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The Impact of Climate Change on Tourism Demand in Spain

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Creating Opportunities

Tourism in Spain could be damaged by climate change if the needed adaptation actions are not taken

Objective

Analyze the current and potential future impacts of climate change on tourism demand in Spain at provincial level, considering various emission concentration scenarios (RCP2.6, RCP4.5, and RCP8.5) until 2100.

Reference: Regional impact of climate change on European tourism demand (JRC)

Main takeaways

- The **northern provinces** of the country are likely to benefit from global warming, while Mediterranean provinces could experience declines in tourism demand.
- Shifting **seasonal** distribution of tourism: less demand in summer and more in spring.
- **Adaptability** is crucial for avoiding a significant negative impact on tourism demand.
- The **thresholds of climate indexes (TCI, HCI)** based on data, surveys, or reference papers, are pivotal and determine the results.

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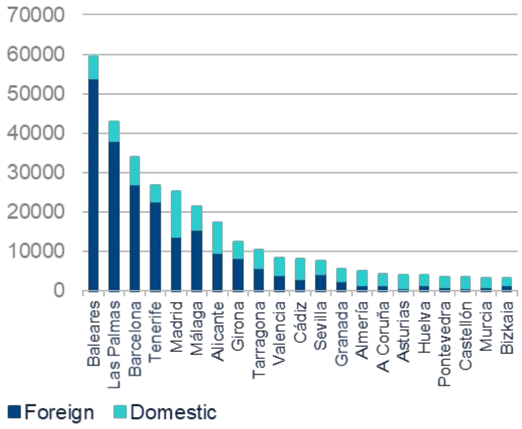
01

Main determinants of tourism demand

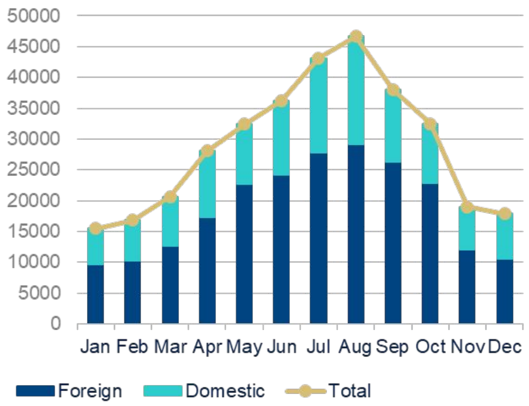
Tourism demand in Spain presents a marked seasonality, with a peak in summer and highly concentrated in foreign tourism seeking sun and beach

BED NIGHTS IN SPANISH PROVINCES
(*) (2023, THOUSANDS)



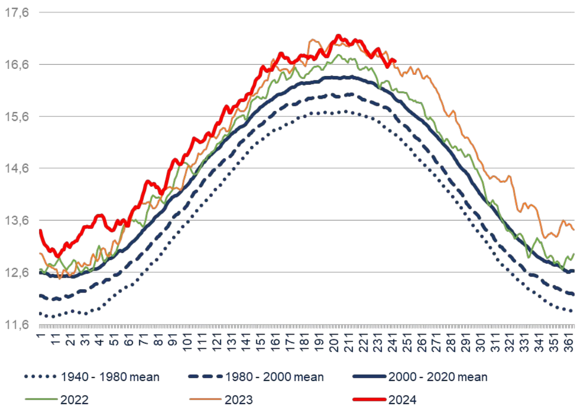
Source: BBVA Research from INE
(*) Provinces displayed with total annual bednights larger than 3 million. Not displayed provinces have on average a 20% share of foreign tourism.

BED NIGHTS PER MONTH IN SPAIN
(2023, THOUSANDS)



Source: BBVA Research from INE

DAILY WORLD TEMPERATURE
(1940-PRESENT, ºC)



Source: BBVA Research from Daily 2-meter Air Temperature.

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02

Data and Empirical Approach

Variables and data

Time Period: 2002-2023

Data frequency: Monthly

Geographical unit: Spanish province

Not seasonally adjusted: data

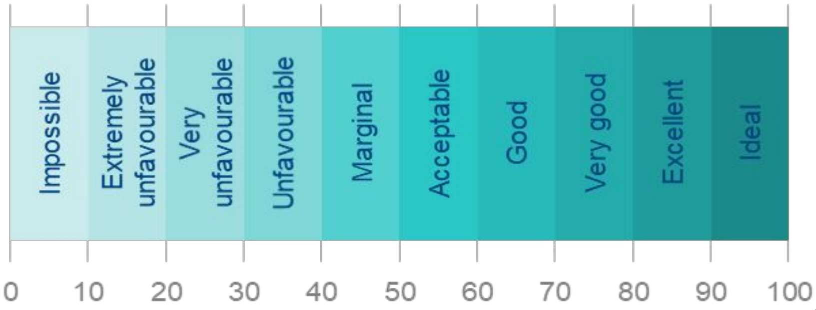
Data transformation: variables in logs

Variables	Definition	Source
Total Bed Nights	Number of bed nights spent at hotel accommodation	INE
Foreign Bed Nights	Number of bed nights from foreigners	INE
Tourism Climate Index (TCI)	Climate composite of thermal comfort, precipitation, cloud cover and wind, with values that range from 0 (potentially dangerous) to 100 (ideal conditions)	Own calculation based on Mieczkowski (1985) using ERA5 monthly data (Copernicus CDS)
Holiday Climate Index (HCI)	Climate composite of thermal comfort, precipitation, cloud cover and wind, with values that range from 0 (potentially dangerous) to 100 (ideal conditions)	Own calculation based on Scott et al. (2016) and Rutty et al. (2020) using ERA5 monthly data (Copernicus CDS)
Real Gross Domestic Product (RGDP)	Monthly RGDP for each province	INE and own calculations based on annual provincial GDP and quarterly regional GDP
Consumer Price Index (CPI)	Monthly CPI for each province	INE
Ratio between GDP per capita of foreign tourists and destination province	Weighted average of the monthly RGDP per capita from the top 10 visitor countries per province, relative to the RGDP per capita of destination province	Haver and own calculations

Tourism Climatic Index (TCI), the most widely used to describe the attractiveness of tourist destinations

The first composite index was the **Tourism Climate Index (TCI)** (Mieczkowski, 1985), designed to integrate climate variables relevant to tourism.

TCI values range from 0 to 100, where 0 represents potentially dangerous conditions and 100 ideal for tourism. A value lower than 50 represents unsuitable conditions.



TCI includes four **components**: daily comfort, precipitation, cloud cover and wind.

TCI **= 5 Daily Comfort Index + 2 Precipitation + + 2 Cloud Cover + Wind**

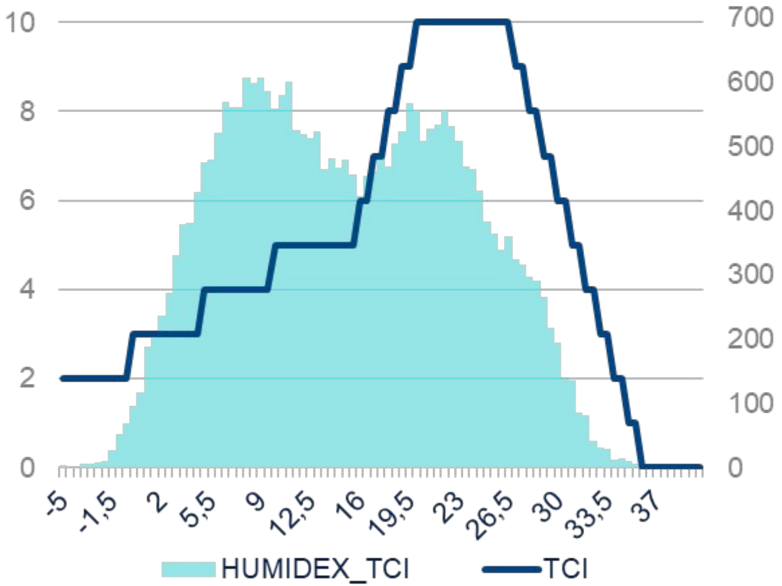
Sub-index	Climate variable	Weight
Daily Comfort Index (CIA) - Humidex	Mean daily air temperature (°C) and Mean daily humidity (%)	50%
Precipitation (P)	Total daily precipitation (mm)	20%
Wind (W)	Mean wind speed (km/h)	10%
Aesthetic (A)	Cloud cover (%)	20%

More details on TCI in Annex

The TCI accounts for temperature variations, with limited observations exceeding the upper threshold

HUMIDEX HISTORICAL DISTRIBUTION 1980-2023 (RIGHT- AXIS) AND TCI RATING (LEFT-AXIS)

(CALCULATED USING MONTHLY AVERAGE MEAN TEMPERATURE)



Source: BBVA Research

Note: The left-hand side axis represents the score from the TCI ranking, while the right-hand side axis represents the number of times (frequency) a temperature level was registered in Spain.

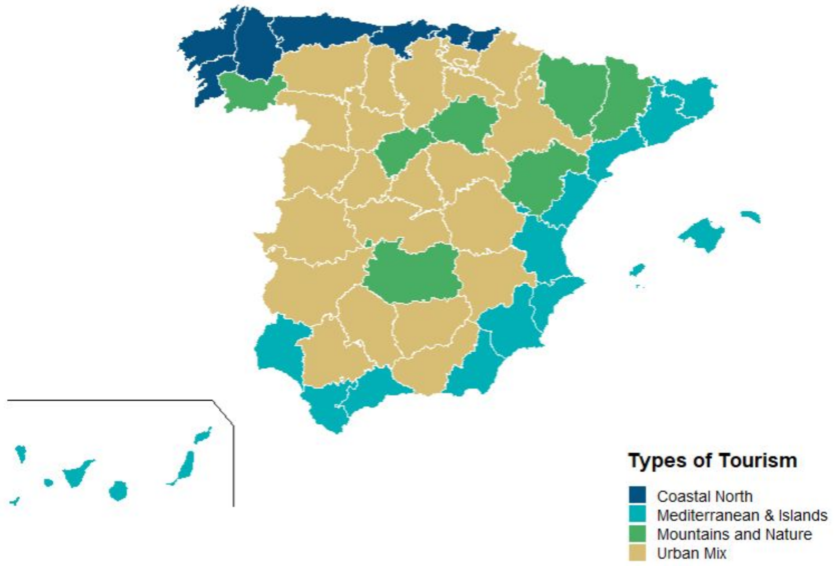
THERMAL COMFORT RATING SYSTEM

Rating	Humidex (ºC)
0	≥ 36
1	[35.0, 35.9)
2	[34.0, 34.9)
3	[33.0, 33.9)
4	[32.0, 32.9)
5	[31.0, 31.9)
6	[30.0, 30.9)
7	[29.0, 29.9)
8	[28.0, 28.9)
9	[27.0, 27.9)
10	[20.0, 26.9)
9	[19.0, 19.9)
8	[18.0, 18.9)
7	[17.0, 17.9)
6	[16.0, 16.9)
5	[10.0, 15.9)
4	[5.0, 9.9)
3	[0.0, 4.9)
2	(-5.9, -0.1]
0	(-10.9, -6.0]
-1	(-15.9, -11.0]
-2	(-20.9, -16.0]
-6	≤ −21

Source: BBVA Research adapted from Mieczkowski, 1985. More details on TCI in Annex

Types of Tourism based on Batista e Silva et al. (2021): a method to differentiate between tourism categories

SPANISH PROVINCES CLASSIFIED BY TYPE OF TOURISM



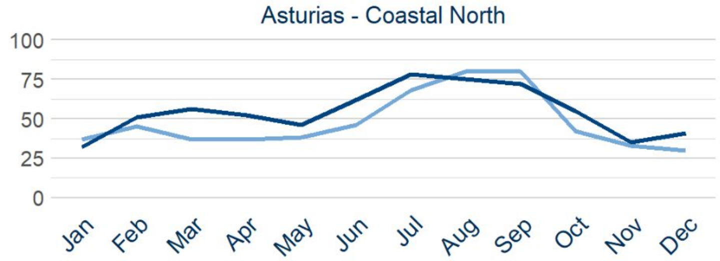
- **TCI is further analyzed together with each province's tourism typology** to capture the climatic preferences across major tourism segments and destination types.
- **The methodology, used by JRC, is well-established.** We slightly modified it by:
  - Splitting the coastal category into North and Mediterranean & Islands.
  - Reclassifying cities into Urban mix and Coastal, affecting only five cases based on their behavior.
  - Merging Rural with Mountains and Nature.

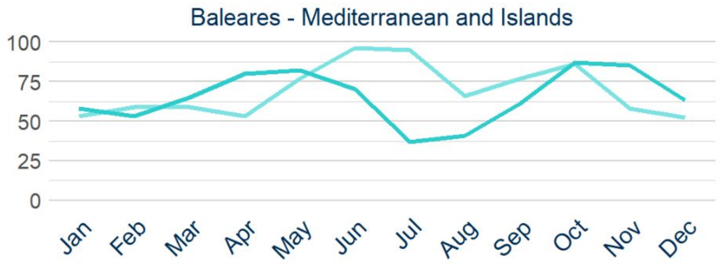
Source: BBVA Research adapted from Batista e Silva et al. (2021)

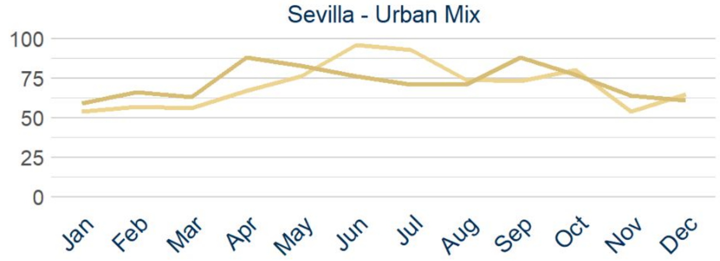
Coastal areas, especially in the East and South, are highly weather-dependent and more vulnerable to climate changes

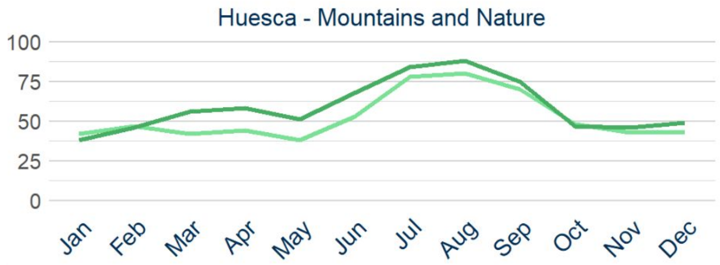
TCI EVOLUTION IN SELECTED PROVINCES (BY TYPE OF TOURISM)

1980 VS 2023 (*)









Source: BBVA Research calculations using ERA 5 Copernicus Climate Change Service (C3S)

(*) The lighter color represents the year 1980, and the darker color the year 2023.

Empirical framework: a panel data regression with fixed effects by province

According to the tests and statistical analysis conducted, the model was estimated using **Feasible Generalized least Squares** with **AR(1)** autocorrelation in the residuals as well as **cross-sectional correlation** across panels.

$$\ln(BN_{it}) = \gamma + \alpha_i + \beta_1 \ln(TCI_{it} \times Tclass_i) + \beta_2 \ln(GDP_{it}) + \beta_3 \ln(CPI_{it}) + \beta_4 \ln(GDPpcfor_{it}) + d_s M_s + d_c Covid + \epsilon_{it}$$

BN_{it}: bed nights(*) in province i at time t
TCI_{it}: Tourism Climate Index in province i at time t
$Tclass_i$: type of tourism in province i (Coastal North, Mediterranean & Islands, Mountains & Nature and Urban Mix)
GDP_{it}: Real GDP at destination province
CPI_{it}: CPI at destination province
GDPpcfor: Ratio between GDP per capita of foreign tourists and destination province
Ms: seasonal dummy variable to which the month belongs (Autumn, Spring, Summer, Winter)
Covid: covid dummy variable (2020 M4 - 2021 M4)
γ intercept, **α_i** fixed effects by province i, **ϵ_{it}** residuals ($\epsilon_{it} = \rho\epsilon_{it-1} + v_{it}$) in province i at time t

(*) Bed nights are further differentiated between total bed nights (BN_tot) and foreign bed nights (BN_for).

For further details on Literature Review

Empirical results: Climate comfort as a key driver of tourism demand

	(1)
	l_BN_tot
Coastal North × l_TCI	0.391***
	(25.05)
Mediterranean and Islands × l_TCI	0.501***
	(24.66)
Mountains and Nature × l_TCI	0.104***
	(8.89)
Urban Mix × l_TCI	0.0603***
	(6.72)
l_GDP	4.470***
	(63.00)
l_CPI	-0.351***
	(-3.63)
l_GDP_pcfor	3.638***
	(60.83)
Autumn	0
	(.)
Spring	-0.0675**
	(-1.96)
Summer	0.189***
	(5.70)
Winter	-0.284***
	(-8.63)
Covid	-1.598***
	(-25.82)
Constant	-55.36***
	(-53.21)

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Climatic conditions, measured by the TCI, have a positive impact on tourism demand. Higher climate comfort increases tourism, with differences by type of tourism. In Spain, coastal areas are the most affected, particularly those in the Mediterranean and islands. Mountain tourism is less affected by changes in climate conditions, while urban areas are relatively inelastic to such changes, which may underlie a substitution effect between coastal and urban destinations.

Economic factors. Real GDP and inflation of destination province significantly impact bed nights, with the former having a positive effect and the later a negative one. The relative foreign real GDP per capita also positively affects tourism demand, indicating the higher purchasing power of foreign tourists boosts external tourism demand in Spain (*).

Seasonal tourism patterns confirm that summer has the highest overnight stays, winter the lowest, with autumn and spring being relatively similar (**).

(*) Foreign CPI was considered but did not significantly affect TCIs. Its inclusion did not result in major changes, and the sign suggested an unexpected effect, likely due to higher growth in activity. Therefore, it was excluded from the final specification, as this effect is already captured by relative GDP. See the annex for more information.
(**) September has been classified in autumn, which significantly affects the results.

For further details on **Statistical Tests & Results**

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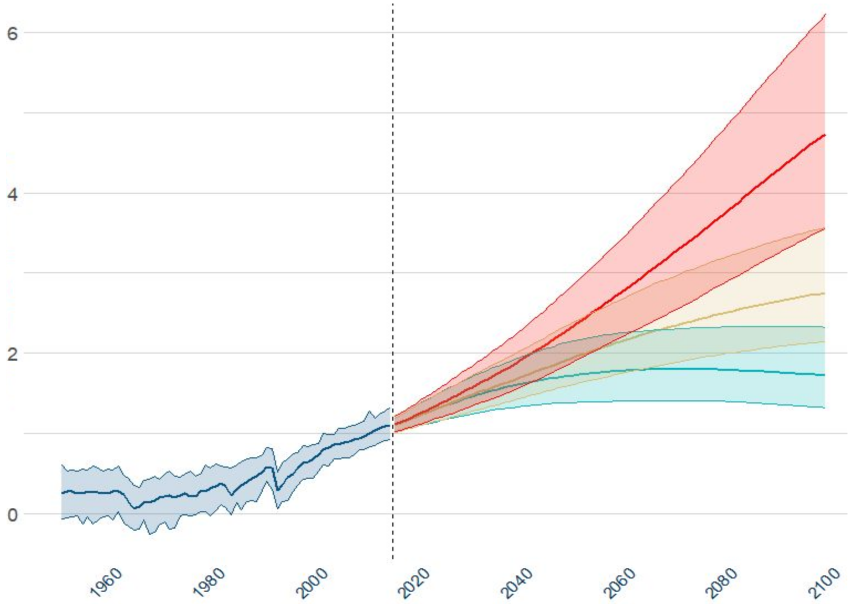
03

Climate Change Future Pathways (RCP)

RCP: Future GHG Concentration pathways for scenario analysis

GLOBAL SURFACE TEMPERATURE CHANGE (ºC)
(RELATIVE TO 1850-1900)



Source: BBVA Research from IPCC Sixth Assessment Report
Note: The dark blue line and shaded area represent the historical observed changes. The lights blue, yellow and red solid line and shaded areas represent the estimated point estimate and 95% uncertainty bands for each of the RCP scenarios

Different scenarios, based on **Representative Concentration Pathways (RCPs)** formally adopted by the **IPCC**, quantify future GHG concentrations.

RCP 8.5: very high future emissions tripling current levels by the end of the century (increase of 4.8ºC by 2100 compared to pre-industrial levels)

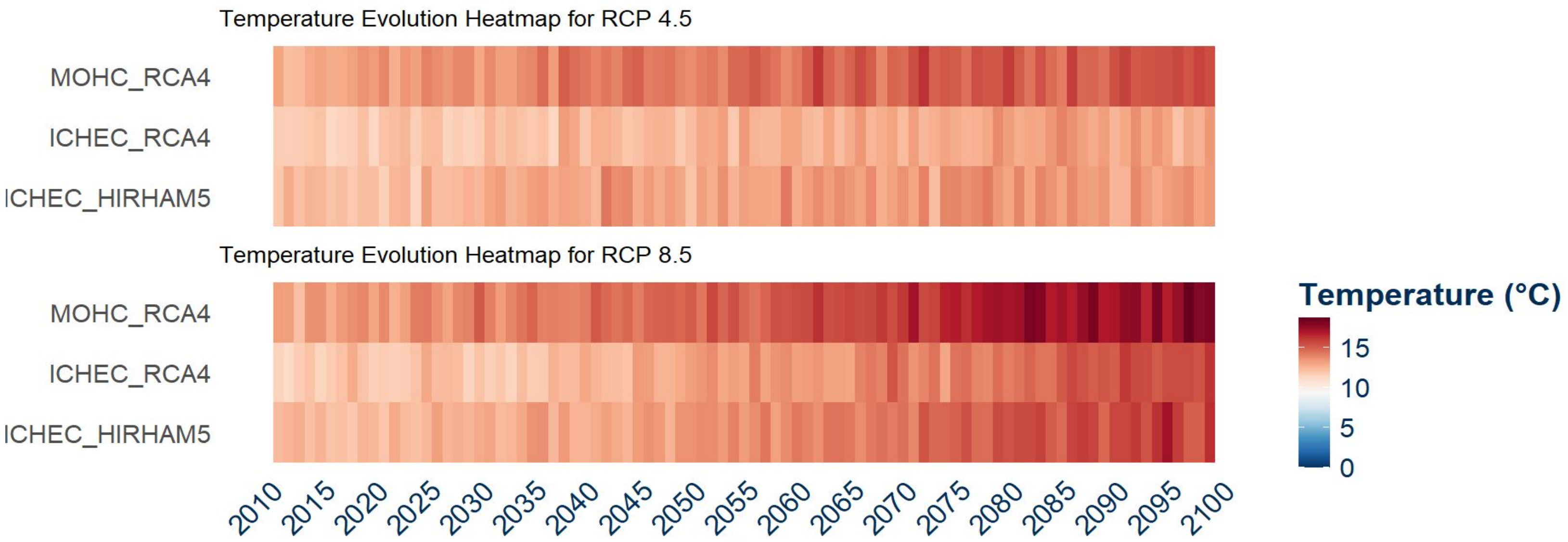
RCP 4.5: low to moderate future emissions (increase of 2.8ºC by 2100 compared to pre-industrial levels)

RCP 2.6: low future emissions trend, declining by 2020 and reaching net zero by 2100 (increase of 1.8ºC by 2100 compared to pre-industrial levels)

Models used to project climatic variables for each RCP scenario

The projections of climate variables were obtained from an ensemble of **3 regional climate models (RCMs) and global circulation models (GCMs)** produced by the Coordinated Regional Climate Downscaling Experiment over Europe (CORDEX) project.

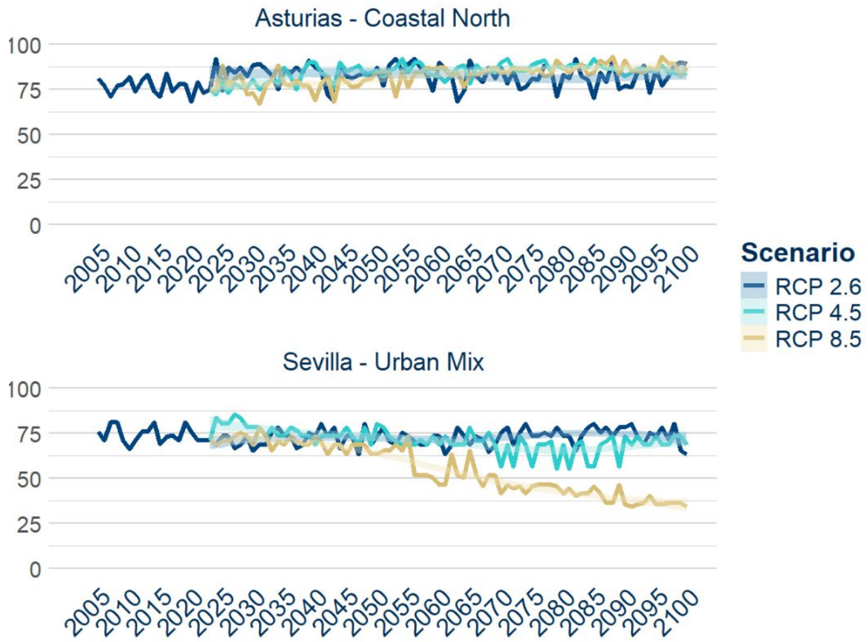
ANNUAL AVERAGE DAILY TEMPERATURE FOR SPAIN, BY RCP SCENARIO AND CLIMATE MODEL



Source: BBVA Research based on EURO-CORDEX

Evolution of tourism demand based on climate scenarios, holding all other factors constant

TCI EVOLUTION IN AUGUST



Source: BBVA Research calculations

- **To project Spanish tourism demand at provincial level,** the TCI has been calculated for different concentration pathways to estimate conditional forecasts up to 2100.
- **Assumptions**:
  - Relationship between bednights and climate variables remains constant over time.
  - Absence of adaptation to changes in climate patterns.
  - Absence of non-linearities in the impact of climate comfort on tourism.
  - Economic variables are held constant over time at their 2023 values.

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04

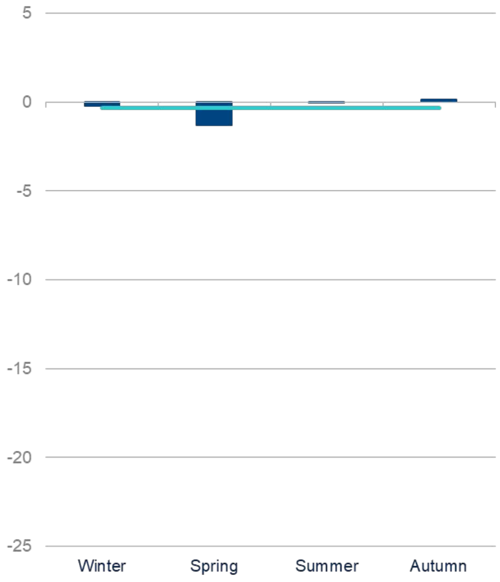
Results: Conditional Forecasts using RCP Pathways

RCP 2.6 | Net effect on tourism: Tourism climate index under RCP scenarios shift future seasonality and destinations

NET EFFECT BY PROVINCE IN RCP2.6, 2091-2100
(%, USING AS BASE 2024-2030)

National Net effect ≈ -0.3%

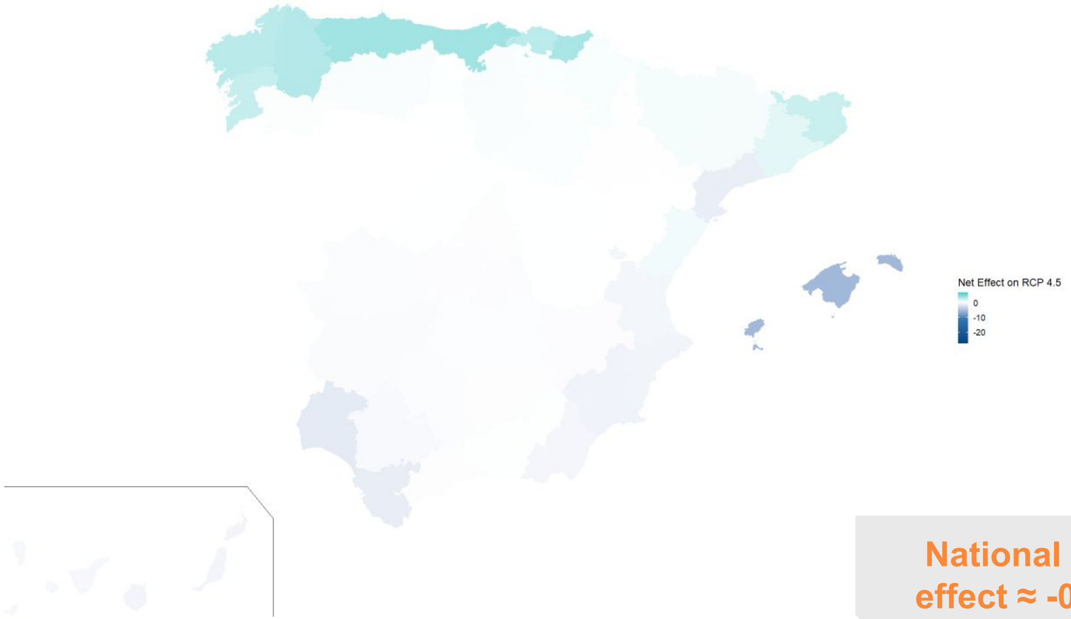
NET EFFECT BY SEASON IN RCP2.6, 2091-2100
(%, USING AS BASE 2024-2030)



Source: BBVA Research calculations

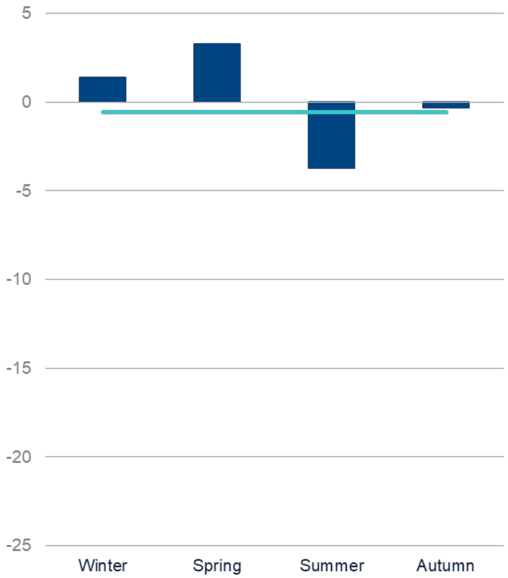
RCP 4.5 | Net effect on tourism: Tourism climate index under RCP scenarios shift future seasonality and destinations

NET EFFECT BY PROVINCE IN RCP4.5, 2091-2100
(%, USING AS BASE 2024-2030)



National Net effect ≈ -0.6%

NET EFFECT BY SEASON IN RCP4.5, 2091-2100
(%, USING AS BASE 2024-2030)

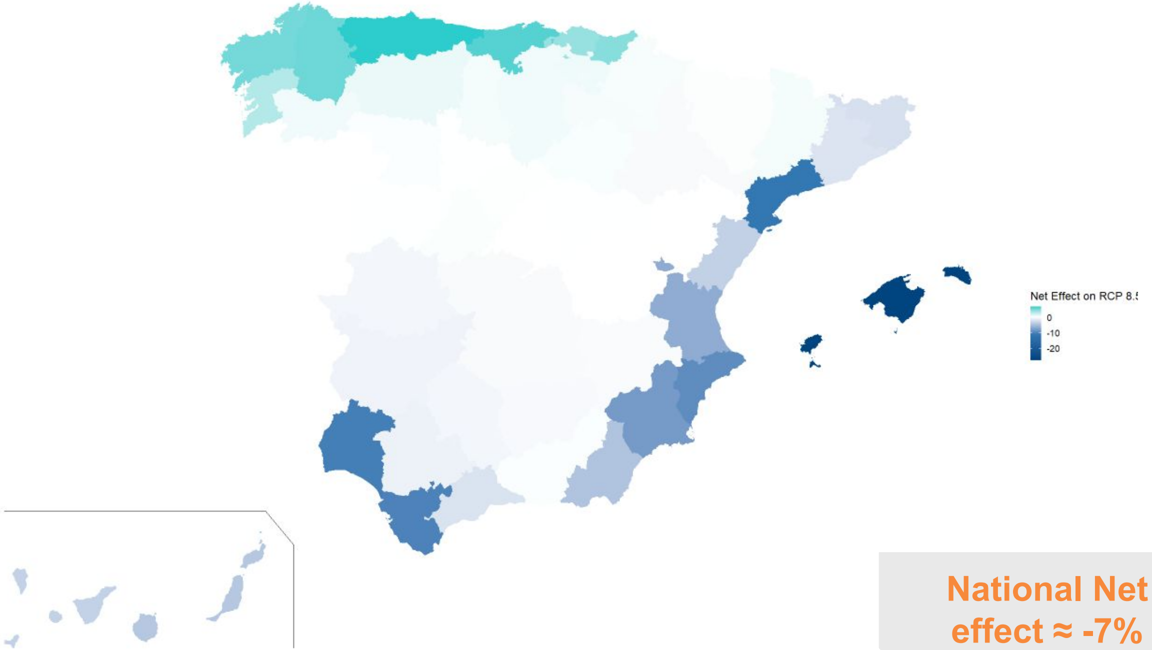


Source: BBVA Research calculations

More details

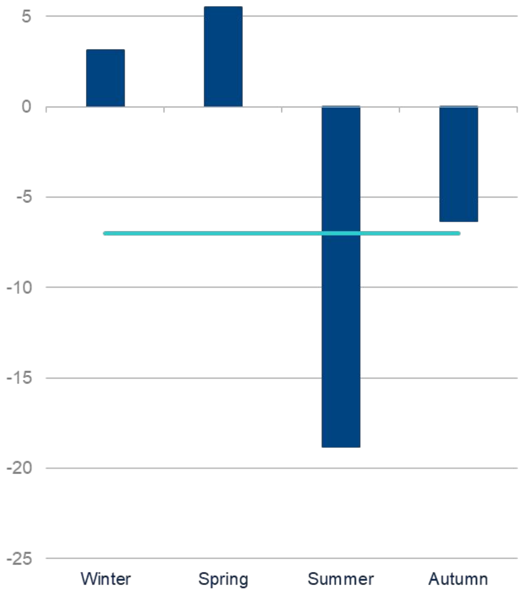
RCP 8.5 | Net effect on tourism: Tourism climate index under RCP scenarios shift future seasonality and destinations

NET EFFECT BY PROVINCE IN RCP8.5, 2091-2100
(%, USING AS BASE 2024-2030)



National Net effect ≈ -7%

NET EFFECT BY SEASON IN RCP8.5, 2091-2100
(%, USING AS BASE 2024-2030)



Source: BBVA Research calculations

Evolution by decades in RCP 8.5 scenario: Coastal North

- The northern coastal provinces experience an increase in their Tourism Climate Index, resulting in a **general rise in tourist demand** throughout the year.
- The significant increases generally peak both during **spring** and **autumn**, while **summers** rise is heterogeneous across the group.
- The net increase in **tourism demand is around 5.8%** on average in this group of provinces, for the 2090's with respect to 2024-2030 period, ranging from a 6.9% in Asturias to a 3.2% in Pontevedra.

CHANGE IN TOURISM DEMAND (%)
(USING AS BASE 2024-2030)

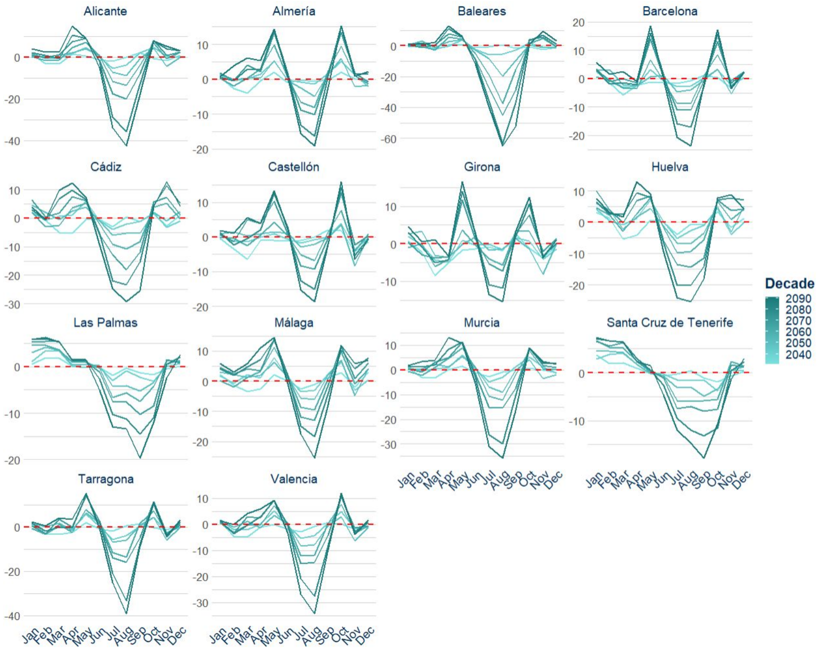
Source: BBVA Research calculations

More details on the net effect

Evolution by decades in RCP 8.5 scenario: Mediterranean and Islands

- The Mediterranean and southern coast provinces are expected to experience **less favourable tourism conditions during summer**, along with a shift in the shoulder seasons (spring and autumn). The mean net impact in Mediterranean provinces is -10%, ranging from -1.7% in Barcelona to -27.4% in Baleares in the 2090's compared to 2024-2030.
- The most significant declines are expected in **Baleares**, with a 60% drop in summer, but a slight recovery in autumn around 10%.
- **Canarias** would face a decline in tourism during summer that extends into autumn, which would lead to a net contraction in tourism demand of around -3.2% in Santa Cruz de Tenerife and -4% in Las Palmas.

CHANGE IN TOURISM DEMAND (%)
(USING AS BASE 2024-2030)



Source: BBVA Research calculations

More details on the net effect

Evolution by decades in RCP 8.5 scenario: Mountains and Nature

- For mountain and nature tourism, there is generally an observed increase in tourist activity during the months of **May** and **September**.
- However, **no significant changes are seen during the winter months**, where one would expect a decline in tourist demand at ski resorts due to higher temperatures and consequently less snowfall.
- This could occur simply because we are unable to adequately distinguish between good-weather mountain tourism and the ski season, which may be offsetting each other's effects.
- Hence, on average the net effect is positive, around 0.6% in the 2090's.

CHANGE IN TOURISM DEMAND (%)

(USING AS BASE 2024-2030)

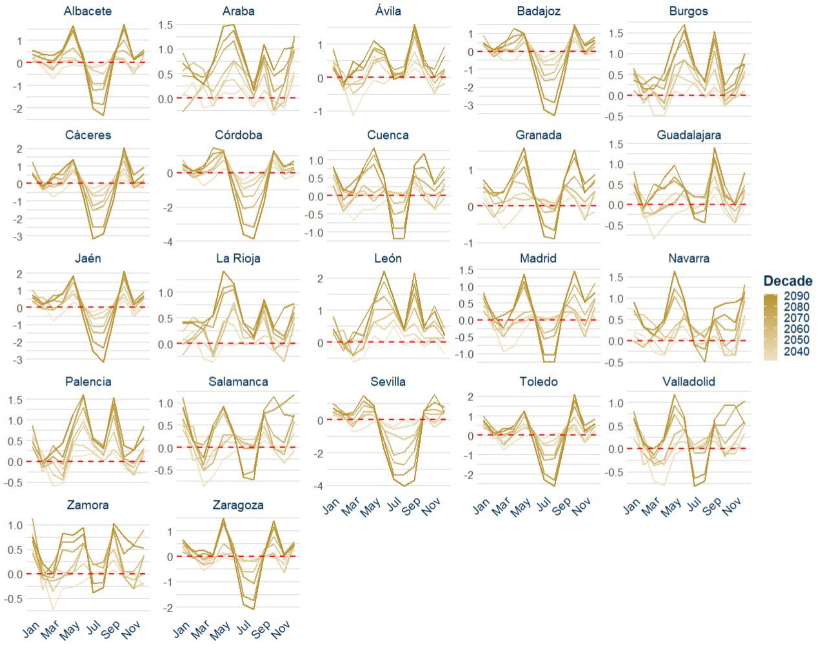
Source: BBVA Research calculations

More details on the net effect

Evolution by decades in RCP 8.5 scenario: Urban Mix

- Northern half provinces with urban tourism generally show an improvement throughout the year with two marked peaks in spring and autumn, resulting in a net positive impact of around 0.48%.
- In contrast, southern half provinces experience a recovery in these two seasons but face a significant **decline in tourist demand during the summer**, resulting in a marginal net positive effect of 0.11%.
- Urban tourism may have a substitution effect with beach tourism, making it less sensitive to weather conditions. Additionally, urban tourism typically involves more indoor activities, like the cultural attractions of Madrid, further reducing its sensitivity to climate conditions.

CHANGE IN TOURISM DEMAND (%)
(USING AS BASE 2024-2030)



Source: BBVA Research calculations

More details on the net effect

Foreign Tourism Demand: similar conclusions with variations along the coast

Model 1: Total tourism demand (BN_tot)

Model 2: Foreign tourism demand (BN_for)

- Tourist Climate Index (TCI) has a positive and significant effect on both total and foreign bednights. Overall, the general conclusions remain very similar.

- **Foreign tourism is more elastic to climate conditions**, provided by the higher elasticities in the model.

- For foreign tourists, it doesn't appear to be a clear distinction between northern coastal and Mediterranean beach tourism. While, the coefficients for mountain and urban tourism are slightly higher when compared to the total tourism demand.

	(1) LBN_tot	(2) LBN_for
Coastal North × LTCI	0.391***	0.462***
	(25.05)	(20.05)
Mediterranean and Islands × LTCI	0.501***	0.503***
	(24.66)	(20.96)
Mountains and Nature × LTCI	0.104***	0.152***
	(8.89)	(5.55)
Urban Mix × LTCI	0.0603***	0.169***
	(6.72)	(10.30)
LGDP	4.470***	5.121***
	(63.00)	(40.34)
LCPI	-0.351***	-0.0395
	(-3.63)	(-0.36)
LGDP_pcfor	3.638***	4.006***
	(60.83)	(43.58)
Autumn	0	0
	(.)	(.)
Spring	-0.0675**	-0.127***
	(-1.96)	(-3.30)
Summer	0.189***	0.000801
	(5.70)	(0.02)
Winter	-0.284***	-0.478***
	(-8.63)	(-12.67)
Covid	-1.598***	-1.846***
	(-25.82)	(-28.08)
Constant	-55.36***	-68.17***
	(-53.21)	(-35.35)

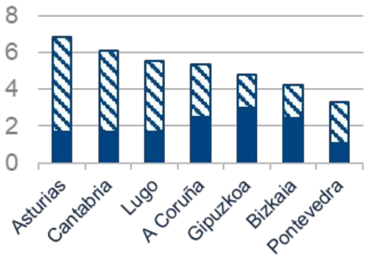
t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Breaking down the effect between foreign and domestic tourists: the significant influence of foreign tourists in the southeast

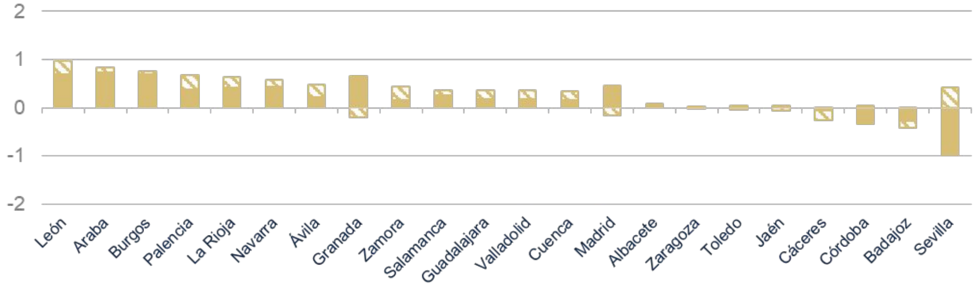
BED NIGHTS CHANGE DECOMPOSITION, RCP 8.5 2091-2100

(%, USING AS BASE 2024-2030)

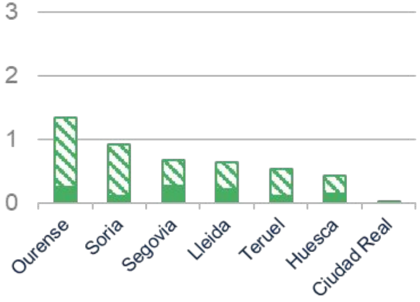
Coastal North



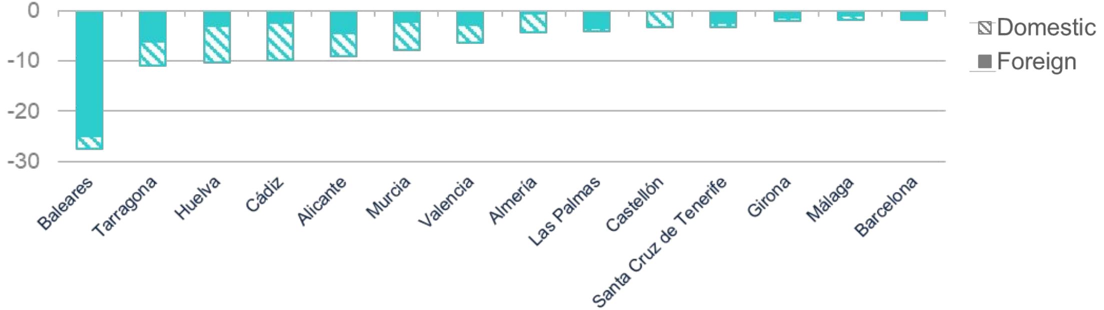
Urban Mix



Mountains and Nature



Mediterranean and Islands



Source: BBVA Research calculations

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05

Robustness Analysis: Holiday Climate Index

Holiday Climate Index (HCI), an alternative proxy for climatic comfort

The **Holiday Climate Index (HCI)**, an alternative proxy for climatic comfort to the TCI, was designed to be specified for major tourism segments and destination types by Scott et al. (2016) and Rutty et al. (2020).

An advantage of HCI is that its design is **not subjective but rather empirically validated** by surveys.

HCI presents **two different specifications,** distinguishing between **Beach** and **Urban** tourism (*). It also employs different thresholds in its rating scheme, reflecting distinct climatic preferences.

(*) Provinces in Coastal north, Mediterranean coast and Islands are calculated with HCI Beach, while provinces in the Urban Mix and Mountains and Nature categories are calculated with HCI Urban.

HCI COMPONENTS AND WEIGHTS

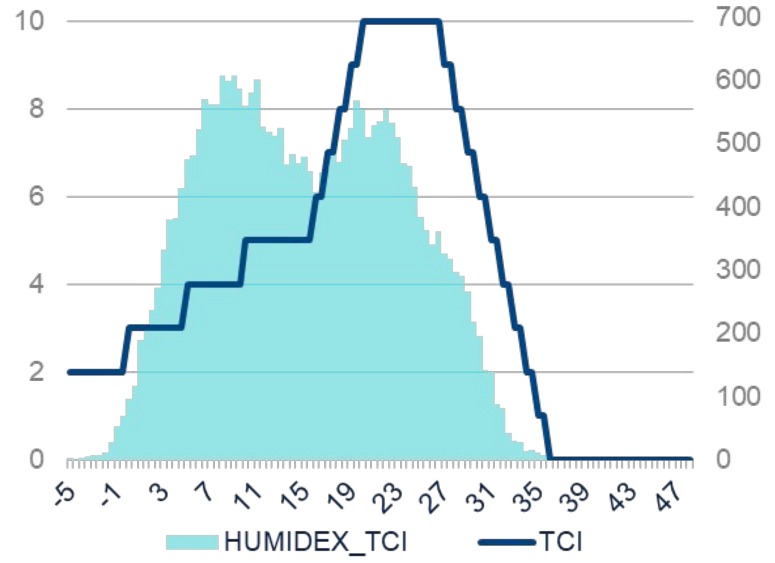
Index Component	Weather Variables	HCI: Urban	HCI: Beach
Thermal comfort (TC)	Average maximum daily air temperature (° C) and relative humidity (%)	40%	20%
Precipitation (P)	Total daily precipitation (mm)	30%	30%
Aesthetic (A)	Cloud cover (%)	20%	40%
Wind (W)	Mean wind speeds (km/h)	10%	10%

Source: BBVA Research adapted from Scott et al. (2016) and Rutty et al. (2020).
More details in the Annex.

Comparing thermal comfort of TCI and HCI: changing the thresholds makes the difference, specially in the upper limit

HUMIDEX HISTORICAL DISTRIBUTION 1980-2023 (RIGHT- AXIS) AND TCI RATING (LEFT-AXIS)

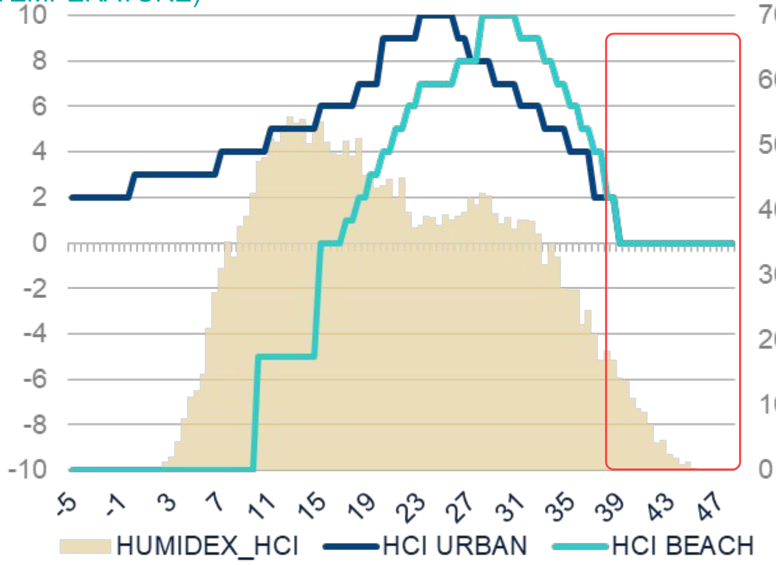
(CALCULATED USING MONTHLY AVERAGE MEAN TEMPERATURE)



Source: BBVA Research
Note: The left-hand side axis represents the score from the TCI ranking, while the right-hand side axis represents the number of times a temperature was registered in Spain.

HUMIDEX HISTORICAL DISTRIBUTION 1980-2023 (RIGHT- AXIS) AND HCI RATINGS (LEFT-AXIS)

(CALCULATED USING MONTHLY AVERAGE MAXIMUM TEMPERATURE)



Source: BBVA Research
Note: The left-hand side axis represents the score from the TCI ranking, while the right-hand side axis represents the number of times a temperature was registered in Spain.

Results: HCI reduces climate impact slightly on beach tourism while making urban tourism more climate-sensitive

Model 1: TCI as climate index

Model 2: HCI (Beach and Urban) as climate index

- **The model remains robust,** with most variables showing similar values.
- **The HCI distinguishes between climatic comfort for urban and beach provinces,** providing a more accurate reflection of the summer tourism surge.
- While the coefficient for Mediterranean beach and Island tourism has slightly decreased, the **urban tourism now shows a larger impact**, as urban HCI gives lower values in summer than TCI did.

	(1)	(2)
	l_BN_tot	l_BN_tot
Coastal North × l_index	0.391***	0.374***
	(25.05)	(29.92)
Mediterranean and Islands × l_index	0.501***	0.390***
	(24.66)	(24.22)
Mountains and Nature × l_index	0.104***	0.0541***
	(8.89)	(2.97)
Urban Mix × l_index	0.0603***	0.229***
	(6.72)	(21.46)
l_GDP	4.470***	4.535***
	(63.00)	(62.44)
l_CPI	-0.351***	-0.389***
	(-3.63)	(-4.37)
l_GDP_pcfor	3.638***	3.630***
	(60.83)	(60.33)
Autumn	0	0
	(.)	(.)
Spring	-0.0675**	-0.0909**
	(-1.96)	(-2.56)
Summer	0.189***	0.287***
	(5.70)	(8.44)
Winter	-0.284***	-0.301***
	(-8.63)	(-8.89)
Covid	-1.598***	-1.620***
	(-25.82)	(-25.45)
Constant	-55.36***	-56.18***
	(-53.21)	(-52.65)

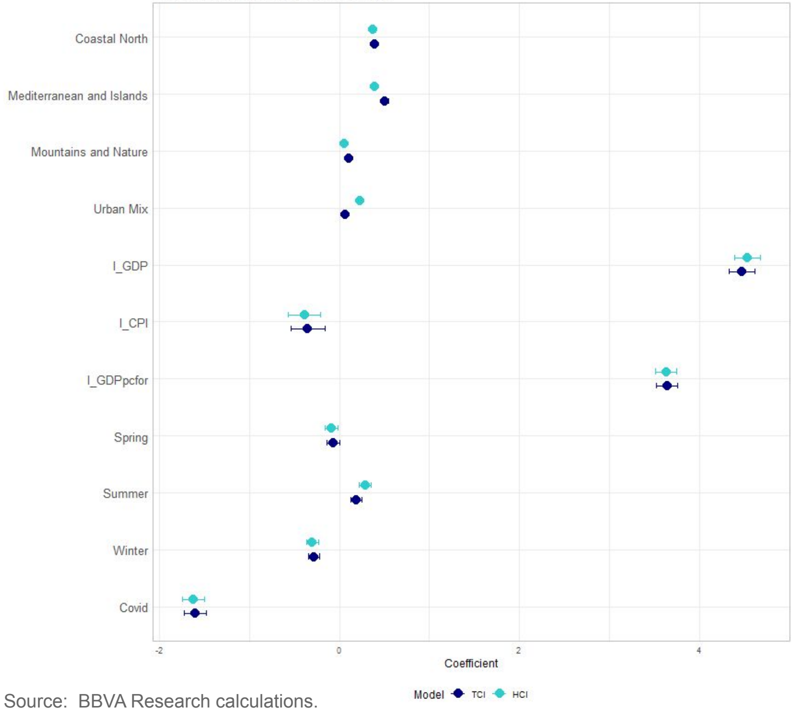
t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

More details on the coefficients in the Annex.

Comparing the results using TCI and HCI: The coefficients are not statistically different in almost every case

- Statistically, **there is no evidence to suggest that the coefficients of the two models are significantly different, except for Urban Mix.**
- The sensitivity of tourism types to climate conditions is quite similar when estimating the model with historical data. The models are almost equivalent.
- Therefore, **differences in the results come mainly from how the reference climate scenarios (RCPs) are translated to the respective proxy, TCI or HCI over the forecasted period (2024-2100)**. That is, given that TCI and HCI use different classifications, what will change is the classification of the same future climate variables and thus the future scenario.

COMPARISON OF TCI AND HCI COEFFICIENTS WITH 95 PERCENT CONFIDENCE INTERVALS

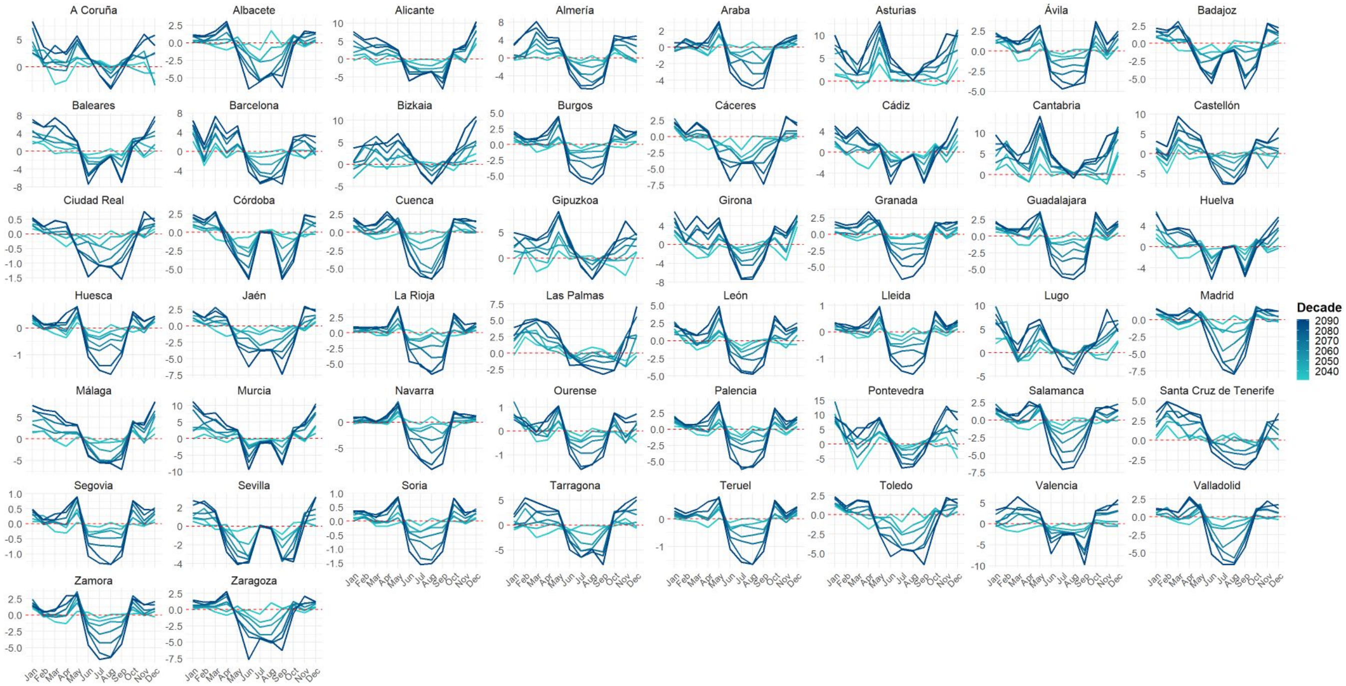


Source: BBVA Research calculations.

Results: HCI reduces climate impact on beach tourism while making urban tourism more climate-sensitive

CHANGE IN TOURISM DEMAND THROUGH DECADES IN RCP 8.5

(%, USING AS BASE 2024-2030)

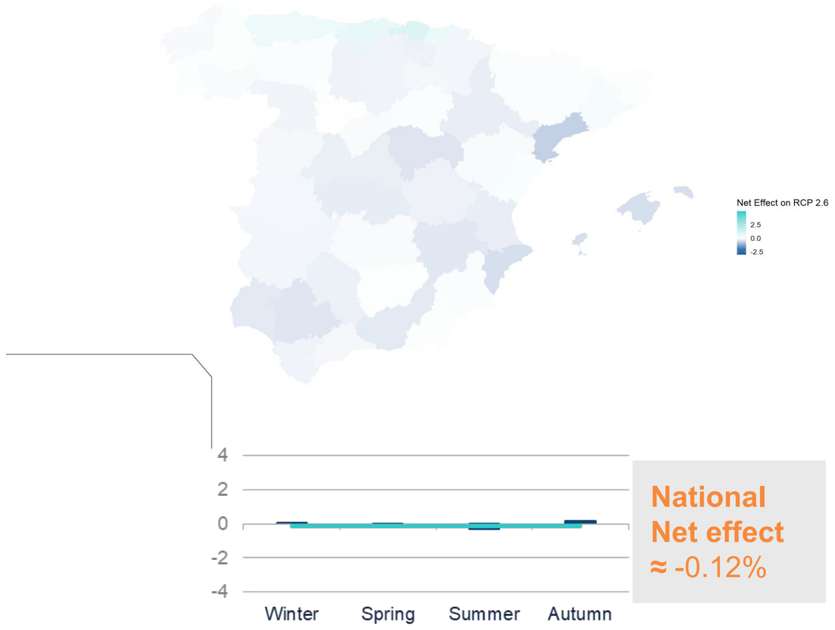


Source: BBVA Research calculations.

Net effect on tourism: Holiday climate index (HCI) under RCP scenarios shows moderate but widespread declines across territories

NET EFFECT BY PROVINCE AND SEASON IN RCP2.6, 2091-2100

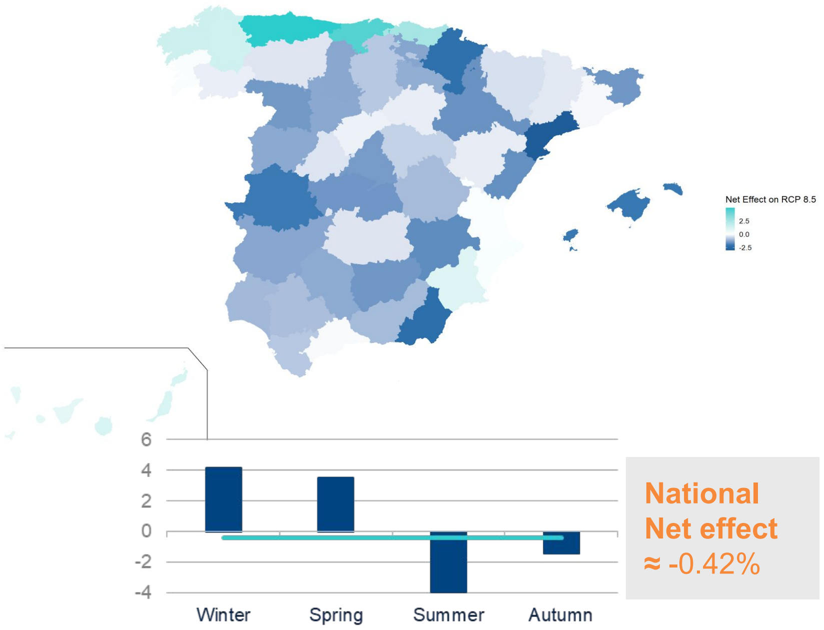
(%, USING AS BASE 2024-2030)



Source: BBVA Research.

NET EFFECT BY PROVINCE AND SEASON IN RCP8.5, 2091-2100

(%, USING AS BASE 2024-2030)



Source: BBVA Research.

Main takeaways (1/2): Climate will shift seasonal and regional patterns of tourism, but the future net effect will depend on the adopted measures

- **The results of the analysis show a potential change in the current seasonal pattern of tourism in Spain, i.e. the shifting tourism demand across seasons.**
- **Adaptability is crucial for avoiding a significant negative net impact of climate conditions on tourism demand** in the future, especially in the southeast, where beach tourism plays a vital role. Destinations will need to adapt, such as increasing hotel capacity in the North and improving hotel climate control systems to cope with the changes in the east and the south.
- The **RCP 4.5 scenario is currently the most likely**, with a projected temperature increase of 2.8°C by 2100 compared to pre-industrial levels. While the net impact may not be excessively large, there will be a shift of tourists between seasons and some provinces will experience negative and positive net-effects. However, more severe impacts are expected during July and August.
- **The results with TCIs indicate that the net effect in tourism for RCP scenarios 2.6, 4.5, and 8.5 by 2100 compared to the current decade is around -0.3%, -0.6% and -7% respectively.** This effect could be higher without implementing flexible school and work holidays. Remote working schemes could enhance this flexibility.

Main takeaways (2/2): Climate will shift seasonal and regional patterns of tourism, but the future net effect will depend on the adopted measures

- Regionally, the impacts are different. **The northern provinces of the country are likely to benefit more from global warming compared to the Mediterranean provinces.**
- **The established thresholds of Climate Indexes determine the results, yet it is challenging to decide which one is more appropriate.** It may be important to account for different thresholds for various types of tourism, as tourists seem to adapt their preferences to their destination. Over time, as we gather more data on high temperatures, the clarity on the actual thresholds will improve, which may also be influenced and changed due to adaptation measures.
- While climate change poses significant challenges to the traditional tourism model in Spain, it also presents opportunities for innovation and adaptation.

BBVA Research

The Impact of Climate Change on Tourism Demand in Spain

September 2024

Creating Opportunities

BBVA Research

06

Further research: Temperature Analysis

Further research: Temperature Analysis (I)

An alternative modeling approach involves estimating the impact of warming levels by employing the humidex (an integrated index of temperature and humidity) as independent variable, rather than TCI or HCI. To account for nonlinear effects of temperature, the squared term of humidex can be included in the model.

A single threshold can be estimated, or alternatively, different threshold for each type of tourism. Both the linear and quadratic terms of the humidex are significant, with positive and negative signs respectively, suggesting an inverted U-shaped relationship between the humidex and tourism demand.

This line of research presents potential for further development in future studies. Nonetheless, the tests conducted on other climatic variables have produced insignificant results.

Further research: Temperature Analysis (II)

- **These results differ significantly from those obtained with comfort indexes (TCI, HCI), not so much in terms of net effect but in geographical distribution.** The lack of data in the upper part of the distribution may bias the results, or the temperature variable may be capturing effects beyond purely climatic factors. The coefficient of the control variables are pretty similar to those obtained with TCI and HCI.
- **Results using a single threshold are closer to those obtained with comfort indexes, in particular with TCI** (by construction, TCI has a threshold while HCI has two, for beach and non-beach settings).
- Conducting a future more detailed analysis could be valuable to determine whether a comprehensive analysis of climatic variables might be a better approach.

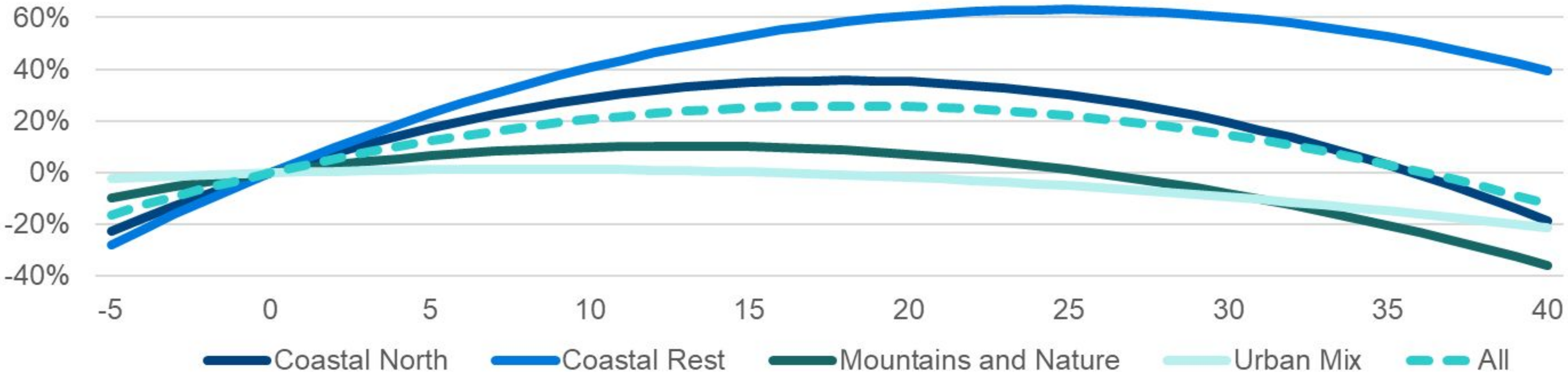
HUMIDEX COEFFICIENTS AND STATISTICAL SIGNIFICANCE. MODEL WITHOUT COMFORT INDEXES

Dependent Variable:	lnBN_tot	
Single threshold specification		
HUM	0.0285155***	(34.89)
HUM2	-0.0007885***	(-37.08)
Multiple threshold specification		
Coastal North × HUM	0.03991***	(28.08)
Mediterranean and Islands × HUM	0.0508615***	(34.99)
Mountains and Nature × HUM	0.0160776***	(34.99)
Urban Mix × HUM	0.0034634***	(4.10)
Coastal North × HUM2	-0.0011152***	(-23.29)
Mediterranean and Islands × HUM2	-0.0010248***	(-25.07)
Mountains and Nature × HUM2	-0.0006259***	(-16.91)
Urban Mix × HUM2	-0.0002203***	(-10.21)

t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Further research: Temperature Analysis (III)

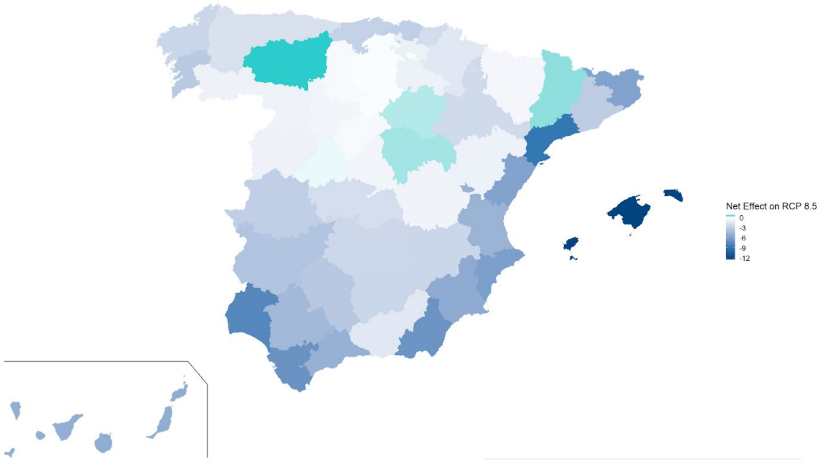
PERCENTAGE EFFECT OF HUMIDEX, °C (X-AXIS) **ON BED NIGHTS,** % (Y-AXIS)



Source: BBVA Research.

Further research: Temperature Analysis (IV)

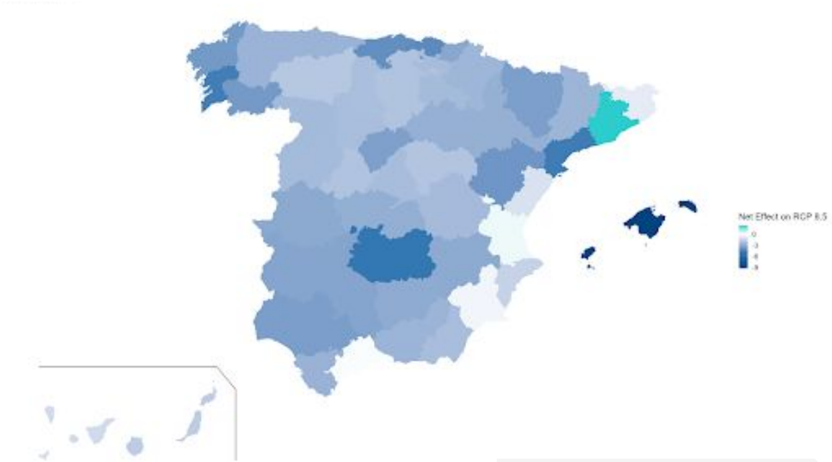
NET EFFECT BY PROVINCES. RCP 8.5. 2091-2100 vs 2024-30. SINGLE THRESHOLD



National Net effect ≈ - 5.5%

Source: BBVA Research.

NET EFFECT BY PROVINCES. RCP 8.5. 2091-2100 vs 2024-30. MULTIPLE THRESHOLDS



National Net effect ≈ - 2.7%

Source: BBVA Research.

Research

07

Annex

Creating Opportunities

A1 - Modelling tourism demand: a literature review

Literature has modelled the tourism demand in multiple ways depending on the analysis goals:

Model Estimation Techniques

- ***Single-equation specifications and time series analysis:*** focus on pure forecasting.
- ***Gravity models:*** identification of factors driving tourism demand and impact from a certain phenomenon or policy.
- ***Panel data models:*** use of regional/ cross-countries dimension to evaluate phenomena.

Dependent Variable

- The choice of the measure for tourism demand can be controversial since the ***tourism activity is a multidimensional variable.***
- Literature mostly uses ***tourist arrivals*** (totals or bilateral). Other times it uses ***number of nights, expenditures, length of stay, purpose.***

Explanatory Variables

- ***Economic and Political***
  - Income of the travelers/countries.
  - Prices.
  - Quality of offer.
  - Government regulations, security, safety, visa agreements.
- ***Non-economic***
  - Geographical and physical factors.
  - Cultural factors.
  - Tastes.
  - Type of tourism.
  - Sociodemographic characteristics of travelers.

A1 - Modelling tourism demand: a literature review

Study	Time	Countries	Climate variable	Methodology	Main Results
Amelung & Moreno (2012)	2080s projections	European countries	Tourism climate index (TCI)	Linear regression and climate scenarios	Southern Europe less favorable in summer and Northern Europe more favorable. Economic impacts depend on tourists' flexibility in holiday planning.
Rosselló & Santana-Gallego (2014)	2005-2007	Spain	Temperature	Gravity model domestic tourism	Temperature is a positive factor in tourism flows. Future competitiveness of northern provinces.
Barrios & Ibañez (2015)	2010-2011, projections	EU regions	Temperature	Tourism demand equation	Southern EU regions lose tourism revenues and Northern EU regions gain modestly, especially due to timing adaptation of holidays.
Scott et al. (2016)	1961-2099	27 EU countries	TCI, HCI	Comparative analysis of TCI and HCI	HCI offer insights for urban and beach tourism.
Rosselló, Becken & Santana-Gallego (2020)	1995-2013	171 countries	Natural disasters	Gravity model international tourism flows, panel data with destination fixed-effects	Disasters generally decrease tourist arrivals, while cold and heat waves do not have major effect on arrivals.
Cevik & Ghazanchyan (2020)	1995-2017	15 Caribbean countries	ND-GAIN Vulnerability index	Panel data analysis using GMM estimator	Climate vulnerability significantly reduces tourism revenues. Adaptation policies are needed.
Oğur & Baycan (2022)	2008-2017, projections until 2100	Türkiye	TCI	Log-linear model specification à la Hein et.al (2009)	Shift in the seasonal patterns of tourism demand from summer to winter and overall decline in tourism demand as a result of climate change.
Matei et al. (2023)	2000-2019	269 European regions	TCI	Fixed effects monthly panel	North-south tourism pattern change and seasonality shift. Coastal regions most impacted.

A2 - Tourism Climate Index: Insights on the climate variables

- All the climate data required to compute the Tourism Climate Index(TCI) was obtained from the ERA5 database provided by Copernicus. This dataset is a grid with a horizontal resolution of 0.25º x 0.25º at a global level from 1940 until the present.
- The TCI consists of 5 variables:

2m temperature (ºC): temperature of air at 2m above the surface of land, sea or inland waters. 2m temperature is calculated by interpolating between the lowest model level and the Earth's surface, taking account of the atmospheric conditions.

2m dew point temperature (ºK): temperature to which the air, at 2 metres above the surface of the Earth, would have to be cooled for saturation to occur. It is a measure of the humidity of the air. Combined with temperature and pressure, it can be used to calculate the relative humidity.

Total daily precipitation (mm): This parameter is the accumulated liquid and frozen water, comprising rain and snow, that falls to the Earth's surface. It is the sum of large-scale precipitation and convective precipitation.

10m wind speed (km/h): this parameter is the horizontal speed of the wind, or movement of air, at a height of ten metres above the surface of the Earth.

Total cloud cover (%): this parameter is the proportion of a grid box covered by cloud. Cloud fractions vary from 0 to 1.

A2 - Tourism Climate Index: Insights on the climate variables

- The main component of the TCI is a compound humidity index indicating the daily thermal comfort know as the Humidex. This indicator is a build as a function of temperature and relative humidity, and was thought to represent how hot the weather feels to the average person.
- The Humidex formula is as follows:

$$H = T_{\text{air}} + 0.5555\left(6.11 \times \exp\left[5417.7530\left(\frac{1}{273.15} - \frac{1}{273.15 + T_{\text{dew}}}\right)\right] - 10\right)$$

where

→ H denotes the Humidex
→ T_{air} is the air temperature in ºC
→ T_{dew} is the dew point temperature ºC
→ The rounded constant 5417.7530 is based on the molecular weight of water, latent heat evaporation, and the universal gas constant. The 0.5555 factor (from the relation 1 °F = 5/9 °C)

- Nevertheless, this index can also be built using the relative humidity (%).

A2 - Tourism Climate Index: Insights on the climate variables

TOURISM CLIMATE INDEX RATING SYSTEM

Rating	Humidex (ºC)
0	≥ 36
1	[35.0, 35.9)
2	[34.0, 34.9)
3	[33.0, 33.9)
4	[32.0, 32.9)
5	[31.0, 31.9)
6	[30.0, 30.9)
7	[29.0, 29.9)
8	[28.0, 28.9)
9	[27.0, 27.9)
10	[20.0, 26.9)
9	[19.0, 19.9)
8	[18.0, 18.9)
7	[17.0, 17.9)
6	[16.0, 16.9)
5	[10.0, 15.9)
4	[5.0, 9.9)
3	[0.0, 4.9)
2	(-5.9, -0.1]
0	(-10.9, -6.0]
-1	(-15.9, -11.0]
-2	(-20.9, -16.0]
-6	≤ -21

Rating	Precipitation (mm)
10	[0.0, 0.5)
9	[0.5, 1.0)
8	[1.0, 1.5)
7	[1.5, 2.0)
6	[2.0, 2.5)
5	[2.5, 3.0)
4	[3.0, 3.0)
3	[3.5, 4.0)
2	[4.0, 4.5)
1	[4.5, 5)
0	≥ 5

Rating	CC (%)
10	0.0-16.6
9	16.7-24.9
8	25.0-33.2
7	33.3-41.6
6	41.7-49.9
5	50.0-58.2
4	58.3-66.6
3	66.7-74.9
2	75.0-83.2
1	83.3-91.6
0	$\geq$91.7

Rating ($\leq$ 23.9ºC)	Rating ($24 - 32.9C$)	Rating ($\geq 32.9C$)	Wind (km/h)
10	4	4	≤ 2.88
9	5	3	2.89-5.75
8	6	2	5.76-9.03
7	8	1	9.04-12.23
6	10	0	12.24-19.79
5	8	0	19.80-24.29
4	6	0	24.30-28.79
3	4	0	28.80-38.51
0	0	0	≥ 38.52

A3 - Statistical Tests & Results

Fixed effects panel with regional clusters and robust standard errors.

$$\ln(BN_{it}) = \gamma + \alpha_i + \beta_1 \ln(TCI_{it} \times Tclass_i) + \beta_2 \ln(GDP_{it}) + \beta_3 \ln(CPI_{it}) + \beta_4 \ln(GDPpcfor_{it}) + d_s M_s + d_c Covid + \epsilon_{it}$$

Test	Test statistic	p-value	Conclusion
Breusch-Pagan LM	195000	0,00	Cross-sectional dependence
Pesaran CD	433,077	0,00	Cross-sectional dependence
Durbin-Watson	1,4350591		Autocorrelation

Considering the results from the above statistics, we decide to control for error correlation across panels (cross-sectional dependence) and autocorrelation in the error terms. Regarding the autocorrelation issue, we assume the error an idiosyncratic AR(1) process to each panel.

To estimate this model we have chosen the General Least Squares estimation method above others others (i.e. Driscoll-Kraay standard errors) given our panel has larger T as compared to the N.

A3 - Statistical Tests & Results

Model 1: Simple form

Model 2: Model 1 controlling for external demand (relative to GDP per capita)

Model 3: Model 2 introducing a dummy for covid months. Base model.

Model 4: Model 3 controlling for foreign prices (relative CPI)

Model 5: Model 4 introducing the percentage of 3-5 stars hotels

Model 6: Model 5 controlling for capacity

	(1) l_BN_tot	(2) l_BN_tot	(3) l_BN_tot	(4) l_BN_tot	(5) l_BN_tot	(6) l_BN_tot
Coastal North × l_TCI	0.339***	0.323***	0.391***	0.398***	0.398***	0.376***
	(21.18)	(20.28)	(25.05)	(25.37)	(25.20)	(17.56)
Mediterranean and Islands × l_TCI	0.438***	0.412***	0.501***	0.505***	0.504***	0.396***
	(22.65)	(20.48)	(24.66)	(24.82)	(24.64)	(15.47)
Mountains and Nature × l_TCI	0.146***	0.126***	0.104***	0.112***	0.110***	0.0881***
	(11.89)	(9.75)	(8.89)	(9.60)	(9.38)	(6.25)
Urban Mix × l_TCI	0.130***	0.102***	0.0603***	0.0694***	0.0649***	0.110***
	(14.32)	(10.89)	(6.72)	(7.79)	(7.08)	(9.52)
l_GDP	0.970***	6.805***	4.470***	4.699***	4.671***	3.668***
	(24.68)	(42.58)	(63.00)	(62.26)	(61.21)	(35.90)
l_CPI	0.528***	-1.625***	-0.351***	-0.407***	-0.370***	0.348***
	(5.15)	(-14.39)	(-3.63)	(-3.72)	(-3.28)	(2.97)
Autumn	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Spring	0.00602	0.00713	-0.0675**	-0.0617*	-0.0608*	0.0151
	(0.18)	(0.23)	(-1.96)	(-1.79)	(-1.75)	(0.46)
Summer	0.222***	0.242***	0.189***	0.191***	0.190***	0.187***
	(6.49)	(7.93)	(5.70)	(5.76)	(5.70)	(6.08)
Winter	-0.245***	-0.230***	-0.284***	-0.270***	-0.272***	-0.262***
	(-7.32)	(-7.69)	(-8.63)	(-8.21)	(-8.20)	(-8.51)
l_GDP_pcfor		5.932***	3.638***	3.854***	3.806***	2.896***
		(40.66)	(60.83)	(60.31)	(58.28)	(31.86)
Covid			-1.598***	-1.515***	-1.526***	-1.373***
			(-25.82)	(-24.30)	(-24.25)	(-22.31)
l_CPI_for				-1.748***	-1.815***	-1.060***
				(-16.17)	(-16.06)	(-7.15)
Stars					1.048***	0.762***
					(48.95)	(28.50)
l_Cap						0.265***
						(61.10)
Constant	-5.465***	-85.26***	-55.36***	-58.04***	-106.7***	-83.63***
	(-6.63)	(-37.74)	(-53.21)	(-50.59)	(-52.07)	(-30.89)

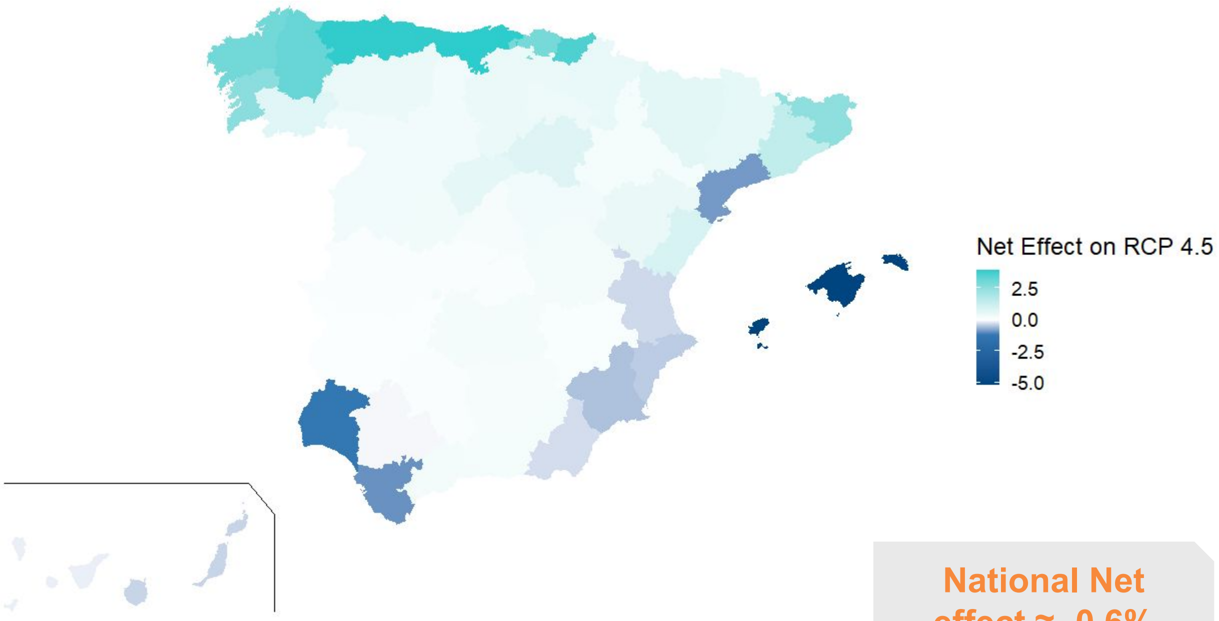
t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(*) Additional variables are sourced from INE and own data. Foreign CPI is calculated as the weighted average of the monthly CPI from the top 10 visitor countries per province, relative to the CPI of the destination province. The "Stars" variable represents the percentage of hotels in the province that have at least 3 stars. The "Cap" variable defines the estimated number of hotel beds available.

A4 - RCP 4.5 | Net effect on tourism: Tourism climate index under RCP scenarios shift future seasonality and destinations

NET EFFECT BY PROVINCE IN RCP4.5, 2091-2100

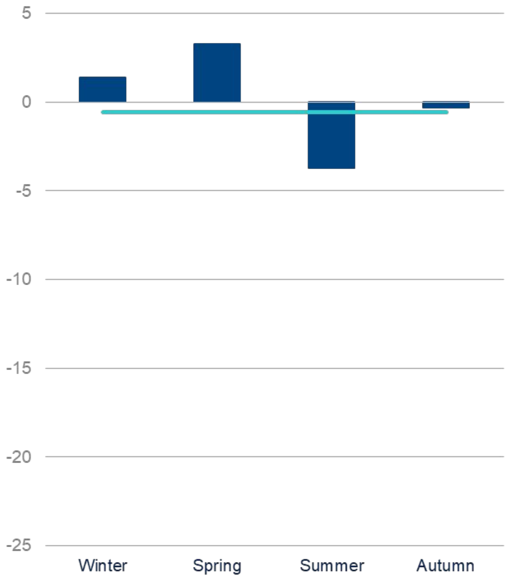
(%, USING AS BASE 2024-2030)



National Net effect ≈ -0.6%

NET EFFECT BY SEASON IN RCP4.5, 2091-2100

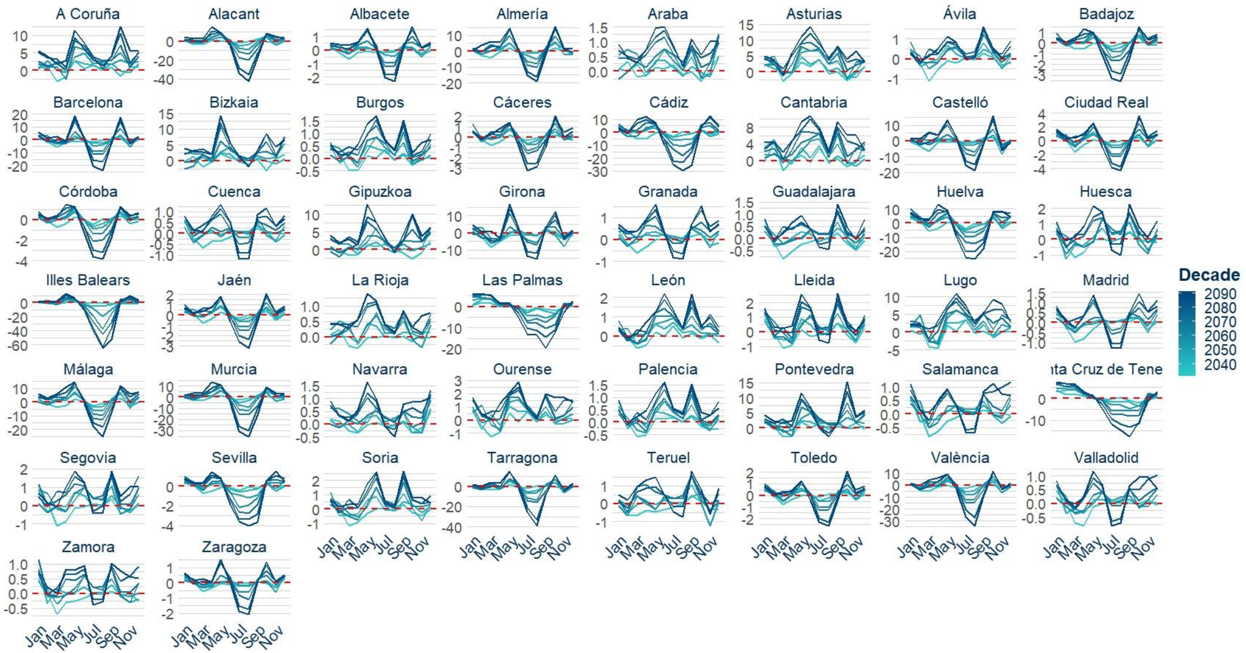
(%, USING AS BASE 2024-2030)



Source: BBVA Research calculations.

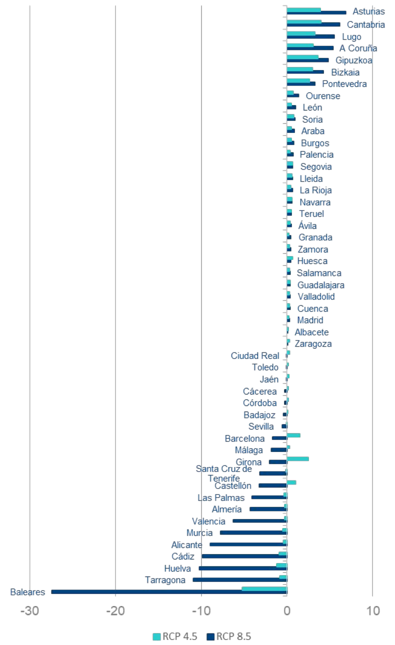
A4 - Overview of the change in tourism demand by province

CHANGE IN TOURISM DEMAND IN RCP 8.5 THROUGH DECADES(*)
(%, USING AS BASE 2024-2030)



Source: BBVA Research calculations.
(*) Notes: Decades from 2040s (light blue) to 2090s (dark blue).

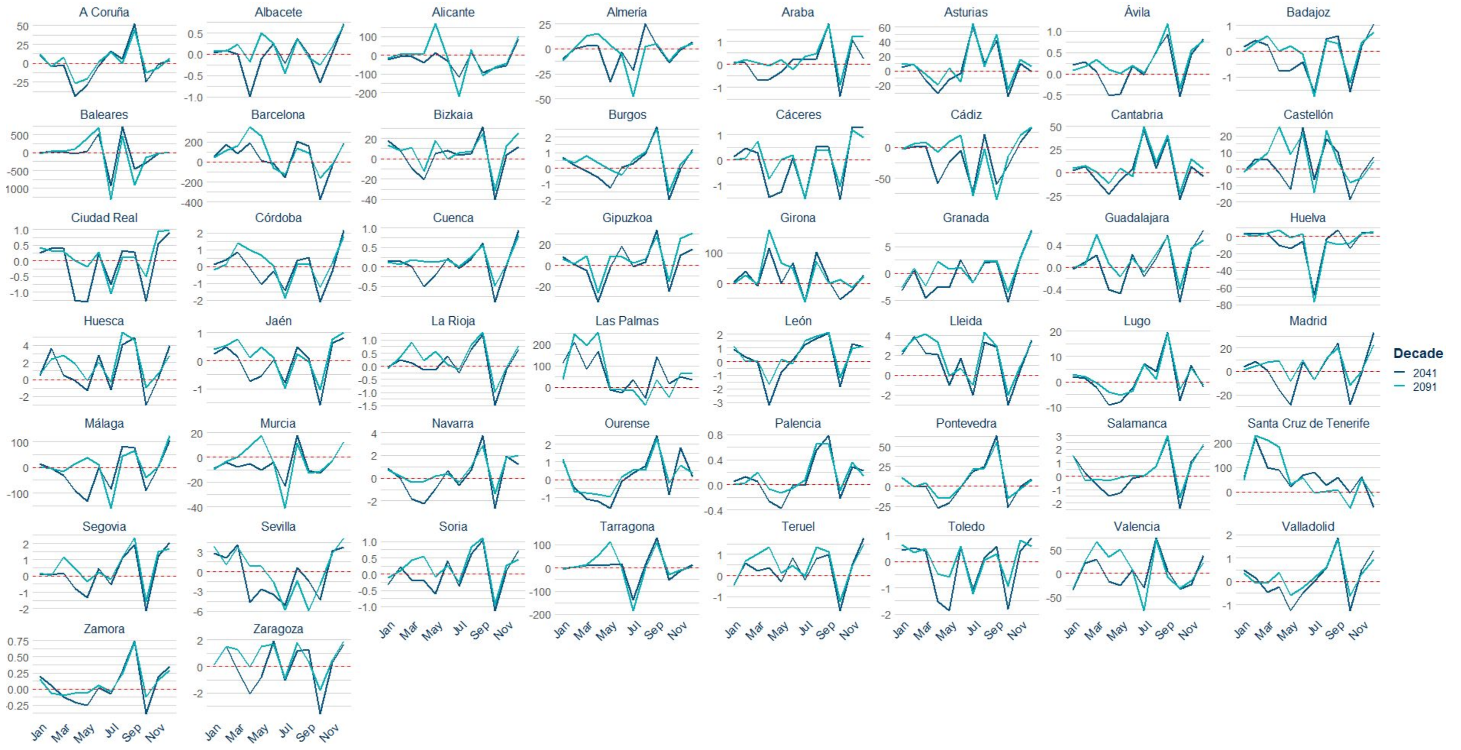
NET EFFECT 2091-2100
(%, using as base 2024-2030)



Source: BBVA Research calculations.

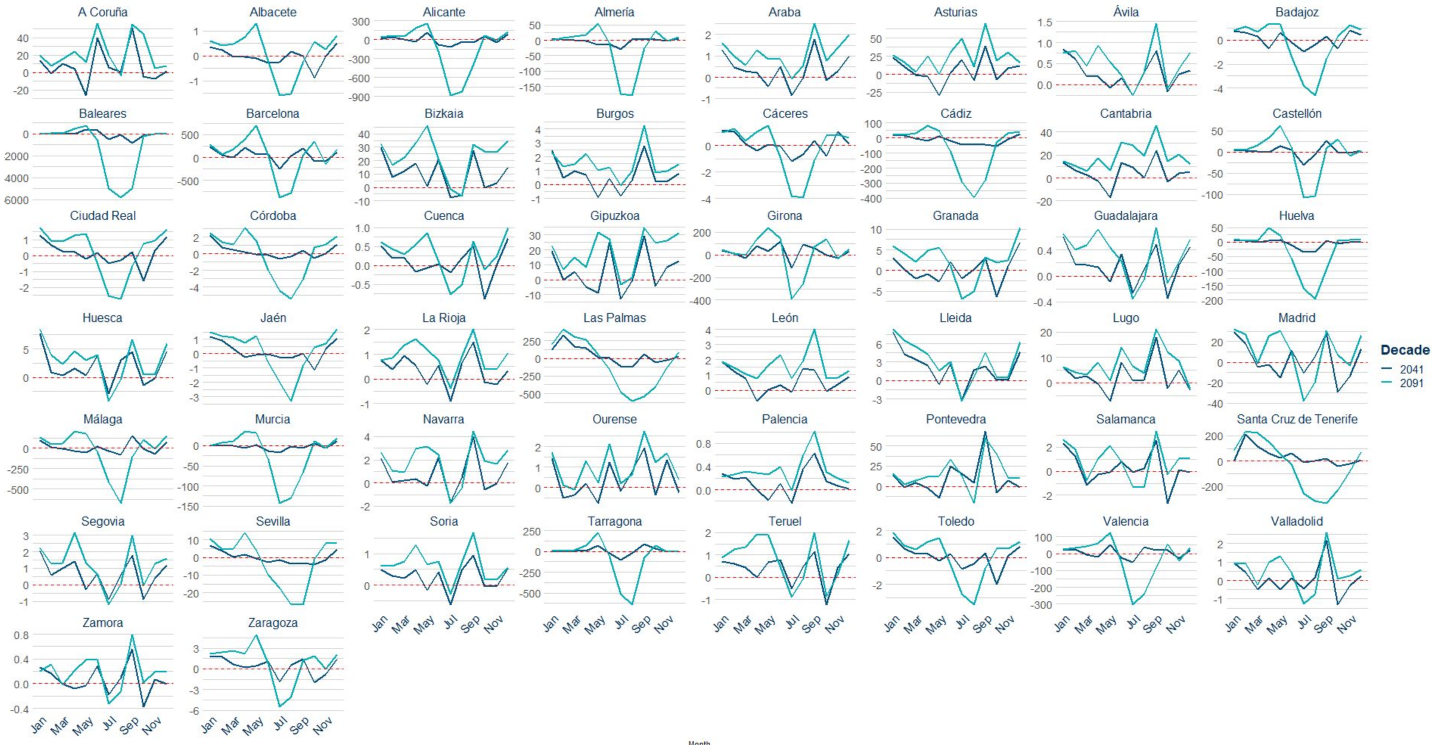
A4 - Overview of the net effect by province

COMPARISON ACROSS SCENARIOS (RCP 2.6 - RCP 4.5), THOUSANDS BEDNIGHTS



A4 - Overview of the net effect by province

COMPARISON ACROSS SCENARIOS (RCP 2.6 - RCP 8.5), THOUSANDS BEDNIGHTS



A5 - Comparison of the TCI and HCI: rating scheme and weights

TCI vs HCI THERMAL COMFORT RATING

TCI		HCI:Urban		HCI:Beach	
Rating	THumidex (°C)	THumidex (°C)	Rating	THumidex (°C)	Rating
0	≥36.0	≥39.0	0	≥39.0	0
		37.0–38.9	2	38.0–38.9	2
1	35.0–35.9			37.0–37.9	4
2	34.0–34.9	35.0–36.9	4	36.0–36.9	5
3	33.0–33.9			35.0–35.9	6
4	32.0–32.9	33.0–34.9	5	34.0–34.9	7
5	31.0–31.9	31.0–32.9	6	33.0–33.9	8
6	30.0–30.9	29.0–30.9	7	31.0–32.9	9
7	29.0–29.9	27.0–28.9	8	28.0–30.9	10
8	28.0–28.9	26.0–26.9	9	26.0–27.9	9
9	27.0–27.9	23.0–25.9	10	23.0–25.9	7
10	20.0–26.9	20.0–22.9	9	22.0–22.9	6
9	19.0–19.9			21.0–21.9	5
8	18.0–18.9	18.0–19.9	7	20.0–20.9	4
7	17.0–17.9	15.0–17.9	6	19.0–19.9	3
6	16.0–16.9	11.0–14.9	5		
5	10.0–15.9	7.0–10.9	4	18.0–18.9	2
4	5.0–9.9	0–6.9	3	17.0–17.9	1
3	0.0–4.9			15.0–16.9	0
2	−0.1–−5.9	−0.1–−5.9	2	10.0–14.9	-5
0	−6.0–−10.9	≤−6.0	1	≤9.9	-10
−1	−11.0–−15.9				
−2	−16.0–−20.9				
−6	≤−21.0				

- The main component of the indexes driving different comfort levels is the compound humidity index, indicating the daily thermal comfort.
- HCI Beach assigns the highest rating for higher temperature levels compared to the other indexes.

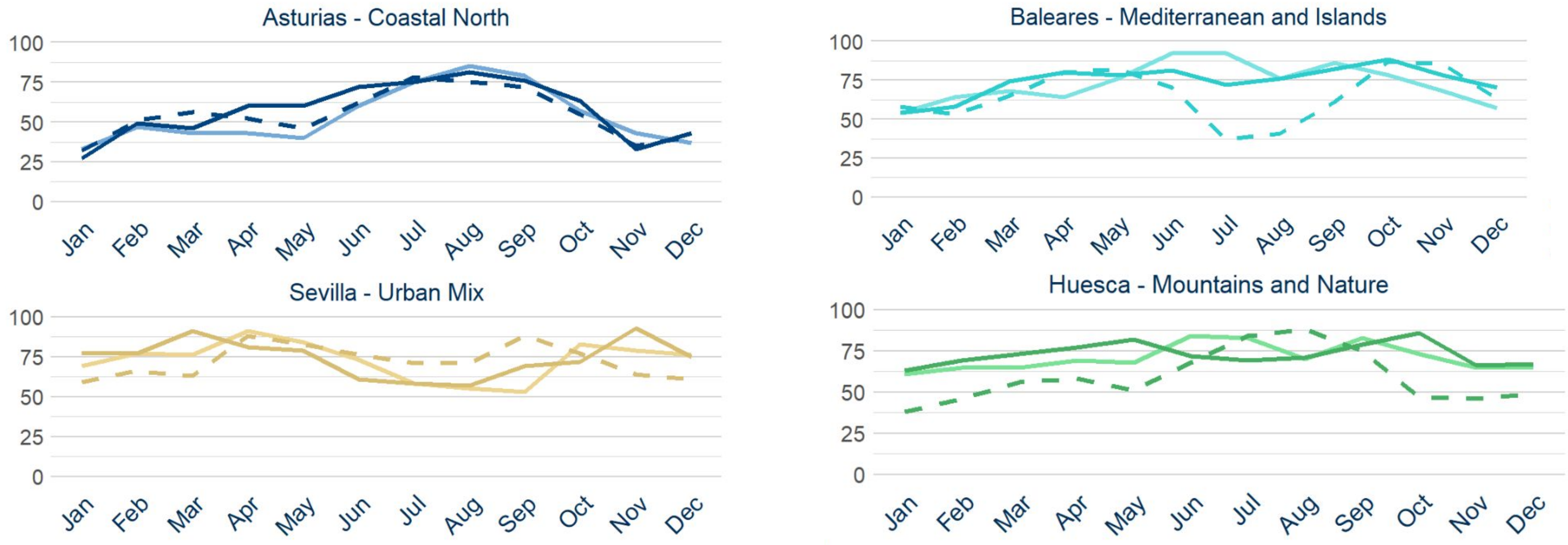
TCI vs HCI INDEX COMPONENTS

Index Component	Weather Variables	TCI	HCI: Urban	HCI: Beach
Thermal comfort (TC)	Temperature and Humidity (°C)	50%	40%	20%
Aesthetic (A)	Cloud cover (%)	20%	20%	40%
Precipitation (P)	Total precipitation (mm)	20%	30%	30%
Wind (W)	Mean wind speeds (km/hr)	10%	10%	10%

A5 - Comparison of the TCI and HCI: High temperatures have less negative impact on beach tourism comfort according to the HCI

HCI AND TCI EVOLUTION IN SELECTED PROVINCES (BY TYPE OF TOURISM)

1980 VS 2023 (*)



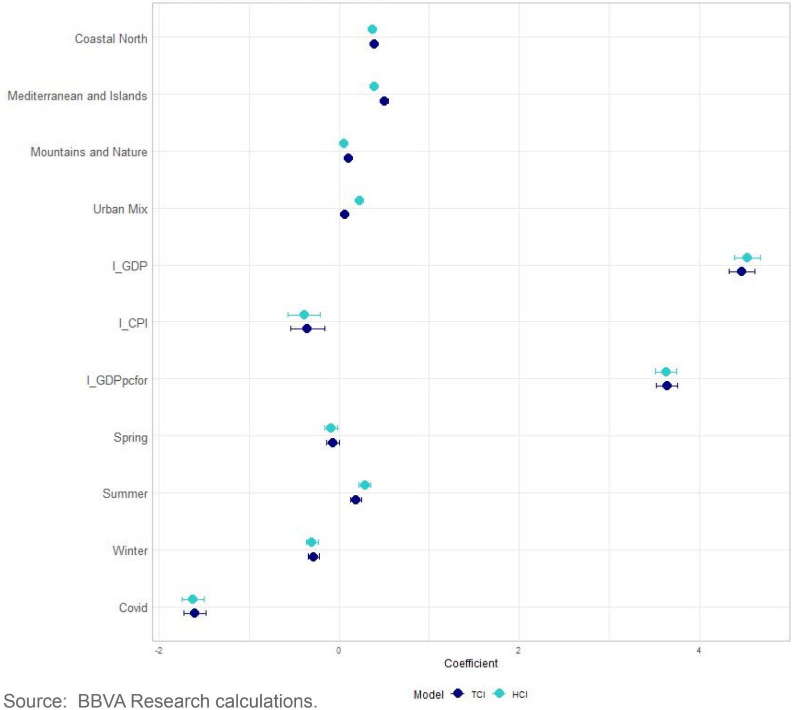
(*) The lighter color represents the HCI in 1980, and the darker color represents the HCI in 2023. The dashed lines are the TCI for 2023.
Provinces in Coastal north, mediterranean coast and Islands are calculated with the HCI Beach, while provinces in the Urban Mix and Mountains and Nature category are calculated with the HCI Urban.

Source: BBVA Research calculations.

A6 - Comparing the results using TCI and HCI: The coefficients are not statistically different in almost every case

- Statistically, **there is no evidence to suggest that the coefficients of the two models are significantly different, except for Urban Mix.**
- The sensitivity of tourism types to climate conditions is quite similar when estimating the model with historical data. The models are almost equivalent.
- Therefore, **differences in the results come mainly from how the reference climate scenarios (RCPs) are translated to the respective proxy, TCI or HCI over the forecasted period (2024-2100)**. That is, given that TCI and HCI use different classifications, what will change is the classification of the same future climate variables and thus the future scenario.

COMPARISON OF TCI AND HCI COEFFICIENTS WITH 95 PERCENT CONFIDENCE INTERVALS



Source: BBVA Research calculations.

A6 - HCI Results: additional regressions

Model 1: Base model

Model 2: Model 1 controlling for external relative CPI

Model 3: Model 2 introducing the percentage of 3-5 star hotels

Model 4: Model 3 introducing hotel capacity

	(1) l_BN_tot	(2) l_BN_tot	(3) l_BN_tot	(4) l_BN_tot
Coastal North × l_HCI	0.273***	0.277***	0.276***	0.229***
	(22.95)	(23.13)	(22.82)	(13.17)
Mediterranean and Islands × l_HCI	0.629***	0.635***	0.634***	0.640***
	(28.76)	(28.74)	(28.47)	(25.45)
Mountains and Nature × l_HCI	0.207***	0.221***	0.220***	0.205***
	(10.79)	(11.43)	(11.35)	(8.94)
Urban Mix × l_HCI	0.0986***	0.111***	0.105***	0.167***
	(7.46)	(8.38)	(7.76)	(9.92)
l_GDP	4.350***	4.560***	4.532***	3.450***
	(59.68)	(58.04)	(57.12)	(33.03)
l_GDPpcfor	3.574***	3.778***	3.733***	2.763***
	(59.20)	(57.83)	(56.24)	(29.75)
l_CPI	-0.452***	-0.508***	-0.457***	0.231*
	(-4.62)	(-4.53)	(-3.98)	(1.93)
Autumn	0	0	0	0
	(.)	(.)	(.)	(.)
Spring	-0.0324	-0.0219	-0.0177	0.0377
	(-0.93)	(-0.63)	(-0.50)	(1.11)
Summer	0.234***	0.234***	0.236***	0.204***
	(7.00)	(7.03)	(7.03)	(6.39)
Winter	-0.263***	-0.242***	-0.242***	-0.219***
	(-7.94)	(-7.32)	(-7.29)	(-6.90)
Covid	-1.568***	-1.485***	-1.495***	-1.370***
	(-24.80)	(-23.43)	(-23.40)	(-21.30)
l_CPI_for		-1.813***	-1.859***	-1.250***
		(-16.99)	(-16.84)	(-9.16)
Stars			0.930***	0.603***
			(41.68)	(22.06)
l_Cap				0.267***
				(61.00)
Constant	-52.65***	-55.02***	-98.26***	-71.79***
	(-48.40)	(-44.91)	(-45.60)	(-25.83)

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(*) Additional variables are sourced from INE and own data. Foreign CPI is calculated as the weighted average of the monthly CPI from the top 10 visitor countries per province, relative to the CPI of the destination province. The "Stars" variable represents the percentage of hotels in the province that have at least 3 stars. The "Cap" variable defines the estimated number of hotel beds available.

BBVA Research

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Creating Opportunities