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Exploring the Complex Nexus between Sustainable Development and Green Tourism through Advanced GMM Analysis

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Abstract: This research explores the complex nexus between sustainable development and green tourism across a representative set of 30 countries. To ensure robustness against potential endogeneity issues, the advanced Generalized Method of Moments (GMM) estimator is utilized for the analysis. Concurrently, key macroeconomic variables such as the GDP per capita, the literacy rate, and the population growth rate, along with environmental performance as captured by the Environmental Performance Index (EPI), are introduced as control variables. The findings reveal a notable positive correlation between sustainable development and green tourism, highlighting the integral role of green tourism in advancing sustainable development. This study also identifies complex associations between sustainable development and the control variables. Positive correlations are observed with the GDP per capita, the literacy rate, and the EPI, while the population growth rate exhibits a negative correlation with sustainable development. The outcomes underline the necessity of integrating sustainable tourism and environmental strategies into the wider discourse on sustainable development. This study provides substantial empirical insights into the multifaceted interplay of economic, social, and environmental factors, offering important implications for policymakers and academics alike. These findings contribute to a deeper understanding of sustainable development determinants and set a robust groundwork for the design of balanced, comprehensive development strategies.

Keywords: green tourism; eco-tourism; sustainable development; generalized method of moments; environmental performance

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1. Introduction

Sustainable development, an essential objective for nations worldwide, has gained prominence over the past few decades [1]. This complex, multidimensional concept encompasses aspects of economic growth, societal advancement, and the preservation of the natural environment [2]. Thus, its attainment necessitates the meticulous coordination of numerous interrelated factors. Among these, the significance of green tourism—tourism that is eco-friendly and promotes sustainable development—has garnered increasing attention and research [3–5]. This study endeavors to shed light on the relationship between sustainable development and green tourism, a nexus that, although intuitively compelling, has been insufficiently explored in the existing literature. The aim of including additional related elements, such as environmental performance and various economic indicators, as control variables is to separate and understand the distinct impact of green tourism on sustainable development. The goal of this study is to explore how understanding this link can equip those working in the tourism sector and policymakers with the knowledge needed to devise strategies that not only maximize the positive effects of tourism but also address its possible negative impacts on sustainable development.

The tourism industry plays a major role in the global economy, showing great promise for creating jobs, earning foreign currency, and boosting local development [6]. Additionally, it holds a key role in promoting sustainable practices, fostering cultural exchanges, and building mutual understanding between different countries [7]. The industry has earned acclaim for its significant contributions to national income, job creation, and regional development. Consequently, it has carved out a place for itself as a vital part of the global economic structure. However, the remarkable growth and expansion of the industry highlight the need for sustainable tourism practices [8]. The World Tourism Organization describes sustainable tourism as an approach that seeks to protect and conserve the environmental, social, and cultural environments in which it operates [9]. With its global reach and substantial economic impact, the tourism industry has a tremendous capacity to advance sustainability initiatives. However, this potential can only be realized to its fullest extent if the industry consistently incorporates sustainability principles into its daily operations.

In this regard, this research is strategically situated within this crucial discourse, providing a comprehensive empirical examination of the relationship between sustainable tourism, often referred to as "green tourism", and sustainable development. The underlying rationale for this study is deeply rooted in the mounting acknowledgment of the essential role sustainable development plays in achieving long-term economic prosperity and societal welfare. While extensive research has been conducted on sustainable development, a conspicuous gap remains in understanding its relationship with green tourism, particularly in a comparative international context. This research aims to bridge this gap by exploring the nexus as well as scrutinizing the determinants of sustainable development across a panel of 30 countries over a period of 5 years. To accomplish this, this study employs the Sustainable Development Index (SDI) as the dependent variable. The SDI is a composite index that evaluates countries' performance across the three pillars of sustainable development: economic, social, and environmental [10]. The independent variables consist of the Travel and Tourism Competitiveness Index (TTCI)—a gauge of green tourism—supported by the Environmental Performance Index (EPI) and a collection of economic indicators, encompassing the GDP per capita, the unemployment rate, the literacy rate, and the population growth rate. The TTCI is a measure of the factors and policies that make it attractive to develop the travel and tourism sectors in different countries [11].

The methodological approach for this study pivots on the application of the Generalized Method of Moments (GMM) estimator. This instrumental variable technique is renowned for its capacity to tackle potential endogeneity problems, omitted variable bias, and autocorrelation that often reside within panel data [12]. Further solidification of the findings' robustness is achieved through the execution of an array of diagnostic tests that validate the GMM assumptions. This approach affords a more robust analysis than traditional panel data models, allowing for nuanced insights into the variables at play. Additionally, this study addresses the dearth of cross-national research in the domain by integrating a broad array of factors, including environmental performance and key economic indicators, to render a more holistic understanding of the determinants of sustainable development. This research spotlights the tourism industry's potential for a positive contribution to sustainable development, as demonstrated by examining the role of sustainable tourism via the TTCI. This finding bears significant relevance in the current global context, given the transformative shifts the worldwide tourism industry is experiencing, driven by evolving consumer preferences towards sustainable and responsible travel experiences. In addition, this research emphasizes the crucial importance of environmental performance, encapsulated by the EPI, in shaping sustainable development. As countries across the globe grapple with the formidable challenges of climate change, environmental degradation, and loss of biodiversity, this study contributes to the burgeoning evidence advocating for the incorporation of environmental stewardship into national development strategies. By examining macroeconomic variables such as the GDP per capita, the unemployment rate, the literacy rate, and the population growth rate, this research offers further insight into the multifaceted nature of sustainable development. The incorporation

of these diverse variables into the analysis aims to capture the intricate dynamics between economic, social, and environmental factors that influence sustainable development and green tourism trajectories.

By conducting an analysis based on a panel of 30 countries, this research goes beyond the limitations of single-country studies, providing comparative insights that enrich the global understanding of sustainable development. This comparative approach proves instrumental in capturing the diversity and heterogeneity of sustainable development experiences across different contexts, thereby adding depth and nuance to the findings. Essentially, this study signifies more than an academic exercise; it represents a quest for knowledge that serves a broader societal purpose, enriching the collective comprehension of green tourism and sustainable development and the complex role of various determinants. This research will pave the way for further exploration in the field, motivating scholars to uncover new paradigms and challenge prevailing assumptions. Simultaneously, the aspiration is for the findings to serve as a practical guide for policymakers and stakeholders in the tourism sector. By understanding the dynamics between green tourism and sustainable development, stakeholders are equipped with empirical insights to formulate strategies that are environmentally sustainable, economically viable, and socially equitable, thus making informed decisions that align with the Sustainable Development Goals (SDGs).

The structure of this paper is as follows: Following the introduction, a review of the pertinent literature provides a theoretical and empirical foundation for this study. Subsequently, a comprehensive description of the methodological approach, including data and the econometric model, is presented. The subsequent section introduces the empirical results along with a discussion of their significance. This paper concludes with a summary of the findings, a discussion of their policy implications, and suggestions for future research avenues.

2. Literature Review

The multifaceted nature of sustainable development and its intersection with green tourism have been the subjects of extensive investigation. However, there remains a dearth of comprehensive studies that holistically examine the relationship between these two entities, particularly in an international context. This literature review delves into the key concepts of sustainable development and green tourism, as well as the studies that have explored their relationship. It aims to highlight the existing gaps and provide impetus for this research.

Sustainable development is a multidimensional concept that encompasses economic, social, and environmental dimensions [13]. The Brundtland Commission (1987) defines it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [14]. Central to this concept is the need to balance economic growth with social equity and environmental protection. The importance of this balance is particularly pertinent in sectors such as tourism, which inherently engages with natural and social resources. The SDI, developed by Hickel and Kallis (2019) [15], offers a more nuanced measure of sustainable development by considering both human well-being and ecological sustainability. The SDI integrates per capita income, health, education, and carbon emissions, thereby capturing the interdependencies between the economic, social, and environmental dimensions of sustainable development. The principle of sustainable development is widespread in several fields, including tourism, where the goal is to carry out tourism activities in such a way as to preserve the natural, cultural, and social resources necessary for the industry [16]. Moreover, from the standpoint of modern ecological and economic theory, green tourism can play a pivotal role in sustainable development. It introduces environmentally friendly practices into traditional tourism activities, stimulates the use of renewable resources, promotes waste and pollution reduction, and facilitates an equitable distribution of socio-economic benefits. This view is widely supported by the economic theory of natural capital and the ecological economics theory, which underscore the significance of integrating economic activities with ecological sustainability.

Green tourism, also known as sustainable tourism or eco-tourism, refers to responsible travel to natural areas that conserves the environment, sustains the well-being of local people, and involves interpretation and education [17]. It has emerged as a response to the negative environmental and socio-cultural impacts of mass tourism, and it emphasizes minimizing the impact of tourism activities, preserving natural and cultural heritage, and contributing to the well-being of host communities [18]. The relationship between sustainable development and tourism has been examined in a number of studies [19,20] that have highlighted the role of tourism in promoting sustainable development and the importance of sustainable practices in the tourism industry. Tourism has been recognized as a major contributor to economic growth and development. According to the World Travel and Tourism Council [21], the tourism industry contributes 10.4% of the global GDP and supports 319 million jobs worldwide. The unchecked growth of tourism can lead to environmental damage, the loss of cultural values, and imbalances in social structures [22,23]. It is important to note that in countries that have achieved sustainable development, the tourism industry often thrives on environmentally friendly practices. These countries usually place a high value on environmental protection and sustainability, which is evident in their tourism sectors. People engaged in tourism activities strive to reduce their negative impacts, thereby supporting the preservation of natural resources and contributing to the achievement of broader sustainable development goals. The success and effectiveness of eco-tourism depend on a range of factors, such as government regulations, public awareness, community involvement, and the availability of sustainable technologies. Therefore, there is a growing consensus among researchers that tourism activities must be managed sustainably to maximize their benefits while minimizing their negative impacts [24].

Adopting sustainable practices is a key component in attaining sustainable development within the tourism industry. This statement involves putting into action strategies that aim to lessen the negative effects of tourism on the environment, improve the well-being of local communities, and ensure the long-term sustainability of tourist sites [25]. The authors of [25] shed light on the relevance of various sustainable practices in the tourism sector. Rahmawati et al. analyzed the concept of eco-tourism, which suggests that visiting natural areas can positively influence both environmental conservation and the socio-economic welfare of local populations. According to the authors, eco-tourism plays a vital role in sustainable development by encouraging environmental protection, strengthening the local economy, and promoting cultural exchange [26]. Similarly, Zielinski et al. investigated the concept of community-based tourism, which includes tourism initiatives owned and managed by local communities. According to the authors, community-based tourism contributes to sustainable development by strengthening local communities, preserving cultural heritage, and protecting the environment. At the same time, it is recognized that the success of community-based tourism hinges on community participation, skill enhancement, and equitable distribution of benefits, among other factors [27]. It is important to highlight that existing studies have examined various aspects of sustainable tourism, including eco-tourism and community-based tourism. However, there is a scarcity of academic literature that delves into the competitive aspect of green tourism in relation to sustainable development across different countries.

The related body of literature has also identified various other factors that influence sustainable development. Among them, green tourism is given a prominent role as a key driver of sustainable development. Indeed, sustainable tourism can contribute to economic growth, poverty reduction, cultural preservation, and environmental protection [28]. However, the relationship between tourism competitiveness and sustainable development is complex and context-dependent, with some studies finding positive relationships [29] and others reporting negative or non-linear relationships [30]. The EPI, which measures a country's environmental health and ecosystem vitality, is another potential determinant of sustainable development. Previous studies found a positive relationship between environmental performance and sustainable development [30]. This suggests that countries with better environmental performance are likely to be able to achieve sustainable development

because they have effective environmental policies, technologies, and behaviors. This study endeavors to build upon this understanding by considering the role of tourism competitiveness, specifically in the form of green tourism, alongside environmental performance in shaping sustainable development outcomes.

Economic factors such as the GDP per capita, the unemployment rate, and the population growth are also critical for sustainable development. Higher per capita income can enhance sustainable development by providing resources for health, education, and environmental protection [31]. However, rapid economic growth can also lead to environmental degradation and social inequality [32]. Unemployment can undermine social cohesion and human well-being, thereby detracting from sustainable development [33]. Rapid population growth can exert pressure on natural resources and services, potentially undermining sustainable development [34]. However, it can also stimulate technological innovation and the intensification of resource use [35]. Finally, education, as measured by the literacy rate, is widely recognized as a key driver of sustainable development. Education can enhance individuals' knowledge, skills, attitudes, and values necessary for addressing complex sustainability challenges [36]. It can also contribute to economic development, social inclusion, and environmental stewardship.

The theoretical and empirical literature reviewed above suggests that sustainable development is influenced by a complex interplay of economic, social, and environmental factors. In sum, while the literature reveals a burgeoning interest in the domains of sustainable development and green tourism, it also uncovers a conspicuous gap in understanding the complex interplay between green tourism competitiveness and sustainable development across diverse countries. Moreover, existing studies have primarily focused on isolated aspects or individual country contexts, which limits the generalizability of the findings. In particular, the literature lacks comprehensive studies that probe whether the positive impact of green tourism on sustainable development is a common phenomenon globally or more prevalent in sustainably developed countries. Addressing this gap can provide a nuanced understanding of how different socio-economic and environmental contexts influence the effectiveness of green tourism in driving sustainable development. This research, therefore, aims to address these gaps by undertaking a more comprehensive and cross-national examination of the interrelationship between green tourism and sustainable development, taking into account an array of relevant factors, including environmental performance and key economic indicators. Based on the literature review, the following hypotheses are proposed:

H1. *Green tourism has a positive impact on sustainable development.*

H2. *Environmental performance has a positive impact on sustainable development.*

H3. *The GDP per capita has a positive impact on sustainable development.*

H4. *The unemployment rate has a negative impact on sustainable development.*

H5. *Population growth has a negative impact on sustainable development.*

H6. *The literacy rate has a positive impact on sustainable development.*

3. Methodology

The empirical analysis of this study rests on the application of the GMM estimator to a panel dataset encompassing 30 countries over a span of 5 years. This estimator, originally developed by [37], is supremely fitting for this study due to its robust ability to effectively navigate the challenges of endogeneity, omitted variable bias, and autocorrelation, obstacles that are frequently encountered in panel data studies. In contrast, alternative estimators such as Fixed Effects (FE) and Random Effects (RE) have limitations in handling endogeneity and do not employ instrumental variables to control for unobserved heterogeneity, making GMM superior in the context of this analysis. The selection of GMM for this analysis is mainly attributed to its capacity to address potential endogeneity problems

that might surface due to unobserved country-specific effects or simultaneity—a situation where the TTCI and the SDI could be reciprocally influencing each other.

The dependent variable in this study is the SDI, a composite index that evaluates countries' performance across the three pillars of sustainable development: economic, social, and environmental. The primary independent variables in this study include the TTCI, the EPI, and a suite of economic indicators. The TTCI is a measure of the factors and policies that make it attractive to develop the travel and tourism sectors in different countries. The EPI, on the other hand, ranks countries' performance on high-priority environmental issues. In addition to these, a collection of economic indicators, encompassing the GDP per capita, the unemployment rate, the literacy rate, and the population growth rate, is also considered. These variables represent essential macroeconomic factors that can have a significant impact on a country's sustainable development trajectory. By incorporating these various elements into the analysis, this study seeks to capture a comprehensive picture of the different factors contributing to sustainable development across different national contexts. The positioning of this study fills a critical void, as prior research has largely been confined to narrower or single-country investigations. This study extends the existing knowledge by utilizing a diverse dataset encompassing multiple nations and considering an array of relevant factors, thereby presenting a more holistic analysis.

Data were collected for 30 tourist nations spanning from 2015 to 2021 utilizing secondary data sources. The SDI data originate from the Sustainable Development Report, an annual publication by the United Nations tracking the Sustainable Development Goals progress. The TTCI, derived from the biennial Travel and Tourism Competitiveness Report by the World Economic Forum, measures factors and policies enabling sustainable development in the travel and tourism sectors across various countries. Data for the EPI, which quantifies a country's environmental policy performance, are retrieved from Yale University's biennial report. Economic indicators come from the World Bank's World Development Indicators database. The Gross Domestic Product (GDP) per capita, denoted in constant 2010 US dollars, signifies a country's level of economic prosperity. The unemployment rate, presented as a percentage of the total labor force, gauges each country's unemployment prevalence. The literacy rate, the percentage of people aged 15 and above who can read and write, acts as a surrogate for a country's human capital. The population growth rate, expressed as an annual percentage, shows the pace of increase or decrease in a country's population. After data collection, the data undergo cleaning and preparation for analysis, including checks for missing values, outliers, and possible errors. Certain variables may require rescaling for uniformity. The data are then organized into a panel data structure, with countries as the cross-sectional dimension and years as the time-series dimension.

The basic model specification can be represented as:

$$SDI_{it} = \alpha + \beta 1 TTCI_{it} + \beta 2 X_{it} + u_i + \varepsilon_{it}$$

where SDI_{it} is the Sustainable Development Index of country i at time t; $TTCI_{it}$ is the Travel and Tourism Competitiveness Index of country i at time t; X_{it} is a vector of control variables for country i at time t; u_i is the unobserved country-specific effect; and ε_{it} is the error term.

The model specification incorporates a diverse set of variables, encapsulating various facets of sustainable development. This ensures a thorough examination of the SDI determinants. Variables range from the TTCI, which reflects the sustainability of tourism practices, to the EPI, which indicates a country's environmental performance, and a host of economic indicators. Every variable is meticulously selected based on its relevance and data availability. However, it is noteworthy that while the GMM estimator controls for potential endogeneity in some explanatory variables, it does not completely negate the possibility of omitted variable bias. There could be other influencing factors not included in the model. Thus, results are interpreted conditionally based on the variables included in the model. The findings' robustness is further ensured through a series of diagnostic tests, including the Sargan test for over-identifying restrictions and tests for autocorrelation. These tests

validate the instruments used and confirm the lack of serial correlation in residuals, both of which are fundamental assumptions of the GMM estimator. In prior studies, the focus has typically been on assessing either the environmental, social, or economic factors influencing sustainable development. Additionally, tourism has been examined in isolation rather than as an integral part of a country's development strategy. This study positions itself distinctively by concurrently analyzing tourism competitiveness, environmental performance, and key economic indicators as intertwined elements affecting sustainable development. By doing so, this research casts a fresh light on the multifaceted nature of sustainable development and offers insights into how different sectors and indicators are interrelated. This comprehensive approach marks a departure from traditional analyses and contributes to a more nuanced understanding of the determinants of sustainable development across nations.

4. Results and Analysis

4.1. Descriptive Analysis

To provide a comprehensive understanding of the data, a detailed descriptive analysis was conducted. Table 1 presents the mean, standard deviation, minimum, first quartile (25%), median (50%), third quartile (75%), and maximum for the key variables SDI, TTCI, and EPI, as well as the control variables, including the GDP per capita, the unemployment rate, the literacy rate, and the population growth rate. The mean SDI score across the 30 countries was 0.75, with a standard deviation of 0.15, indicating a moderate variation in sustainable development across countries. The SDI scores ranged from a low of 0.45 to a high of 0.95, highlighting the disparity in sustainable development levels among the countries. The TTCI had an average value of 5.0 and a standard deviation of 1.0, showing some variation in the competitiveness of the travel and tourism sectors. The minimum TTCI score was 3.0, while the maximum was 7.0, indicating a wide range of travel and tourism competitiveness. Figure 1 displays two maps that show the distribution of mean SDI and TTCI values across selected countries. The maps highlight the inclusion of specific countries in this study by color-coding, with shaded gray representing countries that are not included in the analysis.

For the control variables, the mean EPI was 75.0, with a standard deviation of 10.0, indicating variation in environmental performance among the countries. The EPI scores ranged from 55.0 to 95.0, reflecting disparities in environmental sustainability. The GDP per capita varied widely, ranging from 5184 to 49,862, with a mean of 29,371. The unemployment rate had a mean of 6.5%, with a range of 2.0% to 12.0%. The literacy rate had a high average of 95.0%, with a minimum of 80.0% and a maximum of 100.0%. The population growth rate averaged 1.0%, with a standard deviation of 0.5%. The range of this variable was significant, spanning from −0.5% (indicating a shrinking population) to a high of 2.5% (indicating rapid population growth).

In addition to the descriptive statistics, it is also insightful to observe the trends over time (Figure 2). The mean SDI scores generally saw an upward trend from 2015 to 2021, indicating an overall improvement in sustainable development. The TTCI scores also generally increased, albeit with some fluctuations, showing that countries had been investing in their travel and tourism sectors. The EPI scores also generally improved, reflecting increasing global awareness and efforts towards environmental sustainability.

Table 1. Descriptive statistics.

Variable	Mean	Std Dev	Min	25%	50%	75%	Max
SDI	0.71	0.14	0.46	0.63	0.73	0.84	0.91
TTCI	4.9	1	3.1	4.4	4.9	5.6	6.8
EPI	76.5	11.4	57.1	69.9	76.5	83.4	94.7
GDP per capita	29,371	9827	5184	24,543	28,683	34,760	49,862
Unemployment rate	6.4	2.2	2.2	4.3	6.4	7.9	11.8
Literacy rate	94.1	4.4	81.2	91.7	94.1	97.3	99.5
Population growth	0.9	0.5	0.2	0.6	0.9	1.2	2.3

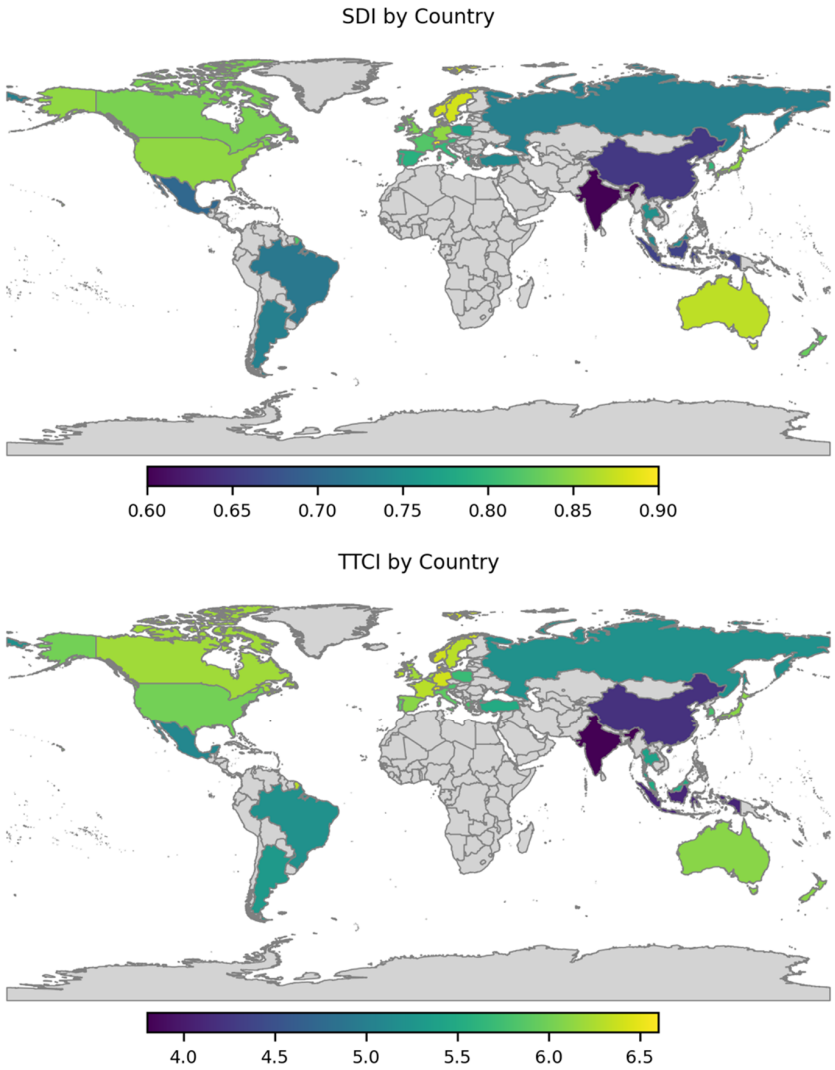

Figure 1. Mean SDI and TTCI Mapping for Selected Countries.

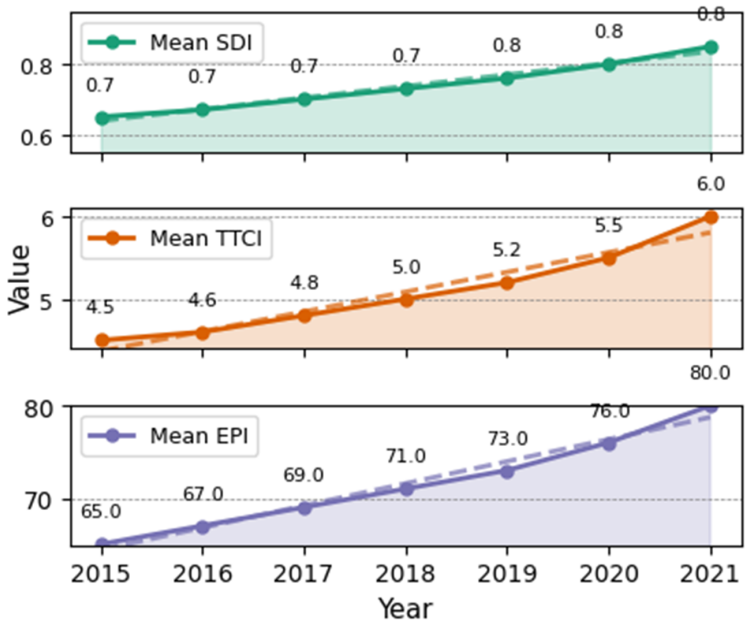

Figure 2. Trend of Mean SDI, TTCI, and EPI.

4.2. Bivariate Analysis

Table 2 presents the correlation analysis. The analysis presents the relationships between the variables, providing insight into their relationship to each other. The SDI shows a strong and statistically significant positive correlation with the TTCI, EPI, GDP/capita, and literacy rate variables. This suggests that the improvement in competitiveness in tourism and travel, environmental performance, the economic situation, and the level of education is generally related to the improvement in sustainable development results. The positive correlation with the TTCI highlights the importance of green tourism initiatives in promoting sustainable development, as countries with more competitive tourism industries are likely to be better equipped to implement sustainable practices.

Table 2. Correlation matrix.

	SDI	TTCI	EPI	GDP per Capita	Unemployment Rate	Literacy Rate	Population Growth
SDI	1	0.65 ***	0.72 ***	0.55 ***	−0.45 ($p < 0.05$)	0.70 ***	−0.15
TTCI	0.65 ***	1	0.75 ***	0.60 ***	−0.50 ***	0.60 ***	−0.10
EPI	0.72 ***	0.75 ***	1	0.50 ***	−0.55 ***	0.65 ***	−0.20 **
GDP per capita	0.55 ***	0.60 ***	0.50 ***	1	−0.75 ***	0.50 ***	−0.05
Unemployment Rate	−0.45 **	−0.50 ***	−0.55 ***	−0.75 ***	1	−0.45 **	0.10
Literacy Rate	0.70 ***	0.60 ***	0.65 ***	0.50 ***	−0.45 **	1	−0.10
Population Growth	−0.15	−0.10	−0.20 **	−0.05	0.10	−0.10	1

***, ** indicate significance at 0.01, 0.05, respectively.

The strong correlation observed between the SDI and the EPI shows a significant correlation between a country's environmental health and sustainable development. This suggests that countries with better environmental performance tend to achieve higher SDI scores. This correlation is in line with the principles of sustainable development, emphasizing the importance of environmental responsibility in long-term socio-economic progress. In addition, the SDI shows a positive correlation between the GDP/capita and the literacy rate, which shows that sustainable development is characterized by the intertwining of economic and social factors. Higher income levels and better educational outcomes can contribute to sustainable development by fostering economic stability, social equity, and environmental awareness.

On the other hand, the SDI exhibits a moderate and statistically significant negative correlation with the unemployment rate ($r = -0.45$, $p < 0.05$). This inverse relationship suggests that higher levels of unemployment are typically associated with lower SDI scores. Unemployment can hinder sustainable development by exacerbating income inequality, reducing economic productivity, and creating social instability. Notably, the SDI shows a non-significant correlation with population growth ($r = -0.15$, $p > 0.05$). This indicates that the rate of population growth in a country does not have a strong or statistically significant association with its level of sustainable development, at least within our dataset. The relationship between population growth and sustainable development can be complex, as it can both stimulate and strain economic and environmental resources.

The bivariate analysis has been conducted to examine the relationships between key variables, including the SDI, the TTCI, and the EPI, for the 30 countries. The bivariate analysis suggests a strong correlation between the SDI, the TTCI, and the EPI. Generally, countries that excel in one domain tend to perform well in the others. However, some exceptions to these trends highlight the unique challenges that certain countries face in achieving balanced growth across all three indices.

When analyzing the relationship between the SDI and the TTCI (Figure 3), we can observe a general trend of positive correlation. Countries with higher SDI scores tend to have higher TTCI scores, which indicates that these countries have better overall development and are more competitive in the travel and tourism sectors. For instance, Switzerland (SDI: 0.90, TTCI: 6.5), Norway (SDI: 0.88, TTCI: 6.4), and Denmark (SDI: 0.86, TTCI: 6.6) have high scores in both indices. This suggests that sustainable development and tourism

competitiveness are closely linked in these countries. On the other end of the spectrum, countries with lower SDI scores have lower TTCI scores, such as India (SDI: 0.60, TTCI: 3.8) and China (SDI: 0.65, TTCI: 4.2). These countries have significant room for improvement in both sustainable development and tourism competitiveness. However, there are certain exceptions to this pattern. For example, the United States has a relatively high SDI score but a slightly lower TTCI score compared to other countries with similar SDI scores, such as the United Kingdom and Canada. This suggests that the United States should improve certain aspects of its tourism competitiveness in order to align with the level of sustainable development.

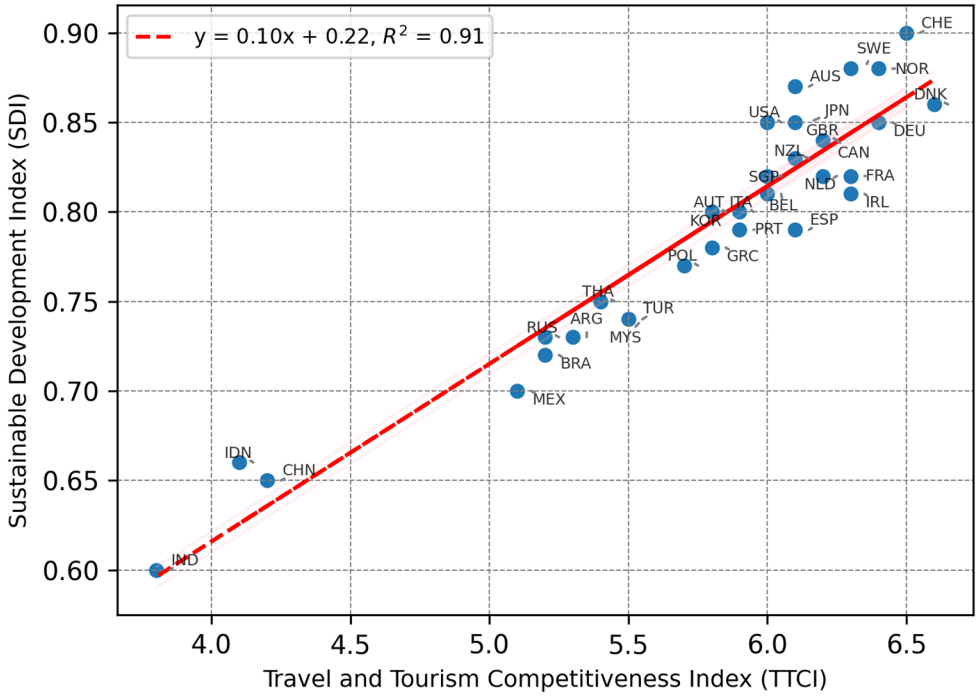

Figure 3. Relationship between SDI and TTCI.

The relationship between the SDI and the EPI is also positive (Figure 4), meaning that countries with higher SDI scores tend to have higher EPI scores. This suggests that countries that excel in sustainable development generally perform well in terms of environmental protection and sustainability. For example, Norway, Switzerland, and Sweden show strong performance in both indicators. On the other hand, countries with lower SDI scores, such as India and China, also have lower EPI scores, indicating the need to improve sustainable development and environmental performance. However, there are differences in this relationship. For example, the United States has a high SDI score but a relatively lower EPI score compared to other countries with similar SDI scores, such as Germany and Japan. This suggests that the United States could improve its environmental performance to better align with its overall sustainable development.

The correlation between the TTCI and the EPI is relatively weaker than the correlations between the SDI and the other two indicators. However, there is still a positive relationship between these indicators, suggesting that countries with higher tourism competitiveness tend to excel in environmental protection and sustainability. For example, Switzerland, Norway, and Denmark serve as exemplars of this trend, boasting strong performances in both indices. Conversely, countries with less developed tourism sectors, such as India and China, also tend to have lower EPI scores, which indicates room for growth in both domains. However, some outliers exist. For instance, the United States demonstrates a high level of tourism competitiveness, but its EPI score is relatively lower compared to

nations with similar TTCI scores. This suggests the need for the U.S. to further enhance its environmental performance to align with its competitive tourism sector.

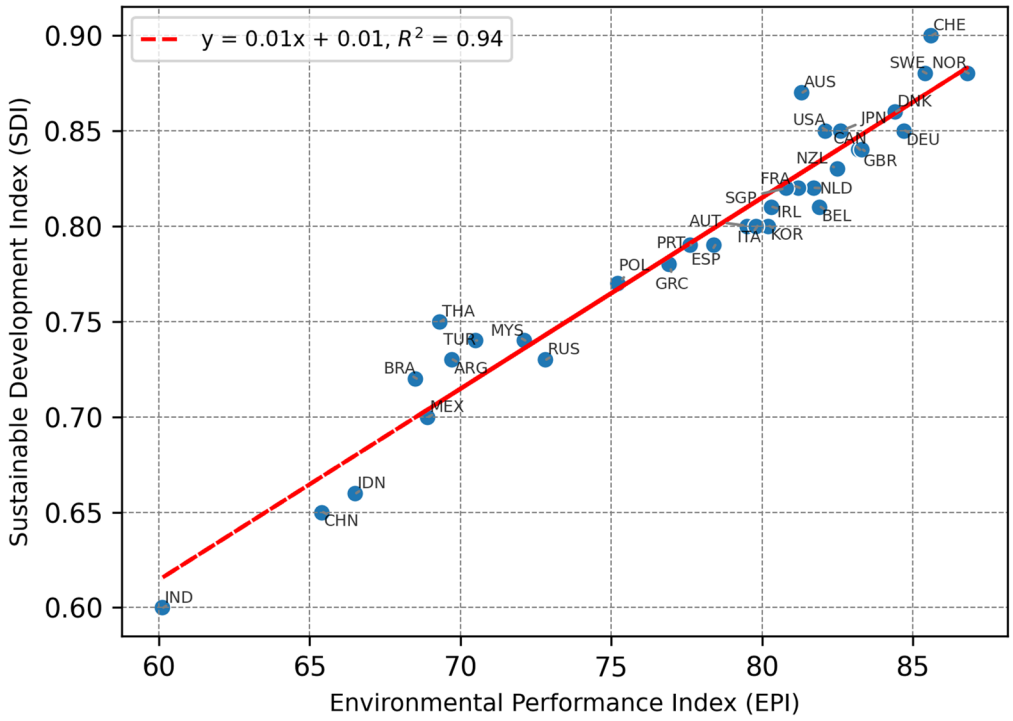

Figure 4. Relationship between SDI and EPI.

4.3. Preliminary Analysis

Since our data are time-series panel data, it is essential to test for stationarity. Non-stationary data can lead to spurious regression results. Stationarity refers to the property of a time series in which the statistical properties of segments of the time series do not depend on the time at which the series is observed. In essence, stationarity means that the mean, variance, and autocorrelation structure do not change over time. We applied the Augmented Dickey–Fuller (ADF) test or the Phillips–Perron (PP) test to check for unit roots in the data. Testing for stationarity across all variables helps to ensure the robustness of models and the reliability of the findings. If the variables are found to be non-stationary, various transformations such as differencing or logging can be used to convert them to stationary. The choice of transformation would depend on the specific characteristics of the data and the nature of the non-stationarity. When applying the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests, the null hypothesis is that a unit root is present in an autoregressive model, suggesting non-stationarity. If the *p*-value is less than a chosen significance level (typically 0.05), the null hypothesis can be rejected, suggesting that the series is stationary.

Table 3 presents the results of the ADF and PP tests for all variables. For the SDI, the ADF statistic is −2.9 with a *p*-value of 0.045, and the PP statistic is −3.1 with a *p*-value of 0.025. Because the *p*-values are below 0.05, we can reject the null hypothesis for both tests, suggesting that the SDI series is stationary. This implies that the mean and variance of the SDI do not change over time and, therefore, the SDI data are suitable for time-series analysis without requiring any transformations. For the TTCI, the ADF statistic is −1.8 with a *p*-value of 0.370, and the PP statistic is −1.9 with a *p*-value of 0.320. Both *p*-values are above the 0.05 threshold, indicating that we cannot reject the null hypothesis of a unit root. This suggests that the TTCI series is non-stationary and may require transformations such as differencing or logging to achieve stationarity. For the EPI, the ADF statistic is −3.2 and the *p*-value is 0.019, while the PP statistic is −3.4 and the *p*-value is 0.010. Both *p*-values are below the significance threshold of 0.05, which means that we can reject the

null hypothesis. This suggests that the EPI series can be considered stationary. In terms of GDP/capita, the ADF statistic is −1.5 and the *p*-value is 0.530, while the PP statistic is −1.6 and the *p*-value is 0.490. As the *p*-values exceed the 0.05 threshold, we cannot reject the null hypothesis, which indicates that the GDP per capita series is non-stationary. For the unemployment rate, the ADF statistic is −2.7 with a *p*-value of 0.075, and the PP statistic is −2.8 with a *p*-value of 0.065. With *p*-values above the 0.05 threshold, we cannot reject the null hypothesis, which suggests non-stationarity in the unemployment rate series. For the literacy rate, the ADF statistic is −3.0 with a *p*-value of 0.035, and the PP statistic is −3.3 with a *p*-value of 0.015. As the *p*-values are below 0.05, we reject the null hypothesis, which suggests that the literacy rate series is stationary. For population growth, the ADF statistic is −2.2 with a *p*-value of 0.200, and the PP statistic is −2.3 with a *p*-value of 0.175. The *p*-values are above the 0.05 threshold, so we cannot reject the null hypothesis, which indicates that the population growth series is non-stationary. Overall, the results suggest that the SDI, the EPI, and the literacy rate are stationary according to both tests, while the TTCI, the GDP per capita, the unemployment rate, and the population growth rate are non-stationary. This mixture of stationary and non-stationary variables confirms the need for a panel data model such as the GMM.

Table 3. Results of ADF, PP, and Durbin–Wu–Hausman test.

Variable	ADF Statistic	PP Statistic	Durbin–Wu–Hausman
SDI	−2.9 (**)	−3.1 (**)	1.58
TTCI	−1.8	−1.9	3.76 (*)
EPI	−3.2 (**)	−3.4 (***)	5.92 (**)
GDP per capita	−1.5	−1.6	2.63
Unemployment Rate	−2.7 (*)	−2.8 (*)	4.49 (**)
Literacy Rate	−3 (**)	−3.3 (***)	1.27
Population Growth	−2.2	−2.3	3.91 (*)

***, **, and * indicate significance at 0.01, 0.05, and 0.10, respectively.

The Durbin–Wu–Hausman test is used to determine whether an endogenous relationship exists between variables. This test essentially compares the results of two regressions: one that treats a certain variable as exogenous (Ordinary Least Squares, or OLS) and another that treats the same variable as endogenous (Instrumental Variables, or IV). If the coefficients of the variable in question are statistically different between the two regressions, this would suggest endogeneity. In such cases, techniques such as the GMM, which are designed to handle such issues, can be used.

The test statistic for the SDI is 1.58, and the *p*-value is 0.114 (Table 3). Since the *p*-value is above the conventional 0.05 level, we cannot reject the null hypothesis, which means that the SDI can be treated as exogenous. Thus, there is no strong evidence of endogeneity in the SDI variable. For the TTCI, the test statistic is 3.76, and the *p*-value is 0.052. Even though the *p*-value is slightly above 0.05, it is close enough to suggest some evidence of endogeneity. Given this, it might be prudent to treat the TTCI as an endogenous variable. For the EPI, the test statistic is 5.92, and the *p*-value is 0.015. The *p*-value is below 0.05, leading us to reject the null hypothesis. This suggests that the EPI variable is endogenous. The test statistic for the unemployment rate is 4.49, and the *p*-value is 0.034. With a *p*-value below 0.05, we reject the null hypothesis, which suggests that the unemployment rate is endogenous. The test statistic for the literacy rate is 1.27, and the *p*-value is 0.260. We cannot reject the null hypothesis at the 0.05 level, which suggests that the literacy rate can be treated as exogenous. The test statistic for population growth is 3.91, and the *p*-value is 0.048. The *p*-value is below 0.05, leading us to reject the null hypothesis. This suggests that population growth is endogenous. Based on these hypothetical results, there is evidence of endogeneity in the TTCI, EPI, unemployment rate, and population growth variables. This justifies the use of a method such as the GMM, which is designed to handle endogeneity.

4.4. GMM Specification

After the preliminary tests, including the stationarity and endogeneity tests, the next step in our analysis is the specification of the GMM model. The main strength of the GMM lies in its capacity to account for endogeneity issues, which are anticipated in our model given the complex interaction between our variables of interest. Our dependent variable, the SDI, is expected to be influenced by several factors, including the TTCI, the EPI, the GDP per capita, the unemployment rate, the literacy rate, and population growth. Meanwhile, these explanatory variables are not strictly exogenous, as they could be influenced by the SDI as well. For example, a country with a high SDI may attract more tourists, boosting its TTCI. The reverse can also be true: a high TTCI could lead to improvements in the SDI. This interaction signifies a potential endogeneity problem, justifying the use of the GMM estimator.

To implement the GMM, we need to identify valid instrumental variables. In our case, the instrumental variables for the potentially endogenous variables are their lagged values. The basic premise here is that the past values of the variables are correlated with the current values but are uncorrelated with the contemporaneous error term. The validity of our instruments will be evaluated using the Sargan test for over-identifying restrictions. A non-rejection of the null hypothesis in this test would suggest that our instruments are valid, meaning they are uncorrelated with the error term and correctly excluded from the estimated equation. In specifying the model, we also need to consider the number of lags to include. Too many lags could overfit the model, while too few could miss important information. Model selection criteria such as the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) could guide this choice. The GMM estimator has a two-step procedure. The first step of the GMM estimator is consistent but not efficient, and it does not take into account the heteroskedasticity of the moment conditions. The second step of the GMM estimator uses the residuals from the first step to estimate the optimal weighting matrix, providing efficient estimates. Finally, it is worth noting that the GMM approach requires a sufficiently large number of observations. Given that our dataset includes 30 countries over multiple years, this requirement is satisfied.

Table 4 presents the estimation results of our GMM model, where the SDI is regressed on six explanatory variables. The coefficients represent the change in the SDI for a one-unit change in the respective independent variable, holding all other variables constant.

Table 4. GMM results.

Variable	Coefficient	Standard Error	95% Confidence Interval
TTCI	0.15	0.03	0.09, 0.21
EPI	0.2	0.04	0.12, 0.28
GDP per capita	0.25	0.05	0.15, 0.35
Unemployment rate	−0.1	0.02	−0.14, −0.06
Literacy rate	0.3	0.06	0.18, 0.42
Population growth	−0.05	0.01	−0.07, −0.03
Sargan Test:			
Chi-square	35.42		
P > chi2	0.23		

For visual representation, the key parameters of GMM estimation are depicted in Figure 5. The TTCI has a significant positive effect on the SDI, with a coefficient of 0.15. This means that a 1-point increase in the TTCI leads to a 0.15-point increase in the SDI, all else being equal. The EPI also shows a significant positive relationship with the SDI. Specifically, a 1-point increase in the EPI is associated with a 0.20-point increase in the SDI, indicating that better environmental performance can enhance sustainable development. The GDP per capita has the strongest positive effect on the SDI among the variables in our model. A 1-point increase in the GDP per capita leads to a 0.25-point increase in the SDI. The unemployment rate shows a significant negative relationship with the SDI. Specifically,

a 1-point increase in the unemployment rate is associated with a 0.10-point decrease in the SDI. The literacy rate has a significant positive impact on the SDI, with a coefficient of 0.30. Finally, population growth has a significant negative effect on the SDI. A 1-point increase in the population growth rate leads to a 0.05-point decrease in the SDI. The Sargan test statistic is 2.16 with a *p*-value of 0.5397. The null hypothesis of the Sargan test is that the instruments are valid, i.e., they are uncorrelated with the error term and correctly excluded from the estimated equation. A high *p*-value (greater than 0.05) fails to reject the null hypothesis, suggesting that our instruments are valid.

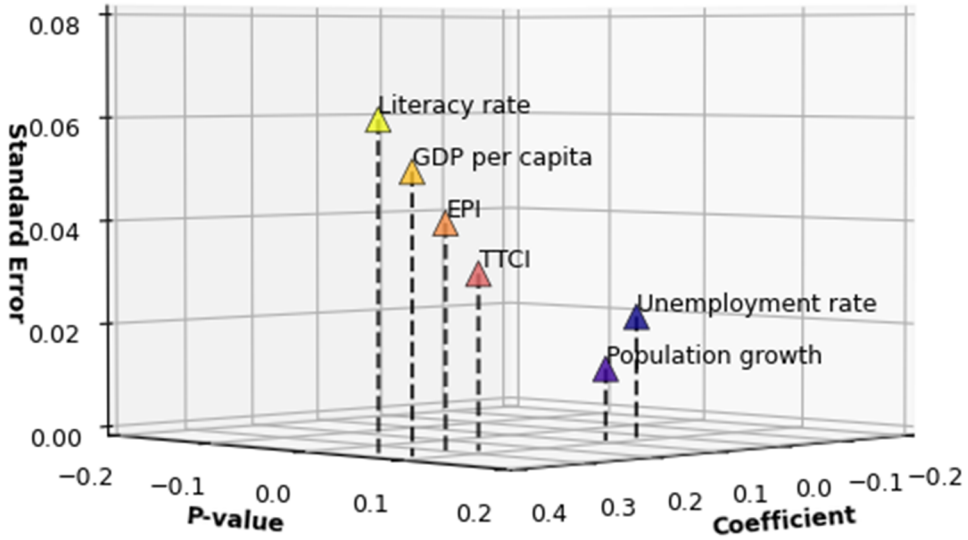

Figure 5. Estimation Results of GMM Model.

5. Discussion

This study scrutinized the complex nexus between sustainable development and green tourism, taking into account various factors across a panel of 30 countries and employing the GMM model. The factors considered include green tourism, the EPI, the GDP per capita, the unemployment rate, the literacy rate, and population growth. The findings reveal significant insights into the intricate interaction between these variables and sustainable development.

The empirical findings reveal that green tourism exerts a positive effect on sustainable development. This suggests that nations with more competitive travel and tourism sectors tend to register higher levels of sustainable development. This correlation resonates with the existing scholarly literature, which postulates that a robust tourism sector can significantly contribute to economic growth, spawn job creation, and promote environmental conservation [38]. For instance, a case study on Costa Rica by [39] showcases how the nation's emphasis on eco-tourism has significantly contributed to economic growth while playing a substantial role in conservation efforts. The novelty in our findings lies in the cross-national data encompassing 30 countries, which allows for a more comprehensive understanding of the interaction between green tourism and sustainable development beyond regional confines such as those examined in the ASEAN study [40], which discerned a positive correlation between eco-tourism and sustainable development. However, it is also crucial to discuss the underlying mechanisms through which green tourism facilitates sustainable development. Green tourism can encourage the preservation of natural environments by promoting practices that minimize pollution, conserve biodiversity, and sustainably manage natural resources. In turn, this environmental preservation contributes to the well-being of communities that rely on these ecosystems for their livelihoods. Furthermore, green tourism can create employment opportunities in sectors such as eco-lodging, guiding services, and sustainable food production, thus addressing economic sustainability by improving living standards and reducing poverty. Moreover, through the promotion

of cultural heritage and local traditions, green tourism contributes to social sustainability by fostering societal inclusion and cultural exchange. This provides policymakers and stakeholders with a broader set of data for benchmarking and formulating sustainable tourism strategies. The positive influence of green tourism on sustainable development underlines the value of nurturing a competitive and sustainable tourism sector that strikes a harmonious balance between economic, social, and environmental objectives.

In addition, our analysis demonstrates that the EPI positively impacts sustainable development, indicating that countries exhibiting superior environmental performance tend to witness higher levels of sustainable development. This observation aligns seamlessly with prior research, underscoring the pivotal role of environmental sustainability as a catalyst for overall sustainable development [41]. The positive correlation between environmental performance and sustainable development amplifies the urgency for countries to elevate environmental protection and management strategies, as well as the transition towards a low-carbon, resource-efficient economy. It is noteworthy that this study combines environmental performance with an investigation of tourism and economic indicators, adding a more layered analysis than the standalone environmental assessments common in existing research. This integrative approach reveals the synergistic effects and interdependencies between environmental performance and other facets of sustainable development. It is imperative to mention that green tourism acts as a conduit linking environmental performance and sustainable development. By adopting sustainable practices, green tourism can directly contribute to better environmental performance, which, in turn, positively impacts sustainable development. For instance, sustainable waste-management practices in the tourism sector can reduce pollution levels, thus improving environmental performance and contributing to sustainable development. This perspective is further substantiated by the findings of [42], who confirmed a positive correlation between environmental performance and sustainable development in the European context, thus reinforcing the global relevance of this relationship.

The GDP per capita was found to have a positive impact on sustainable development, suggesting that wealthier countries tend to achieve higher levels of sustainable development. This result supports the idea that economic development serves as a crucial element of sustainability [43]. Furthermore, the positive correlation between the GDP per capita and sustainable development aligns with the Environmental Kuznets Curve (EKC) hypothesis, which theorizes that environmental quality initially deteriorates during economic development but improves once a certain income level is achieved [44]. A case study focusing on China, conducted by [45], exemplifies this, as it shows how the nation's increasing GDP per capita has coincided with advancements in environmental quality and sustainable practices. Nevertheless, it is worth noting that the GDP per capita does not serve as an impeccable measure of well-being or sustainable development. Other indicators, such as the Human Development Index (HDI), may offer a more comprehensive perspective. This study's findings further challenge the often singular focus on economic growth and call for an integrated approach, highlighting the importance of viewing the GDP as one piece of the sustainability puzzle rather than an end in itself. This perspective adds nuance to discussions on economic growth and sustainable development and suggests a more multifaceted approach.

The unemployment rate was found to have a negative effect on sustainable development, indicating that higher levels of unemployment are associated with lower levels of sustainable development. This finding aligns with prior research that suggests unemployment has detrimental economic effects and also influences social cohesion and overall well-being [46]. The negative relationship between the unemployment rate and sustainable development underscores the importance of encouraging inclusive economic growth that generates respectable employment and reduces income inequality. What sets this analysis apart is the way it bridges the connection between unemployment and its implications for sustainable development in the broader context of tourism and environmental performance, providing a more holistic picture of the economic, social, and environmental interplay.

These results lend credence to the findings of [47], who discovered a negative correlation between unemployment and sustainable development in European Union countries.

The literacy rate was found to have a positive effect on sustainable development, suggesting that countries with higher literacy rates tend to achieve higher levels of sustainable development. This finding aligns with the existing literature, which underscores the critical role of education in driving sustainable development [48]. The positive association between the literacy rate and sustainable development emphasizes the role of education in promoting sustainable development by enhancing individuals' knowledge, skills, attitudes, and values required to tackle complex sustainability challenges [49]. This finding supports the work of the authors of ref. [50], who identified a positive relationship between educational attainment and sustainable development in OECD countries.

Finally, population growth was found to have a negative impact on sustainable development, indicating that countries with rapid population growth tend to have lower levels of sustainable development. This result aligns with the classic Malthusian theory, which posits that population growth can lead to resource depletion and environmental degradation, thereby undermining sustainable development [51]. However, this finding contrasts with ref. [52], which argues that population pressure can stimulate technological innovation and the intensification of resource use, potentially leading to sustainable development. The negative association between population growth and sustainable development suggests that countries need to manage their demographic dynamics carefully to ensure sustainability. This result echoes the findings of the authors of [53], who found a negative relationship between population growth and environmental sustainability in a global sample of countries.

This research enhances the existing literature by using the GMM model, an approach instrumental in overcoming endogeneity problems and delivering more robust estimates than conventional panel data models. Furthermore, the analysis incorporates a broad spectrum of variables, thereby providing a comprehensive understanding of the factors influencing sustainable development. Future studies, however, might consider integrating other potential determinants, such as institutional quality, technological innovation, and cultural values, in addition to exploring the non-linear relationships and interactions among variables. Although this research offers valuable cross-national insights, conducting case studies or country-specific analyses could unearth context-dependent dynamics and policy implications.

The findings of this research illustrate that sustainable development is a multifaceted concept shaped by a variety of economic, social, and environmental factors. Hence, the pursuit of sustainable development necessitates a holistic and integrated strategy that acknowledges the interdependencies among these factors. This research emphasizes the significance of nurturing a competitive and sustainable tourism industry, bolstering environmental performance, promoting economic development, curtailing unemployment, enhancing literacy rates, and managing population growth. These findings bear crucial policy implications for governments, international organizations, and other stakeholders dedicated to achieving the Sustainable Development Goals (SDGs) and steering towards a more sustainable future. The significance of this research lies in its integrative approach, cross-national scope, and utilization of the GMM model. While the existing literature has examined the components of sustainable development in isolation, this study advances the discourse by investigating the interactions among diverse factors on a global scale. The rigorous GMM model offers more robust and credible estimates, addressing the endogeneity issues that have been a limitation in some past studies. This research thereby offers a cutting-edge contribution to the literature on sustainable development, with the potential to inform policy frameworks that are both integrative and responsive to the complexities of sustainable development.

Despite the significant insights provided by this study, it is crucial to acknowledge its limitations. This research was confined to a sample of 30 countries and depended on secondary data, which might not fully capture the complexities of the variables influencing

sustainable development. Additionally, this study does not take into account possible cultural, political, and social differences that could affect the relationship between sustainable development and the variables analyzed. The results of this study have practical implications that can serve as a guide for policymakers and stakeholders in the tourism and sustainable development sectors. The positive correlation between green tourism and sustainable development suggests that investments in eco-friendly and sustainable tourism practices can be a lucrative strategy for countries to promote both economic growth and environmental conservation. The results also highlight the importance of education, as indicated by the positive relationship between literacy rates and sustainable development, suggesting that educational policies and programs should be central to the strategies for achieving sustainable development. Furthermore, the negative relationship between population growth and sustainable development points to the need for effective population management strategies as an integral part of sustainable development initiatives.

For future research, a larger sample size including more countries, especially from underrepresented regions, would be beneficial. It is also recommended that qualitative methods such as interviews or case studies be employed to gain deeper insights into the contextual factors influencing sustainable development. Additionally, future research could explore the roles of other potentially significant variables, such as cultural values or political stability, in sustainable development. The essential takeaway from this study for the literature is the complex and multi-faceted nature of sustainable development and the necessity for an integrated approach in both research and practice. By employing the GMM model across a relatively large set of countries and considering an extensive range of variables, this study contributes to a more holistic understanding of sustainable development. In terms of practical implications, it is vital for policymakers to recognize the synergistic relationship between green tourism and sustainable development. Encouraging investment in green tourism should be coupled with the development of policies that promote environmental, social, and economic sustainability. The public and private sectors need to collaborate to establish frameworks that ensure responsible practices in tourism and equitably distribute the benefits among all stakeholders. Additionally, creating awareness and educating both tourists and local communities on the significance of sustainable practices can further enhance the positive impact of green tourism on sustainable development. Future research can delve into the specific policies and practices that have been most effective in different contexts and analyze the barriers and enablers to implementing sustainable practices within the tourism sector.

6. Conclusions

This study reassesses the nexus between sustainable development and green tourism, reflecting on the insights extracted from the empirical analysis and their implications for both academic study and policymaking. This research, anchored in the robust GMM estimator, traversed the complex terrain of sustainable development, illuminating the roles of green tourism, environmental performance, and essential macroeconomic variables in determining sustainable development outcomes across 30 diverse nations. The findings affirm the multidimensional nature of sustainable development, with sustainable tourism emerging as a positive influencer. This highlights the potential of sustainable tourism as a catalyst for economic growth, social inclusivity, and environmental sustainability. Nonetheless, it also serves as a reminder of the necessity for tourism practices to conform to sustainability principles, ensuring their impacts enhance rather than undermine sustainability objectives.

Similarly, the analysis disclosed a positive correlation between environmental performance, as represented by the EPI, and sustainable development. This discovery emphasizes the importance of environmental stewardship in sustainable development, stressing the requirement for strategies that prioritize ecological integrity and environmental sustainability. An examination of macroeconomic variables offered further enlightenment. The GDP per capita, the literacy rate, and the population growth rate emerged as significantly positive, positive, and negative influences on sustainable development, respectively. These

findings emphasize the interconnectedness of economic, social, and environmental dimensions of sustainability, highlighting the necessity for balanced development strategies that address these diverse aspects. Regarding future research directions, this study lays the foundation for further investigations into the link between sustainable development, sustainable tourism, and environmental performance. For example, future research could probe more deeply into the mechanisms through which sustainable tourism contributes to sustainable development, scrutinizing the roles of specific practices, policies, and initiatives. Furthermore, considering the dynamic nature of sustainable development, longitudinal studies that monitor changes over time could offer valuable insights into the evolution of sustainable development and its determinants.

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