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Tourism-Induced CO2 Emissions and Institutional Contingency: Panel and Quantile Evidence from 27 Democratic Economies

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Abstract

The study examines the dynamic relationship among tourism, the quality of regulatory and democratic institutions, and CO_2 emissions, using panel data that integrate relevant macroeconomic and demographic variables. The econometric approaches Feasible Generalized Least Squares (FGLS) and Quantile Regression were used to analyze data from 1995 to 2024. The study finds that tourism intensity has a direct and statistically significant impact on CO_2 emissions. The energy demands of tourism, encompassing travel, accommodations, and infrastructure projects, result in high CO_2 emissions. Therefore, the effects of democratic institutions and regulatory quality on carbon emissions are heterogeneous. The quality of governance is identified as an important moderating effect between trust and CO_2 emissions. It means that tourism increases environmental risks. Besides, effective political institutions reduce them by establishing strong environmental laws, formulating specific policies, and ensuring strong social checks and balances. The study recommended that policymakers implement governance and emissions controls, connecting tourism expansion with democratic strengthening, effective regulation, and sustainable tourism investment to promote eco-friendly tourism growth and environmental preservation.

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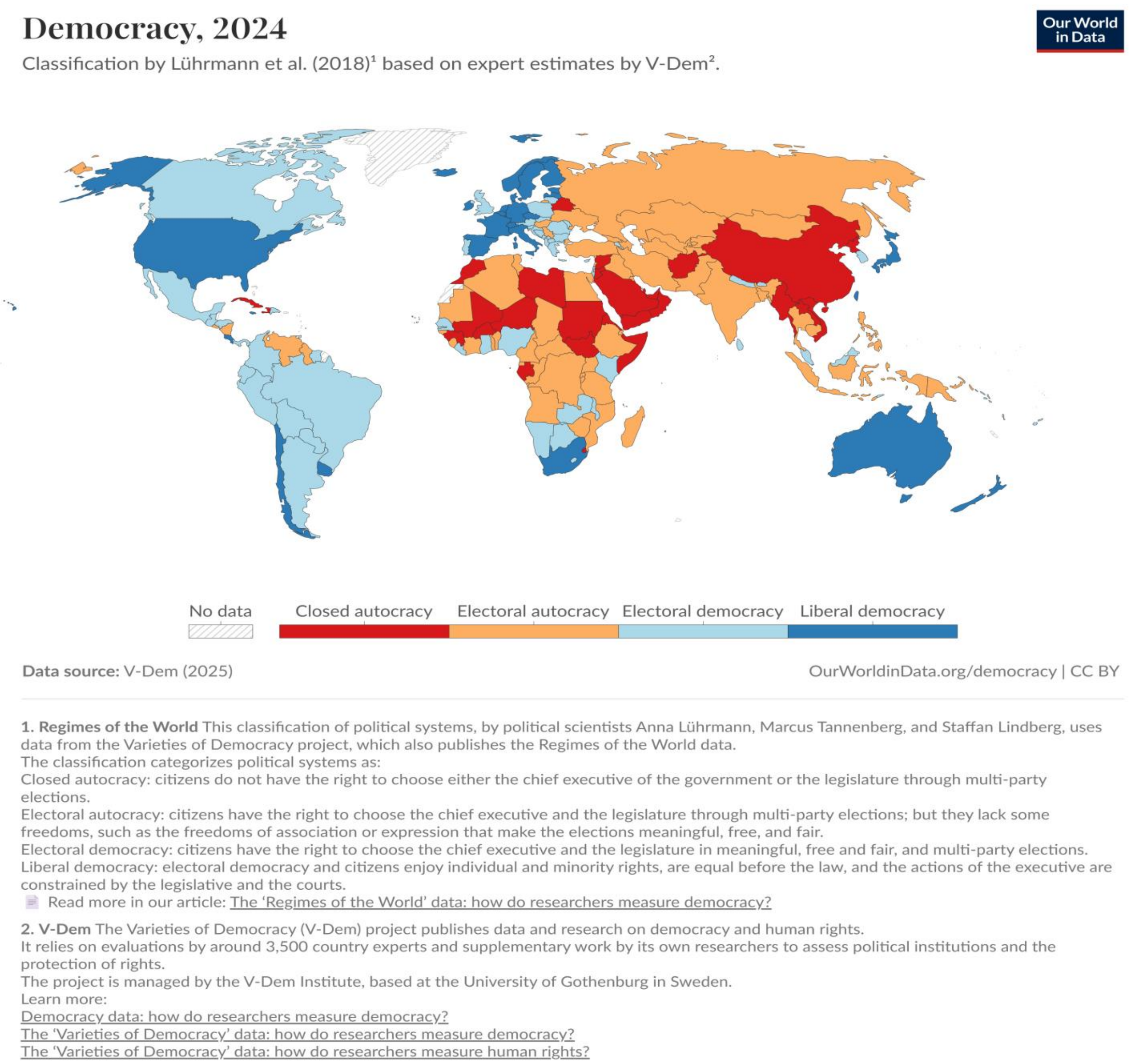
Graphical Abstract

1. Introduction

The tourism industry has become one of the fastest-growing sectors worldwide, playing a significant role in employment generation, economic development, and foreign-exchange revenues. Beyond its direct income generation, human capital formation, infrastructure development, and the expansion of trade networks, tourism contributes positively to poverty reduction and economic growth. Globally, the leading service industry is tourism, which provides employment and generates millions of jobs, accounting for a substantial share of GDP and international trade (Ullah et al., 2023; Kayani et al., 2023). In developing economies, tourism growth is facilitated by deeper integration into the global market, reinforcing the view that tourism is the main tool for achieving sustainable socio-economic growth. However, tourism development has contributed to environmental degradation, particularly through increased carbon emissions from transportation, accommodations, and leisure activities (Fatima et al. 2025). These emissions pose significant risks to climate change and stability, as well as public health (Safdar et al., 2026). Climate change is a global challenge for policymakers, who must balance tourism development with environmental management, emphasizing the need to identify the main drivers of CO2 emissions in tourism-dependent economies (Begum et al., 2025; Khalid & Abdul, 2025).

Institutional quality plays an important role in mitigating the environmental impacts of economic activities, like tourism. Strong government, democratic institutions, effective regulation, and institutional transparency facilitate the enforcement of environmental standards, promote sustainable behaviour, and reduce the negative environmental effects associated with economic growth (Khan et al. 2023; Adedoyin 2022).Conversely, weak governance, poor regulatory enforcement, and limited democratic accountability tend to harm environmental degradation, as economic objectives dominate ecological concerns in the long term (Ahmed et al., 2022; John-Eke and Gabriel, 2023). Accordingly, the combined impact of institutional quality and tourism plays a central role in understanding how tourism growth translates into carbon emissions, emphasizing the importance of governance-sensitive environmental policies. Moreover, demographic and macroeconomic factors, including FDI, GDP growth, and population growth, significantly influence tourism's environmental footprint (Wang et al., 2023).



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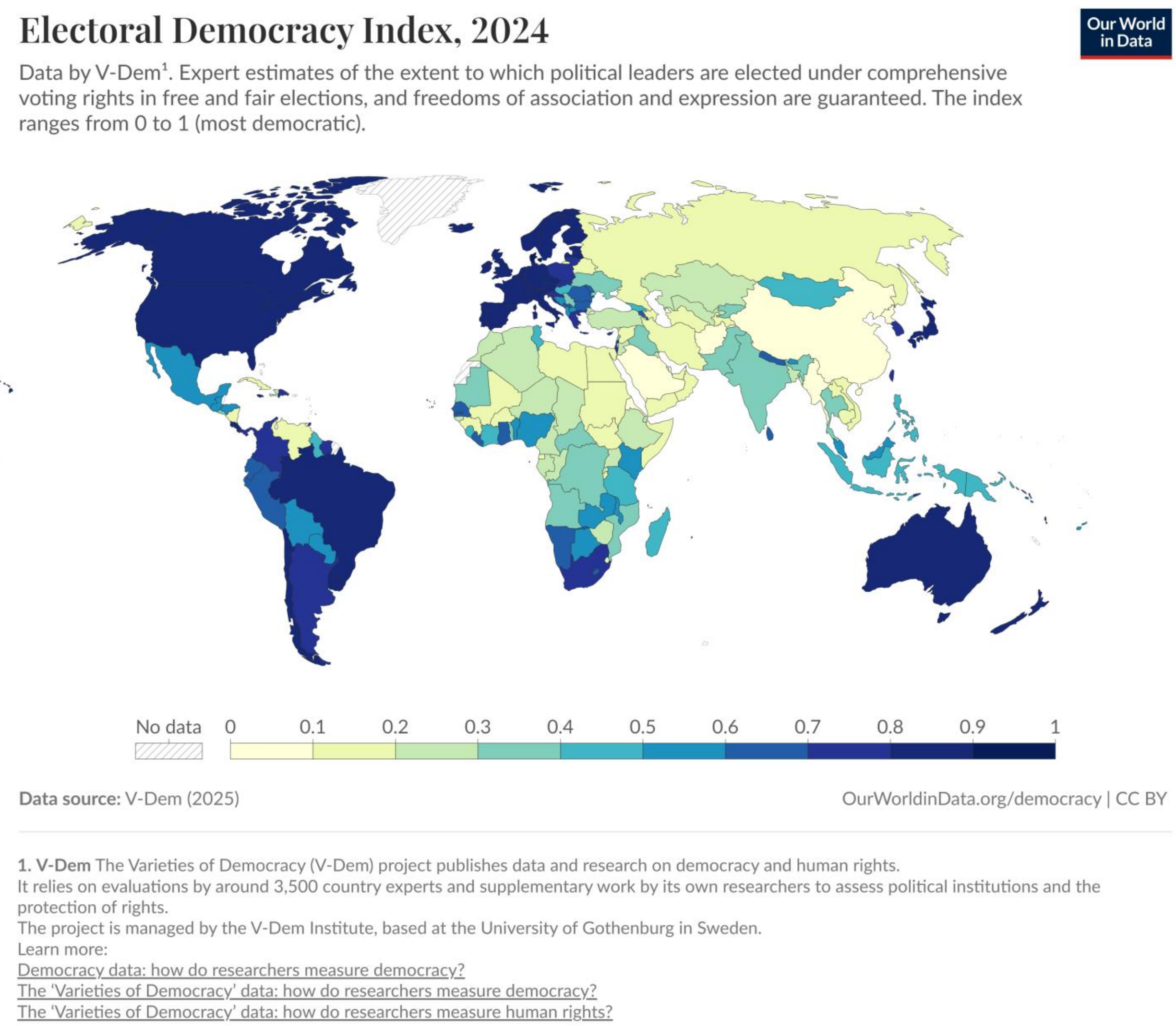

Sources: https://ourworldindata.org/democracy

Therefore, this paper explores the dynamic nexus between tourism activity, regulatory quality, and CO2 emissions, accounting for key macroeconomic and demographic factors. Employing panel data techniques, the analysis offers relevant insights to help policymakers balance tourism development with environmental sustainability and promote a carbon-sensitive growth framework. The study's main hypotheses are presented below:

H_1: Tourism activities are connected to the increase of CO2 emissions.

H_2: A positive relationship exists between the quality of democratic institutions and regulations governing and lowering CO 2 emissions.

H_3: The quality of governance mediates the relationship between tourism and CO2 emissions.

Objectives of the Study

1. To evaluate the effect of tourism on CO2 emissions, it is necessary to determine whether increased tourism activity results in higher carbon emissions.
2. To determine the impact of the quality of governance, democratic institutions versus regulatory quality, in reducing CO2 emissions, it is necessary to determine whether stronger governmental mechanisms help reduce environmental degradation.

Even though academic research has significantly advanced understanding of the economic effects of tourism, there remains a major gap in understanding its environmental effects, especially on carbon emissions. Most of the literature either examines the association between tourism and CO_2 emissions or the general interaction between tourism and environmental quality, but not the interplay between tourism and institutional quality. Besides, the role of governance indicators, such as democracy and regulatory quality, in promoting sustainable development is well established. However, there is limited information on the extent to which governance mediates the nexus between tourism and emissions. Previous researchers have not paid enough attention to the cumulative impact of important macroeconomic and demographic factors, including GDP growth, foreign direct investment, and population growth, which require tourism to leave an environmental footprint. The empirical findings on the combined impact of tourism, governance quality, and second-order economic variables on CO_2 emissions in countries with different institutional capacities are limited. The study attempts to fill this research gap by integrating tourism, democratic institutions, the quality of regulations, and major economic variables within a single panel design, thereby providing a detailed explanation of the factors that determine environmental sustainability.

The rest of this paper is structured as follows. Section 2: literature review; Section 3: outlines the data, variables, and econometric methods; Section 4: results and discussion. Lastly, Section 5: Conclusion and Policy Recommendation.

2. Literature Review

2.1 Tourism and CO_2 Emissions

The impact of tourism on CO_2 emissions is generally recognized and is mainly due to fossil-based transport, the use of fossil fuels in the accommodation industry, and infrastructure growth. There is empirical evidence that supports the claim that tourism activities increase carbon emissions. Indicatively, De Vita et al. (2015) analysed Turkey over the 1960-2009 period and found that long-term increases in CO_2 emissions were linked to the development of tourism, and that energy consumption and GDP served as key intermediates. A similar trend was found by Sharif et al. (2017), who noted that there is a positive correlation between the number of tourists entering the country and the level of CO_2 emissions in Pakistan and by Katircioglu (2014), who found that the CO_2 emissions in Turkey have increased statistically because of the energy consumption caused by tourists. This trend is supported by additional evidence in regions. As stated by Azam et al. (2018), tourism increased the rate of environmental degradation in Malaysia, and Akadiri et al. (2020) reported similar findings across 16 small island developing economies. Further, Chishti et al. (2020) and Koçak et al. (2019) stressed that tourism leads to environmental degradation in South Asian countries, but the extent of this impact varies across the countries. However, empirical evidence is not constant. Lee and Brahmasrene (2013) find that in EU countries, tourism reduces CO_2 emissions, suggesting that sustainable tourism policies can moderate the tourism emissions nexus to supports for Hypothesis 1.

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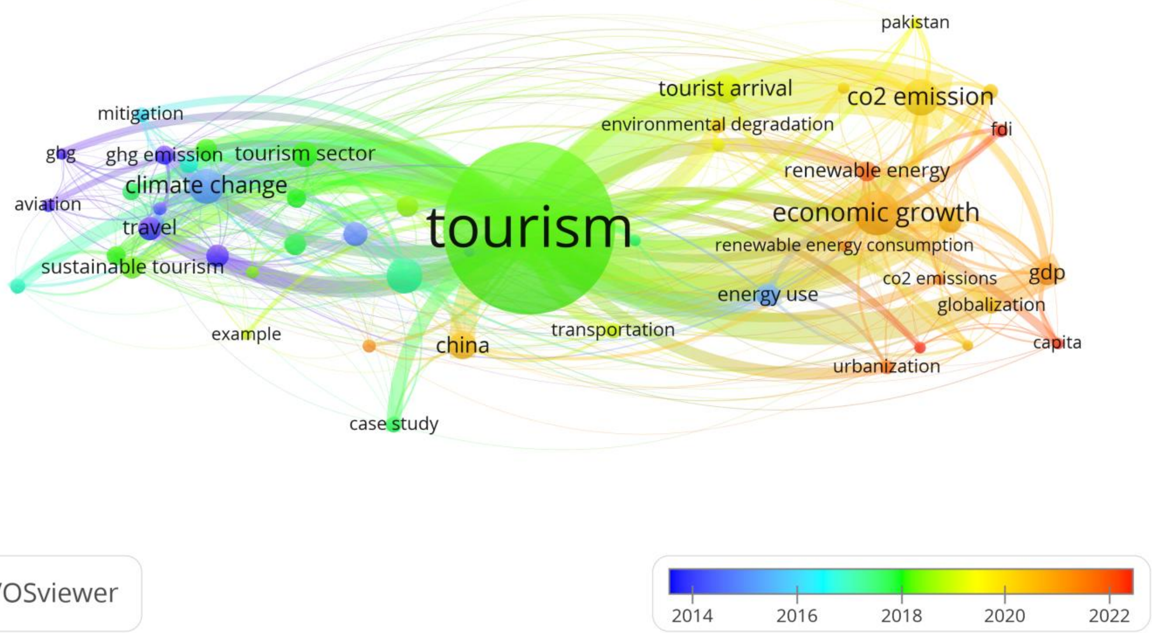

Figure 2: Tourism and CO2 Emission from 2000 to 2025

2.2. Democracy, Governance, and CO_2 Emissions

Institutional quality, particularly regulatory quality and democratic governance, is a critical determinant of environmental sustainability. The main argument is that democratic systems, through stronger environmental legislation, greater overall and social accountability, and heightened public awareness, directly promote better environmental outcomes. For instance, Deacon (1999) argued that democracies tend to achieve lower emissions in high-pollution economies due to increased transparency and strict responsiveness to environmental regulation. Empirical evidence shows that democratic governance can reduce emissions levels in high-pollution contexts by promoting transparency, legal compliance with environmental regulations, and stronger goals achieved through citizen participation in democratic institutions. However, some studies highlighted that democratic processes may have adverse effects, while others link democracy to higher emissions through population growth, economic growth, income inequality, or industrialization (Jahanger et al., 2022). Despite these mixed results, they support the view that strong democratic institutions and effective regulation mitigate CO2 emissions, thereby supporting Hypothesis 2.

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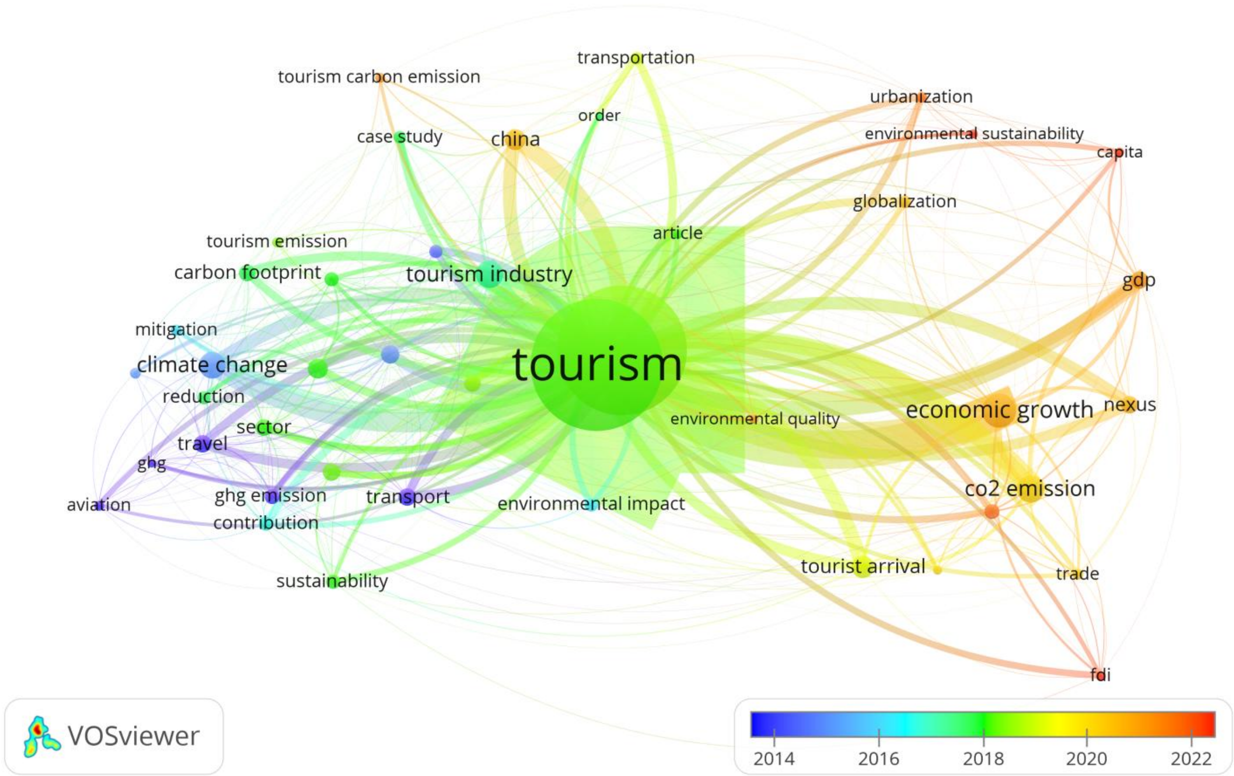

Figure 3: Democracy, Governance, and CO_2 Emissions

The prior literature emphasized the mediating role of good governance in the tourism interplay. Strong institutional quality, such as regulatory quality, control of corruption, and the rule of law, helps reduce CO_2 emissions by supporting sustainable tourism, promoting adaptation to renewable energy, and regulating high-impact tourism activities. Empirical evidence indicates that although tourism increases emissions in several countries, strong government significantly mitigates these effects (Usman and Atif, 2021; Bakhsh et al., 2021). Likewise, findings are reported for Asia-Pacific and developing economies, where high-quality governance reduces the environmental impact of tourism and trade through sustainable practices and green investment (Ulucak, 2020; Zafar et al., 2025; Muhammad et al., 2025; Chhabra et al., 2023). Taken together, these results provide empirical and theoretical support for H3, which suggests that the quality of governance modulates the relationship between tourism and CO_2 emissions.

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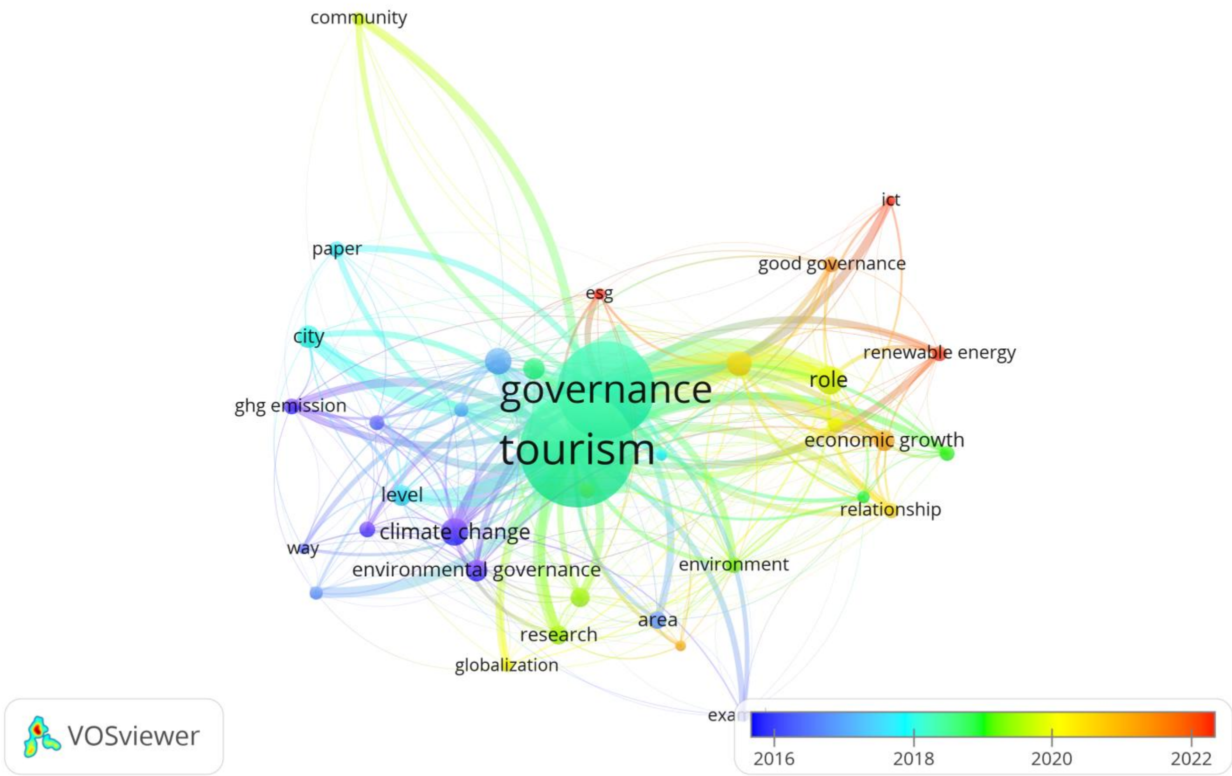

Figure 4: Governance and Tourism

3. Methodology

3.1 Data and Model Specification

To examine the factors that determine environmental quality, the current study treats carbon dioxide (CO_2) emissions as the dependent variable. It used panel data from 1995 to 2024 for 27 democratic states (see Figure 4 at the end of the paper for the list of states). The explanatory variables include tourism activity, political institutions, population size, economic growth, regulatory quality, and foreign direct investment (FDI). In addition, an interaction term between tourism and political institutions is included to assess whether the impact of tourism on CO_2 emissions depends on the level of democratic governance.

$$CO2_{it} = \beta_0 + \sum_{k=1}^{n=7} \beta_k X_{k,it} + \varepsilon_{it} \dots (1)$$

The econometric specification is as follows:

$$CO2_{it} = \beta_0 + \beta_1 LNTOUR_{it} + \beta_2 POLITY_{it} + \beta_3 POP_{it} + \beta_4 GDPG_{it} + \beta_5 REGQUA_{it} + \beta_5 FDI_{it} + \beta_5 (LNTOUR_{it} * POLITY_{it}) + \varepsilon_{it} \dots (2)$$

where i represents the unit of cross-section (country) and t represents the time-scan. CO_2 is the emission of carbon dioxide, lnTOUR is the natural logarithm of tourism activity, POLITY is the level of democratic rule, POP is the population size, GDPG is economic growth, REGQUA is the quality of regulation, and FDI is foreign direct investment. The interaction term (lnTOUR × POLITY) shows the moderating effect of democratic institutions in tourism environment nexus. The stochastic error is denoted by the term ε_{it}. The democratic nations used as the sample are listed below:

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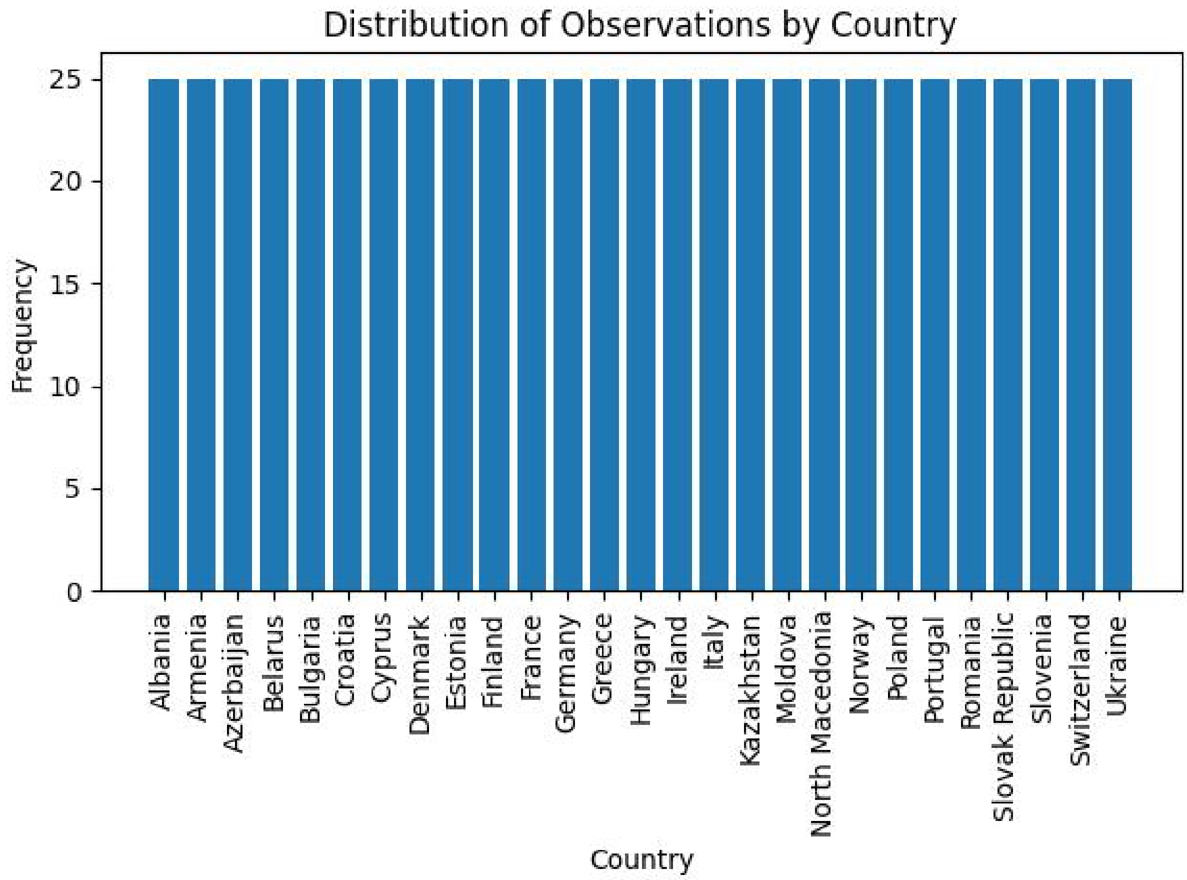

Figure 5: List of Democratic countries

3.2. Descriptive Statistics

Researchers can use descriptive statistics to briefly summarize and identify the core attributes of their data. Central tendency measures describe the general value of a data set. To obtain the arithmetic mean, all the observed values are added, and the total is then divided by the number of observations. But for ordinal-level data, the median is a more suitable measure, which is the value at the middle of an ordered series. In cases of skewed distributions, the median is considered a more accurate measure of central tendency than the mean. Dispersion measures determine how variable the data is. Even though the standard deviation can be used with ranked ordinal observations, it is best suited when the underlying distribution is close to normal (Gul et al., 2023; Gul et al., 2023; Shahid et al., 2025).

3.4. Correlation

The correlation analysis examines the value and direction of relationships between variables. The most commonly used measure for this is the Pearson correlation coefficient (Ikram & Gul, 2024). A negative coefficient indicates an inverse relationship, in which an increase in one variable is associated with a decrease in the other; a positive coefficient indicates a direct relationship, in which the two variables tend to move in the same direction (Khan et al., 2023). Correlation coefficients of 0.70 or higher are traditionally considered strong, with those between 0.50 and 0.70 moderate. In the social sciences, statistically significant coefficients exceeding 0.35 or falling below -0.35 are often considered significant. Multicollinearity occurs when the independent variables are highly correlated with each other. A large proportion of pair-wise correlations above 0.80 among the explanatory variables indicate severe Multicollinearity. Another indicator is a high R-squared in a regression model, but with a sparse number of statistically significant t-statistics for the predictors.

3.5. Model Estimation Feasible Generalized Least Squares (FGLS)

The given heteroscedasticity, serial correlation, and cross-sectional dependence, the current research will use the Feasible Generalized Least Squares (FGLS) estimator, as recommended by Leal and Marques (2019). It is recognized that FGLS is more efficient it yields lower standard errors than the Ordinary Least Squares (OLS) estimator in the presence of cross-sectional dependence (Bai et al., 2021). Parks (1967) initially proposed the FGLS methodology to approximate linear regression models in the presence of heteroscedasticity, serial correlation, and cross-sectional correlation. Long-run estimation with balanced panel data is especially beneficial, as it directly addresses these econometric difficulties and provides unbiased and consistent estimates (Bai et al., 2021; Zakari et al., 2022). Standard panel data estimators (OLS, fixed effects, random effects, weighted least squares, etc.) can also yield baised causal inferences when error variances are not homogeneously specified and when variables are cointegrated (Lin and Omoju, 2017). Conversely, FGLS estimators are consistent and asymptotically more efficient than OLS, since they accord lower weights to noisier observations. However, FGLS can be considered the most valid under the condition that the time dimension (T) is larger than the number of cross-sectional units (N) (Hoechle, 2007; Nuță et al., 2024). The FGLS equation may be represented as:

$$\widehat{\vartheta_{FGLS}} = (X' \aleph')^{-1} X' \aleph' y \dots (3)$$

Where

$\aleph' = Var(e)$ represents the variance covariance matrix of the error term, which explicitly accommodates heteroscedasticity, serial correlation and cross-sectional dependence; its estimation forms the first part of the analysis. Even though it is possible to criticise FGLS because standard errors might be underestimated under the assumption that the error-term parameters are known, it can still be applied to panel data with a small cross-sectional dimension (N) and a large time dimension (T). This condition is met in the current research, where T = 24 and N = 4 (Mumuni & Mwimba, 2023). The data used are a combination of time-series and cross-sectional data, thus allowing an examination of long-term changes among financial institutions. In line with earlier investigations, the study uses a panel data regression model. In particular, a dynamic panel data model estimated via FGLS is adopted to obtain credible, unbiased parameter estimates even when cross-sectional dependence, heteroscedasticity, and autocorrelation are present (Al-Qedah and Jaradat, 2013; Huynh, 2024; Xia et al., 2022; Ullah et al., 2023; Jamal et al., 2024)

3.6. Quantile Regression Model

This paper uses panel quantile regression because it enables it to capture heterogeneous effects of tourism, political institutions, and other macroeconomic variables across different levels of carbon dioxide emissions. The CO2 emission is a conditional quantile, defined as follows:

$$Q_0(CO2_{it}/X_{it}) = \beta_{0(\tau)} + \beta_{1(\tau)} LNTOUR_{it} + \beta_{2(\tau)} POLITY_{it} + \beta_{3(\tau)} POP_{it} + \beta_{4(\tau)} GDPG_{it} + \beta_{5(\tau)} REGQUA_{it} + \beta_{6(\tau)} FDI_{it} + \beta_{7(\tau)} (LNTOUR_{it} * POLITY_{it}) + \tau\varepsilon_{it(0\,1)} \dots (4)$$

$Q\tau$ (CO 2 it | X it) is the τ th -quantile of unit i CO2 emissions at time t (e.g., 0.10, 0.25, 0.50, 0.75, 0.90). The coefficients β(τ) are different in quantiles, and hence the influence of each explanatory variable can be different at low-, median-, and high-emission regimes. The explanatory variables are denoted by X_{it} and all variables maintain their previously defined meanings. Compared with mean-based estimators, quantile regression is resistant to outliers and heteroscedasticity and provides a better picture of the determinants of CO2 emissions across the entire conditional distribution.

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4. Empirical Results

Table 1: ***Descriptive Statistics***

Variable	Obs	Mean	Std. Dev.	Min	Max
CO2 emissions	675	6.478	2.896	0.47	15.341
LNTOUR	675	21.73	1.762	16.4	25.007
Politydemo	675	0.862	0.264	0.15	1
POP	675	0.115	0.750	-3.84	2.891
GDPG	675	3.129	4.465	-15.1	34.5
REGQUA	675	0.661	0.813	-1.59	1.927
FDI	675	7.387	22.13	-40.0	279.36

The key information about the dataset is provided in Table 1. There are 675 observations in the sample of all variables. The average CO_2 emissions are 6.48, with a wide range: a mean of 0.47 and a maximum of 15.34. Tourism activity (LNTOUR) has a mean of 21.73 and a standard deviation of 1.76, meaning moderate dispersion in tourism levels across the sample. The mean of the index of democracy (Politydemo) is relatively high (0.86), indicating that the majority of observations are dominated by stronger democratic institutions, though there is still some variation. There is a significant amount of distribution in the population growth, ranging from -3.84 to 2.89, thus demonstrating the demographic trends that differ among nations. The gross domestic product: the mean growth rate is 3.13 per cent, and the range is between -15.1 per cent and 34.5 per cent, indicating both deceleration and high growth in the economy. Based on this, the mean of regulatory quality (REGQUA) is 0.66, with a range of -1.59 to 1.93, indicating a difference in institutional effectiveness. Lastly, foreign direct investment (FDI) is the least stable, with a mean of 7.39, a standard deviation of 22.13, and a range of -40.0 to 279.36, indicating large fluctuations in capital inflows in the sample.

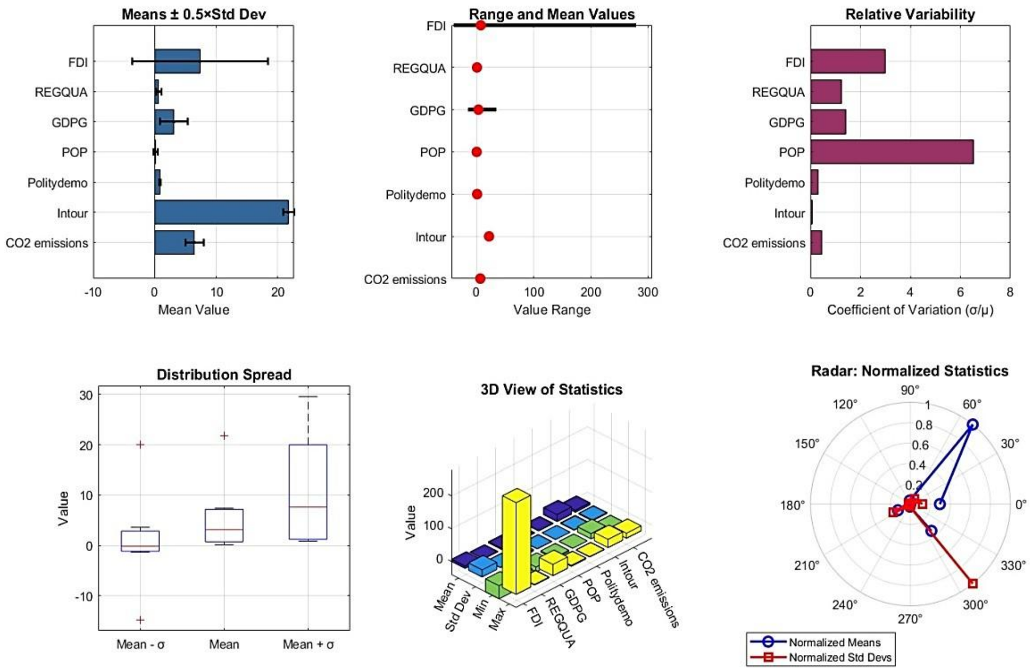

Figure 6: Descriptive statistics

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Table 2: *Matrix of Correlations*

Variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
(1) CO2 emissions	1.000						
(2) lntour	0.326	1.000					
(3) politydemo	0.109	0.488	1.000				
(4) POP	0.314	0.245	-0.000	1.000			
(5) GDPG	-0.052	-0.256	-0.236	0.011	1.000		
(6) REGQUA	0.487	0.636	0.729	0.362	-0.158	1.000	
(7) FDI	-0.007	-0.044	0.008	0.188	0.020	0.057	1.000

Table 2 shows the correlation matrix results. The results show that CO_2 emissions are positively related to tourism, regulatory quality and population, while negatively correlated with GDP and FDI. Moreover, tourism has a positive correlation with population, regulatory quality and political democracy, while a negative correlation with economic growth. Economic growth is negatively associated with all variables except FDI, which shows no strong association. In addition, regulatory quality and population size are positively associated with democracy.

Table3: ***Cross-sectional time-series FGLS regression with interaction Term Politydemo*lntour***

CO2 emissions	**Coef.**	**St.Err.**	**t-value**	**p-value**	**[95% Conf- Interval]**
lntour	0.331	0.015	21.99	0.000***	[0.301 00.36]
Politydemo	3.115	0.339	9.18	0.000***	[2.45 3.781]
POP	0.068	0.006	12.23	0.000***	[0.057 0.079]
GDPG	0.021	0.001	38.25	0.000***	[0.02 0.022]
REGQUA	0.873	0.015	56.52	0.000***	[0.843 0.904]
FDI	-0.003	0.004	-7.95	0.000***	[-0.005 -0.002]
Politydemo*lntour	-0.188	0.017	-10.84	0.000***	[-0.222 -0.154]
Constant	-0.582	.296	-1.97	0.049**	[-1.162 -0.003]
Mean dependent var		6.478	SD dependent var		2.896
Number of obs		675	Chi-square		6568.282

*Note: *** p<.01, ** p<.05, * p<.1*

Table 3 shows the results of the cross-sectional time series FGLS regression using CO_2 emissions as the dependent variable. The estimated coefficients indicate that tourism activity, measured as the natural logarithm of the number of tourists visiting the country (ln tour), has a positive and significant impact on CO_2 emissions. To be more precise, an increase in tourism activity by 1 unit leads to an increase in emissions by 0.33 units, all else equal. The democratic consolidation indicator (Politydemo) also shows a strong, positive, and significant correlation with emissions, indicating that jurisdictions with higher democratic ratings emit more. The coefficients for both population growth (POP) and gross domestic product growth (GDPG) are strongly significant and therefore indicate the contributory roles of population growth and economic growth in the worsening of CO_2 emissions. Regulatory quality index (REGQUA) on the other hand shows a positive coefficient, which means that high-level regulatory systems are associated with high levels of emissions, which might be because of increased economic process. Conversely, the positive coefficient of foreign direct investment (FDI) is not only significant but also negative which means that an increase in FDI inflows correlates to lower emission levels, perhaps because the new technologies are less polluting or because they are using more efficient production methods. The democracy tourism interaction term is also

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negative and significant (Politydemo x lntour) and it implies that the positive effect of tourism on emissions is diminished in more democratic contexts, a result that hints at the possibility of democratic institutions damping the effect of tourism on the environment by establishing better or stronger environmental regulation mechanisms.

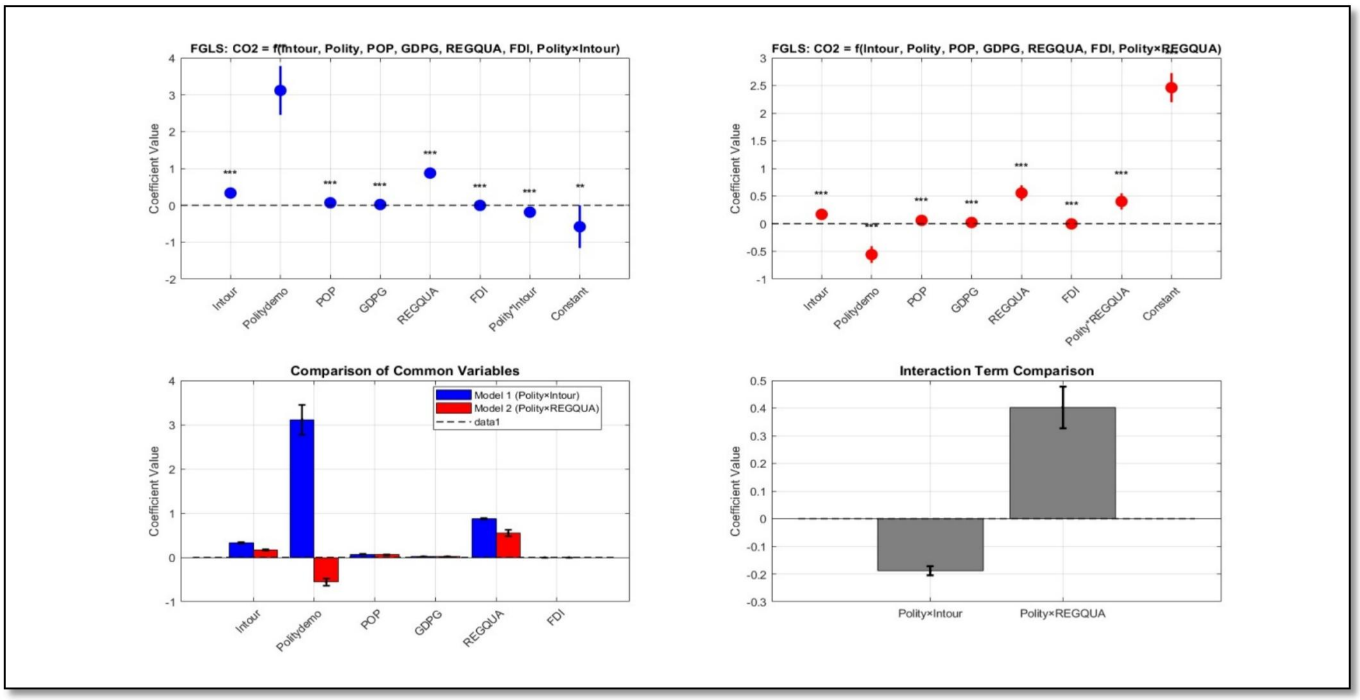

Figure 7: Interaction term comparison

Table 4: *Results of the cross-sectional time-series FGLS regression including the interaction term between democracy and regulatory quality (Politydemo × REGQUA)*

CO2 emissions	Coeff.	St.Err.	t-value	p-value	[95% Conf- Interval]
lntour	0.169	0.008	21.85	0.000***	[0.154 0.184]
Politydemo	-0.558	0.078	-7.17	0.000***	[-0.71 -0.405]
POP	0.06	0.007	8.08	0.000***	[0.045 0.075]
GDPG	0.022	0.001	39.16	0.000***	[0.021 0.023]
REGQUA	0.555	0.071	7.84	0.000***	[0.416 0.693]
FDI	-0.003	0.004	-9.05	0.000***	[-0.004 -0.003]
Polity* REGQUA	0.403	0.075	5.36	0.000***	[0.255 0.55]
Constant	2.461	0.135	18.20	0.049***	[2.196 2.726]
Mean dependent var		6.478	SD dependent var		2.896
Number of obs		675	Chi-square		7181.593

*Note: *** p<.01, ** p<.05, * p<.1*

Table 4 gives the results of the FGLS specification, including the interaction between Politydemo and REGQUA. The tourism activity (lntour) has a positive and significant effect on CO2 emissions. Still, the coefficient's magnitude is lower than in the previous model, highlighting tourism's role as a relevant variable in determining emissions levels. Politydemo itself has a negative, significant coefficient, indicating that more democratic regimes are likely to have lower CO2 emissions when the quality of regulations is controlled for. Statistically significant, positive interaction effects of the two factors, POP and GDPG, with emissions, thus confirm the hypothesis that further environmental pressure is created by demographic and economic growth. The REGQA regression coefficient is positive and significant, indicating that stronger regulatory entities are associated with higher CO2 emissions, likely because of higher economic activity. There is once again a negative, statistically significant correlation between foreign direct investment (FDI) and emissions, as previously hypothesized, because FDI is expected to encourage cleaner production or higher efficiency. More importantly, Politydemo shows a statistically significant, positive correlation with REGQA, indicating that the impact of regulation quality on CO2 emissions is greater in more democratic settings; thus, a complementary effect between democratic institutions and regulation quality is evident in shaping environmental outcomes.

Table 5: ***Quantile Regression with Polity*lntour***

Variables	Q10	Q20	Q30	Q40	Q50	Q60	Q70	Q80	Q90
lntour	0.157*	0.139**	0.073	0.062	-0.004	0.031	0.104	0.106	-0.019
	(0.085)	(0.07)	(0.087)	(0.106)	(0.117)	(0.146)	(0.108)	(0.115)	(0.137)
Politydemo	-0.579	1.035	1.772**	1.368	-2.4	- 8.553***	- 8.566***	- 9.883***	- 11.625***
	(0.664)	(1.023)	(1.093)	(1.086)	(2.944)	(1.764)	(0.726)	(1.315)	(2.387)
POP	0.065	0.094	0.384*	-0.339	-0.118	-0.002	0.011	-0.108	-0.068
	(0.078)	(0.336)	(0.249)	(0.353)	(0.191)	(0.177)	(0.049)	(0.252)	(0.213)
GDPG	0.022**	-0.022	-0.009	-0.008	-0.021	0.011	0.011	0.021	0.010
	(0.008)	(0.021)	(0.018)	(0.022)	(0.037)	(0.049)	(0.049)	(0.041)	(0.029)
REGQUA	0.551	- 3.538***	- 3.529***	- 4.566***	3.994***	4.406***	5.606***	7.722***	7.722***
	(0.803)	(0.783)	(0.923)	(0.753)	(1.291)	(0.528)	(0.655)	(1.271)	(1.271)
FDI	0.000	0.005**	-0.002*	0.008	- 0.006***	- 0.010***	- 0.010***	- 0.011***	-0.011**
	(0.001)	(0.002)	(0.001)	(0.022)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Polity*lntour	.454	5.753***	6.166***	5.788***	3.675*	-0.494	-1.067	- 2.220***	- 4.538***
	(0.849)	(0.835)	(0.805)	(0.628)	(1.909)	(1.439)	(0.762)	(0.703)	(1.172)

*Note: *** p<.01, ** p<.05, * p<.1*

Table 5 presents the findings of the quantile regression and evaluates the heterogeneous effects of tourism, democracy, and their interaction on the conditional distribution of CO2 emissions. The estimates show a significant difference across the quantiles, indicating that the determinants of emissions vary between low-emission and high-emission countries. Tourism activity (ln tour) is positive and statistically significant when it is at lower quantiles (Q 10, Q 20), which indicates that tourism has a role to play in high CO 2 emission amongst low-emission countries. It, however, becomes statistically insignificant in the middle and upper quantiles, suggesting that tourism does not have a homogeneous effect on emissions across the distribution. There is a significant difference in the impact of democracy (Politydemo) across quantiles.

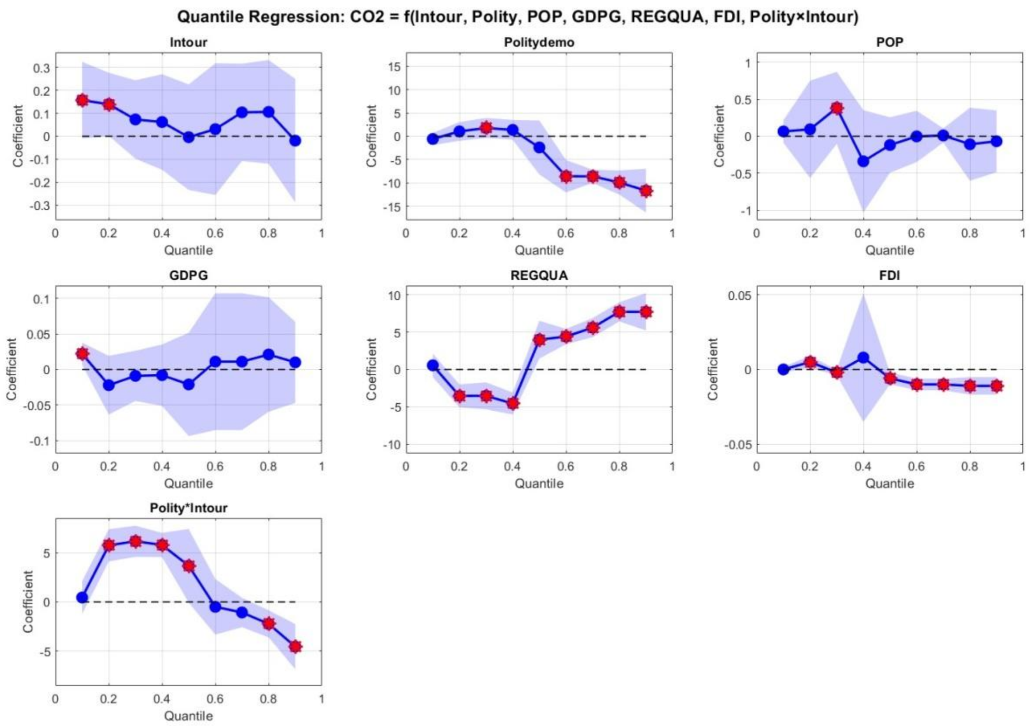

*Figure 8: Quantile regression with interaction term Polity*Intour*

Although democracy has a slight or even negligible impact at lower quantiles, it becomes negative and significant at higher quantiles. This indicates that in high-emission countries, more democratic institutions are associated with lower CO_2 emissions, possibly reflecting more effective environmental governance in the face of high pollution levels. Population growth (POP) has few and generally trivial effects across quantiles, with only weak evidence of a positive effect at lower to middle quantiles. The effect of GDP growth (GDPG) is only positive and significant at the lowest quantile and decreases and becomes insignificant at higher quantiles. The pattern of regulatory quality (REGQUA) is different. It shows a significant negative correlation with CO_2 emissions at lower and middle quantiles, but a significant positive correlation at higher quantiles, suggesting that stricter regulatory institutions could reduce emissions in low-emission contexts but coincide with increased emissions in more industrialized, high-emission contexts. The median has a negative and significant influence on foreign direct investment (FDI). As the median increases, FDI inflows are correspondingly low, indicating a negative correlation between the two and a reduction in CO_2 emissions, especially in high-emission nations. The term of interaction between democracy and tourism (Politydemox lntour) is positive and significant at the lower and middle quantiles and negative and significant at the upper quantiles. This shows that democracy will first enhance tourism's impact on low-emission countries and reduce its environmental consequences in high-emission countries.

Table 6: ***Quantile Regression with Polity* REGQUA***

Variables	Q10	Q20	Q30	Q40	Q50	Q60	Q70	Q80	Q90
lntour	0.235	0.169	0.028	0.235	1.637**	1.14**	1.3*	1.968***	2.389***
	(0.292)	(0.35)	(0.681)	(0.22)	(0.761)	(0.482)	(0.677)	(0.67)	(0.392)
Politydemo	3.819	0.893	-1.044	-1.671	28.427*	15.936*	18.189	33.841***	43.354***
	(6.006)	(8.217)	(13.593)	(5.87)	(14.638)	(9.683)	(13.483)	(12.421)	(6.851)

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POP	0.684** (0.271)	0.695*** (0.227)	0.538*** (0.198)	0.579** (0.283)	0.059 (0.156)	-0.154 (0.178)	-0.045 (0.216)	-0.239 (0.267)	-0.264 (0.172)
GDPG	-0.065* (0.035)	-0.032 (0.036)	-0.013 (0.036)	0.009 (0.024)	-0.027 (0.041)	-0.024 (0.033)	-0.002 (0.037)	-0.006 (0.041)	-0.01 (0.023)
REGQUA	1.755*** (0.192)	1.688*** (0.288)	2.127*** (0.306)	1.633*** (0.478)	3.179*** (0.263)	3.571*** (0.291)	3.477*** (0.274)	3.507*** (0.233)	3.613*** (0.272)
FDI	0.002* (0.001)	0.001 (0.001)	-0.002 (0.002)	0.008 (0.019)	-0.006*** (0.002)	-0.008*** (0.002)	-0.01*** (0.003)	-0.01*** (0.003)	-0.012*** (0.003)
Polity* REGQUA	-0.203 (0.285)	-0.045 (0.41)	-0.019 (0.72)	0.004 (0.276)	-1.739** (0.755)	-1.196** (0.485)	-1.295* (0.682)	-2.086*** (0.644)	-2.628*** (0.344)

*Note: *** p<.01, ** p<.05, * p<.1*

A quantile regression, including an interaction between the regime of democracy and the quality of regulation, is presented in Table 6. The findings indicate strong heterogeneity in the conditional distribution of CO_2 emissions, suggesting that the effects of institutional quality and democracy vary significantly across low- and high-emission settings. The statistically significant impact of tourism activity (lntour) is not significant at lower quantiles, but is positive and significant at the median.

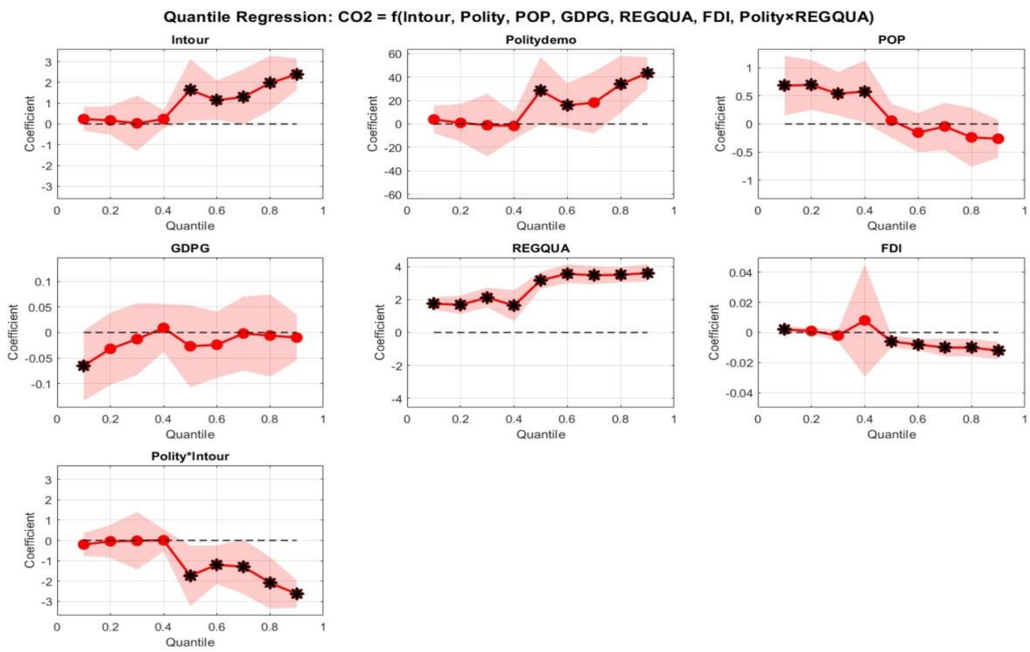

Figure 9: Quantile Regression with Interaction Term Polity*REGQUA

The coefficient value increases gradually with increasing quantile, suggesting that tourism's influence on CO_2 emissions is greater in nations with higher emissions. Democracy (Politydemo) shows weak, statistically insignificant effects at the lower quantiles and positive, significant effects at the upper quantiles, especially between Q80 and Q90. This trend suggests that the higher the regulatory quality, the greater the CO_2 emissions in high-emission economies with democratic institutions. There is a positive, significant correlation between population growth (POP) and CO_2 emissions at the lower quantiles, but a negative, lower, and insignificant correlation at the higher quantiles. The GDP growth (GDPG) has a modest impact on the quantiles, with very weak evidence of a negative impact at the lower end of the distribution. The regulatory quality (REGQUA) has a significantly positive and large impact across all quantiles analysed, and the coefficients of this effect are relatively consistent. The findings show that stricter regulatory frameworks are systematically associated with higher emissions. The existence of such a relationship is likely to be associated with faster economic growth in states with strong institutional resources. The heterogeneity in the effects of foreign direct investment (FDI) is evident across quantiles. However, the coefficient on FDI becomes negative and statistically significant beyond the median quantile, indicating that higher FDI inflows are associated with worse CO_2 emissions, and this trend is particularly pronounced in high-emission jurisdictions. Importantly, the relationship between democracy and the quality of regulation is negative and statistically significant at the median and above. This finding suggests that the beneficial effect of regulatory quality on CO_2 emissions is weaker in highly democratic nations and in situations that are well-endowed with high emissions.

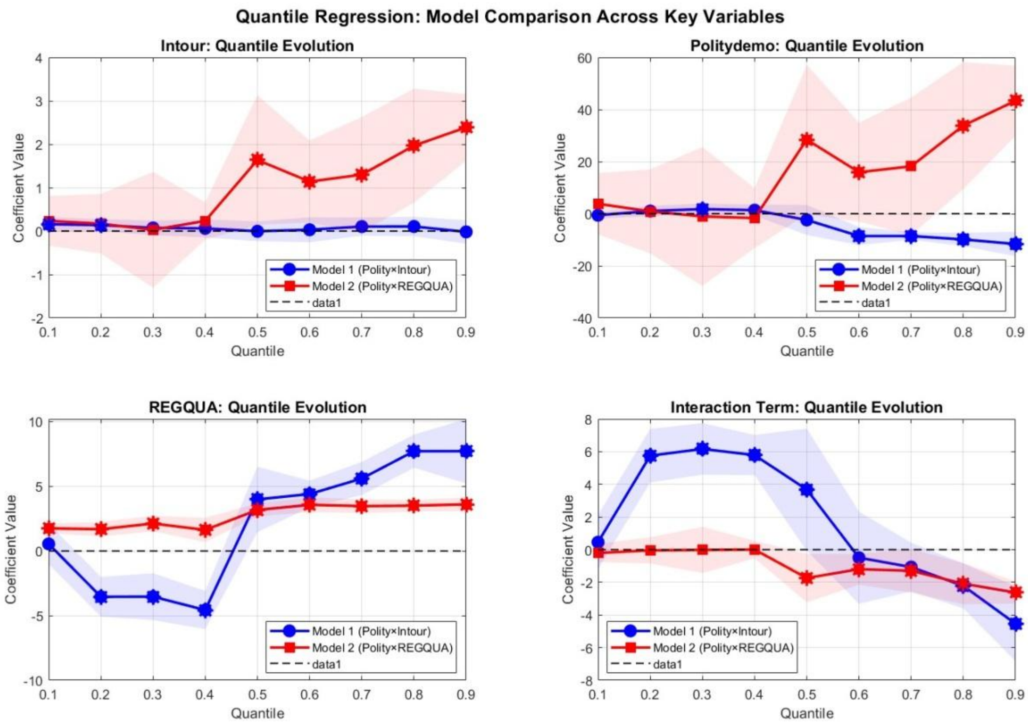

Figure 10: Quantile Regression comparison across the Key Variables

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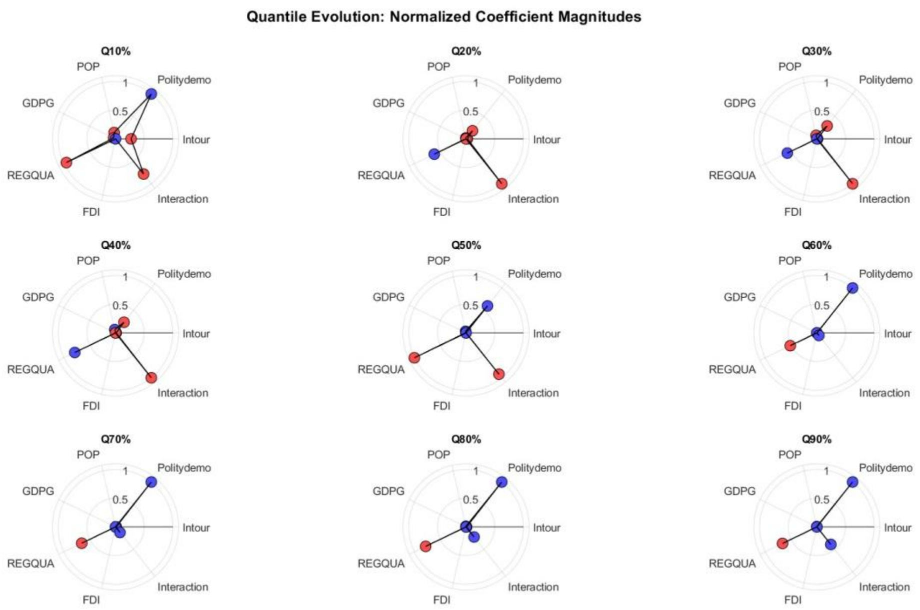

Figure 11: Quantile Regression with normalized coefficient

Conclusion

This paper explores the dynamic interplay among tourism development, institutional quality, and CO_2 emissions, employing a panel data approach that accounts for regulatory quality, democratic institutions, and key macroeconomic and demographic factors. We applied Feasible Generalized Least Squares (FGLS) and a quantile regression-based analysis, which not only estimates average effects but also accounts for distributional heterogeneity across national entities with heterogeneous levels of emissions. Evaluations of empirical data demonstrate that tourism activity has a statistically significant positive effect on CO_2 emissions, which can be explained by the fact that this activity is inherently energy-intensive, i.e., transportation, accommodation, and infrastructure. However, quantile regression findings show that this relationship differs in the spread of the emission distribution; the tourism impact is increased at the low and high quantiles of the emission distribution, depending on institutional circumstances, highlighting the context-specificity of tourism environmental impacts relative to a homogeneous impact. Further, the results show that the effects of democratic institutions and the quality of regulation on emissions are different. Even though the traditional estimates indicate a positive relationship, which could be an increase in the economic activity in the nation with well-developed institutions, the distributional analysis indicates that democracy weakens emissions in the economy with a high concentration of emissions. This trend suggests that the effectiveness of democratic accountability, transparency, and people's participation in curbing environmental degradation increases as pollution levels rise. In addition, governance quality is a key moderating variable in the interplay between tourism development and carbon emissions. The FGLS outcomes reveal a negative effect of democratic institutions, indicating that democratic institutions mitigate tourism-induced emissions. Furthermore, the quantile regression findings show that carbon emissions have a positive effect on lower quantiles, while a strong reduction in emissions occurs in higher quantiles. These findings suggest that tourism development may reduce environmental pressure, but that strong institutions can ultimately reverse these effects through effective policy implementation, social control, and regulatory quality. Similarly, the interaction between regulatory quality and democratic governance may raise emissions in relatively independent countries, but its influence is significantly weaker in high-emissions countries, where the institutions are stronger. The control variables, population and GDP growth, both positively influence CO2 emissions, indicating that they play a key role in environmental degradation, while FDI negatively influences carbon emissions, suggesting that it may contribute to cleaner technologies and energy efficiency.

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