Economic Prosperity and Political and Civil Freedom: Can One Offset the Other in Attracting International Tourists?

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Abstract

Economic prosperity and political and civil freedoms are important determinants of international tourism, yet their joint influence remains insufficiently understood. Using a global panel of 171 countries (2006–2024), we employ a flexible translog regression framework to examine their non-linear interactions and estimate the elasticity of substitution between them. We additionally use transfer entropy to investigate directional predictive information flow between tourism demand and its determinants. Our findings reveal that both economic prosperity and freedom are significantly associated with inbound tourist arrivals, with freedom exhibiting a larger average marginal effect. Their negative interaction suggests that the marginal contribution of either factor diminishes as the other strengthens. Substitution elasticities indicate that these factors can partially compensate for one another in many countries, although their substitutability varies considerably across countries and over time. These findings offer insights for developing tourism policies tailored to countries' economic and institutional conditions.

Keywords: Civil liberties, Economic prosperity, Elasticity of substitution, International tourism, Political freedom, Transfer entropy

1. Introduction

International tourism benefits both the tourist and the host country. Tourists derive a net positive value from travel, since the decision to travel itself reveals that expected value exceeds cost. Even a small persistent share of this surplus implies a substantial cumulative welfare benefit to sending countries, though conventional data typically do not capture them. By promoting international tourism, host countries deliver enjoyable experiences to travelers while earning foreign exchange which helps them create jobs, and raising living standards in communities whose main tradable assets are natural beauty or cultural heritage (Gökovali and Bahar, 2006). The drivers of tourist flows therefore matter beyond destination planning; they shape the broader welfare impact of tourism. This paper examines how economic capacity (ECO hereafter) and political freedom and civil liberties (CIVIL hereafter) shape inbound international tourism intensity.

Earlier studies have examined how ECO and CIVIL influence inbound tourism but have not examined how they interact in shaping it. Both factors have been shown to attract tourists. Some of these focus on ECO alone (see, e.g., Eugenio-Martin et al., 2008; Eita et al., 2011; Cho, 2010; Ozcan et al., 2017; Martins et al., 2017), while others examine CIVIL in isolation (see, e.g., Bulut et al., 2020; Cao, 2025). The few studies that include both factors (e.g., Saha et al., 2017; Ogbuabor et al., 2024) typically model these as separate, additive determinants of tourist arrivals, ignoring that tourists may treat ECO and CIVIL as imperfect substitutes in their travel decisions. This implies a gain in ECO attracts the same additional tourists regardless of the level of CIVIL, and vice versa. At an extreme, this assumption means a destination with zero or very low CIVIL could attract just as many visitors by being sufficiently prosperous. For most destinations, this is an assumption that is difficult to sustain. Tourists are likely to weigh both conditions jointly, and

improvements in one plausibly matter more when the other is present or absent. Imposing additive separability risks obscuring an interaction that may be central to tourism outcomes, particularly when the question concerns policy levers available to policymakers and private travel firms seeking to raise inbound tourist arrivals. We move beyond this restriction by modeling the two factors in a flexible form that captures their interdependence.

To see how this interdependence operates, consider two scenarios. In the first, two countries, one that protects civil liberties, another that permits arbitrary detention, each build a new international airport. In the first country, the airport connects a safe destination to the world, and arrivals rise sharply. In the second, the same airport draws fewer additional visitors because the risk of arbitrary detention continues to deter most potential tourists despite the improved connectivity. The investment is identical; the tourism return is higher where political freedom is higher. In the second scenario, two countries, one prosperous with reliable services, another with limited accommodation and unstable prices, each pass legislation guaranteeing freedom of movement for foreign visitors. In the prosperous country, tourists respond because the destination can already deliver the experience they expect. In the poor country, the same reform draws fewer additional visitors because limited services and unstable prices raise the economic risk of the trip, lowering the likelihood of actual visits. The reform is identical; the tourism return is higher where prosperity is higher. In both cases, the marginal effect of one factor changes with the level of the other. This is the interdependence that an additive specification assumes away.

The interdependence becomes visible when inbound tourism is placed in a standard demand framework where tourism demand depends on its price, tourist income, and other demand-shifting factors. The roles of ECO and CIVIL emerge once price is read as the full price in the sense of Becker (1965) – including not only monetary cost but also the costs of time, travel risk, and hassle from inadequate infrastructure. When that happens, a linearly separable specification cannot capture the interdependence. To capture these interdependence, we adopt a translog functional form (Christensen et al., 1973), where tourism intensity is modeled as a nonlinear function of ECO, CIVIL, their interaction, and controls. This functional form captures the interdependence: the marginal effect of each factor varies with the level of the other, reflecting the mechanism described above. It also lets us assess the substitutability between the two factors, offering policymakers and private firms a basis for strategic action.

The tourism return to a prosperity-driven improvement depends on political freedom, and the return to a political reform depends on prosperity. In addition, the translog yields a measure of substitutability between the two factors. This indicates how far a country can offset a deficit in one by strengthening the other without reducing tourism intensity. Unlike standard specifications that fix this measure at a single value, the translog allows it to differ across countries and over time, revealing where the two factors act as substitutes and where both are jointly necessary. The degree of substitutability carries direct policy implications. Where substitutability is high, a country with limited political freedom can partially compensate through strong economic conditions. Policymakers in such settings can prioritize whichever reform is less costly to implement. Where substitutability is low, strengthening one factor alone may yield little additional return or even reduce it, signaling that both dimensions require simultaneous attention. The translog framework thus moves the analysis beyond estimating whether each factor matters. It asks how they combine, and what tradeoffs policymakers face in shaping tourism outcomes.

The results show that ECO and CIVIL shape tourism both directly and through their interaction, with the effect of CIVIL roughly three times that of ECO. ECO matters for destination demand, but as a steady contributor rather than a primary lever – a pattern that holds across both economic levels and freedom levels. For instance, if Brazil reached the freedom of expression and belief observed in the United States or the United Kingdom, the marginal effect would be substantially

larger. Low-income countries gain most by advancing ECO and CIVIL in parallel. On substitutability, the results show that ECO and CIVIL are partial substitutes in attracting tourists. In 2024, the estimated substitutability between ECO and CIVIL is 1.25 at mean explanatory-variable values, indicating mild gross substitutability. Most countries with interpretable estimates also show modest substitutability. Improvements in one dimension may partly compensate for limited progress in the other, allowing countries to place greater emphasis on whichever is easier to improve.

Rest of the paper is structured as follows. A succinct account of existing literature is in Section 2. We present our theoretical framework in Section 3 while the methodological details are explicated in Section 4. Results along with necessary discussions and policy implications are illustrated in Section 5. The paper concludes with some important remarks in Section 6. Auxiliary materials are deferred to the Appendix.

2. Literature review

Existing literature on this subject has several studies which have focused on how tourism in a country depends on the prevailing economic and freedom conditions, but most of these studies have researched only one of these two factors in detail.

Several researchers have studied the effect of a country's economic strength on its inbound tourist arrivals. Turner and Witt (2001) and Crouch (1994a) showed that a country's economic strength, national income in particular, is a significant influencing factor for its inbound tourism. Eita et al. (2011) explored the relationship between economic strength of South Africa and its inbound tourism. Using data from 1999 to 2007, the authors established that income and infrastructure conditions positively influence inbound tourism. In addition to establishing economic development as a significant factor, Eugenio-Martin et al. (2008) also found that the marginal effects of economic strength are non-linear in their effect on inbound tourism. Later, Cho (2010) established that tourism demand is highly heterogeneous across source regions and that non-economic destination characteristics play a significant role alongside traditional economic factors. This article also provided practical implications for destination management and policy, suggesting that tourism promotion and infrastructure investment should be tailored to the preferences of specific origin markets. Ozcan et al. (2017) explored the causality between a country's economic growth and its tourism. In another detailed study, Martins et al. (2017) examined the impact of key macroeconomic variables such as World GDP per capita, nominal exchange rates, and relative prices, on global tourism demand using a panel of 218 countries from 1995 to 2012. They distinguished between tourism quantity (arrivals) and tourism value (real expenditures per arrival and per GDP), and found that arrivals respond most strongly to global income, while expenditures are more sensitive to relative prices. Their results showed that low and middle-income countries are particularly responsive to price competitiveness, whereas high-income countries' arrivals are more influenced by world income. In a more recent study, Yerdelen Tatoglu and Gul (2020) assessed the determinants of international tourist flows between destinations by using the panel gravity model. Using data from 30 originating countries to the 14 most visited countries during 2008 to 2016, they found that economic factors such as income and trade were significant determinants of tourist arrivals.

Note that the above studies restrict the analysis to economic variables, and do not include a perspective on the effect of a country's political and civil freedom conditions on its tourism. To that end, we first refer to Su and Lin (2014) who showed how a country's inbound tourism is impacted by world heritage sites prevailing there. In an earlier work, Caruana and Crane (2011) used critical discourse analysis to argue that perceptions and constructions of freedom greatly influence the experience of tourists, but they lacked appropriate empirical evidence. Saha et al. (2017) contributed with an assessment of the impact of political and economic freedom on inbound tourism by taking

data from more than 110 countries for the years 1995–2012. They utilized country-level fixed-effects to control for other factors that contribute to inbound tourism, and evaluated the isolated impact of political and economic freedom, which was identified to be significantly positive. In another similar study, Bulut et al. (2020) investigated the impact of freedom conditions of a country, i.e., the effects of political rights and civil liberties on tourist arrivals; but this study was limited to the eight countries with the highest tourist arrivals in 2016. Further, Cao (2025) recently found that tourism demand is driven more by institutional and cultural factors than spatial proximity. Ogbuabor et al. (2024) also highlighted the role of institutional quality in tourism, especially tourism involving FDI and trade.

Interestingly, despite the growing body of research examining the roles of economic conditions and institutional or freedom-related factors in shaping international tourism, a unified analytical framework that jointly evaluates these influences remains largely absent in extant literature. There have been few attempts at analyzing the impact together, and these studies are limited in scope. For example, Kubickova (2016) researched the effects of a country's economic and freedom conditions on its tourism, but only focused on the Central American countries. Demir and Gozgor (2019) expanded the geographic scope by studying 160 countries for the period from 1995 to 2016, but in addition to the economic factors, only the effects of the freedom of the press was examined, not the freedom of people in a general sense. More recently, for emerging economies, Corne et al. (2024); Zhao et al. (2025) found that strong natural and cultural resources and price competitiveness compensate for weak governance and low-quality infrastructure; whereas in advanced economies, good governance and high-quality tourism infrastructure enable strong performance despite high prices. We particularly note the importance of institutional quality, economic freedom, and policy related factors in shaping international tourism demand (Agbola et al., 2020). Although prior studies have estimated income and price elasticities of tourism demand (Peng et al., 2015), they have treated economic and institutional factors as additively separable, without explicitly examining how these forces interact or substitute for one another in influencing tourist arrivals. Outside the tourism domain, Goel and Nelson (2005) explored the interplay between economic and political freedom in the context of corruption, but their inferences were based on coefficient-based comparisons rather than a formal elasticity-based framework. Motivated by this gap, the present study analyzes the joint impact of economic conditions and political and civil freedom on inbound tourism at a global scale. We adopt a flexible statistical framework that allows nonlinear interactions between economic strength and freedom conditions, and we explicitly estimate the elasticity of substitution between these factors in shaping inbound tourism demand. Overall, this article contributes to the tourism literature by moving beyond isolated effect estimation and providing a systematic, elasticity-based assessment of how economic and institutional conditions interact in determining international tourism flows across countries and over time.

3. Theoretical framework

3.1. The implicit price of tourism

A trip abroad has two kinds of costs for tourists. The first is the money the tourist pays for flights, hotels, meals, and local services. The second is the time, effort, and riskiness involved with the trip. Becker (1965) formalized these time, effort, and risk components in his theory of the allocation of time, developed in a different context. The price relevant to consumer choice is not the market price alone but the full price, which sums the pecuniary outlay and the money-equivalent value of the non-pecuniary inputs.

For a tourist visiting country j, the full price takes the form

$$P_j^{\text{full}} = P_j^{\text{money}} + \lambda T_j + \mu R_j + \nu H_j, \tag{1}$$

where P_j^{money} is the market cost of the trip, T_j is travel and waiting time, R_j is a risk index covering crime, instability, health hazards, and H_j is a hassle index covering infrastructure quality, visa friction, and language barriers. The parameters λ, μ, and ν convert each non-pecuniary input into money-equivalent units. DeSerpa (1971) extended Becker's framework to handle cases where time enters the activity itself rather than appearing only as a cost, which is the natural setting for tourism.

The demand for tourism to country j takes the general form

$$A_j = D(P_j^{\text{full}}, I, \mathbf{Z}_j), \tag{2}$$

where A_j is total tourist arrivals to country j, I is tourist income, and $\mathbf{Z}_j$ collects other demand-shifting factors.

Understanding the interaction and their joint effects on the full price requires identifying what kind of good tourism is. Existing empirical evidence shows that tourism is a luxury good. Peng et al. (2015) report an average income elasticity of 2.526 across 195 studies, well above the unit threshold that defines luxury status[1]. Higher elasticities appear for long-haul leisure travel, and lower values appear for short trips (Crouch, 1994b; Song and Li, 2008). The luxury classification implies that tourism is a normal good, meaning $\partial D/\partial I > 0$. A fall in the full price therefore raises the quantity demanded through both the substitution and income effects, $\partial D/\partial P^{\text{full}} < 0$, lifting inbound tourism.

3.2. Host country characteristics as implicit price shifters

Host-country characteristics are unlikely to determine tourist income, though tourists at different income levels may self-select across destinations. They change the non-pecuniary components of the full price in equation (1). Two host characteristics matter for our purpose.

ECO (denoted by E_j), measured by GDP per capita and related indicators, lowers T_j and H_j. Better infrastructure, more reliable services, and higher-quality accommodation reduce the time and effort the tourist must spend on logistics. Khadaroo and Seetanah (2007); Seetanah and Khadaroo (2009) document the role of transport and tourism infrastructure in attracting international visitors. On the other hand, CIVIL (denoted by F_j) lowers R_j. Stable institutions, predictable rule of law, and low risk of arbitrary action reduce the risk premium attached to the destination. Neumayer (2004); Saha and Yap (2014) show that institutional quality and political stability are significant determinants of international tourism flows. These relationships take the general form

$$T_j = T(E_j, F_j), \quad H_j = H(E_j, F_j), \quad R_j = R(E_j, F_j), \tag{3}$$

with $\partial T/\partial E \leqslant 0$, $\partial H/\partial E \leqslant 0$, $\partial R/\partial E \leqslant 0$, $\partial T/\partial F \leqslant 0$, $\partial H/\partial F \leqslant 0$, and $\partial R/\partial F \leqslant 0$. Each mapping is assumed twice-differentiable. No restriction is placed on the second derivatives or cross partials; the curvature of these mappings and the degree of channel overlap between E_j and F_j are left to the data.

As (3) shows, both characteristics enter the demand function through the price channel. The tourist's money income is unchanged. What changes is the full price of visiting country j, which falls

[1] This income elasticity implies that a one percent increase in income raises tourism by 2.53 percent.

as E_j, F_j rise. Demand responds through two channels. The substitution effect redirects spending toward country j, which has become relatively cheaper in full-price terms. Other destinations and other forms of consumption look more expensive by comparison, and the tourist reallocates accordingly. The income effect operates through the budget constraint. The tourist's money income has not risen, but the lower full price expands the set of consumption bundles they can afford. Their real purchasing power increases even though the nominal income has not. Since tourism is a normal good, the income effect reinforces the substitution effect rather than offsetting it (Peng et al., 2015). Both push tourist arrivals to country j upward. Substituting (3) into (1), and the resulting full price into demand equation (2) yields a reduced-form arrival function. Tourism intensity, defined as arrivals per capita, $Y_j = A_j/N_j$ (where N_j is the host-country population) is then

$$Y_j = Y\left(E_j, F_j, I, \mathbf{Z}_j\right).$$

3.3. Substitution between economic capacity and political freedom

Both ECO and CIVIL lower the full price of visiting country j, but they act through different components of P_j^{full}. Economic capacity reduces the time and hassle costs T_j and H_j. Political freedom reduces the risk premium R_j. The two work on the same object – the implicit price – through partially overlapping channels. This raises a natural question. Can a country compensate for weakness in one dimension through strength in the other? A high-income country with weaker political freedoms and civil liberties may still lower P_j^{full} through superior infrastructure and predictable services. A lower-income country with stronger democratic institutions may lower P_j^{full} through the risk channel. Whether the two characteristics are interchangeable in their effect on tourist arrivals depends on how their channels interact.

The formal object that captures this is the elasticity of substitution between E_j and F_j along an iso-arrival contour. Fix a level of tourist arrivals per capita, $\bar{T}$. The contour $\{(E_j, F_j) : T(E_j, F_j) = \bar{T}\}$ traces all combinations of economic capacity and political freedom that attract the same number of tourists per capita. The slope of the contour gives the marginal rate of substitution,

$$\text{MRS}_{E,F} = \left.\frac{dF_j}{dE_j}\right|_{T=\bar{T}} = -\frac{\partial T/\partial E_j}{\partial T/\partial F_j}. \tag{4}$$

The elasticity of substitution measures how this slope changes as the country moves along the contour:

$$\sigma_{EF} = \frac{d\ln(F_j/E_j)}{d\ln|\text{MRS}_{E,F}|}. \tag{5}$$

A large σ_{EF} means the contour is flat and the two characteristics substitute easily. A small σ_{EF} means the contour bends sharply and the two reinforce each other.

The economic content is straightforward. If ECO and CIVIL work on P_j^{full} through overlapping channels, the marginal contribution of one falls as the other rises. The two appear as substitutes. A wealthy country and a free country can attract the same number of tourists, each through its own channel of price reduction. If the channels reinforce each other – if infrastructure delivers more when institutions are stable, or if institutions deliver more when infrastructure is in place – the marginal contribution of one rises with the level of the other. The two appear as complements. Countries that advance on both dimensions together gain disproportionately. Figure 1 illustrates this phenomenon graphically through an iso-arrival contour map in (E, F) space. In this figure, each curve traces combinations of economic capacity and political freedom that produce the same level of tourist arrivals per capita. Higher curves correspond to higher arrivals. The slope at any point is the marginal rate of substitution defined in (4). The curvature reflects σ_{EF} in (5). The

shape of these contours depends on the curvature and cross-partials of the mappings in (3), which the theory leaves unrestricted. A second-order Taylor approximation of $\ln Y_j$ in $(\ln E_j, \ln F_j)$ yields the translog specification used in the estimation (see equation (8)).

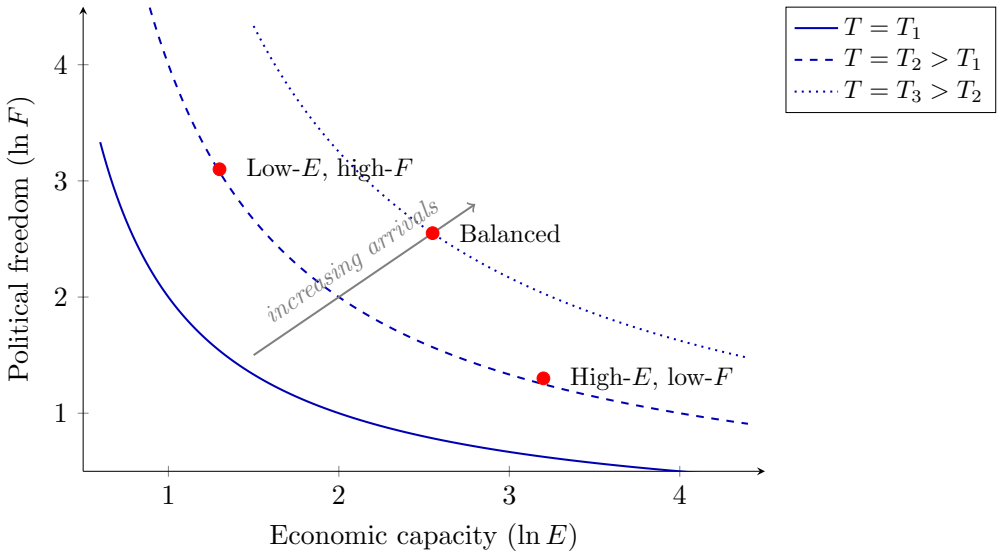


Fig. 1: Iso-arrival contours in the space of host economic capacity and political freedom. Each curve gives combinations that yield the same tourist arrivals per capita. The curvature measures the ease with which one characteristic substitutes for the other along the contour. The three labeled points lie on the same contour, showing that countries can reach a given level of arrivals through different combinations of E and F.

4. Material and methods

4.1. Data and exploratory analysis

We take the above-mentioned framework to cross-country data spanning 2006 to 2024 and conduct an in-depth analysis. The data come from three widely used sources: (1) the United Nations World Tourism Organization's (UNWTO) Tourism Statistics Database[2]; (2) the World Development Indicator[3]; and (3) Freedom House[4]. The raw data, while comprehensive, do not arrive in a form suited to the analysis. We therefore construct the outcome variable (tourism intensity) and the main explanatory variables (ECO and CIVIL) to align with the analytical framework.

4.1.1. Dependent variable: tourism intensity

The UNWTO publishes a cross-country database covering inbound, domestic, and outbound tourism, along with data on tourism industries, employment, and related indicators. Drawing from this database, we use inbound tourist numbers to construct our main outcome variable. While prior work has employed tourism revenue for a similar purpose (Martins et al., 2017; Saha et al., 2017), we argue that tourist counts offer a more faithful representation of demand. Revenue captures both price and volume simultaneously, meaning that a shift in the cost of tourism-related goods or services can alter revenue even when arrivals remain unchanged. Tourist counts isolate the volume dimension and thus provide a more direct basis for empirical analysis.

[2]Available at https://www.unwto.org/tourism-statistics/key-tourism-statistics.
[3]Available at https://data.worldbank.org/.
[4]Available at https://freedomhouse.org/report/freedom-world.

Raw counts, however, pose a challenge in cross-country settings. Larger countries tend to attract more visitors simply because of their size, and differential population growth can further distort comparisons over time. To address this, we divide the total number of inbound tourists in a given year by the host country's population in that same year. The resulting measure, hereafter called 'tourism intensity', strips out the scaling effect and yields a comparable indicator across nations. This formulation also serves a substantive purpose beyond comparability. Public revenue from tourism ultimately flows to the population through various channels of redistribution. A per capita measure therefore captures what inbound demand means for the average resident, rather than for the country in aggregate. Tourism intensity thus ties our outcome variable more closely to the welfare dimension of tourism, connecting arrivals to their potential economic benefit at the individual level.

The visualization in Figure 2 provides an idea of tourist arrival patterns and how these have changed over the years. For ease of reference for the reader, a map of the continents in the world, along with some selected large countries, is presented in Figure 3[5]. For example, we observe that, in the years prior to 2020, the tourism intensity was high for Canada, Central American countries, the European nations, and sporadically a few countries from Asia, Africa and South America. Evidently, arrivals reduced across the globe during the COVID-19 pandemic. Qu et al. (2026) showed how international tourism dynamics were affected by the pandemic and how recovery patterns changed across countries. Interestingly, from the plot of the year 2020, it is clear that the numbers were maintained only in the European nations, potentially due to different types of travel restrictions for countries within Europe (Neumayer et al., 2021).

4.1.2. Explanatory variables (ECO and CIVIL)

The primary explanatory variables we study are from two categories: economic strength and freedom conditions. Specifically, we consider every country's GDP per capita, year-over-year ratio of Consumer Price Index (which serves as a proxy for inflation), and a scientific index to reflect freedom conditions of a country. These choices are guided by the understanding that the fundamental drivers of tourism, such as a country's natural geography and cultural heritage, are largely exogenous and immutable in the short to medium term. While geographic features are inherently fixed and cannot be changed, cultural characteristics take a very long time (hundreds of years) to evolve. As these intrinsic drivers of tourism cannot be manipulated, the feasible way of increasing tourism demand is to focus on improving access to tourist destinations. This can be achieved both through infrastructure investments as well as favorable regulatory environments. Developing and maintaining tourism-related infrastructure is easier for countries with higher economic strength, while higher levels of freedom, both political and civil, translate to ease of travel and reduced regulatory barriers for foreign tourists. Moreover, people perceive societies with higher levels of freedom to be less riskier and more open and welcoming, and hence prefer to travel to these places.

The economic indicators – GDP per capita and the Consumer Price Index (CPI) – for every year and country are sourced from the World Bank Database. Next, these indicators are converted to suitable covariates to be used in our regression model. First, we take the GDP per capita lagged by one year, as economic conditions in the preceding year are more likely to influence current tourism demand. Second, we calculate the CPI ratio, defined as the ratio of the current year's CPI to the previous year's CPI. This ratio serves as a proxy for inflation while ensuring the variable remains

[5]Note: All maps in this paper are generated using the `ggplot2` package in `R`, with geographic boundary data from the `maps` package. Country boundaries and territorial designations are shown for illustrative purposes only and may not reflect current or disputed international borders; no position regarding territorial claims or sovereignty is implied.

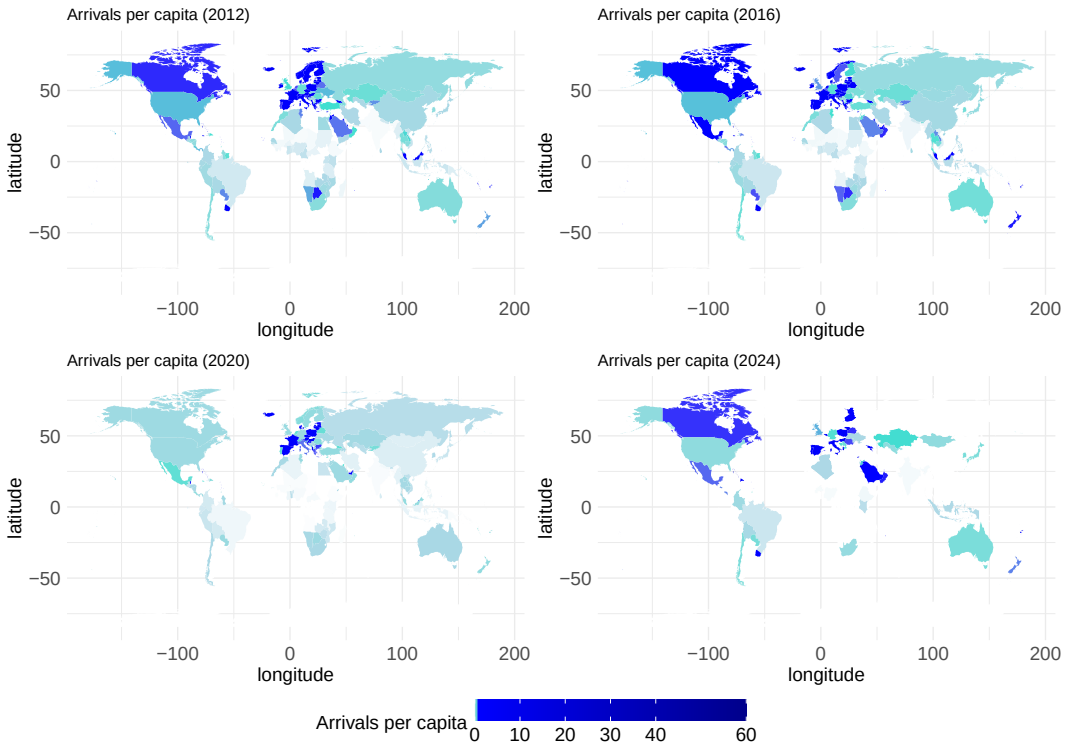


Fig. 2: Distribution of tourism intensity (captured by arrivals per capita) for all countries in the world.

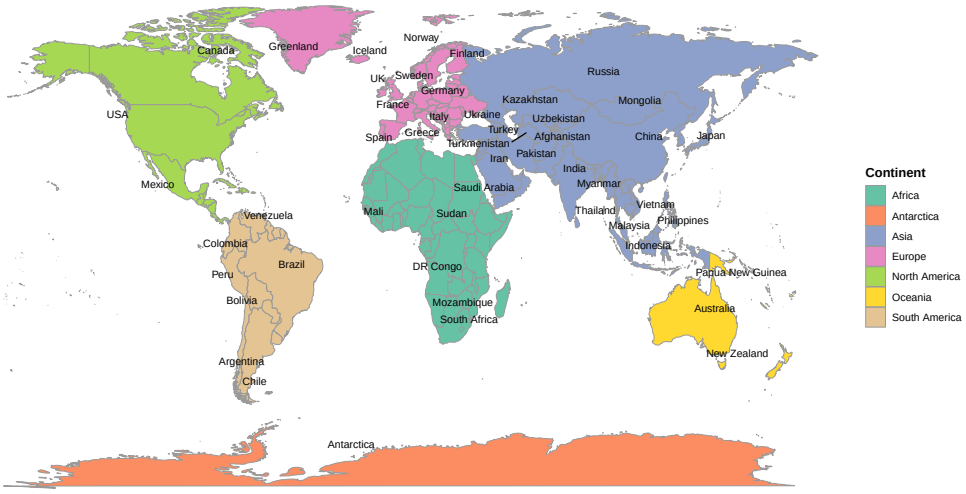


Fig. 3: A map of all the continents (shown using different colors) and some selected countries in the entire world.

strictly positive, an essential requirement for compatibility with the translog production function used in our estimation framework.

Data on political freedom and civil liberty at country and year level are obtained from Freedom

House, an organization dedicated to promoting democracy and protecting human rights. Freedom House compiles data on various aspects of political and civil liberties across countries and assigns scores based on these data. These scores are reported across seven dimensions: under political rights, the subcategories are (A) electoral process, (B) political pluralism and participation, and (C) functioning of government; under civil liberties, the subcategories include (D) freedom of expression and belief, (E) associational and organizational rights, (F) rule of law, and (G) personal autonomy and individual rights.

A correlation analysis between these scores indicates that these scores are highly correlated. A multivariate correlation plot illustrating this has been presented in the appendix (Appendix Appendix A). Considering this, to avoid running into issues due to the multicollinearity present in this data, we choose to combine the individual scores into a single variable. To that end, we turn to the popular approach of principal component analysis (PCA) which is a linear dimensionality reduction technique with applications in exploratory data analysis, visualization and data pre-processing (Abdi and Williams, 2010). Though a simple average could have been taken to construct the consolidated freedom indicator, we feel that this would not be the right approach as each of the freedom scores has different ranges and averaging them directly would lead to an unsuitable weighting strategy. PCA, on the other hand, is concerned with explaining the variance-covariance structure of a set of variables via suitable linear combinations, known as the principal components (PCs). The variable this constructed is hereafter denoted as FI or 'freedom index'. The mathematical construction of this variable, for brevity, is deferred to Appendix Appendix A.

We further recognize that in addition to the economic and freedom measures, there may be other important determinants of tourism demand, such as specific attractions, security conditions, environmental quality, infrastructure, marketing efforts, or visa policies, that are not captured explicitly in our model, potentially biasing coefficient estimates. Our study covers data from 171 countries and the inherent characteristics of each country can significantly influence its tourism demand. Certain countries consistently attract tourists regardless of their economic performance or freedom status, often due to the presence of natural attractions, cultural heritage, or religious pilgrimage sites. Conversely, some countries may receive limited tourist inflows even if they are economically prosperous and politically free. To account for these intrinsic, time-invariant differences across countries, we include historical inbound tourist arrivals as a baseline control variable (note that complete information for our main analysis is available 2006 onward). This variable is referred to as 'tourism baseline' in our analysis. Descriptive statistics of this and the other covariates mentioned above are presented in Table 1. These statistics provide insight into the central tendency and dispersion of key variables influencing international tourist arrivals per capita. Note that a logarithmic transformation is applied to all variables barring tourism interest to mitigate skewness and to allow elasticity-based interpretations in the subsequent regression analysis. The table also shows the correlations between the dependent variable (Arrivals per capita) and the four main covariates. We can see that the response variable is significantly correlated with all the explanatory variables. Specifically, we observe that it is positively correlated with GDP per capita, Freedom Index, and tourism baseline, while negatively correlated with the CPI ratio.

The dependent variable, arrivals per capita, has a mean of 0.5492 and a relatively high standard deviation (0.6660), suggesting considerable heterogeneity in tourism intensity across regions. The distribution is right-skewed, with a maximum value of 4.2801, indicating the presence of high-tourism destinations. This is further substantiated by the pronounced dispersion of the tourism baseline variable. Broadly, it implies significant variation in global or regional interest in tourism, possibly driven by seasonal, event-based, or location-specific surges in attention. The dispersion in GDP per capita, which is used as a measure for economic development, suggests notable income differentials across countries or regions in the sample. Lagging this variable helps mitigate concerns

Table 1: Descriptive statistics and correlation (all variables are log-transformed i.e. log(1+x) except for tourism baseline).

Variable (x)	Mean	Standard Deviation	Minimum	Maximum	Correlation coefficient			
					GDP	CPI	FI	TB
Arrivals per capita	0.5492	0.6660	< 0.001	4.2801	0.57^{***}	-0.25^{***}	0.33^{***}	0.80^{***}
GDP per capita (GDP)	8.6824	1.5355	< 0.001	11.6299	-	-0.31^{***}	0.47^{***}	0.60^{***}
CPI ratio (CPI)	0.7165	0.0673	< 0.001	2.0245	-	-	-0.20^{***}	-0.26^{***}
Freedom index (FI)	4.1519	0.1665	3.7161	4.3538	-	-	-	0.32^{***}
Tourism baseline (TB)	1.5210	5.6091	0.0011	71.4043	-	-	-	-

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

of simultaneity and reverse causality. The CPI ratio, reflecting relative consumer prices, has a narrower spread but a slightly longer right tail, highlighting that in some cases, elevated domestic price levels may act as a deterrent to inbound tourism. Finally, the freedom index variable that captures civil and political freedom is found to be concentrated in the range 3.7161 to 4.3538. A strong correlation with the response variable is suggestive of its explanatory power, in line with the hypothesis that democratic institutions and civil liberties positively influence tourist inflows. Overall, these descriptive statistics provide early evidence of meaningful relationships between the covariates and tourism.

4.2. Information flow between macroeconomic indicators and tourism

The theoretical framework above claims that ECO and CIVIL shape inbound tourism demand, but the reverse direction is also plausible. Higher tourism contributes directly to GDP and therefore to ECO. Sustained exposure to tourists may also broaden the host country's openness and tolerance, eventually reflected in its CIVIL measures. Regression analysis captures correlations rather than causal directions, so the data must support the directionality the specification assumes: ECO and CIVIL drive tourism intensity, not the reverse. As a measure of directional predictive dependence, we examine the information flow between ECO, CIVIL and other macroeconomic indicators and tourism by estimating the transfer entropy (TE) between these series. This helps in examining the directional relationships between tourist arrivals per capita and the other indicators (GDP per capita, CPI ratio and FI). For a comprehensive understanding, the analysis is done across the full sample, as well as during the pre-COVID period and the post-COVID period separately.

In statistical literature, TE provides a directional, information-theoretic measure of the influence of one stochastic process on another (Schreiber, 2000). Specifically, it quantifies how much knowledge of the past of one process, say $U = (U_t)_{1 \leqslant t \leqslant n}$, improves the prediction of the future state of another process $V = (V_t)_{1 \leqslant t \leqslant n}$, beyond what is already explained by the past of itself. In other words, TE captures deviations from the conditional independence condition $V_{t+1} \perp U_t \mid V_t$. Mathematically, TE from U to V is defined as

$$\mathrm{TE}_{U \to V} = \sum_{v_{t+1}, v_t, u_t} p\left(v_{t+1}, v_t, u_t\right) \log \frac{p\left(v_{t+1} \mid v_t, u_t\right)}{p\left(v_{t+1} \mid v_t\right)}, \tag{6}$$

for discrete-valued variables, and the summation is replaced by an integral for continuous-valued variables. Equation (6) can be expressed as an expectation under the joint distribution $p(v_{t+1}, v_t, u_t)$:

$$\mathrm{TE}_{U \to V} = \mathbb{E}_{p(v_{t+1}, v_t, u_t)} \left[\log \frac{p(v_{t+1} \mid v_t, u_t)}{p(v_{t+1} \mid v_t)} \right].$$

Indeed, from the above formulation, we can see that transfer entropy is the expected Kullback–Leibler (KL) divergence (Kullback and Leibler, 1951) between two conditional probability distributions:

$$\mathrm{TE}_{U\to V} = D_{\mathrm{KL}}\big(p(v_{t+1} \mid v_t, u_t) \,\big\|\, p(v_{t+1} \mid v_t)\big)\,,$$

averaged over the joint distribution of (u_t, v_t). Conceptually, this measure can be interpreted as a conditional mutual information, i.e., TE represents the expected information gain about the future of V obtained from observing the past of U, beyond the information already contained in the past of V. In this sense, transfer entropy may be succinctly described as the expected KL divergence between two predictive models: one that includes the source process and one that does not.

4.3. Regression analysis

We rely on a regression model as our main framework for estimating how ECO and CIVIL affect inbound tourism intensity. The efficacy of each factor, however, often depends on the other. A simple additively separable linear regression cannot capture this interdependence. A production function framework, by contrast, provides a natural structure for modeling how these factors interact in shaping tourism outcomes. Accordingly, let tourism intensity, $\log Y$, be a function of a vector of explanatory variables:

$$\log Y = f(\mathbf{X}, \Theta) \tag{7}$$

where $\mathbf{X} = (E, F, I, \mathbf{Z})$ includes economic and political and civil freedom indicators alongside other determinants; and Θ is the vector of model parameters. The function f specifies how these factors combine to produce the outcome.

Estimating (7) requires a specific functional form, and we adopt the translog production function for this purpose. Our analysis demands a specification capable of three things: identifying whether each factor independently contributes to tourism intensity, measuring the degree to which one factor can substitute for the other, and permitting these relationships to vary across countries and time. Standard alternatives such as the Cobb-Douglas and Constant Elasticity of Substitution specifications satisfy the first of these objectives but fall short on the remaining two, as both constrain the elasticity of substitution to a fixed value across all observations. The translog form relaxes this constraint. By allowing the elasticity of substitution to vary with the data, it accommodates all three analytical objectives within a unified specification. The translog form also has precedent in tourism research. Croes et al. (2018, 2021) employed it to examine the link between tourism specialization and economic growth, while Bakkal and Scaperlanda (1991) used it to study price elasticity of tourism demand across countries.

In its general form, the translog production function for the response variable Y takes the following specification:

$$\log Y_{j,t} = \alpha_0 + \sum_i \alpha_i \log X_i + \delta_t t + 1/2 \sum_{i_1} \sum_{i_2} \beta_{i_1 i_2} \log X_{i_1} \log X_{i_2} + \sum_i \gamma_{it} \log X_i t + 1/2 \delta_{tt} t^2,$$

where X_is represent the covariates, t indicates the time period, and $\beta_{i_1 i_2} = \beta_{i_2 i_1}$ for $i_1 \neq i_2$.

In this study, we consider the dependent variable $Y_{j,t}$ that denotes the inbound tourist arrivals per capita in the j^{th} country at the t^{th} year, where $t = 1, \ldots, 19$ corresponds to the years 2006 to 2024. The primary three covariates included in the regression model are GDP per capita, the composite Freedom Index, and the CPI ratio (we consider the lagged values of the GDP per capita and the Freedom Index to evaluate their impact on the following year's tourism). In general, the value of the i^{th} covariate for the j^{th} country at the t^{th} year is going to denoted by $X_{i,j,t}$, where

$i = 1, 2, 3$ represent the above-mentioned three covariates in order. At this point, we highlight that the translog production function requires all input variables to be strictly positive (to permit log transformation). That is automatically ensured for GDP per capita and CPI ratio, and for the freedom index (FI), which is computed from the projection of freedom related indicators using PCA, Lemma 1 guarantees the same.

Next, to control for other extraneous factors, we include fixed effects for every continent and for the COVID-19 pandemic. The latter one is used to capture the sharp global decline in international tourism following the outbreak in 2020, as documented by several authors (e.g., Škare et al., 2021; Qu et al., 2026). On the other hand, Papagianni et al. (2024) studied the impact of geopolitical risk shocks on tourism demand, and found it to be a significant influencing factor, explaining up to 77% of tourism variance in some countries and hence warranting consideration in tourism forecasting as well as policy design. Though studies in this domain commonly employ country-level or country-year fixed effects to account for inherent geographical factors influencing tourist arrivals (Ogbuabor et al., 2024; Saha et al., 2017), we instead adopt continent-level fixed effects. This approach mitigates the risk of overfitting while still capturing broad geographical influences on tourism demand. Also, since the variable CIVIL exhibits limited country-wise variation over time, country-year fixed effects would absorb most of the variation resulting in imprecise estimates and inflated standard errors for the other variables. Considering these factors, for our analysis, the proposed model is structured as follows:

$$\log Y_{j,t} = \alpha_0 + \sum_{i=1}^{3} \alpha_i \log X_{i,j,t} + \delta_1 t + \frac{1}{2}\delta_2 t^2 + \frac{1}{2}\sum_{i_1=1}^{3}\sum_{i_2=1}^{3} \beta_{i_1 i_2} \log X_{i_1,j,t} \log X_{i_2,j,t} + \sum_{i=1}^{3} \gamma_i t \log X_{i,j,t} + \theta \mathbb{1}(t > 14) + \sum_{r=1}^{5} \eta_r \mathbb{1}(j \in \mathcal{C}_r) + \zeta \, \mathrm{TB}_j + \epsilon_{j,t} \tag{8}$$

where $\mathbb{1}(\cdot)$ is an indicator function which takes the value 1 when the condition is true and 0 otherwise, θ is the COVID fixed effect which is applied for years after 2019, η_r is the fixed effect for the r^{th} continent (denoted as $\mathcal{C}_r$) where r takes values 1 to 5 for the continents Asia, Europe, North America, Oceania and South America respectively (note that Africa is kept as the baseline), and TB_j is the tourism baseline value for the j^{th} country. Although the model controls for continent-level differences and historical tourism patterns, the estimated relationships should be interpreted as conditional associations and not identified causal effects.

The estimated parameters from (8) allow us to address all three questions: whether each factor independently contributes to tourism intensity and by how much, what the degree to which one factor can substitute for the other is, and how these relationships can vary across countries and time. Specifically, the impact of each individual factor on tourism intensity, can be assessed through the partial derivative:

$$\frac{d \log Y_{j,t}}{d \log X_{ijt}},$$

which can be evaluated using the data along with estimated β and γ coefficients. It measures the percentage change in tourism intensity associated with a one percent change in either economic or political freedom.

To quantify the substitutability between economic conditions and freedom in influencing inbound tourism, we compute the elasticity of substitution between inputs using the translog production function estimates. The translog specification is a second-order flexible functional form

that allows for variable elasticities across observations. Following the method outlined by Henderson and Quandt (1971), the elasticity of substitution between two inputs, say X_1 and X_2, can be derived using first and second partial derivatives of the production function. Let Y denote the output (in our case, the inbound tourist arrivals per capita), and X_1 and X_2 represent the two input variables (GDP per capita and the Freedom Index). Then, the relevant partial derivatives to compute marginal productivity with respect to X_1, X_2 and their rates of changes are defined as

$$f_1 = \frac{\partial Y}{\partial X_1},\ f_2 = \frac{\partial y}{\partial X_2},\ f_{11} = \frac{\partial^2 Y}{\partial X_1^2},\ f_{22} = \frac{\partial^2 Y}{\partial X_2^2},\ f_{12} = f_{21} = \frac{\partial^2 Y}{\partial X_1 \partial X_2},$$

which leads to

$$e_s = \frac{f_1 f_2 (f_1 X_1 + f_2 X_2)}{X_1 X_2 \left(2 f_{12} f_1 f_2 - f_1^2 f_{22} - f_2^2 f_{11}\right)}. \tag{9}$$

This expression reflects the percentage change in the input ratio (X_1/X_2) divided by the percentage change in the marginal rate of technical substitution (MRTS) between the inputs, holding output constant. It makes it possible to calculate the elasticity of substitution at a particular point on an isoquant for any production function for which the first and second derivatives exist. A higher value of e_s implies greater ease of substitution between the two inputs, while a lower value suggests complementarity. Overall, by estimating this elasticity for each country-year observation using the fitted translog coefficients, we are able to investigate how the economic and institutional conditions interact to shape inbound tourism, and whether these relationships differ across countries with varying levels of political and civil freedom.

A detailed interpretation in our context is of the essence here. Inclusion of the cross-product terms $\log X_{i,r,t} \log X_{j,r,t}$ in (8) allows the translog model to capture interaction effects between the explanatory variables. In particular, the interaction between the GDP per capita and the Freedom Index represents how the economic environment and institutional conditions jointly influence tourism demand. The sign and magnitude of the estimated coefficient β_{12} provide the first indication of whether these factors act as *substitutes* or *complements* in attracting international tourists. A positive β_{12} suggests that improvements in freedom amplify the positive impact of economic prosperity on tourism (and vice versa), while a negative β_{12} would indicate that improvements in freedom would lower the proportional positive impact of economic prosperity on tourism (and vice versa).

The elasticity of substitution e_s (Hicks-Macfadden) computed for each country-year observation provides a quantitative summary of this interaction. Values of $e_s > 1$ (gross substitutes) indicate greater ease of substitution than the Cobb–Douglas benchmark, meaning that economic prosperity can more readily compensate for lower freedom (or vice versa), while values of $0 < e_s < 1$ (gross complements) indicate more limited substitutability between economic conditions and freedom. Negative values typically indicate that the function fails to satisfy the required regularity conditions and therefore cannot be meaningfully interpreted. The flexibility of the translog specification enables these elasticities to vary across countries and time periods, reflecting how the interplay between economic and institutional drivers of tourism evolves in response to global events, regional integration, or domestic policy changes.

5. Results and discussions

This section presents the empirical results obtained from the transfer entropy as well as the regression analysis to ascertain the influential effects of economic strength and freedom levels on inbound tourism demand. The transfer entropy based analysis in Section 5.1 reveals the presence

of influence of the macroeconomic factors over inbound tourism of a country, while the translog function form of the regression model enables us to account for and estimate non-linear relationships and interactions between the two factors (economic strength and freedom level), as well as the interaction effects of these factors individually with time. The results from this analysis in Section 5.2 enable us to gain a comprehensive understanding of how these factors jointly impact tourism demand. Subsequently, from the regression estimates, we calculate the elasticity of substitution between these two factors, which helps us identify substitutional and complementarity patterns between these two dimensions.

5.1. Evidence of information flow between tourism and macroeconomic indicators

From the results of the information transfer analysis based on transfer entropy calculations presented in Table 2, we can see that in the time period before the COVID-19 pandemic, we observe significant directional information transfer from GDP to arrivals, while no reverse information transfer is observed. On the other hand, significant information transfer from tourist arrivals to CPI ratio is observed, indicating that relative price levels could have been influenced by inbound tourism demand. The Freedom Index showed no significant information transfer to arrivals. In the post-COVID period, except for the transfer entropy from GDP per capita to tourist arrivals, all other transfer entropy values were negligible. However, the sample size for this period is too small to make any reliable statistical inference. For the full sample (before as well as after COVID-19), GDP per capita had a significant effect on tourist arrivals, while the relationship between tourist arrivals and the CPI ratio is observed to be bidirectional. Overall, the empirical results suggest that tourism arrivals are strongly influenced by macroeconomic factors, particularly GDP per capita of a country. This highlights how broader economic conditions play a key role in shaping tourism flows and suggests that policymakers should take these factors into account when designing strategies for tourism development and recovery.

Table 2: Transfer entropy between arrivals per capita and macroeconomic indicators. Arrows indicate the direction of information flow. Significance: $p < 0.001$ (***), $p < 0.01$ (**), $p < 0.05$ (*), and $p < 0.1$ (.).

Period	V		U	Transfer entropy	p-value
All data	Arrivals per capita	←	GDP per capita	0.0037	0.0067 (**)
	GDP per capita	←	Arrivals per capita	0.0009	0.2000
	Arrivals per capita	←	CPI Ratio	0.0020	0.0767 (.)
	CPI Ratio	←	Arrivals per capita	0.0028	0.0267 (*)
	Arrivals per capita	←	Freedom Index	0.0000	0.3400
	Freedom Index	←	Arrivals per capita	0.0000	0.5633
Before COVID	Arrivals per capita	←	GDP per capita	0.0078	< 0.0001 (***)
	GDP per capita	←	Arrivals per capita	0.0000	0.8233
	Arrivals per capita	←	CPI Ratio	0.0010	0.1500
	CPI Ratio	←	Arrivals per capita	0.0036	0.0167 (*)
	Arrivals per capita	←	Freedom Index	0.0006	0.2333
	Freedom Index	←	Arrivals per capita	0.0000	0.9000
After COVID	Arrivals per capita	←	GDP per capita	0.0263	< 0.0001 (***)
	GDP per capita	←	Arrivals per capita	0.0000	0.6300
	Arrivals per capita	←	CPI Ratio	0.0017	0.2967
	CPI Ratio	←	Arrivals per capita	0.0022	0.1933
	Arrivals per capita	←	Freedom Index	0.0000	0.7067
	Freedom Index	←	Arrivals per capita	0.0000	0.9533

5.2. Estimation from the translog regression analysis

Table 3 reports the estimates from the regression analysis described in Section 4.3. The individual coefficients are inputs to a broader pattern rather than standalone results, so the discussion centers on ECO and CIVIL — the host-country conditions that shape destination demand. The remaining covariates serve as controls. Recall that GDP per capita and FI act as proxies for ECO for CIVIL respectively, and enter the regression in linear, quadratic, and interaction forms. The pattern across these terms tells a clear story. The linear as well as quadratic terms of GDP per capita are significant, and its interaction with FI is significant as well. FI shows a similar pattern with its linear and quadratic terms and its interaction term with GDP per capita turning out to be statistically significant. Taken jointly, the significant coefficients establish ECO and CIVIL as meaningful drivers of destination demand.

Table 3: Output of the translog regression model given in (8). The x sign indicates interaction effect, and FE stands for 'fixed effect'. Significance is based on p-values: <0.001 (***), <0.01 (**), <0.05 (*), and <0.1 (.).

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	12.7195	7.3393	1.73	0.0832	.
Time	−0.0234	0.0599	−0.39	0.6960	
$\text{Time}^2/2$	0.0044	0.0011	3.98	0.0001	***
GDP	1.2376	0.1922	6.44	< 0.001	***
FI	−8.2390	3.4136	−2.41	0.0159	*
CPIRatio	−5.2925	3.7098	−1.43	0.1538	
FI x Time	−0.0051	0.0123	−0.41	0.6799	
GDP x Time	−0.0007	0.0014	−0.51	0.6125	
CPIRatio x Time	0.0374	0.0389	0.96	0.3364	
$\text{FI}^2/2$	2.5475	0.8363	3.05	0.0023	**
$\text{GDP}^2/2$	0.0338	0.0040	8.55	< 0.001	***
$\text{CPIRatio}^2/2$	0.2005	0.3880	0.52	0.6054	
FI x CPIRatio	1.2352	0.8951	1.38	0.1677	
GDP x CPIRatio	−0.0603	0.0501	−1.20	0.2289	
GDP x FI	−0.3231	0.0489	−6.60	< 0.001	***
Tourism Baseline	0.0548	0.0016	35.01	< 0.001	***
(Continent FE)Asia	−0.0120	0.0291	−0.41	0.6791	
(Continent FE)Europe	0.2080	0.0302	6.88	< 0.001	***
(Continent FE)North America	0.3687	0.0318	11.60	< 0.001	***
(Continent FE)Oceania	0.0009	0.0392	0.02	0.9814	
(Continent FE)South America	−0.1801	0.0385	−4.68	< 0.001	***
COVID FE	−0.4348	0.0429	−10.14	< 0.001	***

The control variables tell a more selective story. Time and the CPI ratio, in their various forms, remain statistically insignificant, the only exception being the time indicator in its quadratic form. The continent fixed effects do not — and this is expected, since geographic and climatic differences across continents shape the destinations tourists choose. Relative to Africa, North America and Europe have higher tourism intensity, while South America have less; Asia and Oceania do not differ significantly from the African baseline. The negative COVID dummy confirms the pandemic's expected mark: tourism intensity fell in the post-COVID period.

5.3. Robustness checks

To assess the reliability of our regression results, we conduct a series of robustness checks focusing on both the overall model fit and the stability of coefficient estimates under alternative data

partitions. For each setting, we compute three different metrics: the coefficient of determination or R^2, root mean squared error (RMSE) and mean absolute percentage error (MAPE). Detailed formulae about these metrics are given in Appendix Appendix B. The first one (R^2) measures the proportion of total variation in the dependent variable explained by the model. We note that R^2 captures explanatory power, while the other two metrics are useful to assess predictive ability. Between them, RMSE is expressed in the same units as the dependent variable, making it directly interpretable in terms of prediction error magnitude. Because it squares the residuals, the larger errors are penalized more heavily, making it particularly useful when large deviations are undesirable. MAPE, meanwhile, is scale-independent, allowing for comparison across models and datasets with different units or magnitudes. Together, these metrics provide a comprehensive evaluation framework.

Numerically, the proposed model, when implemented on the complete dataset, yields an R^2 of 0.5861, indicating a reasonably good fit given the cross-country, panel structure of the data. We then test the model on three different train-test splits. The first setting (hereafter denoted as $\mathbb{S}_1$) keeps the data from year 2019 as test data and all observations up to year 2018 are used as training data. For the second setting ($\mathbb{S}_2$), we randomly select 20% of the observations as test data and use remaining 80% for training. For the final setting ($\mathbb{S}_3$), observations corresponding to randomly selected 10% of all countries are taken as test data and the remaining 90% countries' data are used for training. These settings help assess our model's performance across different dimensions of generalization, including temporal stability, robustness to random sampling, and cross-country heterogeneity. The R^2, RMSE and MAPE values observed in test setting $\mathbb{S}_1$ are 0.6145, 0.4865 and 0.3879 respectively. These numbers for the test settings $\mathbb{S}_2$ and $\mathbb{S}_3$ are 0.5825, 0.4361, 0.3071; and 0.5915, 0.4245, 0.3156 respectively. From the results of these robustness checks, we see that the model performance is fairly consistent across all three settings, showing that it is not unduly sensitive to temporal or cross-sectional splits in the data and maintains predictive accuracy across different subsamples.

We further examine the stability of our estimated coefficients under alternative data stratification. When the dataset is divided into two groups based on the median GDP per capita, the regression coefficients in both subsamples remain consistent in magnitude and direction with those obtained from the full sample. A similar pattern is observed when the data is split above and below the median value of the Freedom Index, further supporting the robustness of our findings. To reinforce these results, we also make use of bootstrapping to assess the consistency of coefficient estimates across repeated resampling. The estimated parameters remain stable, providing additional confidence in the reliability of our regression results.

5.4. Impact: Marginal effects

The coefficients in Table 3 are not directly interpretable in isolation. Because ECO and CIVIL enter the regression nonlinearly, their effect on tourist arrivals operates through marginal effects computed from the full set of estimates. Table 4 presents these effects and reveals how host-country conditions translate into destination demand.

The average marginal effect of ECO is 0.14: a one percent rise in GDP per capita raises tourist arrivals per capita by 0.14 percent, holding other factors constant. The economic impact is modest. A three percent rise in GDP per capita – within recent growth rates in many emerging markets — translates into a 0.42 percent increase in tourist arrivals per capita, or roughly 42000 additional visitors annually, using Australia in 2018 as a reference scale, with a population of approximately 25 million and 10 million inbound tourist arrivals. Political freedom tells a different story. The average marginal effect of CIVIL is 0.37 – more than double the effect of ECO. A one percent improvement in the freedom index raises tourist arrivals per capita by 0.37 percent, translating to roughly

37,000 additional visitors annually at the same reference scale. Considering Brazil and Kenya in the same year (2018), the corresponding increases are approximately 28,000 and 8,500 additional visitors, respectively, for a three percent rise in GDP per capita, and 24,500 and 7,500 additional visitors, respectively, for a one percent improvement in the freedom index. These numbers become particularly useful in countries' decision making, which is illustrated in later sections.

5.5. Impact heterogeneity

The average marginal effect summarizes the overall pattern, but it obscures the variation that policy actually confronts. Countries differ widely in economic and institutional conditions, and effects that hold on average can mask large differences across groups. For policy choices to be effective, the relevant marginal effect is the one that applies to the country or group in question, not the one that applies to the sample mean. Table 4 reports marginal effects across subsamples that capture this variation. The effect of GDP per capita varies across countries' income distribution. Column 1 shows marginal effects of log(GDP per capital) ranging from 0.11 to 0.17 across the bottom four quartiles. The narrow band confirms what the average reports: regardless of economic prosperity level of a country. A one percent rise in GDP per capita lifts inbound tourism by no more than 0.17 percent. The pattern holds when we slice the sample by political freedom instead. Across the bottom four quartiles of the freedom index, the marginal effect of GDP per capita ranges from 0.11 to 0.19 – again a narrow band. Economic prowess matters for destination demand, but it appears to be a slow and steady contributor rather than a primary lever – a finding that holds across both GDP levels and freedom index.

Table 4: Average Marginal Effects of log(GDP per capita) and log(Freedom Index)

Average Marginal Effect	log(GDP per capita) (ECO)	log(Freedom Index) (CIVIL)
Entire dataset	0.1396	0.3685
Quartile 1 of log(GDP)	0.1060	0.7636
Quartile 2 of log(GDP)	0.1412	0.3832
Quartile 3 of log(GDP)	0.1398	0.3289
Quartile 4 of log(GDP)	0.1713	-0.0016
Quartile 1 of log(FI)	0.1916	0.0133
Quartile 2 of log(FI)	0.1236	0.5417
Quartile 3 of log(FI)	0.1126	0.5682
Quartile 4 of log(FI)	0.1305	0.3516

The heterogeneity in the effect of freedom index is substantial and patterned. Across the bottom four quartiles of the freedom index, the marginal effect ranges from 0.013 to 0.568, following an inverted-U shape: low at the extremes, high in the middle. The pattern reflects how tourists evaluate civil liberties. Below a threshold of tolerable conditions, marginal improvements hardly matter; above it, additional freedoms add little when the country is already open. The marginal returns concentrate where institutional change crosses thresholds that matter to travelers — the moderate range of the freedom index. The pattern by economic prowess is sharper. Among countries in the lowest quartile of GDP per capita, the average marginal effect of freedom index is 0.764 — by far the largest effect in the analysis. The effect declines through the middle quartiles to 0.3 to 0.4 and fades to insignificance at the top. Poor countries gain the most from institutional reform, and the policy implication is direct. GDP per capita is usually a long term outcome of policy changes and reforms, and is not easily changed in the short term. Institutional quality, however,

can be more directly influenced through democratic transitions in a relatively short term (Méon and Sekkat, 2022). This makes the freedom index – civil liberties and political freedom, the more actionable and efficient lever for inbound tourism in low-income contexts. In continuation of this, Figure 4 makes the patterns explicit through simulated data.

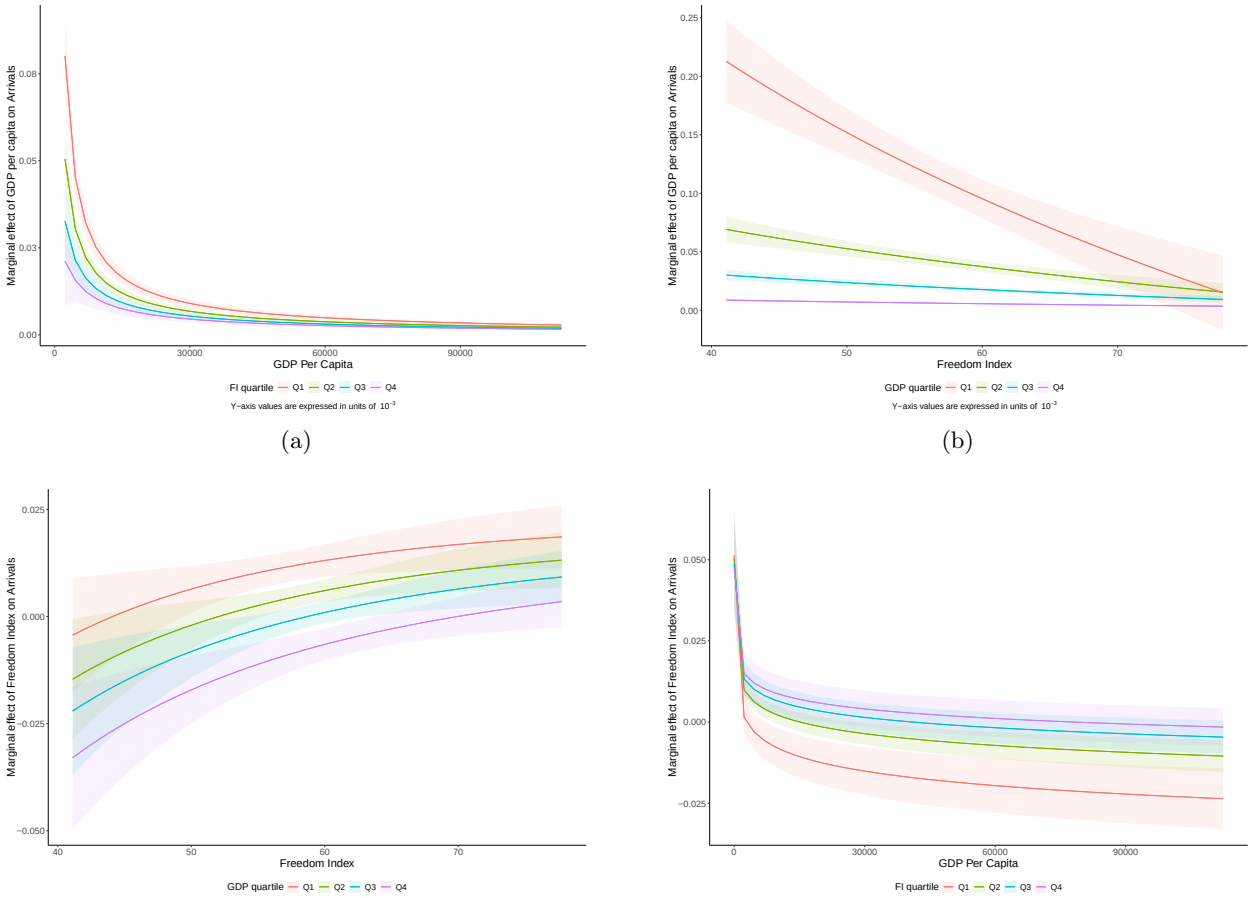


Fig. 4: Quartile-wise marginal effects of GDP per capita and Freedom Index

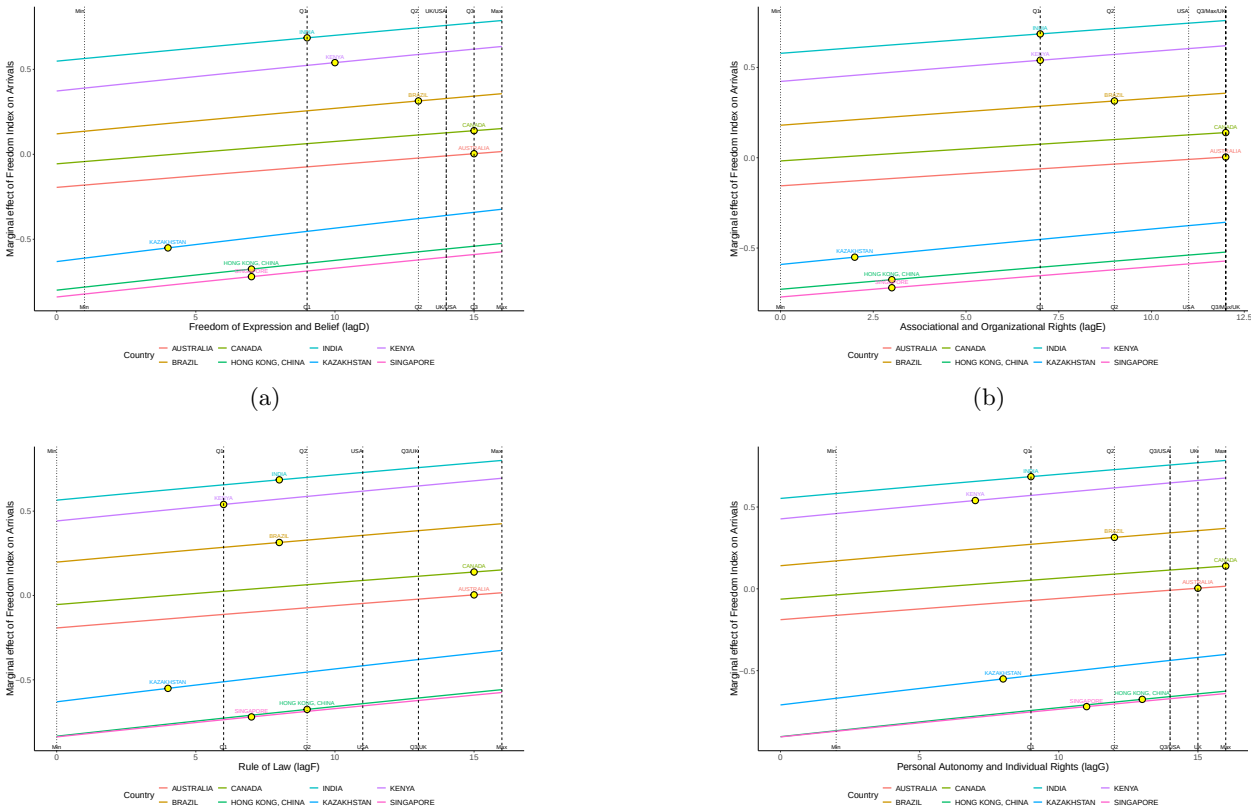
Panel (a) plots the marginal effect of ECO against the level of GDP per capita. The effect is the highest at low GDP per capita, drops sharply, and then flattens. Economic growth contributes meaningfully to inbound tourism in poor countries, but the contribution fades quickly as the country gets richer. Thus, beyond a moderate threshold, GDP per capita ceases to be a meaningful driver. The asymptotic shape holds across freedom-index levels, though for any given GDP per capita, the marginal effect of ECO is larger in less-free countries. Panel (b) tells a related but sharper story. At low levels of the freedom index, the marginal effect of GDP per capita is concentrated in the poorest quartile of countries; the other quartiles look similar, and the effect declines uniformly as freedom rises. The substitution between economic capacity and political freedom is most active when a country is poor. Once the freedom index improves, the leverage of GDP per capita weakens — institutional change crowds out the economic channel rather than complementing it. Tourism strategy in low-income countries should pursue economic development and institutional reform in parallel, not in sequence. Waiting for growth before building political freedom and civil liberties forfeits tourism gains that would otherwise be available.

The freedom index effect rises with freedom itself, but in a concave manner. Panel (c) of Figure 4 makes this clear. The shape looks counterintuitive at first, but it reveals something specific about how tourists choose destinations. The largest tourism gains accrue to countries that have already established moderate institutional openness, not to the least-free ones, where additional reform struggles to register with potential visitors. Tourists evaluate destinations against a minimum acceptable threshold. Below it, incremental reform moves few visitors; above it, the gains are real but progressively smaller. The pattern is invariant to income level, indicating that the mechanism operates through perception and consideration rather than through wealth. Panel (d) mirrors the structure of Panel (b). The marginal effect of freedom declines as GDP per capita rises, and the decline is uniform across freedom levels. Freedom delivers its largest tourism returns when GDP per capita is low — and the returns concentrate at the very low end of the income distribution, fading as countries grow richer. Combined with the threshold result in Panel (c), the policy target sharpens: institutional reform pays best in poor countries that have already cleared the basic-openness threshold, not those still well below it. For this group, political freedom is the most efficient lever available for inbound tourism.

The results establish that economic capacity and political freedom shape tourism both directly and through their interaction. These findings clarify the underlying dynamics of the relationship. For policymaking, however, they raise a measurement challenge that complicates the design of actionable plans. GDP per capita is a natural metric: dollars are dollars, and growth rates carry direct meaning. The freedom index does not work this way. It ranks countries on freedom rather than measuring it, and its magnitude does not reveal the underlying degree of political freedom and civil liberties in a country. A move from 2 to 3 on the index does not represent the same institutional change as a move from 6 to 7. When that happens, it remains unclear how much political freedom and civil liberties must rise in real terms, or which specific reforms would deliver that rise, to produce the projected gain in inbound tourism. The limitation is not specific to the freedom index. It applies to index measures generally, which order observations without anchoring them to a common interpretable values. The quartile-wise analysis sharpens the interpretation of the effects, but it still falls short of providing direction when actionable plans are required.

To address this complication, we adopt a more direct approach. We ask what the marginal effect would be if a country with a low freedom index reached the level of a specified high-freedom country. This reframing introduces a concrete reference point. The policies, institutional arrangements, and reforms that produced the higher freedom score in the reference country are observable, which gives the lower-freedom country a tangible model for action — a set of policy choices to emulate, rather than an abstract movement along an index, in pursuit of a specified tourism gain.

Figure 5 plots the marginal effects across the four components of the freedom index: freedom of expression and belief, associational and organizational rights, rule of law, and personal autonomy and individual rights. These plots shows the same rising pattern observed earlier — the marginal effect increases with the level of the freedom index. The component-level view adds something the aggregate analysis could not. From the plot in panel (a), we see that, at its current level of freedom of expression and belief, Brazil's marginal effect is slightly positive: a one percent rise in this component would deliver a small gain in inbound tourism. If Brazil reached the level of freedom of expression and belief observed in the United States or the United Kingdom, the marginal effect would be substantially larger. Reforms that move Brazil toward this reference level would therefore raise the tourism return on each subsequent improvement, not merely deliver a one-time gain. Panels (b), (c), and (d) show the same pattern for the remaining three components.



(a) (b)

(c) (d)

Fig. 5: Country-wise marginal effects of components of the Freedom Index

5.6. Choosing between economic and institutional reform

Changing either economic capacity or political freedom involves costs, and these costs differ across countries. This raises a direct question: can a country compensate for weakness on one dimension through strength on the other, or must it invest in both? The framework developed here answers this question through the elasticity of substitution along the iso-arrival contour, which measures how readily the two characteristics trade off in attracting inbound tourism. The direct elasticity of substitution between ECO and CIVIL, which holds all other inputs constant, ranges from 1.25 in 2024 to 3.81 in 2007 when evaluated at each year's mean of every input in the translog function. ECO and CIVIL are therefore gross substitutes at these points (Henningsen et al., 2021). A country that finds GDP growth difficult but institutional reform tractable can pursue the latter to expand inbound tourism, and the reverse holds equally. The average masks country-level variation and should not be applied uncritically to any specific case. What it establishes is the broader principle: focused improvement on a single dimension can lower the full price of the destination sufficiently to raise inbound tourism, without requiring simultaneous gains on both.

Unrestricted translog estimates often violate regularity conditions (monotonicity or quasi-concavity) at some data points, and the direct (Hicks–McFadden) elasticity of substitution can then fall outside its theoretical range of zero to infinity. The usual practice is to interpret the elasticity only where both conditions hold. Figure 6 shows how the direct elasticity of substitution and the other variables of interest vary across countries in 2024. In this year most elasticity estimates lie within the range of zero to infinity that the regularity conditions imply. The first map in the figure shows

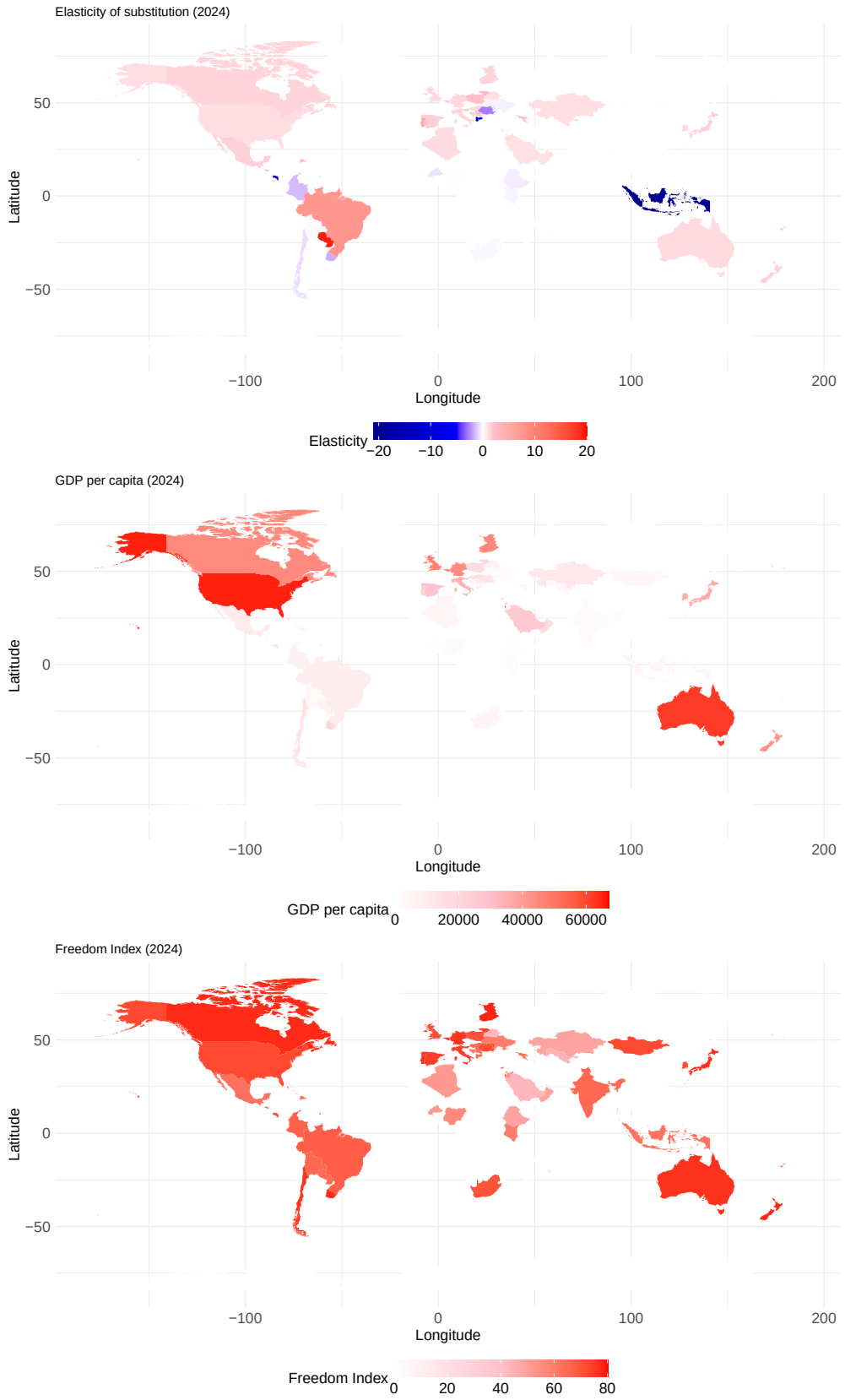


Fig. 6: Geographic distribution of the elasticity of substitution between ECO and CIVIL, GDP per capita, and Freedom Index in 2024.

the estimated values of elasticity of substitution of countries, with blue shades indicating negative values and red shades indicating positive values. We see that except for a few countries, almost all countries have a positive value of elasticity of substitution. Across all 63 countries in 2024, the country-specific estimates average 0.56, but this average includes countries where the elasticity estimates are negative. In the 45 countries (71%) where the elasticities are positive, the estimates average 2.23. Like the estimate of 1.25 at the mean of the inputs, this exceeds one, implying ECO and CIVIL are gross substitutes. The second and third maps show the distribution of GDP per capita and Freedom Index across countries in the same year. From the three figures, we observe that countries with high levels of ECO and CIVIL enjoy positive elasticities of substitution which decrease with increase in either of these factors. Countries with either of these factors being very low have negative elasticities, suggesting that one of these factors might be below a certain threshold value and hence these countries cannot expect to improve tourism demand by focusing on improving the other factor alone.

Figure 7 shows how the distribution of elasticity of substitution has evolved over the years in the study period. The share of countries with positive estimates of elasticity rises gradually from 47% in 2007 to 71% in 2024. In every year, the average of these positive estimates exceeds one, ranging from 1.47 to 3.85. ECO and CIVIL are therefore gross substitutes on average in every year, although some individual countries have estimates between zero and one. Though the full dataset covers 171 countries, the elasticity analysis uses the country-year observations for which the necessary inputs are available, and annual proportions of positive elasticities are computed over the countries with available estimates in each respective year.

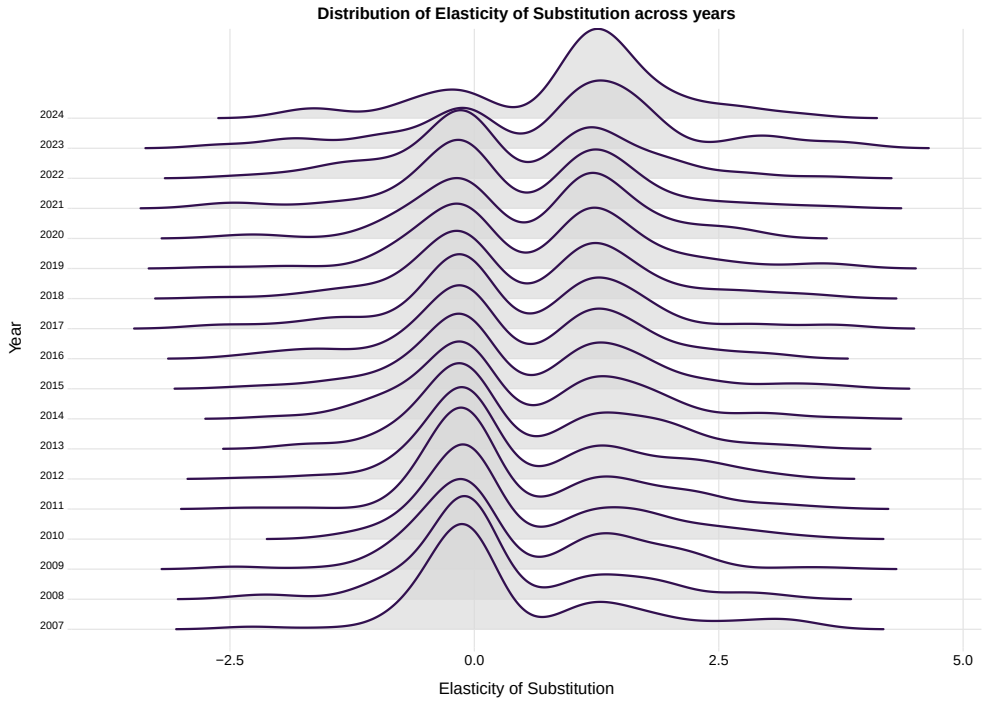


Fig. 7: Evolution of the distribution of the elasticity of substitution between ECO and CIVIL over years.

For business strategy and policy decisions, the stability of elasticity estimates matters because substantial variation may lead to large differences between anticipated and realized responses. We therefore examine whether variation in elasticity estimates is associated with economic strength (GDP per capita), political and civil freedom (freedom scores), and inherent tourism attractiveness

(tourism interest levels). We find that countries with higher GDP per capita exhibit significantly less variation in elasticity estimates than countries with lower GDP per capita. Similarly, countries with higher freedom scores have less variation in elasticity estimates than those with lower scores. The same pattern holds for tourism interest, with countries having higher tourism interest exhibiting less variation than those with lower interest. Taken together, these findings suggest that the dispersion of elasticity estimates is associated with economic strength, political and civil freedom, and tourism attractiveness.

We also find it imperative to point out that the variable *tourism baseline* is defined through historical arrivals per capita, thereby reflecting tourism intensity, but not necessarily capturing tourist attractions. For example, some of the highest values of tourism baseline are observed in countries like Bahamas, Antigua and Barbuda which are popular vacation destinations with low populations, while a country like India that contains a significant number of tourist attractions has a low value of tourism baseline due to their large populations. It motivates us to specifically look at few countries with well known tourist attractions. First, we notice that Iceland – which is famous for natural beauty and northern lights – shows relatively stable elasticity values (with the exception of years 2008 and 2009, when it was going through a severe financial crisis), suggesting that its strong tourism infrastructure and established reputation support consistent tourism demand. Second, in the western part of Africa, Morocco and Algeria display greater fluctuation of elasticity, indicating that their economic and freedom conditions still play an important role despite their inherent attractiveness as tourist destinations. A similar pattern is visible in destinations such as Kenya and Tanzania, known for their wildlife diversity, and for Zimbabwe, which is home to the famous Victoria Falls. In these countries, elasticity values fluctuate more, suggesting that tourism demand remains sensitive to changes in economic performance and freedom levels.

We also observe that certain countries display drastic changes in elasticity over certain years, which are explained by changes in their economic or freedom conditions in those years. In 2015, Slovenia which had so far experienced steady inflation suddenly went through deflation, which led to its elasticity increasing drastically (Statistical Office of the Republic of Slovenia, 2015). We also see a sudden jump in elasticity in 2021 for Antigua and Barbuda. This can be attributed to the GDP per capita falling significantly in 2020 as this is a country for which tourism is a significant contributor to income, and this was greatly impacted due to the COVID pandemic (CountryEconomy, 2020).We also observe the elasticity going back to its previous trend as the country's economy recovered. Ethiopia in 2018 went through a civil conflict (Mullaw, 2025), causing its freedom levels to fall significantly leading to a sudden increase in its elasticity. The sudden jump in elasticity for Central African Republic is also due to a similar reason - the region went through severe civil and political conflicts in 2015 (Human Rights Watch, 2016).

5.7. EOS and Marginal Effect: Implications for strategy

While ECO and CIVIL act as substitutes on average, the magnitude of the elasticity carries specific meaning. A large value indicates that the relative productivity of ECO and CIVIL stays roughly invariant as the country reallocates between them. Resources transferred from ECO to CIVIL continue to deliver similar tourism gains across the reform horizon, rather than running into rapidly diminishing returns. Finland illustrates the pattern clearly. In 2007, its elasticity stood at 3.7, indicating strong substitutability: the country could build CIVIL substantially at the expense of ECO while sustaining the same inbound tourism. By 2024, the elasticity declines to 1.4, indicating that further substitution has become more costly per unit gained. Sweden and Iceland follow similar trajectories, with substitutability narrowing as their freedom and capacity profiles mature. Many countries record elasticities near unity, where each additional unit of CIVIL requires a proportionally larger sacrifice of ECO — still substitutable, but at a steeper rate of loss for ECO.

A second group of countries records elasticities near zero, indicating that economic capacity and political freedom function as complements rather than substitutes. For such countries, the two factors must move together: improvement in one delivers little additional tourism unless improvement in the other accompanies it. Their tourism strategies call for coordinated advancement on both dimensions rather than concentrated investment in either alone. The complementarity finding sharpens the policy guidance. It identifies the countries where the substitution strategy does not apply, and where integrated reform across both economic and institutional dimensions becomes the more effective path to inbound tourism growth.

Strategic decisions weigh gains against losses, and the two empirical objects in this analysis map cleanly onto each side of that calculation. The elasticity of substitution captures the loss side: a high value means reallocating resources from ECO to CIVIL carries a low cost in lost productive contribution, while a low value means the same reallocation comes at a steeper price. The marginal effect captures the gain side: it tells the country what each percentage point of improvement in CIVIL delivers in additional tourist arrivals. Table 4 presented earlier shows that the marginal effect of CIVIL is roughly two-and-a-half times that of ECO, identifying CIVIL as the more productive lever at the margin. The two objects combine to determine how aggressively a country can act on this advantage. A country with both a high marginal-effect ratio favoring CIVIL and a high elasticity of substitution can sustain a substantial reallocation toward institutional reform, since the productive advantage holds up as the substitution proceeds. Finland's 2007 position, with an elasticity of 3.7 and a strong relative return on CIVIL, exemplifies this configuration — the country could pursue institutional deepening at scale without sacrificing tourism momentum. A country with the same marginal-effect advantage but a low elasticity faces a different calculation: the same direction is favored, but the reallocation can be sustained only over a shorter range before the trade-off becomes prohibitive. India, Nigeria, and several other countries with relatively low GDP per capita fall into this second case.

6. Conclusion

This study investigates the impact of a country's economic strength and political freedom on its inbound tourism demand, employing a linear regression framework grounded in the translog production function. This functional form was chosen specifically for its flexibility, allowing us to capture heterogeneity in the elasticity of substitution between economic and freedom-related factors across countries and over time.

Our analysis reveals a negative interaction effect between economic strength and political freedom: the marginal contribution of one factor to inbound tourism decreases as the level of the other increases. In other words, the tourism-enhancing effect of political freedom is attenuated in economically stronger countries, and vice versa. Furthermore, our elasticity estimates suggest that countries with higher levels of political freedom and civil liberties exhibit lower elasticity of substitution between economic and freedom-related factors, indicating a more complementary relationship. Conversely, countries with lower freedom levels show higher substitutability, implying greater potential for boosting tourism by improving freedom conditions.

A key limitation of this study lies in the availability of data on political and civil freedom. At the time of analysis, the freedom indicators used to construct the composite freedom index were available only up to the year 2024. As a result, our dataset does not include more recent developments that may have influenced the tourism landscape. Future research could extend this analysis by incorporating post-2024 data, once available, to validate and potentially refine our findings. Also, the composite freedom index used in this study relies on publicly available scores, which, while comprehensive, are still subject to subjectivity in measurement and aggregation.

While this study focuses on cross-country inbound tourism, future research could explore several promising extensions. For instance, subnational analyses—such as state-level tourism flows within federal countries like the United States—could shed light on how within-country variations in economic and freedom conditions influence domestic travel. Additionally, incorporating bilateral or cross-country tourism flows (i.e., origin–destination pairs) would allow for the study of travel patterns shaped by both source and host country characteristics. Another natural extension is to examine outbound tourism, which may respond differently to domestic economic and political conditions. These directions, though outside the scope of our present work due to data and resource constraints, could provide a richer and more nuanced understanding of the relationship between institutional factors and tourism behavior.

7. Data statement

The data used in this study are obtained from publicly available sources. The data sources and procedures used to construct the variables are described in the manuscript. The data and code used for the analysis will be made available in a public repository upon publication.

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Appendices

Appendix A. Additional discussions on the freedom index

We can see, from a correlation analysis of the 7 freedom scores, that these scores are highly correlated. This is illustrated in the multivariate correlation plot in Figure A.1.

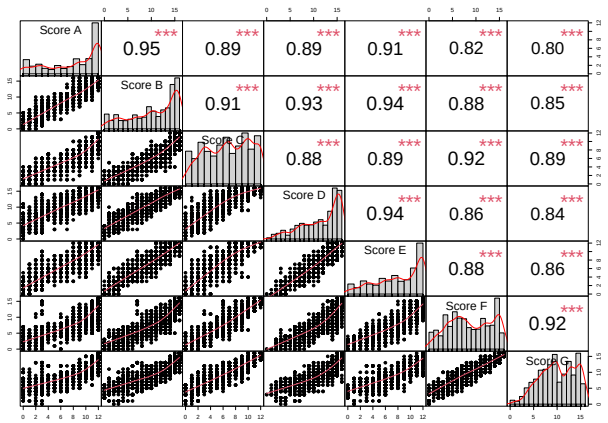


Fig. A.1: Correlation plot of the scores in the seven freedom categories

To avoid issues due to this multicollinearity, we use principal component analysis to create a single composite score. Mathematically, in a dataset of p components (in our case, $p = 7$), although p number of PCs are required to reproduce the total variability in the system, often much of this variability can be accounted for by a smaller number of PCs. In our analysis, we are going to consider only the first PC as it explains almost 91% of the variation in the freedom parameters. If we use $\mathcal{F}_{r,t,1}, \ldots, \mathcal{F}_{r,t,7}$ to denote the freedom scores for the r^{th} country at the t^{th} time-point in the seven subcategories A, B, ..., G, respectively, then the corresponding combined score (according to the first PC) can be expressed as

$$\mathcal{F}_{r,t} = \sum_{i=1}^{7} w_i \mathcal{F}_{r,t,i}$$

where w_is are the coefficients corresponding to the first principal component. Furthermore, note that theoretically the value of the first PC can be positive or negative, but our proposed econometric model which leverages the translog production function requires the explanatory variables to be positive. Keeping that in view, we consider the transformation

$$\mathrm{FI}_{r,t} = \mathcal{F}_{r,t} + 40, \tag{A.1}$$

which is guaranteed to be positive due to the following. This is denoted as FI or 'freedom index'.

Lemma 1. *The freedom index defined through* (A.1) *is bounded in the interval* $(-40, 40)$.

Proof. For two vectors $\boldsymbol{u} = (u_1, \ldots, u_n)'$ and $\boldsymbol{v} = (v_1, \ldots, v_n)'$ in the Euclidean space $\mathbb{R}^n$, recall the Cauchy-Schwarz inequality which states that

$$\left(\sum_{i=1}^{n} u_i v_i\right)^2 \leqslant \left(\sum_{i=1}^{n} u_i^2\right)\left(\sum_{i=1}^{n} v_i^2\right) \iff \left|\sum_{i=1}^{n} u_i v_i\right| \leqslant \sqrt{\left(\sum_{i=1}^{n} u_i^2\right)\left(\sum_{i=1}^{n} v_i^2\right)}. \tag{A.2}$$

For the proposed PC that considers the linear combination of individual scores, say $\boldsymbol{s} = (s_1, \ldots, s_7)'$, let $\boldsymbol{w} = (w_1, \ldots, w_7)'$ represent the vector of weights associated with the scores. Then, any PC is of the form $\sum_{i=1}^{n} w_i s_i$, with the condition that the sum of squares of the weights would be 1. Furthermore, as mentioned in the original resource of the dataset, the scores in the seven dimensions have the upper bounds of 12, 16, 12, 16, 12, 16 and 16, respectively. Therefore, we may write

$$\sum_{i=1}^{7} w_i^2 = 1, \ \sum_{i=1}^{7} s_i^2 \leqslant 1456.$$

The above condition, along with the inequality presented in (A.2), implies that

$$\left| \sum_{i=1}^{7} w_i s_i \right| \leqslant \sqrt{\left(\sum_{i=1}^{7} w_i^2 \right) \left(\sum_{i=1}^{7} s_i^2 \right)} \leqslant \sqrt{1456} < 40. \tag{A.3}$$

From the above, we infer that for any choice of the weights that can be used to construct a PC,

$$40 + \sum_{i=1}^{7} w_i s_i \geqslant 0, \tag{A.4}$$

and this is used to define the freedom index $\mathrm{FI}_{r,t} = \mathcal{F}_{r,t} + 40$, which ensures that the variable is always positive and can be used appropriately in the proposed regression model. □

It is pertinent to point out that the approach of using PCA to construct a single hybrid measure from a number of individual measures is not uncommon in econometric analysis. Caudill et al. (2000) demonstrated the technique of constructing components using PCA of difference measures in an index and also established that the index performance is comparable to a single component of the index. Uzelac et al. (2020) used PCA to construct a measure of economic freedom from different types of measures such as business freedom, investment freedom, financial freedom, trade freedom, monetary freedom and labor freedom. Dialga and Vallée (2021) also illustrated how PCA can be used to construct a composite score of economic freedom which help overcome limitations that different individual scores and their scoring methodologies might have.

The loadings (weights) obtained from the PCA on the 7 individual freedom scores are shown in Table A.1. Note that we use the weights given in the first column in our analysis.

Table A.1: Loadings of the variables A-G on the seven PCs, arranged in decreasing order of variability explained.

Variable	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7
A	0.3744	−0.4693	0.4505	0.2865	−0.1576	0.1197	−0.5616
B	0.3854	−0.2852	0.1228	0.1608	−0.1887	0.2730	0.7868
C	0.3808	0.1681	0.5193	−0.4028	0.5430	−0.2968	0.1088
D	0.3786	−0.2544	−0.6034	−0.1244	0.5183	0.3465	−0.1540
E	0.3835	−0.1963	−0.3703	−0.1422	−0.3565	−0.7280	−0.0050
F	0.3750	0.4777	−0.0127	−0.4554	−0.4828	0.4018	−0.1707
G	0.3678	0.5820	−0.1048	0.6976	0.1262	−0.1078	−0.0278

The scree-plot which shows the percentages of variation in the data explained by each of the principal components is presented in Figure A.2. We can see that the first PC explains 90.5%

of the variation in the data. It helps in justifying why we consider only the first PC of the individual freedom scores to be a good representative variable of the freedom status of a country. As mentioned, we represent this by $\mathcal{F}_{r,t}$.

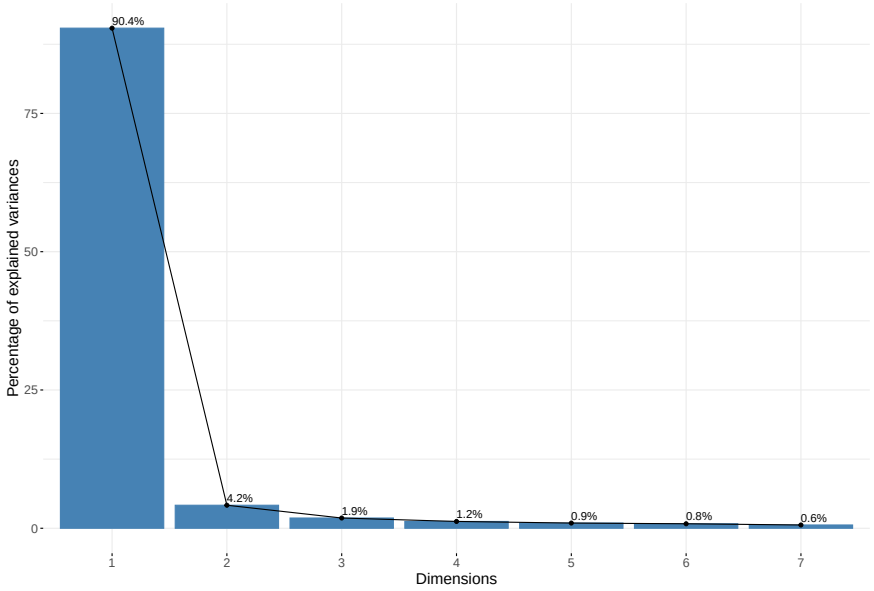


Fig. A.2: Scree-plot corresponding to the principal component analysis of the seven type of freedom scores.

Appendix B. Formulae used in robustness checks

Let Y_i denote the observed values and $\hat{Y}_i$ the fitted values for $i = 1, \ldots, n$. Then, R^2 measures the proportion of the total variation in the dependent variable explained by the model and is defined as

$$R^2 = 1 - \frac{\sum_{i=1}^{n} \left(Y_i - \hat{Y}_i\right)^2}{\sum_{i=1}^{n} \left(Y_i - \bar{Y}\right)^2}, \quad \text{where } \bar{Y} = \frac{1}{n} \sum_{i=1}^{n} Y_i,$$

It is ubiquitous in measuring the model fit, by computing the proportion of total variation of outcomes explained by the model.

For predictive assessment, using $\hat{Y}_i$ as the predicted values for observations in the test set $\mathcal{T}$, the root mean squared error (RMSE) is defined as

$$\text{RMSE} = \sqrt{\frac{1}{|\mathcal{T}|} \sum_{i \in \mathcal{T}} \left(Y_i - \hat{Y}_i\right)^2},$$

and measures the standard deviation of the residuals. On the other hand, the mean absolute percentage error (MAPE) is defined as

$$\text{MAPE} = \frac{100}{n} \sum_{i=1}^{n} \left| \frac{y_i - \hat{y}_i}{y_i} \right|,$$

which measures the average absolute percentage deviation between observed and predicted values.