Do Carbon Taxes Reshape International Tourism? Cross-Country Evidence on International Travel and Expenditure

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Abstract:

This paper investigates the impact of carbon taxation on cross-border tourism by distinguishing between monetary and physical measures of tourism activity. We apply two-way fixed effects (TWFE) OLS model and instrumental variable approach (2SLS) to assess the international tourism consequences of carbon taxation intensity, using a global panel of 186 countries from 1995 to 2024. Our estimates show that 1% increase in carbon tax rate is associated with 0.13% increase in outbound tourism expenditure, while evidence of an increase in outbound departures is weaker across specifications. In contrast, carbon tax intensity does not affect inbound tourism significantly. Meanwhile, we exploit variation in carbon-tax adoption timing via staggered difference-in-differences framework, while assessing changes in treatment intensity via dynamic continuous-treatment difference-in-differences. However, neither specification provides significant evidence that carbon-tax adoption affects outbound or inbound tourism outcomes. Hence, our paper provides novel global evidence that the international tourism consequences of carbon taxation are driven more by tax intensity than by adoption alone.

Keywords: Climate policy, Carbon tax, Tourism

JEL classification: H23, Q54, Q58, Z38

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1.0 Introduction

Travel and tourism emerged as world's fastest growing sector in 2025, positioning itself as one of the major components of global economy. During the same year, the sector contributed approximately US$11.6 trillion to global economy, 9.8% of global GDP (WTTC, 2026). However, this economic prominence is accompanied by a substantial environmental footprint (Sun et al., 2024). According to Environmental

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and Social Research by WTTC (2025), travel and tourism sector accounted for 7.3% of global greenhouse gas emissions in 2024.[3] Meanwhile, carbon pricing, including carbon taxes (CT) and emissions trading systems (ETS), has emerged as an appropriate policy mechanism to reduce carbon emissions (Kohlscheen et al., 2025), which encourages energy efficiency, low-carbon investment and relevant changes in production and consumption. Markedly, 80 direct carbon-pricing instruments were operating globally in 2025, covering approximately 28% of global greenhouse-gas emissions (World Bank, 2025). Nonetheless, carbon pricing may also affect tourism via higher costs regarding aviation (Fageda and Oesingmann, 2025), road-transport (OECD, 2025), electricity (IEA, 2020) and other input costs. The cost surge may thereby alter destination competitiveness, travel expenditure and the number of international travellers. In this context, investigating the potential effects of carbon taxation on tourism activity can provide evidence to guide efforts to reconcile the sector's economic contribution with its environmental costs. Accordingly, this paper addresses two questions. Are higher carbon tax rates associated with higher/lower tourism outcomes? Does carbon tax implementation have an adoption effect on tourism outcomes during the post-implementation period?

The extant literature on the effect of carbon pricing on tourism is fragmented and largely relies on ex-ante country-specific simulation models (Dwyer et al., 2013; Meng and Pham, 2015; Zhang and Zhang, 2018; Cao et al., 2021). Limited cross-country research examines how carbon tax influences tourism outcomes. Some studies report temporary reductions in arrivals, expenditure, or aviation activity; while others find weak, insignificant, or even positive effects on particular outcomes (Rotar, 2023; Doan and Nguyen, 2025); hence, the evidence is inconclusive. Our paper addresses this research gap by analysing four complementary international-tourism outcomes across the globe, using country-year panel data and alternative econometric specifications. Hence, this paper provides cross-country knowledge on whether carbon taxation affects the volume, direction and economic value of international tourism, thereby supporting integration of climate policy into tourism development planning.

We analyse a global panel of 186 countries over the period 1995 to 2024, among which 30 countries have adopted carbon tax policies. Our analysed four complementary international-tourism outcomes across the globe are: outbound tourism expenditure, outbound tourism departures, inbound tourism expenditure and inbound tourism arrivals. Finally, our sample consists of 4,783 country-year observations. We have applied two-way fixed effects (TWFE) OLS model to assess

[3] However, this emission intensity was 8.3% in 2019, demonstrates the sectors' successful decoupling of economic growth from emissions.

whether higher carbon tax rates have causal effect on international tourism outcomes. Meanwhile, we consider that causality between tourism and CO_2 emissions can be bidirectional, which may in turn prompt governments to adopt or intensify carbon taxation. Hence, we employ instrumental variable approach to mitigate this simultaneity concern from possible reverse causality. In addition, we apply staggered difference-in-differences model to exploit cross-country variation regarding the timing of carbon-tax implementation. Moreover, to compare countries experiencing changes in carbon-tax intensity with countries whose treatment had not yet changed, we have conducted a dynamic continuous-treatment difference-in-differences analysis.

Our findings provide robust empirical evidence that carbon tax rate intensity increases outbound tourism expenditure. Although the TWFE-OLS estimates provide no significant evidence that carbon-tax intensity affects outbound tourist departures, the 2SLS results provide some evidence of a significant positive effect after addressing potential endogeneity, albeit with weaker identification for this specification. Therefore, carbon tax-influenced greater purchasing power or higher domestic travel costs can enhance per-trip expenditure towards foreign destinations, although evidence on outbound trips is relatively weak. A 1% increase in carbon tax rate is associated with a 0.13% increase in outbound tourism expenditure, and 0.28% increase in outbound departures. Meanwhile, we find that changes in a destination country's carbon tax rate affect either its inbound tourism expenditure or the number of inbound tourist arrivals. The finding remains consistent with the inclusion of a COVID-19 dummy. However, our staggered difference-in-differences models findings do not provide robust empirical evidence that carbon-tax implementation affects outbound or inbound tourism outcomes, which are supported by the estimates of dynamic continuous-treatment difference-in-differences model.

Our contribution is multifaceted. First, we extend the climate-policy and tourism literature by identifying the causal effect of carbon taxation as a policy shock on cross-border tourism expenditure and mobility. Hence, our study conceptualises carbon taxation, traditionally viewed as an environmental policy instrument, as a broader policy intervention. Second, this paper provides novel global evidence that the international tourism consequences of carbon taxation depend on carbon tax intensity than on carbon tax adoption. Therefore, we distinguish between the adoption and intensity of carbon taxation. Third, this paper assesses tourism responses by jointly examining outbound tourism expenditure, outbound departures, inbound tourism expenditure, and inbound arrivals. By focusing on monetary tourism flows and physical tourist movements, we uncover an important asymmetry.

Our empirical evidence is more consistent for the intensive margin of outbound tourism expenditure, while the effect on the extensive margin of trip frequency is mixed across specifications. Finally, our study offers a robust and distinctive methodological contribution. Our paper employs multiple empirical identification strategies. While the baseline analysis employs two-way fixed-effects estimation, the paper also addresses potential reverse causality using an instrumental-variable framework. Meanwhile, we exploit cross-country differences in the timing of carbon-tax implementation through staggered difference-in-differences, and examine changes in treatment intensity using dynamic continuous-treatment difference-in-differences. Therefore, our study applies a novel integrated identification framework to disentangle the effects of carbon-tax intensity, the discrete adoption of carbon taxation, and subsequent changes in policy intensity. Accordingly, it provides a more granular assessment of how different dimensions of carbon-pricing policy influence tourism outcomes.

The remainder of the paper is organised as follows. Section 2 reviews the relevant literature on carbon taxation, climate policy, and their implications for international tourism, and identifies the research gap this study addresses. Section 3 describes the data, variable construction, sample characteristics, and descriptive statistics. Section 4 presents the empirical results, including the baseline estimates, alternative identification strategies, and robustness analyses. Finally, Section 5 concludes the paper by summarising the main findings, discussing their policy implications, and outlining directions for future research.

2.0 Literature Review

Climate policy encompasses a broad range of regulatory, fiscal and market-based interventions aimed at reducing greenhouse gas (GHG) emissions and facilitating the transition towards a low-carbon economy (IPCC, 2022; OECD, 2023). Among these interventions, carbon pricing has emerged as a prominent policy instrument, as its explicit cost assigned to emissions influences production, consumption and investment decisions (High-Level Commission on Carbon Prices, 2017; OECD, 2021). Within this broader climate-policy framework, carbon taxation has received growing policy attention because of its relatively direct pricing mechanism and its potential to encourage cleaner energy use, technological adjustment and lower-carbon economic activity (Metcalf, 2021; Parry et al., 2022; Kohlscheen et al., 2025). Its revenue provides a domestic source of funding for low-carbon investment, climate-resilient infrastructure and other mitigation measures (Marten and Dender, 2019; World Bank, 2026); thereby strengthening the financing dimension of climate policy.

Carbon tax is implemented by applying a direct price to carbon content of fossil fuel supply (Pan et al., 2024). While its coverage for global GHG emissions increased only marginally from 4% to 5% during 2016 to 2025, and revenue exhibited a modest upward trend, several jurisdictions have increased the rate, such as 80% carbon tax increase in Singapore (World Bank, 2026). Meanwhile, carbon taxation involves a trade-off between environmental benefits and associated economic costs. Because this carbon pricing method increases energy costs (Xu et al., 2023), inflationary pressures (Bettarelli et al., 2025), and unequal effects across households and industries (Wang et al., 2016). Hence, a deeper understanding of the economic and distributional effects of carbon taxation is necessary to develop environmentally effective and economically efficient climate policies.

However, extant tourism–climate literature has predominantly focused on the environmental footprint of the tourism industry (Gössling et al., 2002; Sun et al., 2020; 2022; Lenzen et al., 2018; Kohlscheen et al., 2025). Meanwhile, tourism is also vulnerable to climate change and climate policies (Rotar, 2023). Tourism industry is highly exposed to carbon-pricing policies due to its strong dependency on energy-intensive activities, such as aviation and other forms of transport (Lenzen et al., 2018). These can increase transportation and travel costs, and may therefore affect tourism demand (Tol, 2007; Boto-García et al., 2024). But relatively less attention has been given to the causal effect of carbon taxation on international tourism outcomes.

Early research on the relationship between carbon taxation and international tourism has mostly used simulation models. Using a Hamburg Tourism Model (HTM), Tol (2007) simulates international tourist flows across countries globally and shows that a carbon tax on aviation fuel could change the geographical distribution of international tourism by increasing the relative cost of air travel. Similar evidence is provided by Mayor and Tol (2010) analysing European climate policies. The authors' simulation results show carbon pricing and flight-related taxes can alter international tourist flows and destination choice. Using a dynamic CGE framework for Australia, Dwyer et al. (2013) find that carbon taxation would lead to small but significant contractions in tourism industries, with particularly strong effects on accommodation, air and water transport, and food-service activities, alongside reductions in tourism employment. Similarly, the simulation results of Meng and Pham (2017) indicate that carbon tax could reduce emissions considerably but cause a significant decline in real inbound and domestic tourism expenditure in Australia. Zhang and Zhang (2018) conduct a simulation study on the Chinese tourism industry and show that higher carbon-tax rates produce greater reductions in tourism-related CO_2 emissions, but also reduce tourism value added and

employment, with considerable heterogeneity across tourism sectors. Likewise, Cao et al. (2021) extend deterministic simulation by employing a multi-sector DSGE model for China. Their simulation results show that tourism output and emissions respond heterogeneously to carbon-tax shocks; carbon taxation tends to dampen positive economic shocks.

Notably, ex-post empirical studies assessing the factual effects of carbon-tax implementation on international tourism outcomes remain relatively scarce. Among the few studies, Rotar (2023) and Doan and Nguyen (2025) are remarkable. Rotar (2023) examines the association between carbon-tax implementation and tourism employment in European countries. In contrast to the prior simulation studies, the author finds a small but statistically significant positive relationship between carbon taxation and tourism employment. The author illustrates that carbon taxation does not necessarily have an adverse effect on tourism-sector. Meanwhile, Doan and Nguyen (2025) investigate the effects of carbon tax implementation on outbound and domestic tourism expenditure globally. This study employs a difference-in-differences model and finds that carbon tax is associated with a statistically significant reduction in domestic tourism expenditure, while effect on outbound tourism expenditure is positive but weak. The authors' suggestive evidence refers that carbon taxation raises domestic prices, and consequently leads to decreased domestic tourism consumption.

In sum, the earlier extant literature largely relies on simulation or CGE models, which focus on individual countries or concentrate mostly on Europe. Moreover, most existing studies examine either tourism expenditure or tourist arrivals rather than simultaneously distinguishing the monetary dimension of international tourism (inbound and outbound expenditure) from its physical dimension (international arrivals and departures). While Doan and Nguyen (2025) provide important global evidence in this research area, they focus on outbound and domestic expenditure. Accordingly, further cross-country evidence is required for comprehensive understanding on how carbon taxation reshapes international tourism activity. Therefore, policymakers can utilize novel knowledge to trade-off environmental objectives against the economic consequences for tourism-generating and tourism-receiving countries.

3.0 Data and Descriptive Statistics

In this paper, we have studied 186 countries over the period 1995 to 2024. We collect Carbon Tax Rate data from World Bank Carbon Pricing Dashboard[4], which

[4] https://carbonpricingdashboard.worldbank.org/about-us

is expressed in USD per metric tonne of CO2 equivalent units. Among our sample countries, 30 countries have adopted carbon tax policy. Our outcome variables are: Outbound Tourism Expenditure, Outbound Tourism Departures, Inbound Tourism Expenditure and Inbound Tourism Arrivals. These tourism data are collected from the United Nations World Tourism Organisation (UNWTO).[5] We use multiple macroeconomic variables as control variables: GDP, inflation, population, and exchange rate. These economic data are collected from World Development Indicators (WDI) database of World Bank.[6] All continuous variables are transformed using natural logarithm for scaling and reducing skewness, except inflation. Inflation is retained to annual percentage rate as it may contain either zero or negative values. Finally, we have dropped observations with missing values, which results in a sample consisting 4,783 country-year observations for 186 unique countries. Definitions of all variables are provided in the Appendix.

Table 1: Descriptive Statistics for the Global Sample

Variable	N	Mean	SD	10^{th} Percentile	50^{th} Percentile	90^{th} Percentile
Panel A: Carbon Tax Variable						
Carbon Tax Rate	393	39.642	42.936	0.820	22.619	107.784
Panel B: Tourism Outcomes						
Outbound expenditure	4783	5113.432	16294.67	24	410	12548
Outbound departure	2092	7146.402	15520.90	161	1862.50	17914
Inbound expenditure	4754	5402.656	14424.32	30	765.145	13401
Inbound arrival	3995	5672.976	12108.76	75	1018	16232
Panel C: Control Variables						
GDP	4783	18744.90	21432.96	1930.819	10803.56	46123.48
Inflation	4783	9.241	76.225	0.476	3.653	13.555
$\text{Population}_{(\text{millions})}$	4783	40.50	148	0.327	7.76	71.10
Exchange rate	4783	451.357	1827.882	0.876	8.00	693.713

[5] UN Tourism: https://www.untourism.int/how-we-are
[6] https://databank.worldbank.org/source/world-development-indicators

Table 1 reports the descriptive statistics of all continuous variables of this study, which demonstrate substantial cross-country variation in carbon taxation, tourism activity and macroeconomic conditions. Panel A of Table 1 shows mean carbon tax rate of our sample is 39.642 US$/tCO2e, and median value is 22.619 US$/tCO2e. It indicates existence of few high-tax observations resulting right-skewed distribution for carbon tax rate. In Panel B of Table 1, tourism variables also show similar positive skewness, suggesting that tourism flows and expenditures are concentrated among a relatively small group of high-tourism countries. Panel C of Table 1 shows that GDP per capita varies widely across countries, as its mean (USD 18,744.90) and median (USD 10,803.56) have relatively large gap. Standard deviation of inflation (76.23%) exhibits high dispersion across countries and presence of extreme inflation episodes. Population and exchange rate also show considerable heterogeneity across countries. However, the large differences between the means, medians and 90th percentiles support our application of logarithmic transformations for most continuous variables.

4.0 Empirical Results

4.1 Two-Way Fixed-Effects (TWFE) OLS Estimates

To assess whether countries with higher carbon tax rates are associated with higher or lower tourism outcomes, we have applied the following two-way fixed effects (TWFE) OLS model:

$$Tourism\ Outcome_{i,t} = a + \beta_1 \times Carbon\ Tax\ Rate_{i,t} + \delta' X_{i,t} + \theta + \gamma + \varepsilon_{i,t} \ldots\ldots\ldots (1)$$

Where Tourism Outcome is measured alternatively using four different variables for country *i* at year *t*: Outbound Tourism Expenditure, Outbound Tourism Departures, Inbound Tourism Expenditure and Inbound Tourism Arrivals. Carbon Tax Rate is the implemented carbon tax rate of country *i* at year *t*. We use X as a vector of control variables following the extant literature to affect tourism outcomes (Martins et al., 2017; Rosselló Nadal and Santana Gallego, 2022; Barkat et al., 2026;). Definition of these control variables is discussed in Appendix. θ and γ represent year and country fixed effects, respectively, thereby accounting for time-invariant country characteristics and common shocks across years. All variables are contemporaneous for baseline specifications.[7]

[7] To address simultaneity generating from reverse causality, we repeat OLS estimations for all specifications using lagged explanatory variables. Our results remain qualitatively consistent.

Table 2: The Effect of Carbon Tax Rates on Outbound Tourism: TWFE-OLS Model

Variables	Outbound Expenditure	Outbound Expenditure	Outbound Departure	Outbound Departure
	(1)	(2)	(3)	(4)
Carbon Tax Rate	0.1286***	0.1306**	-0.1103**	-0.0543
	(0.0395)	(0.0526)	(0.0515)	(0.0568)
GDP		0.6988**		1.7176***
		(0.3345)		(0.3098)
Inflation		0.0136***		0.0079**
		(0.0021)		(0.0035)
Population		0.7854		3.1371***
		(0.9301)		(0.6718)
Exchange Rate		-0.7423***		-0.4918*
		(0.1376)		(0.2433)
Constant	7.7724***	-10.7025	7.6225***	-58.3461***
	(0.1961)	(17.1959)	(0.6490)	(12.4138)
Observations	343	343	269	269
Adj R-squared	0.742	0.790	0.741	0.808
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

*Note: Country-clustered standard errors are shown in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

The TWFE-OLS model results are reported in Table 2 and 3, for outbound and inbound tourism respectively. Column (1) of Table 2 reports the estimated effect of carbon-tax rates on outbound tourism expenditure, while column (2) incorporates macroeconomic control variables. Across both specifications, the estimated coefficients suggest that higher carbon-tax rates are associated with greater outbound tourism expenditure. Column (1) shows a positive and statistically significant coefficient on carbon tax rate (0.1286). This estimate implies that a 1% increase in carbon tax rate is associated with a 0.1286% increase in outbound tourism expenditure, holding other factors constant. After adding macroeconomic control variables, the coefficient on carbon tax rate remains positive with higher magnitude and statistically significant (0.1306). Thus, the positive and statistically significant effect of carbon tax rate on outbound tourism expenditure is relatively robust. It

indicates that countries with higher carbon tax implementation are more prevalent in well-regulated economies, having residents with greater purchasing power and stronger capacity to travel internationally (Vietze, 2011; Best and Zhang, 2020; Linsenmeier et al., 2022;). Moreover, carbon-tax influenced higher domestic travel costs can promote substitution towards foreign destinations (Athanasopoulos et al., 2014; Doan and Nguyen, 2025).

Column (3) of Table 2 reports the estimated effect of carbon tax intensity on outbound tourism departure numbers. The results show that the estimated coefficient (β_1) of carbon tax rate is negative and statistically significant. However, results in column (4) show that inclusion of control variables leads to declined magnitude of carbon tax coefficient, which is statistically insignificant as well. Hence, there is no robust empirical evidence that carbon taxation affects outbound departure numbers.

Table 3: The Effect of Carbon Tax Rates on Inbound Tourism: TWFE-OLS Model

Variables	**Inbound Expenditure**	**Inbound Expenditure**	**Inbound Arrival**	**Inbound Arrival**
	(1)	(2)	(3)	(4)
Carbon Tax Rate	0.0444	0.0601	-0.1115	-0.0658
	(0.0645)	(0.0523)	(0.1185)	(0.0727)
GDP		0.5090**		0.2669
		(0.2108)		(0.4128)
Inflation		0.0128***		0.0169***
		(0.0034)		(0.0046)
Population		1.3024*		3.9184**
		(0.7342)		(1.6455)
Exchange Rate		-0.6491***		-0.9936***
		(0.2157)		(0.2655)
Constant	7.9602***	-17.1520	8.6521***	-55.8855*
	(0.1800)	(12.7728)	(0.4395)	(29.2602)
Observations	343	343	295	295
Adjusted R-squared	0.677	0.713	0.601	0.688
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

*Note: Country-clustered standard errors are shown in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

Table 3 reports the estimated impact of carbon tax intensity on inbound tourism. Columns (1) and (2) show estimates of inbound tourism expenditure, without and with control variables, respectively. Meanwhile, columns (3) and (4) demonstrate effect of carbon tax rate on inbound arrival numbers, without and with control variables, respectively. In all specifications of Table 3, the coefficients of carbon tax rate are statistically insignificant. Hence, there is no statistically significant empirical evidence that changes in a destination country's carbon tax rate affect either its inbound tourism expenditure or the number of inbound tourist arrivals. While carbon tax signals stronger environmental governance and a more sustainable destination image, it also increases domestic transport and accommodation costs, and other energy-intensive tourism services (Tol, 2007; Dwyer et al., 2013; Best and Zhang, 2020; Bilynets et al., 2023; Doan and Nguyen, 2025). The statistically insignificant estimates indicate that these opposing mechanisms may offset each other.

4.2 Instrumental Variable Approach (2SLS)

The association between carbon tax rate and tourism outcomes can be subject to endogeneity. Koçak et al. (2020) argue that causality between tourism and CO_2 emissions is bidirectional. Hence tourism outcomes' effect on CO_2 may affect any country's carbon tax policy. To mitigate this concern regarding simultaneity arising from possible reverse causality, we employ an instrumental variable approach. We apply country-specific average carbon-tax rate in levels over the sample period as an instrument on carbon tax rate of that country. This instrument is projected to capture the focal country's persistent long-run carbon-pricing orientation, which is expected to be strongly associated with annual variation in its observed carbon-tax rate. Meanwhile, it is predicted to be less sensitive to short-term fluctuations in tourism outcomes. For IV estimations, we apply only year fixed effect and country-clustered standard errors, as country average carbon tax rate is constant over time within each country.

Table 4: The Effect of Carbon Tax on Tourism Outcomes: IV Approach

Variables	Outbound Expenditure	Outbound Departure	Inbound Expenditure	Inbound Arrival
	(1)	(2)	(3)	(4)
Carbon Tax Rate	0.1287**	0.2812**	-0.0277	-0.1237
	(0.0602)	(0.1112)	(0.0643)	(0.0767)
GDP	1.1975***	-0.0466	1.2729***	0.8165**
	(0.3348)	(0.5592)	(0.3234)	(0.3745)
Inflation	0.0018	0.0002	-0.0057***	-0.0058***
	(0.0027)	(0.0022)	(0.0021)	(0.0021)
Population	0.7371***	0.7597***	0.7053***	0.6688***
	(0.0634)	(0.0574)	(0.0943)	(0.0764)
Exchange Rate	-0.0648	-0.1242***	-0.1079	-0.1255**
	(0.0486)	(0.0415)	(0.0675)	(0.0529)
Constant	-15.2312***	-4.5830	-15.3000***	-9.7671**
	(3.6260)	(5.6318)	(3.2153)	(3.9763)
Observations	343	269	343	295
Year FE	Yes	Yes	Yes	Yes
Country FE	No	No	No	No
Cragg-Donald Wald	263.441	122.662	263.441	193.556
KP rk Wald F	21.19	8.324	21.19	11.68

*Note: Country-clustered standard errors are shown in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

Table 4 reports the second stage regressions estimations of two-stage least-squares (2SLS) tests concerning the causal link between carbon tax rate and tourism outcomes.[8] Columns (1) and (2) show the results for carbon tax rate's effect on country's outbound tourism expenditure and departures, respectively. The instrumented carbon tax rate coefficient in column (1) is positive and statistically significant (0.1287), indicating that 1% increase in carbon-tax rate is associated with 0.13% increase in outbound tourism expenditure. Column (2) shows that the coefficient of carbon tax rate is also positive and statistically significant for outbound tourist departures (0.2812), which indicates 0.28% increase in outbound departures

[8] Estimates without control variables remain consistent with those with control variables, unreported for brevity.

following a 1% increase in carbon-tax rate. In contrast, the estimated carbon-tax coefficients for inbound tourism are statistically insignificant, reported in columns (3) and (4). Hence, the IV estimates provide evidence that carbon tax rates do not affect inbound tourism significantly, consistent with baseline OLS estimates.[9]

We also report the instrument-strength diagnostics test results for all 2SLS specifications. For cluster-robust diagnostic of instrument strength, Kleibergen–Paap rk Wald F-statistic is preferable (Kleibergen and Paap, 2006; Baum et al., 2007). Our test results exceed conventional threshold of 10, for outbound expenditure, inbound expenditure, and inbound arrivals. Hence, the diagnostics test results suggest that the instrument is valid and strong for these models. Moreover, the reported Cragg-Donald Wald F-statistics provide evidence on the strength of our instrument. Additionally, from supplementary tests (not reported for brevity), we find only weak correlations between the instrument and the tourism outcome measures, providing reassurance against a strong direct association with the outcomes. However, for outbound departures, the cluster-robust Kleibergen–Paap rk Wald F-statistic falls below the conventional threshold, although the Cragg–Donald statistic indicates stronger identification under the assumption that errors are independent and identically distributed. Accordingly, the 2SLS estimates for outbound departures are interpreted as suggestive.

4.3 Staggered Difference-in-Differences Model

To exploit cross-country variation regarding the timing of carbon-tax implementation, we employ the following staggered difference-in-differences model:

$$Tourism\ Outcome_{i,t} = a + \beta_2\, CT_{i,t} + \delta' X_{i,t} + \theta_i + \gamma_t + \varepsilon_{i,t} \ldots\ldots\ldots (2)$$

Here, countries are assigned to treatment cohorts according to their first year of carbon-tax implementation. Control or comparison group of countries are those which have not yet implemented carbon tax policy, together with countries that remain untreated throughout the study period. Accordingly, CT is a binary variable to measure carbon tax adoption:

$$CT_{i,t} = 1 \text{ if } t \geq G_i \text{ and } 0 \text{ if } t < G_i \ldots\ldots\ldots (3)$$

Here, G_i is the first year when country i implements a carbon tax policy. Once a country adopts the carbon tax policy, it remains treated for all subsequent periods.

[9] We repeat 2SLS estimations for all specifications using lagged explanatory variables. Our estimates remain qualitatively consistent, hence robust across most model specifications.

For never-treated countries, $CT_{i,t}$ remains zero throughout the sample period. β_2 represents the staggered DiD estimate of the effect of carbon-tax implementation on the tourism outcome. $X_{i,t}$ is a vector of time-varying control variables. Country and year fixed effects are represented by θ_i and γ_t, respectively. This application of difference-in-differences approach mitigates endogeneity arising from time-invariant omitted country characteristics, common year-specific shocks and potential selection bias associated with persistent country attributes (Callaway and Sant'Anna, 2021).

Table 5: The Effect of Carbon Tax Adoption on Outbound Tourism: Staggered DiD Model

Variables	Outbound Expenditure	Outbound Expenditure	Outbound Departure	Outbound Departure
	(1)	(2)	(3)	(4)
CT	-0.1097	0.0109	-0.1898*	-0.0594
	(0.1986)	(0.1716)	(0.1140)	(0.1266)
GDP		1.0616***		1.0483***
		(0.1972)		(0.2361)
Inflation		-0.0001		0.0002
		(0.0002)		(0.0003)
Population		1.2396***		1.7016***
		(0.2926)		(0.4613)
Exchange Rate		-0.0233		-0.0134
		(0.0303)		(0.0278)
Constant	5.2004***	-23.0152***	6.8198***	-29.5887***
	(0.0708)	(5.2619)	(0.0731)	(7.9749)
Observations	4,783	4,783	2,120	2,120
Adj R-squared	0.467	0.518	0.531	0.598
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

*Note: Country-clustered standard errors are shown in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

Table 5 reports the estimates of staggered difference-in-differences models assessing the effect of carbon-tax adoption on outbound tourism outcomes. Columns (1) and (2) of Table 5 show estimates on outbound tourism expenditure, without and with control variables respectively. These estimates suggest statistically insignificant relationship between a country's carbon tax adoption and outbound expenditure. Meanwhile, column (3) demonstrates a negative and statistically significant effect of

carbon tax implementation on outbound departure numbers, without control variables. But adding macroeconomic control variables offsets this statistically significant effect, reported in column (4) of Table 5. Hence, our findings do not provide robust empirical evidence that carbon-tax adoption affects outbound tourism outcomes.

The estimates of Table 5 are different from the estimates of OLS and 2SLS models presented in Table 3 and 4, respectively. These differences are attributable to differences in both the source of identifying variation and the definition of treatment. In baseline OLS specifications, we have used continuous carbon-tax rate, hence assessing the association between carbon-tax intensity and tourism outcomes. In contrast, the staggered diff-in-diff specifications employ a binary indicator for carbon-tax implementation. Therefore, these estimates assess the average change in the outbound tourism outcome following policy adoption, irrespective of the subsequent tax rate.

Table 6: The Effect of Carbon Tax Rates on Inbound Tourism: Staggered DiD Model

Variables	Inbound Expenditure	Inbound Expenditure	Inbound Arrival	Inbound Arrival
	(1)	(2)	(3)	(4)
CT	-0.0737	0.0530	-0.1582	-0.0767
	(0.1300)	(0.1318)	(0.1097)	(0.1135)
GDP		0.9014***		0.8457***
		(0.1661)		(0.1438)
Inflation		-0.0003*		-0.0003***
		(0.0002)		(0.0001)
Population		1.0927***		0.8129***
		(0.2888)		(0.2174)
Exchange Rate		0.0484		0.0408*
		(0.0326)		(0.0214)
Constant	5.4389***	-19.2963***	6.1595***	-13.6163***
	(0.0781)	(4.6394)	(0.0520)	(3.6838)
Observations	4,779	4,779	4,175	4,175
Adj R-squared	0.495	0.533	0.496	0.548
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

*Note: Country-clustered standard errors are shown in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

Table 6 presents the coefficients of staggered difference-in-differences models assessing the effect of carbon-tax implementation on inbound tourism outcomes. Columns (1) and (2) of Table 6 show estimates on inbound tourism expenditure, without and with control variables, respectively. Meanwhile, columns (3) and (4) demonstrate effect of carbon tax implementation on inbound arrival numbers, without and with control variables, respectively. Estimates of all these specifications suggest statistically insignificant association between carbon tax implementation and inbound expenditure.

4.4 Robustness Check

4.4.1 Exogenous Global Shock: COVID-19 Pandemic

As a robustness check, we treat COVID-19 as an external global shock, which markedly disrupted international tourism. International tourist arrivals worldwide declined by almost 74% in 2020 (UNWTO, 2021). COVID-19 indicator is included in the OLS models as control variable to account for the exceptional decline in tourism activity during those pandemic years. Table 7 reports the estimates.

Table 7: OLS Estimates with COVID-19 Control

Variables	Outbound Expenditure	Outbound Departure	Inbound Expenditure	Inbound Arrival
	(1)	(2)	(3)	(4)
Carbon Tax Rate	0.1306**	-0.0543	0.0601	-0.0658
	(0.0526)	(0.0568)	(0.0523)	(0.0727)
GDP	0.6988**	1.7176***	0.5090**	0.2669
	(0.3345)	(0.3098)	(0.2108)	(0.4128)
Inflation	0.0136***	0.0079**	0.0128***	0.0169***
	(0.0021)	(0.0035)	(0.0034)	(0.0046)
Population	0.7854	3.1371***	1.3024*	3.9184**
	(0.9301)	(0.6718)	(0.7342)	(1.6455)
Exchange Rate	-0.7423***	-0.4918*	-0.6491***	-0.9936***
	(0.1376)	(0.2433)	(0.2157)	(0.2655)
COVID-19	-0.6100	-1.8900**	-0.4223	-0.8717
	(0.5257)	(0.7491)	(0.3315)	(0.7507)
Constant	-10.7025	-58.3461***	-17.1520	-55.8855*
	(17.1959)	(12.4138)	(12.7728)	(29.2602)
Observations	343	269	343	295
Adj R-squared	0.790	0.808	0.713	0.688
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

*Note: Country-clustered standard errors are shown in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

In Table 7, columns (1) and (2) show estimates on outbound tourism expenditure and departure numbers, respectively. Meanwhile, columns (3) and (4) demonstrate association between carbon tax rate and inbound tourism outcomes. Covid-19 dummy takes a value of 1 for years 2020 and 2021, and 0 otherwise. The results of Table 7 suggest that effects of carbon tax rate remain qualitatively consistent with the baseline OLS results. The carbon tax rate continues to have a positive and statistically significant effect only with outbound tourism expenditure (β_1=0.1306), while its coefficients for other tourism outcomes remain statistically insignificant. Hence, the baseline OLS finding is robust after controlling for pandemic period.

Table 8: 2SLS Estimates with COVID-19 Control

Variables	Outbound Expenditure	Outbound Departure	Inbound Expenditure	Inbound Arrival
	(1)	(2)	(3)	(4)
Carbon Tax Rate	0.1287**	0.2812**	-0.0277	-0.1237
	(0.0602)	(0.1112)	(0.0643)	(0.0767)
GDP	1.1975***	-0.0466	1.2729***	0.8165**
	(0.3348)	(0.5592)	(0.3234)	(0.3745)
Inflation	0.0018	0.0002	-0.0057***	-0.0058***
	(0.0027)	(0.0022)	(0.0021)	(0.0021)
Population	0.7371***	0.7597***	0.7053***	0.6688***
	(0.0634)	(0.0574)	(0.0943)	(0.0764)
Exchange Rate	-0.0648	-0.1242***	-0.1079	-0.1255**
	(0.0486)	(0.0415)	(0.0675)	(0.0529)
COVID-19	-1.7787***	0.1373	-1.4140***	-1.4676***
	(0.4328)	(1.0522)	(0.4230)	(0.4092)
Constant	-15.2312***	-4.5830	-15.3000***	-9.7671**
	(3.6260)	(5.6318)	(3.2153)	(3.9763)
Observations	343	269	343	295
Year FE	Yes	Yes	Yes	Yes
Country FE	No	No	No	No
Cragg-Donald Wald	263.441	122.662	263.441	193.556
KP rk Wald F	21.19	8.324	21.19	11.68

*Note: Country-clustered standard errors are shown in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

Table 8 reports 2SLS estimates of carbon tax rate's effect on tourism outcomes, employing Covid-19 dummy as a control variable. The results remain qualitatively consistent with the 2SLS results (reported in Table 4).

4.4.2 Continuous-treatment Difference-in-differences Model

We have also conducted a dynamic continuous-treatment difference-in-differences model. Our paper compares countries experiencing changes in carbon-tax intensity with countries whose treatment had not yet changed, using three post-treatment effects and pre-treatment placebo effects. However, all individual and cumulative estimates were statistically insignificant, consistent with the results of staggered difference-in-differences model. Results are unreported for brevity.

5.0 Conclusion

Our study provides global evidence on how carbon taxation affects international tourism by distinguishing between carbon-tax intensity and mere adoption of a carbon-tax regime. This paper also separates monetary from physical measures of tourism activity. Our results demonstrate a clear asymmetry between outbound and inbound tourism responses. Such as, higher carbon-tax intensity is positively associated with outbound tourism activity, but has no statistically significant effect on inbound tourism outcomes. Meanwhile, the difference-in-differences analyses provide no significant evidence that the carbon tax adoption, in itself, changes either outbound or inbound tourism outcomes. This novel evidence indicates that the international tourism consequences of carbon taxation depend more on the magnitude of the tax than on whether a carbon tax has simply been introduced.

Our findings have several implications for climate and tourism policy. First, the study demonstrates that carbon tax intensity can generate cross-border tourism responses; therefore, policymakers should weigh its environmental benefits along with potential effects on international tourism expenditure, particularly in tourism-intensive economies. Second, we find that carbon tax intensity has distinct effects on tourism spending and travel behaviour, underscoring the need to consider both monetary outcomes and tourist flows when evaluating broader economic consequences of carbon pricing. Third, the limited response of inbound tourism suggests that carbon taxation does not necessarily undermine destination competitiveness. This gives decision-makers scope to pursue decarbonisation through carbon taxation while using the resulting revenues to support cleaner transport, energy efficiency, sustainable tourism infrastructure and related innovation. Finally, our evidence on heterogeneous effects of carbon tax across

inbound and outbound tourism suggests that carbon-tax policies should be tailored to country-specific tourism structures. Accordingly, decision-makers of tourism-dependent economies should therefore consider environmental objectives alongside economic efficiency and destination competitiveness. More broadly, well-designed carbon pricing, supported by effective revenue recycling and complementary investment in low-carbon tourism infrastructure, can advance decarbonisation while minimising potential adverse effects on international tourism.

However, our analysis focuses primarily on carbon taxation and therefore does not fully capture interactions with other climate-policy instruments, such as emissions trading systems, aviation-related levies and complementary environmental regulations. Future research could extend this analysis by examining these instruments as well. Moreover, while this study uses aggregate tourism expenditure and tourist-flow indicators, it does not identify the specific behavioural mechanisms through which carbon taxation affects international tourism, such as changes in airfares, destination substitution, trip duration, travel frequency or expenditure per trip. Hence, using more disaggregated tourist, country/region or transport-level data could further clarify the behavioural channels and longer-term adjustment effects of environmental taxation on international tourism.

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Appendix
Table A1: Variables Description

Variable Name	Variable Description
1. Carbon tax rate (CT)	Carbon tax rate, measured in USD per metric tonne of CO2 equivalent units (US$/tCO2e)
2. Carbon Tax Adoption (CT_treatment)	A binary variable equal to one from the first implementation year onward; and zero otherwise
3. Outbound expenditure	Outbound travel expenditure within the destination, measured in million US dollars (nominal values)
4. Outbound departure	Outbound overnight visitors or tourists, measured in thousand trips
5. Inbound expenditure	Travel expenditure in the destination, excluding international passenger transport, expressed in million US dollars (nominal values)
6. Inbound arrival	Overnight visitors or tourists, expressed in thousand trips
7. GDP	GDP per capita based on PPP, measured in current international dollars
8. Inflation	Change in the consumer price index, measured in annual %
9. Population	total domestic population
10. exchange rate	Official exchange rate, measured in local currency units per US dollar
11. Covid-19 Dummy	A binary variable equal to one for years 2020 and 2021, and zero otherwise.