$lnGDPp^2$	25.90 *	0.000	29.36 *	0.000
lnEC	26.45 *	0.000	15.09 *	0.000
lnITA	29.88 *	0.000	21.21 *	0.000
lnTO	5.46 *	0.000	6.71 *	0.000

Note: Confidence levels of * 99%. Source: Authors' design based on estimates made in STATA 17.

4.3.2. Homogeneity Test of the Slope Coefficients

The homogeneity test of Pesaran and Yamagata (2008) is used to evaluate the homogeneity of slope coefficients with the following hypotheses: Ho: homogeneity in slope coefficients, and Hi: heterogeneity in slope coefficients.

The test reveals the existence of heterogeneity of the slopes of developing and developed APEC economies (Table 6), so the null hypothesis is rejected.

Table 6. Test for homogeneity of slope coefficients.

Developing Economies		Developed Economies	
Δ	***p*-Value**	**Δ**	***p*-Value**
15.07 *	0.000	8.876 *	0.000
17.62 *	0.000	10.38 *	0.000

Note: Confidence levels of * 99%. Source: Authors' design based on estimates made in STATA 17.

4.3.3. Unit Root Tests

When the series presents cross-sectional dependence, the first generation unit root tests are not reliable. Therefore, the CADF and CIPS techniques (second generation unit root tests) were used, developed by Breitung and Pesaran (2008) and Pesaran (2007), to determine the order of integration of the variables. The hypotheses tested are: Ho: The series are non-stationary, and Hi: The series are stationary.

According to the results in Table 7, all variables have an order of integration of 1, which means that their variance, covariance, and the mean of the series are constant over time for developing and developed economies. Since all the variables have the same order of integration, we proceed to investigate the long-run relationship using the panel cointegration test proposed by Westerlund (2007).

Table 7. Unit root tests.

	Developing Economies		Developed Economies	
Variables	**CADF**	**CIPS**	**CADF**	**CIPS**
$lnCO_2$	−1.783	−1.812	−1.795	−2.069
lnGDPp	−1.468	−1.386	−2.139	−3.383
$lnGDPp^2$	−1.472	−1.383	−2.103	−1.667
lnEC	−2.078	−2.194	−1.768	−1.934
lnITA	−1.718	−1.515	−1.394	−1.409
lnTO	−1.095	−1.110	−1.810	−1.562
		First differences		
$\Delta lnCO_2$	−3.111 *	−4.350 *	−3.098 *	−4.432 *
ΔlnGDPp	−2.453 *	−2.752 *	−2.360 *	−3.383 *
$\Delta lnGDPp^2$	−2.432 *	−2.770 *	−2.766 *	−3.050 *
ΔlnEC	−3.407 *	−4.152 *	−3.052 *	−4.814 *
ΔlnITA	−2.666 *	−3.695 *	−2.681 *	−3.733 *
ΔlnTO	−3.259 *	−3.703 *	−2.798 *	−3.548 *

Note: Confidence levels of * 99%. Source: Authors' design based on estimates made in STATA 17.

4.3.4. Westerlund Test

The cointegration test of Westerlund (2007) generates four statistical tests (Ga, Gt, Pa, and Pt) to assess the long-run association between variables as a function of the estimates of αi. These statistics are produced using the least squares estimator. Ga and Gt examine the group cointegration relationship, where the null hypothesis is assumed to be no cointegration and the alternative hypothesis is that at least one of the individual panel members is cointegrated. Pa and Pt analyze the cointegration relationship for the whole panel, where the null hypothesis of no cointegration is assumed against the alternative hypothesis that there is a cointegration process for all *i*.

The value of the Bartlett kernel window was obtained by taking as a basis the formula $4(T/100)^{2/9}$. It is substituted according to the number of cross-sections, and we have

$4(25/100)^{2/9} = 2.25 \approx 3$. Therefore, the Kernel window to be handled is approximately 3 (Westerlund 2007).

The estimation results in Table 8 indicate at a 99% confidence level that there is a cointegrating relationship for the panel as a whole in the developing and developed economy panels.

Table 8. Westerlund cointegration test.

Developing Economies			
Statistic	**Value**	***p*-Value**	**Robust *p*-Value**
Gt	−4.13 *	0.000	0.000
Ga	0.22 *	0.586	0.000
Pt	−3.76 *	0.000	0.000
Pa	0.24 *	0.595	0.000
Developed economies			
Gt	−3.32 *	0.000	0.000
Ga	−9.99 *	0.783	0.000
Pt	−11.29 *	0.000	0.000
Pa	−6.8 **	0.695	0.025

Note: Confidence levels of * 99%, and ** 95%. Source: Authors' design based on estimates made in STATA 17.

4.4. Estimation of DOLS Models

The relationship between CO_2 emissions, GDPp, $GDPp^2$, EC, ITA, and TO was estimated for twelve developing economies and nine developed economies in APEC from 1995 to 2020 employing two DOLS models, one for each type of economy. After conducting the cross-section dependence test, homogeneity test of the slope coefficients, unit root test, and cointegration test, based on Stock and Watson (1993), the regression was performed with DOLS to obtain long-run estimates. These models enable the correction of autocorrelation, endogeneity, simultaneity bias, and serial correlation in small samples (Naradda et al. 2017; Pedroni 2001; Masih and Masih 1996). They are commonly used in recent research based on small panels because they provide efficient and unbiased long-run estimates (Dogan and Seker 2016; Dogan et al. 2017; Pedroni 2001; Kao and Chiang 2000; Danish et al. 2020).

Table 9 shows the results of the DOLS models for developing and developed economies. In the case of developing economies, it stands out that GDPp and EC are the main drivers of the increase in CO_2 emissions, followed by ITA. Similarly, $GDPp^2$ would be an important factor in reducing emissions, as well as TO, but to a lesser extent. Regarding developed economies, DOLS estimates show that GDPp is the main factor by which CO_2 emissions increase, followed by EC, ITA, and TO. As well as that, $GDPp^2$ has a negative relationship with emissions.

Table 9. DOLS model estimates.

$\ln CO_2$ = f (lnGDPp, $\ln GDPp^2$, lnEC, lnITA, lnTO)						
	Developing Economies			**Developed Economies**		
Variables	**Coef.**	**z-Statistic**	**P > [z]**	**Coef.**	**z-Statistic**	**P > [z]**
lnGDPp	4.291 **	2.03	0.043	5.472 *	2.92	0.004
$\ln GDPp^2$	−0.412 *	−3.41	0.001	−2.548 *	−4.08	0.000
lnEC	1.690 *	8.98	0.000	0.829 *	8.53	0.000
lnITA	0.672 *	13.99	0.000	0.464 *	4.65	0.000
lnTO	−0.857 *	−5.91	0.000	0.275 **	2.05	0.040

Note: Confidence levels of * 99%, and ** 95%. Source: Authors' design based on estimates made in STATA 17.

Contrasting the per variable results of both models, it can be seen that a 1% increase in GDPp would represent a 4.3% increase in CO_2 emissions for developing economies, while for developed economies the increase is 5.5% of their emissions level. Likewise, a one-percentage-point increase in GDPp^2 would decrease emissions in developing economies by 0.41%, while the decrease would be 2.5% for developed economies. With regard to the EC, the 1% increase would in turn lead to a 1.7% and 0.82% increase in CO_2 emission levels for developing and developed economies, respectively. As far as tourism is concerned, for each percentage unit increase in the ITA, environmental pollution will also increase by 0.67% in developing economies and 0.46% in developed economies. Similarly, a one-point-percentage increase in TO would decrease emissions by 0.86% in developing economies and would result in a 0.27% increase in CO_2 emissions in developed economies.

In relation to Kuznets' hypothesis, evidence of the functional form of the EKC is found in both developing and developed economies. Such a pattern is indicated in the results of the DOLS models by the positive sign of the economic growth variable coefficient (GDPp) and the negative sign of the increase in the economic growth variable coefficient (GDPp^2).

4.5. Heterogeneous Panel Causality Test

Due to the heterogeneity of the coefficients in the cross-sections, the long-run dynamic causality analysis was determined using the panel non-causality test of Dumitrescu and Hurlin (2012), whose test requires all variables to be stationary in first differences, (I(1)).

The test indicates that, for developing economies, the causal relationship between CO_2 emissions and GDPp is bidirectional. This means that economic growth provides crucial insights that aid in forecasting emissions, and vice versa, CO_2 emissions also offer valuable information to predict economic growth. The same is true for the CO_2 and EC connection. Regarding the causal CO_2 –tourism association, there is a unidirectional relationship that goes from ITA to CO_2 emissions. Regarding the link between CO_2 and TO, there is a causal connection from trade openness to emissions (Table 10).

Table 10. Heterogeneous panel causality testing.

	Developing Economies		Developed Economies	
Null Hypothesis	**Z-Bar**	***Prob.***	**Z-Bar**	***Prob.***
CO_2 does not homogeneously cause GDPp	4.44 *	0.000	1.31	0.188
GDPp does not homogeneously cause CO_2	5.03 *	0.000	3.14 *	0.002
CO_2 does not homogeneously cause EC	5.83 *	0.004	−0.083	0.934
EC does not homogeneously cause CO_2	2.86 *	0.000	2.36 **	0.018
CO_2 does not homogeneously cause ITA	2.47	0.748	1.75	0.280
ITA does not homogeneously cause CO_2	6.11 *	0.000	1.13	0.258
CO_2 does not homogeneously cause TO	2.24	0.316	2.97 *	0.003
TO does not homogeneously cause CO_2	5.52 *	0.000	1.97 **	0.049

Note: Confidence levels of * 99%, and ** 95%. Source: Authors' design based on estimates made in STATA 17.

In the analysis of developed economies, it is found that the emissions' causal relationship with economic growth is unidirectional, i.e., it goes from GDPp to CO_2. This implies that economic growth provides important information that helps to better predict the behavior of emissions; however, emissions have no predictive power over economic growth. The same is true for the CO_2 and EC bond. As for the causal link between CO_2 and tourism, there is a neutral relationship, so neither variable can explain the other. Regarding the CO_2–TO association, there is a bidirectional causality relationship, so trade openness contains important information that helps predict the behavior of emissions, while emissions also have significant data to predict the performance of TO (Table 10).

4.6. Discussion of the Results

The results of this research are close to those of Martial et al. (2023); Alam and Paramati (2016); Kongbuamai et al. (2023); Ravinthirakumaran and Ravinthirakumaran (2022); and Zaman et al. (2016), who establish that countries' economic growth has an impact on the increase in CO_2 emissions. They also agree with those of Martial et al. (2023); Alam and Paramati (2016); De Vita and Kyaw (2016); Katircioğlu (2014); Kongbuamai et al. (2023); Ozturk et al. (2016); and Zaman et al. (2016) by arguing that economic growth will lead to a decrease in environmental pollution. The findings that suggest that an increase in fossil energy consumption is positively correlated with higher CO_2 emissions, aligning with the results reported by Ravinthirakumaran and Ravinthirakumaran (2022) and Zaman et al. (2016). Regarding the fact that tourist activity increases environmental pollution, it is similar to what was stated by Martial et al. (2023); Dogan and Seker (2016); Gövdeli (2019); Kongbuamai et al. (2023); Tabash et al. (2023); and Zaman et al. (2016). Similarly, the results of this paper align with the conclusions drawn by Dogan and Seker (2016) and Ravinthirakumaran and Ravinthirakumaran (2022), which suggest that trade openness has a positive impact on CO_2, while Kongbuamai et al. (2023) gives evidence that TO has a negative impact on CO_2.

The research results from the implementation of DOLS models and causality tests show the existence of a functional form of the EKC for both developing and developed economies in APEC during the period 1995–2020. This is consistent with the work of Martial et al. (2023); Kongbuamai et al. (2023); Alam and Paramati (2016); Fethi and Senyucel (2021); Katircioğlu (2014); Ozturk et al. (2016); Paramati et al. (2017); Shakouri et al. (2017); and Zaman et al. (2016).

5. Conclusions

This research studied the relationship between tourism, economic growth, and environmental pollution in the twelve APEC developing economies (Brunei, Chile, China, Indonesia, Malaysia, Mexico, Papua New Guinea, Peru, The Philippines, Russia, Thailand, and Vietnam) and the nine developed economies (Australia, Canada, the United States, Hong Kong, Japan, New Zealand, South Korea, Singapore, and Taiwan), during the period 1995–2020. The statistical tests confirmed cross-sectional dependence in the data panels and a stable long-term relationship between the variables in each model. Consequently, two DOLS models were estimated, and causal relationships were established employing the Dumitrescu–Hurlin test using CO_2 as the dependent variable and GDPp, $GDPp^2$, CE, ITA, and TO as independent variables. These methods were selected for their effectiveness in producing accurate estimators with small sample sizes.

The results of the research confirm a stable long-term relationship between environmental pollution, economic growth, fossil energy consumption, tourism, and trade openness in APEC economies during the period 1995–2020. Specifically, in the case of developing economies, estimates highlight that GDPp, and EC are the main drivers of CO_2 increase, followed by ITA. However, the increase in $GDPp^2$ would be an important factor in the reduction of CO_2, as is the case with TO but to a lesser extent. With respect to developed economies, GDPp is the main cause of the increase in CO_2 emissions, followed by EC, ITA, and TO. In contrast, $GDPp^2$ has a negative relationship with emissions.

From the causalities analysis, it was found that in developing economies there is a bidirectional relationship between GDPp and CO_2, while in developed economies this relationship is unidirectional from GDPp to CO_2. It was also observed that in developing economies there is a bidirectional relationship between EC and CO_2, while in developed economies it is unidirectional from EC to CO_2. Regarding ITA, a unidirectional relationship towards CO_2 was found in developing economies and a neutral relationship in the case of developed economies. In developing economies, there is a unidirectional causal relationship from TO to CO_2 and a bidirectional relationship in developed economies.

The results of the two DOLS models and the causality analysis, in the sense of the relationship between tourism, economic growth, and environmental pollution, are close to the conclusions established by Tabash et al. (2023); Martial et al. (2023); Kongbuamai et al. (2023); Konstantakopoulou (2022); Alam and Paramati (2016); De Vita and Kyaw (2016); Katircioğlu (2014); Ozturk et al. (2016); Paramati et al. (2017); Ravinthirakumaran and Ravinthirakumaran (2022); Shakouri et al. (2017); and Zaman et al. (2016).

The model results also confirm the presence of the Environmental Kuznets Curve (EKC) in both developing and developed economies of APEC during the period 1995–2020. This functional form shows that after a certain level of income is reached, CO_2 emissions would be reduced in both economies, with a greater reduction observed in developed economies. This finding is consistent with the results obtained by Paramati et al. (2017), Kongbuamai et al. (2023); Martial et al. (2023); and Shakouri et al. (2017). However, it differs from the results of Ravinthirakumaran and Ravinthirakumaran (2022), who analyzed twenty economies in the APEC region without finding evidence of EKC during the period 1995–2017.

This result highlights the importance of conducting research that distinguishes levels of development between economies because it allows the identification of specific behaviors and the establishment of more effective recommendations. So, the research contributes to the literature by studying twelve developing APEC economies and nine developed economies over a 25-year period; estimating two DOLS models and applying Dumitrescu–Hurlin causality tests; identifying a stable long-term relationship between pollution environment, economic growth, fossil energy consumption, tourism, and trade openness in APEC economies; and finding evidence of EKC for both groups of economies.

This study provides empirical evidence of the necessity to establish policies aimed at reducing CO_2 emissions and promoting sustainable tourism in APEC. Therefore, it is recommended to leverage the framework of cooperation between APEC economies to implement policies that increase the income of the population. This, according to the EKC hypothesis, would lead to a long-term reduction in pollution in APEC, especially in developing economies. However, this increase in income must be decoupled from environmental degradation by promoting efficient use of fossil fuels and transitioning towards renewable energy sources. This would bring significant environmental benefits, particularly for the developing economies in the region. Similarly, the study identified that tourism is a strategic sector for long-term economic growth in APEC, as well as one of the main sources of pollution. Consequently, it is recommended that policymakers implement strategies to modernize tourism infrastructure, improve local transportation systems, and provide education to tourism personnel regarding sustainability and resilience practices. In the context of economic and trade openness, it is crucial to increase efforts that facilitate the region's economies to gain a stronger foothold in global markets. This can be achieved through the development of sustainable productive capacities and the consolidation of technological spillovers that promote production processes with minimal or zero pollution. In that regard, to ensure the success of these policies, it is important to promote cooperation and coordination between government institutions, universities, and companies. Furthermore, it is crucial to exchange knowledge and experiences with countries that have been successful in sustainable resource management and implementing stricter environmental regulations.

Future Lines of Research

While this research has produced important findings, there are still limitations that can be addressed in future research. For example, the availability of an environmental variable that better reflects the impact of tourism in a given area could be explored. Additionally, variables that enable an analysis of the social and economic dimensions of environmental challenges related to climate change, such as social well-being, poverty, marginalization, and human development, could be examined. Furthermore, it is possible to use other estimation methods to determine the individual and group behavior of APEC economies, as well as to evaluate the success or failure of government actions to make tourism a sustainable activity.

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