



Climate Change and Tourism Seasonality: The Role of Rising Temperature in Hotel Performance in Urban Southern Europe Destinations

Cambio climático y estacionalidad turística: El papel del aumento de las temperaturas en el rendimiento hotelero para destinos urbanos del sur de Europa

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Abstract

Climate change is driving substantial changes in the tourism industry, influencing tourist flows, seasonality patterns, and hotel profitability. However, there is a research gap regarding the impact of rising temperatures on urban destinations. This study analyses 600 monthly observations from five Southern European urban destinations using a panel data approach. The empirical results suggest that higher temperatures during peak-demand periods decrease occupancy rates; in August, a 1 °C increase in maximum temperature reduces occupancy by 2.1%. The analysis also confirms a nonlinear effect of temperature on occupancy rates, with 25.5°C representing the level that maximises occupancy rates, *ceteris paribus*. Finally, for the five analysed cities, rising temperatures contribute, with a small but statistically significant effect, to the smoothing of seasonal patterns. These findings suggest that climate change may gradually reshape the distribution of demand and affect destination competitiveness and hotel profitability among the sample of Southern European cities analysed.

Keywords: Climate Change, Tourism Seasonality, Rising Temperature, Theil index, Occupancy rate.

Resumen

El cambio climático está suponiendo cambios sustanciales para la industria turística, influyendo en los flujos de turismo, la estacionalidad y la rentabilidad hotelera. Sin embargo, existe un vacío en la investigación referida a como el incremento de la temperatura afecta a los destinos urbanos. Este estudio analiza 600 observaciones mensuales para cinco distintos destinos del sur de Europa utilizando datos de panel. Los resultados empíricos indican que un aumento en la temperatura máxima reduce marginalmente la ocupación hotelera en el periodo de mayor demanda: en agosto un aumento de 1° C reduce la ocupación hotelera en 2.1%. El análisis también confirma que el efecto del aumento de la temperatura en la ocupación hotelera es no lineal, siendo 25,5°C la temperatura que maximiza la ocupación hotelera, *ceteris paribus*. Finalmente, el aumento de la temperatura contribuye, con un efecto pequeño, pero estadísticamente significativo, a suavizar la estacionalidad. Estos resultados sugieren que el cambio climático puede cambiar progresivamente la distribución de la demanda y afectar a la competitividad de los destinos y a la rentabilidad hotelera de los destinos analizados en el sur de Europa.

Palabras clave: Cambio Climático, Estacionalidad del Turismo, Aumento de la Temperatura, Índice de Theil, Ratio de Ocupación Hotelera.

1. Introduction

Climate change is a critical challenge for humankind and the Earth; more than a future threat, it is already shaping our world with profound social, economic, and ecological consequences. The Secretary-General of the United Nations declared it a "red code" for our society and called for global action (Scott & Gössling, 2022). Using the baseline scenario for the pre-industrial revolution period (1850–1900), average surface temperatures have risen by approximately 0.8°C to 1.3°C (IPCC, 2023). The future trend depends on the models of economic growth and technological change, as well as the transition toward a greener economic and social framework. However, current estimates suggest that average temperatures may rise by around 1.5 °C during the period 2030–2050 (Alizadeh, Mirzaei & Dittmann, 2021).

Climate change alters the status quo through many different channels. Global warming critically affects agricultural productivity, with more frequent droughts jeopardising food security (Gomez et al., 2020). Extreme weather events have increased in frequency, with negative consequences including damage to infrastructure (Bell et al., 2018). The rise in sea levels may have significant social and economic consequences, including expected large-scale future migration from flooded zones (Arabadzhyan et al., 2021). Higher average temperatures and air pollution also influence consumer behaviour in many industries by creating thermal discomfort (Kinney, 2018; Hoogendoorn & Fitchett, 2018). Overall, climate change may influence a wide range of industries in different ways, a fact that is particularly relevant to the tourism industry.

Tourism is highly sensitive to the effects of climate change (Alizadeh et al., 2021), partly because tourists spend a significant amount of their leisure time engaging in outdoor activities. How much they enjoy these activities depends on weather conditions, such as average temperatures, rainfall, wind, and hours of sun exposure. These weather conditions influence tourism demand and, therefore, hotel performance (Mun & Park, 2023). There is a clear link between climate change and weather, as it increases the



frequency of extreme events and leads to higher temperatures, more frequent heatwaves, and greater thermal discomfort when temperatures approach 30°C. There is also reduced snow volume and shorter winter seasons at ski destinations (Ngin, Chlom & Neef, 2020; Steiger et al., 2024).

Paradoxically, the tourism industry is both a contributor to climate change and one of its victims. On the one hand, tourism activities generate significant CO₂ emissions, making the sector partially responsible for climate change. On the other hand, tourism is a highly climate-sensitive industry that directly suffers the consequences, affecting not only demand but also supply through higher production costs required to adapt to changing environmental conditions (Nacipucha, Ruhanen & Cooper, 2017; Ben Youseff & Zeqiri, 2022). Accordingly, a growing body of research has examined the relationship between climate change and tourism from multiple perspectives. The existing literature addresses a wide range of topics, including the impacts of climate change on tourism demand and hotel performance as well as changes in destination competitiveness (Arabadzhyan et al., 2021).

A key gap in the academic literature is the limited availability of in-depth empirical analyses across destination types examining how climate change affects tourism seasonality. Existing evidence suggests that the relationship between rising average temperatures and tourism demand or occupancy rates may be nonlinear (Balsalobre-Lorente, Driha, Shahbaz, & Sinha, 2020). This paper addresses this gap by investigating the impact of increasing average temperatures on tourism seasonality and occupancy rates in five Southern European cities. Using panel data comprising 600 monthly observations covering the period 2015–2024, the analysis identifies statistically significant effects. Rising temperatures during the peak-demand period can reduce occupancy rates, as increased thermal discomfort lowers demand. The empirical analysis confirms the nonlinear relationship between temperatures and occupancy rates. Finally, for the five cities analysed, the rise in average temperatures is contributing to smoother demand seasonality.

The structure of the paper is as follows. Section 2 reviews the most relevant literature on climate change and the tourism industry, focusing on how weather conditions influence hotel performance and on the role of seasonality in tourism demand. Section 3 presents the methodology. Section 4 reports the main results. Section 5 discusses the implications for hotel managers, investors, and local governments. Finally, the conclusion outlines the study's main limitations and suggests avenues for future research.

2. Literature review

2.1 Climate Change's influence on the tourism industry

The tourism industry is increasingly aware of the challenges, risks, and need for action posed by climate change. In 2020, more than 400 tourism organisations declared a climate emergency, followed by the Glasgow Declaration in 2021, in which over 900 organisations committed to reducing emissions by half by 2030 (Scott, 2024). More frequent extreme events, higher temperatures, sea-level rise, and droughts affect virtually all economic activities (Ben et al., 2022; Craig & Feng, 2018; Gómez-Martín et al., 2014; Scott et al., 2012). Increased weather variability, higher temperatures that induce thermal discomfort, and extreme events such as floods, wildfires, and heatwaves reduce demand for tourism services and increase costs for producers adapting to these conditions.

The effects of climate change on tourism are not homogeneous, as projections of future weather conditions differ substantially across regions. Countries such as Spain, where tourism is a fundamental economic activity, may experience a 5% to 14% decline in tourism demand over the next 50 years (Alizadeh et al., 2021). Substantial analysis shows that ski resorts are already affected. They are experiencing shifts in demand, shorter snow seasons, and reduced profitability, the latter partially due to the need to adapt to new conditions, for instance, by producing artificial snow (Steiger et al., 2024). Developing countries may face particularly severe challenges, as they tend to have fewer resources to adapt infrastructure to climate-related impacts such as sea-level rise; their business ecosystems are characterised by smaller firms and a larger informal sector, which limit their capacity to adapt (Hoogendoorn & Fitchett, 2018; Jarratt & Davies, 2020). Overall, climate change can exacerbate income inequality and reshape destination competitiveness, with significant implications for economic growth, employment, and development.

Climate change impacts on tourist destinations vary according to geography and destination type. One of the tools frequently used in this line of research is the Tourism Climatic Index. In coastal destinations, higher average temperatures and more frequent heatwaves are expected to increase thermal stress during the warmest months. These conditions may reduce demand in peak summer periods; however, by increasing demand during historically colder months, seasonality may become less pronounced (Arabadzhyan et al., 2021). Moreover, extreme weather events and sea-level rise risk damaging the infrastructure essential to tourism, with important supply-side implications (Hoogendoorn & Fitchett, 2018).

Mountain destinations, and particularly ski resorts, are also widely covered in the academic literature. Existing studies indicate that mountain areas are highly sensitive to climate change and that adaptation strategies, such as artificial snow production, have yielded mixed results (Steiger et al., 2024). Empirical research analysing the case of Norway finds that snow availability is a key determinant of tourism demand, and that the number of tourists interested in outdoor sports increases demand during periods



that have historically recorded lower activity. These findings support the view that climate change can significantly alter tourism seasonality patterns (Korsan-Kumińska, 2016).

Two additional ideas are particularly relevant for analysing how climate change influences the tourism industry. First, higher temperatures affect tourism demand and hotel performance through a nonlinear relationship; evidence suggests an inverted U-shaped pattern: as temperatures rise, tourism demand and occupancy rates may initially increase; however, once a threshold is reached, further increases in temperature harm tourism demand (Balsalobre-Lorente et al., 2020; Falk, 2014; Ibragimov, Perles-Ribes & Ramón-Rodríguez, 2022). Second, and of particular relevance to policymakers, the literature highlights that the tourism industry remains insufficiently prepared to cope with the expected consequences of climate change (Nacipucha et al., 2017; Ngin et al., 2020).

2.2 Weather and hotel performance

Weather conditions influence tourists' experiences and expectations. Negatively perceived weather may reduce tourism demand, while adverse conditions at the destination can affect tourists' decisions and behaviour, with consequences for length of stay and levels of expenditure (Falk, 2014; Baños-Pino et al., 2023). These effects on demand may influence key performance indicators such as Average Daily Rate (ADR), Occupancy Rate, and Revenue per Available Room (RevPAR). Moreover, weather conditions also affect the supply side, as hotels may face higher operational costs, such as increased energy use, to maintain comfortable indoor conditions (He et al., 2019).

Weather conditions include temperature, rainfall, snow, wind, and sunlight hours, with potential effects on tourism demand and hotel performance. The academic literature has examined different variables and performance indicators across geographical contexts, with most studies focusing on temperature. Evidence from an analysis of approximately 1,700 hotels across 50 U.S. states suggests that an average temperature between 18°C and 20°C can be considered optimal, with deviations from this range reducing hotel profitability. The effect of temperature on hotel performance is asymmetric: decreases generate stronger negative impacts than increases, consistent with a nonlinear relationship and with more pronounced effects for lower-quality hotels (He et al., 2019).

Several studies find a positive association between higher temperatures and hotel prices, as measured by ADR. Evidence is consistent across destinations such as Taiwan and the Mediterranean region. While higher temperatures tend to increase hotel prices, abnormal rainfall negatively affects ADR. Unsurprisingly, greater exposure to sunlight has a positive effect on hotel performance (Arabadzhyan et al., 2021; Chen & Lin, 2014; Mun & Park, 2023). Hotels may partially mitigate weather-related risks through financial instruments such as futures and options on weather variables (Franzoni & Pelizzari, 2019).

2.3 Seasonality

Seasonality is a structural characteristic of the hotel industry. Seasonality refers to a repeated, variable pattern of demand over the year, though its intensity and timing differ across destination types. Different methodological approaches are used to measure seasonality; two of the most common in the tourism economics literature are the Gini index and the Theil index (De Cantis, Ferrante & Vaccina, 2011; Duro, 2018). The Gini index measures inequality in tourist arrivals over time, while the Theil index is more sensitive to extreme values.

More pronounced seasonality can negatively affect hotel performance. Optimal pricing strategies depend on the price elasticity of demand, which varies between peak- and low-demand periods. More inelastic demand during peak periods leads to relatively higher ADR, combined with higher occupancy rates, resulting in improved RevPAR (Aznar, 2024; Wang, Sun & Wen, 2019). Some authors argue that strong seasonality implies overcapacity, leading to investment in facilities that are underutilised during low-demand periods and, therefore, reducing returns on investment; however, the empirical evidence is inconclusive (Zhang, Xie & Sikveland, 2021).

Some factors, such as the quality of the service offered, can moderate the influence of seasonality on hotel performance. Using quantile regression and online hotel ratings, previous research has shown that hotels offering higher levels of quality may be less affected by seasonality when analysing the impact of seasonality on prices (Wang et al., 2019). The effects of seasonality extend beyond hotel performance; at the local level, higher seasonality may negatively affect employment levels and job quality, shaping destinations' competitiveness (Karamustafa & Ulama, 2010; Mitra, 2020).

Climate change is closely linked to tourism seasonality. For some destinations, higher average temperatures resulting from climate change can make destinations more attractive during low-demand periods, positively affecting ADR, occupancy rates, and, ultimately, RevPAR (Arabadzhyan et al., 2021; Wertlieb & Ottung, 2025). However, because the relationship between temperature and hotel performance may not be linear, this positive effect may eventually become negative. Excessively high temperatures in warmer destinations, such as the Mediterranean region, may reduce their attractiveness during the summer.



2.4 Research gap and hypotheses

Climate change affects multiple dimensions of society, including health, economic activity, and migration patterns. The academic literature has already acknowledged the risks that climate change poses for the tourism industry. It shifts tourism demand across destinations, with evidence from coastal and mountain/ski destinations showing its impact on profitability (Arabadzhyan et al., 2021; Korsan-Kumińska, 2016; Martínez & Morales, 2025; Steiger et al., 2024). One of the consequences of climate change is increased weather variability, and weather conditions directly influence hotel performance, prices, and occupancy rates (Angelini, Figini & Leoni, 2024; Mitra, 2020; Wang et al., 2019). A relevant conclusion emerging from this body of research is the nonlinear relationship between temperatures and hotel performance (Balsalobre-Lorente et al., 2020; Ibragimov et al., 2022).

However, a gap remains in the academic literature. While climate change leads to rising temperatures, the impacts on tourism seasonality are not yet fully understood. Higher average and maximum temperatures may generate thermal discomfort during peak-demand periods, while increasing the attractiveness of destinations during traditionally low-demand periods. This paper addresses this gap by focusing on urban destinations in Southern Europe, analysing whether the effects of rising temperatures vary across seasons, whether the relationship is nonlinear, and whether rising temperatures contribute to smoothing seasonal patterns. The following hypotheses are tested:

H1: For Southern European urban destinations, rising average temperatures contribute to an increase in occupancy rate for the months with traditionally low demand.

H2: For Southern European urban destinations, rising average temperatures contribute to lower occupancy rates for the months with traditionally higher demand.

H3: For Southern European urban destinations, rising average temperatures contribute to smoothing the seasonality pattern.

Figure 1 summarises the hypotheses and the mechanism explaining the relationship between rising temperatures and the final effect on hotel performance.

Figure 1-Hypotheses

H1: Rising temperatures increase occupancy rate in low-demand periods

Rising temperatures → Warmer conditions in colder months → Increase in demand, new demand and some substitution effect attracted by weather conditions and better prices → Higher occupancy rate

H2: Rising temperatures in peak-demand periods reduce occupancy rates

Rising temperatures → Higher temperatures, over 30°C, generate thermal discomfort → thermal discomfort decreases demand, which switches to colder destinations or periods with better weather conditions → Decrease in occupancy rate

H3: Rising temperatures in Southern Europe destinations contribute to smoothing seasonality

The combination of higher demand during low-demand periods and less demand during peak periods → Smooths seasonality pattern by reducing the gap between periods

Source: Own elaboration.

3. Methodology

The dataset used to analyse how rising average temperatures affect hotel performance comprises 600 monthly observations across five urban destinations in Southern Europe. The selected cities are Athens, Naples, Lisbon, Seville, and Córdoba. Hotel performance data was obtained from STR, a well-known provider of hotel market information commonly used in hotel industry research (Anguera-Torrell, Aznar-Alarcón & Vives-Perez, 2021; Yeong, Song & Lee, 2020). The monthly hotel data includes, for each destination: hotel demand, hotel supply, ADR, occupancy rate, and RevPAR. As additional control variables, we include hotel supply, measured as the number of available rooms according to STR, and inflation, measured as the year-on-year percentage change in the Consumer Price Index (CPI), obtained from Eurostat.

To compute average temperatures, we collected daily data from Meteostat. The dataset includes daily information from the weather station closest to each city centre, recording average, maximum, and minimum daily temperatures. Based on this data, we calculated the corresponding monthly averages, maximums, and minimums.

As seasonality influences hotel performance, productivity, employment, and investment, it is relevant to examine how rising temperatures are reshaping seasonal patterns. There are different measures of seasonality, each with distinct characteristics; the Gini index and the Theil index are the most commonly used (De Cantis et al., 2011). As the Theil index is more sensitive to extreme values, it is the seasonality measure applied in this empirical analysis. The Theil index can be defined as follows:



$$Theil\ Index_{it} = \frac{1}{12} \sum_{m=1}^{m=12} \left(\frac{D_{mit}}{\mu_{it}} \ln \frac{D_{mit}}{\mu_{it}} \right) \quad (1)$$

$$\mu_{it} = \sum_{m=1}^{m=12} \frac{D_{mit}}{12}$$

The Theil is computed for each year, considering monthly demand (D_{mit}) and the year average demand is μ_{it} . The Theil index is the average value of twelve-monthly components, each one computed as $\frac{D_{mit}}{\mu_{it}} \ln \frac{D_{mit}}{\mu_{it}}$. The subindex i refers to the city and t to the year.

The database includes 600 observations, with monthly data for a set of cities in Southern Europe, covering the period 2015-2024. Table 1 presents the descriptive statistics for the main variables.

Table 1- Descriptive Statistics

	Mean	SD	Median	Min	Max	Number of observations
Occupancy rate (%)	64.72	21.32	69.56	3.00	93.85	595
ADR (€)	111.81	39.44	102.44	49.69	316.26	595
RevPAR (€)	75.71	42.65	69.21	2.83	277.38	595
Demand Theil index	0.05	0.07	0.02	0.01	0.37	48
Average temperature (°C)	18.23	6.34	17.84	6.63	31.46	600
Minimum temperature (°C)	13.18	5.75	12.75	0.72	25.79	600
Maximum temperature (°C)	23.93	7.25	22.96	10.35	40.35	600
Supply (number of rooms)	420539.8	270962.22	373680	71904	869457	595
CPI Annual change rate	1.73	2.98	0.8	-2.8	12.6	595

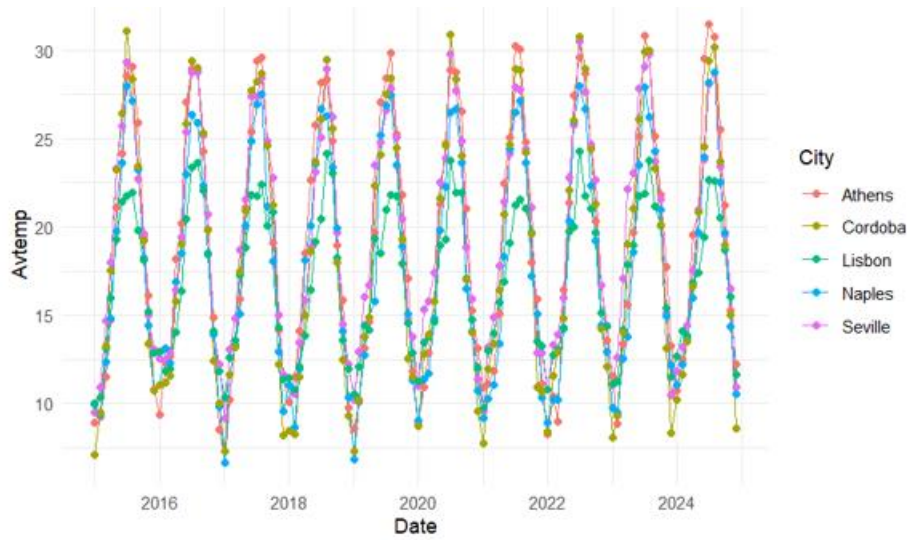
Source: Own elaboration.

Southern European cities show occupancy rates above 60%, with a maximum of almost 94%, and particularly high occupancy from May to September. The minimum occupancy rate is explained by the 2020 lockdown associated with the COVID-19 pandemic. As this represents an exceptional situation, a robustness check was conducted, excluding 2020. It yielded similar results.

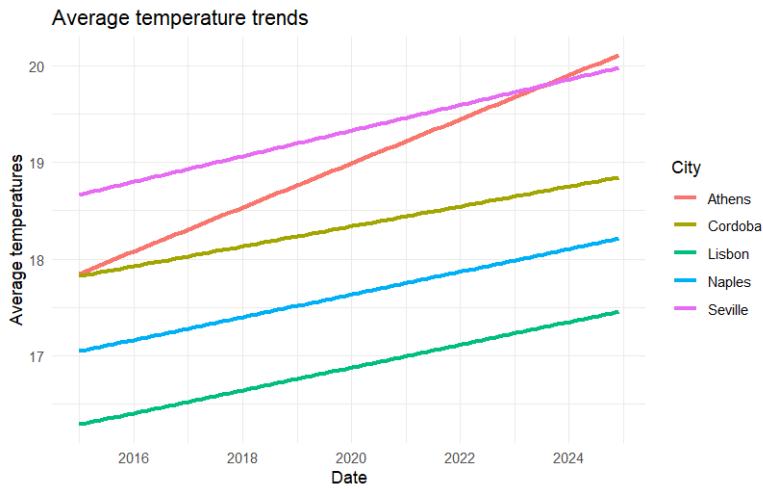
Comfortable temperatures are typically considered to range between 16°C and 25°C. For the selected cities, the average temperature is 18.23°C, with a median value of 17.84°C, while temperatures during peak-demand periods often exceed 25°C. These relatively warm conditions contribute to the attractiveness of these destinations.

Regarding maximum temperatures, the highest recorded value is 40.35°C. A dynamic analysis shows that temperatures above 35°C have become more frequent during the last five years of the dataset, consistent with the trend of rising temperatures. The Theil index, based on monthly demand data, is computed for every year, with a total of 48 observations. It shows an interesting level of variability, with a mean of 0.05 and a median of 0.02.

Figures 2 and 3 show the evolution of average temperatures. Figure 2 confirms the well-known pattern of cyclical temperatures across all selected cities, with lower temperatures in winter and higher temperatures in summer. However, Figure 3 shows the trend for each of the five cities; a clear upward trend is evident across all five, with Athens and Seville showing particularly steep slopes.

Figure 2 -Average temperatures evolution 2015-2024


Source: Own elaboration.

Figure 3 -Average temperature trends 2015-2024


Source: Own elaboration.

To test the influence of rising average temperatures on hotel performance, we ran the following regression analysis:

$$y_{mit} = \beta_1 Maxtemp_{mit} + \sum_{j=1}^{j=11} \beta_j Month_j + \sum_{k=1}^{k=11} \beta_k (Month_{it} \times Maxtemp_{it}) + \beta_l Supply_{mit} + \beta_r \pi_{mit} + \gamma_i + \gamma_t + \varepsilon_{mit} \quad (2)$$

The regression measures how maximum monthly temperatures influence different measures of hotel performance. As dependent variables, y_{mit} , where m refers to a concrete month of the year, i refers to a concrete city, and t refers to the year, we analyse occupancy rate and hotel prices (log ADR). As independent variables, we use 11 monthly variables, with January as the baseline reference, for each of the subsequent 11 months. The variable $Maxtemp_{mit}$ refers to the monthly registered temperature for the 600 data observations. Our interest lies in the interaction effect between maximum temperature and months. ($Month_{it} \times Maxtemp_{it}$). As rising temperatures may not have a linear impact, we expect that for some months, the ones with traditionally



lower demand and colder periods, higher temperatures improve hotel performance, β_k positive, whereas for the warmer months, a higher temperature which increases thermal discomfort may reduce occupancy rates and/or prices (ADR), therefore β_k will be negative.

The model includes two control variables. Firstly, hotel supply is measured as the number of available rooms for each city and month, based on STR data. Hotel supply may influence hotel performance, as increases in supply can accommodate higher demand and moderate changes in occupancy rates and ADR. Secondly, inflation is measured using Eurostat CPI data, defined as the year-on-year percentage change for each monthly observation. Differences in inflation may influence demand dynamics.

The model is estimated using OLS, including city fixed effects to absorb time-invariant city characteristics, such as location, infrastructure, or cultural attractiveness, and year fixed effects to control for common shocks across cities each year. Standard errors are cluster-robust at the city level. All estimations are conducted in R, version 4.5.2.

4. Results

Table 2 presents results showing how rising temperatures influence monthly occupancy rates. The table reports only those months for which either the monthly dummy or the interaction between maximum temperature and month is statistically significant. Model 1 includes the full sample period (2015–2024), while Model 2 excludes 2020 to mitigate the influence of the exceptional disruptions associated with the COVID-19 pandemic. For each model, results are reported both with and without the inclusion of control variables, specifically hotel supply and inflation.

Table 2- Regression results, occupancy rates analysis

	Model 1: Occupancy rate 2015-2024		Model 1: Occupancy rate 2015-2024 Adding control variables		Model 2: Occupancy rate Excluding 2020 (Covid-19 effect)		Model 2: Occupancy rate excluding 2020 (Covid-19 effect) adding control variables	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Maxtemp	1.262	0.473	0.833	0.684	1.321*	0.317	1.079**	0.225
Apr	10.315	9.177	17.431	6.506	28.893**	4.371	28.622**	5.068
May	33.431**	5.888	30.7930*	7.613	48.772**	5.913	45.126***	2.741
Jul	67.426*	21.284	60.128*	21.303	87.461*	26.672	82.656*	25.395
Aug	64.082**	10.050	54.004*	11.191	83.548**	10.401	76.719***	7.918
Sep	74.236**	14.269	68.569**	14.743	84.728**	15.143	80.565**	13.229
Oct	32.881*	10.387	23.495	15.198	54.317***	5.380	47.908*	10.767
Nov	46.348**	9.759	38.423*	9.594	58.194*	19.957	51.254*	12.808
Maxtemp x Apr	0.027	0.552	-0.064	0.494	-0.542*	0.164	-0.435	0.188
Maxtemp x May	-0.831	0.423	-0.555	0.579	-1.183*	0.379	-0.976*	0.233
Maxtemp x Aug	-1.939*	0.532	-1.456	0.714	-2.397**	0.423	-2.104**	0.316
Maxtemp x Sep	-2.092*	0.649	-1.712	0.790	-2.258*	0.645	-2.021*	0.566
Maxtemp x Nov	-1.868*	0.483	-1.336	0.554	-2.145	0.981	-1.733	0.668
Supply			0.0001*	0.012			0.000	0.000
Inflation (CPI)			0.547	0.296			0.198	0.203
Within R squared	0.487		0.550		0.697		0.715	
Year fixed effects	Yes		Yes		Yes		Yes	
City fixed effects	Yes		Yes		Yes		Yes	
Number of observations	595		595		540		540	

*0.01

**0.001

***0.000

Source: Own elaboration.

The four estimated regressions confirm the relevance of seasonality. August and September present occupancy rates substantially higher than the baseline month, January. In most specifications, August occupancy rates are between 54% to 83% higher than in January, while September occupancy rates increase by around 80% in the model excluding the 2020 COVID-19 effect. When excluding the COVID-19 period, the average temperature has a positive and statistically significant effect on occupancy rates. According to the model including control variables, the coefficient is approximately 1.08, indicating that a 1°C increase in maximum



temperature is associated with an increase of about 1.08 percentage points in occupancy rates. However, the interaction effects between monthly dummies and temperature reveal a nonlinear relationship. In particular, higher temperatures during peak-demand months reduce occupancy rates. A 1 °C increase in maximum temperature in August is associated with a 2% reduction in occupancy, statistically significant at the 0.1% level. A similar effect is observed in September. In contrast, temperature effects are not statistically significant during low-demand months, typically November to March.

Although a reduction of around 2% in occupancy may appear moderate, it becomes economically relevant when considering the long-term nature of climate change. One likely mechanism underlying this relationship is thermal discomfort. When temperatures exceed approximately 25–27°C, tourists may experience less comfort during outdoor activities. In extreme cases, with temperatures exceeding 40°C, tourists may experience significant thermal discomfort (Matzarakis, 2007). In the sample cities analysed, some already experience maximum temperatures close to 40°C; at these temperatures, tourists may adjust their behaviour by shifting to cooler destinations or travelling at different times. This effect may vary across tourist segments; domestic versus international visitors may differ in their flexibility to adjust their plans as the holiday period approaches. The hotel category and the quality of the service offered may also have a moderating role in how thermal discomfort affects hotel guests.

The robustness checks reinforce the previous results. The model excluding the year 2020 shows an R-squared value close to 0.7, suggesting that it provides a good fit for explaining occupancy rate variability. Seasonal positive effects are particularly strong in July, August, and September, adding nearly 80% additional occupancy relative to the January baseline.

As the dataset includes only five cities, the reliability of robust standard errors requires careful consideration. From an econometric perspective, one solution is to apply the wild bootstrap procedure to construct new random samples with similar characteristics and to test whether the coefficient on the interaction effect remains statistically significant.

Using 999 bootstrap replications and applying Webb weights, the coefficient for the interaction effect ($August_{it} \times Maxtemp_{it}$) is statistically significant at the 5% level, with a confidence interval of [-2.098, -1.147] (t-statistic = -6.623). These results reinforce the evidence that rising temperatures negatively affect the August seasonal effect. Therefore, continued increases in temperatures may reduce the profitability of the hotel industry during peak periods, particularly in August and September in the analysed sample, when temperatures exceed the thermal comfort threshold.

Rising temperatures influence occupancy rates; however, we do not observe the same effect on prices. Using the same model specification, but with the logarithm of ADR as the dependent variable, we do not find a statistically significant interaction between month and maximum temperatures.

The last result may appear counterintuitive, as it would be logical to expect that if higher temperatures reduce occupancy rates, hotels would adjust by reducing prices, a result not supported by the empirical analysis. There are several possible explanations for this apparent paradox. Firstly, August and September already show occupancy rates close to their maximum levels, so the marginal reduction associated with rising temperatures may have a limited impact on pricing decisions. However, it may become more relevant over longer periods. Secondly, forecasting maximum temperatures with sufficient accuracy and adjusting prices accordingly may involve costs that hotel managers consider inefficient relative to the expected gains. Thirdly, the effect of rising temperatures on occupancy rates may be heterogeneous across market segments, such as domestic versus international tourists, or across hotel categories. The dataset does not allow for these segmentations; however, such heterogeneity may help explain the absence of a statistically significant price response.

Previous literature suggests that the relationship between temperatures and occupancy rates may not be linear (Falk, 2014; Balsalobre-Lorente et al., 2020). To test this hypothesis, we estimate the following regression:

$$Occupancy\ rate_{mit} = \beta_1 Maxtemp_{mit} + \beta_2 Maxtemp_{mit}^2 + \sum_{j=1}^{j=11} \beta_j Month_j + \beta_i Supply_{mit} + \beta_r \pi_{mit} + \gamma_i + \gamma_t + \varepsilon_{mit} \quad (3)$$

Table 3 presents the regression results, confirming that both the linear and quadratic temperature terms are statistically significant at the 0.1% level. These findings support the existence of a nonlinear relationship between temperature and occupancy rates.

Table 3.-Regression analysis for a nonlinear model

	Occupancy rate - Excluding 2020 (Covid-19 effect)	
	Coefficient	Standard error
Maxtemp	3.491**	0.485
Maxtemp ²	-0.068**	0.011
February	9.006**	1.901
March	13.016**	1.158
April	20.219**	2.066



May	24.618**	2.455
June	25.520**	1.516
July	22.450**	1.917
August	23.685**	3.007
September	30.282**	1.559
October	27.435**	2.783
November	17.157**	1.802
December	6.008	2.191
Supply	0.00006	0.0003
CPI	0.1749	0.202
Within R-squared	0.715	
Year fixed effects	Yes	
City fixed effects	Yes	
Number of observations	540	

*0.01
 **0.001
 ***0.000

Source: Own elaboration.

Considering the quadratic specification, the temperature that maximises occupancy rate is approximately 25.5°C, corresponding to the turning point of the parabolic function. This result is coherent with the existing literature on thermal discomfort and tourism, which suggests that deviations from a certain threshold induce thermal discomfort, thereby influencing tourists' decisions (Falk, 2014; Balsalobre-Lorente et al., 2020; Matzarakis, 2006).

A relevant question is: to what extent are rising temperatures smoothing the seasonality pattern? To answer the question, we run the following regression model:

$$\text{Theil month component}_{mit} = \beta_1 \text{Maxtemp}_{mit} + \beta_2 \text{Low}_{mit} + \beta_3 (\text{Low}_{mit} \times \text{Maxtemp}_{mit}) + \varepsilon_{it} \quad (4)$$

The dependent variable in this model is the monthly Theil component, which, for each month, compares monthly demand to the average annual demand. The explanatory variables include maximum temperature (Maxtemp_{mit}), a dummy variable, Low_{mit} , which takes the value 1 when the monthly demand is below the annual average, and the interaction effect between months with lower demand and temperatures. ($\text{Low}_{mit} \times \text{Maxtemp}_{mit}$). A statistically significant β_3 coefficient indicates that the interaction between months with low demand and rising temperatures matters. A positive coefficient suggests that higher temperatures in low-demand periods, usually the colder ones, increase the monthly Theil component, therefore, reducing and smoothing seasonality. Table 4 presents the results of the analysis.

Table 4- Regression analysis for changes in the seasonality pattern

	Seasonality Demand monthly - Theil components analysis	
	Coefficient	Standard error
Maxtemp	0.0001	0.0002
Low	-0.0148***	0.003
Maxtemp x Low	0.0005*	0.0001
Within R-squared	0.5806	
Year fixed effects	Yes	
City fixed effects	Yes	
Number of observations	540	

*0.01
 **0.001
 ***0.000

Source: Own elaboration.

The analysis confirms that months with low demand have a lower Theil component, an expected result based on how the index is constructed, but the relevance of the model relies on the interaction effect. Rising temperatures, only for months with low demand, raise the Theil component, reducing seasonality. The effect appears statistically significant at the 0.1% level, but the number of cities suggests a robustness check is needed.

As a robustness check, we applied a Wild bootstrap with Webb weights, to test whether the combined effect of temperature and temperature interaction with being a month of low demand ($\beta_1 + \beta_3$) is statistically significant. The t-test is 4.462 with a p-value of 0.049, indicating significance at the 5% level. Higher temperatures in months of low demand increase the monthly Theil value,



implying that seasonality becomes less pronounced. The empirical analysis suggests that rising temperatures are smoothing the seasonal pattern for Southern Europe urban destinations.

5. Discussion

Climate change is no longer a future consequence of human activity; it is already reshaping economic activity, affecting human health, and challenging the sustainability of societies (Scott & Gössling, 2022). Although the tourism industry is expected to be one of the sectors most affected by climate change, previous studies suggest that tourism stakeholders are still not sufficiently prepared to cope with its consequences (Ben Youssef & Zeqiri, 2022; Nacipucha et al., 2017). This study contributes to the growing literature by examining one of the most direct consequences of climate change, rising temperatures, and their influence on hotel performance, particularly occupancy rates and tourism seasonality, in Southern European urban destinations.

The empirical analysis of five Southern European cities provides further evidence that the relationship between temperature and hotel performance is non-linear, supporting previous findings reported in different geographical contexts (He et al., 2019; Ibragimov et al., 2022). While He et al. (2019) show that hotel profitability is maximised within an optimal temperature range (18°C to 20°C) in the United States, Ibragimov et al. (2022) demonstrate that climate change alters tourism demand depending on the climatic characteristics of the destination. Our results indicate that this non-linear relationship is also present in Mediterranean urban destinations. More specifically, higher maximum temperatures significantly reduce hotel occupancy only during the warmest months, August and September, with an additional 1°C decreasing the occupancy rate by approximately 2 percentage points, whereas no statistically significant effects are observed during the cooler months.

The paper also contributes to the discussion on the non-linear relationship between temperature and hotel performance by testing a specific non-linear specification, namely a quadratic relationship between maximum temperature and occupancy rate. Our regression model confirms that both the coefficient for maximum temperature and its squared term are statistically significant, supporting the expected inverted U-shaped relationship (Falk, 2014). Moreover, the quadratic specification allows us to estimate the temperature that maximises occupancy rate, which is approximately 25.5°C. This optimal temperature is likely to vary across geographical locations, reflecting differences in climatic conditions and tourists' adaptation to local weather. The value estimated in this paper applies to urban destinations in Southern Europe. Future research could examine whether similar or different optimal temperatures are observed in other geographical contexts and destination types.

The mechanism linking rising temperatures to tourists' behaviour is explained by the concept of thermal discomfort (Arabadzhyan et al., 2021; Falk, 2014; Matzarakis, 2007). According to Matzarakis (2007), when temperatures rise above levels considered comfortable for tourists, their level of satisfaction decreases, they enjoy outdoor activities less, and the negative feelings associated with thermal discomfort reduce the attractiveness of destinations. Our results are consistent with this mechanism. As suggested by Falk (2014) and Arabadzhyan et al. (2021), rising temperatures may initially have a positive influence on tourism demand; however, this effect becomes negative once the thermal discomfort threshold is reached. In our sample, this pattern is reflected in the significant reduction in hotel occupancy observed only during August and September, when maximum temperatures are highest. By contrast, no statistically significant effects are found during the cooler months, suggesting that rising temperatures become relevant only after a certain temperature threshold is exceeded.

The paper also analyses how rising temperatures may reshape tourism seasonality. Higher temperatures during the summer, once they exceed certain thresholds, may reduce occupancy rates, while warmer conditions during traditionally colder months may increase tourism demand during these low-demand periods, contributing to a flatter seasonal pattern (Arabadzhyan et al., 2021; Korsan-Kumińska, 2016; Scott, 2024). To the best of our knowledge, few studies have examined how rising temperatures influence tourism seasonality by analysing changes in the monthly components of the Theil index, a widely used measure of seasonality. Our results suggest that the monthly Theil components for low-demand months increase as maximum temperatures rise, contributing to a reduction in the overall level of seasonality. These findings provide empirical evidence that climate change may progressively smooth seasonal demand patterns in Southern European urban destinations by reducing the gap between peak- and low-demand periods.

Most of the literature on the influence of climate change on tourism has focused on coastal destinations (Arabadzhyan et al., 2021; Gómez-Martín et al., 2014) or on mountain destinations and ski resorts (Korsan-Kumińska, 2016; Steiger et al., 2024). A gap in the academic literature remains regarding how rising temperatures influence urban destinations. This paper addresses this gap by focusing on Southern European urban destinations, contributing to a better understanding of how rising temperatures affect hotel performance in this type of destination, which represents an important segment of the tourism industry.

Overall, these findings suggest that climate change is already influencing hotel performance in Southern European urban destinations. Although the current effects appear moderate, they are likely to become more pronounced as temperatures continue



to rise. Consequently, climate change may progressively reshape destination competitiveness, tourism demand, and hotel profitability. The results also highlight the importance of incorporating climate-related variables into tourism planning, destination management, and hotel investment decisions, particularly in destinations where summer temperatures are expected to exceed tourists' thermal comfort thresholds.

6. Conclusions

This study contributes to the literature by focusing on urban destinations and providing empirical evidence that higher temperatures are already reducing occupancy rates during peak-demand periods while smoothing seasonality patterns. The analysis confirms that the relationship between rising temperatures and hotel performance is not linear. Once the thermal discomfort threshold is reached, higher temperatures affect tourists' behaviour, leading to lower occupancy rates. These findings suggest that climate change is already affecting tourism demand in Southern European urban destinations. However, the effects may differ across regions with different climatic conditions, confirming the asymmetric impacts of climate change on tourism competitiveness.

6.1 Theoretical Implications

This paper contributes to the academic literature by focusing on urban destinations, a destination type that has received considerably less attention than coastal and mountain destinations in studies examining the effects of climate change. From a theoretical perspective, the results suggest that thermal discomfort is the primary mechanism underlying the observed changes in occupancy rates. Higher temperatures do not necessarily reduce tourism demand; rather, their effects become significant once maximum temperatures exceed tourists' thermal comfort threshold, an effect that, in Southern European urban destinations, is mainly observed during the summer period. This interpretation is supported by the interaction between month and temperature, with statistically significant effects found only for August and September.

A second theoretical implication is that the relationship between rising temperatures and hotel performance is characterised by threshold effects rather than by a continuous linear response. Consequently, modelling the influence of climate change on hotel performance requires more flexible specifications, such as quadratic or other non-linear models, instead of relying exclusively on traditional linear approaches. These findings also suggest that the effects of climate change on tourism demand should be analysed by considering destination-specific climatic conditions, as the temperature threshold beyond which hotel performance deteriorates is likely to differ across geographical contexts.

6.2 Practical Implications

These results are relevant for hotel investors, managers, and policymakers. The period covered spans only 10 years, whereas climate change is a long-term phenomenon. Therefore, the analysis should be interpreted as evidence of the short-term effects of rising temperatures rather than long-term climate dynamics. What may appear to be a moderate effect in the short term may become much more significant over longer time horizons. By 2050, the influence of rising temperatures on destination competitiveness may be considerably stronger. These effects not only affect hotel profitability but may also have implications for employment and economic growth.

Local governments responsible for tourism planning should incorporate the implications of rising temperatures into destination management policies. The expected flattening of seasonality will influence tourism flows, the provision of tourism services, and employment patterns throughout the year. In the long term, the competitiveness of Southern European destinations may increasingly depend on their capacity to adapt to the effects of climate change.

Hotel managers and investors may also benefit from incorporating climate-related variables into revenue forecasts and investment decisions. Since hotel operations are characterised by high fixed costs, changes in occupancy rates have a direct impact on expected profitability. Understanding how rising temperatures affect demand patterns, seasonality, and future occupancy will therefore become increasingly important for strategic planning and investment decisions.

6.3. Limitations and Future Research

Finally, several limitations should be acknowledged. The analysis focuses solely on five Southern European destinations, and the dataset relies on aggregate information. Expanding the sample to include more cities and different geographical contexts, such as Nordic or Central European destinations, would help validate the findings. Future research using more granular data, including demand segmentation and hotel-level heterogeneity, may improve our understanding of the relationship between rising temperatures and hotel performance.

Future research can also consider the differences between domestic and international tourists. Domestic and international tourists may differ in their capacity to adapt their travel decisions to heatwaves or rising temperatures. Future research using more detailed



data, enabling segmentation by demand groups and hotel characteristics, may provide further insights into the mechanisms linking rising temperatures to hotel performance.

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Declaration on the Use of Artificial Intelligence

During the preparation of this manuscript, the author used ChatGPT to assist with English language editing, grammar correction, and the review of the R code used in the empirical analysis. After using these tools, the author carefully reviewed and edited the manuscript and takes full responsibility for its content.

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