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Summary

This paper investigates the empirical magnitude of climate conditions on tourist flows in Tuscany, exploring the use of a fine spatial scale analysis. In fact, we explore the use of an 8-year panel dataset of Tuscany's 254 municipalities, examining how tourist inflows respond to variation in local weather conditions. In particular, as the area enjoys a fairly mild Mediterranean climate, our analysis focused on temperature extremes at key times of the tourist season, i.e., on maximum summer temperature and minimum winter temperature. Separate analyses are conducted for domestic and international tourists, so as to test the differences in the preferences among these distinct groups (or types of demand). Estimation results show the impact of climate change on tourist flows appears to vary significantly among destinations depending on the kind of attractions they offer, and those areas that host the main artistic and historical sights, affecting predominantly the domestic rather than the international tourists.

Keywords: Domestic Tourists, International Tourists, Municipalities, Maximum And Minimum Daily Temperature, Dynamic Model, Temperature Demand Elasticity, GMM

JEL Classification: C23, D01, L83

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Climate change and tourism in Tuscany, Italy.
What if heat becomes unbearable?

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Abstract

This paper investigates the empirical magnitude of climate conditions on tourist flows in Tuscany, exploring the use of a fine spatial scale analysis. In fact, we explore the use of an 8-year panel dataset of Tuscany's 254 municipalities, examining how tourist inflows respond to variation in local weather conditions. In particular, as the area enjoys a fairly mild Mediterranean climate, our analysis focused on temperature extremes at key times of the tourist season, i.e., on maximum summer temperature and minimum winter temperature. Separate analyses are conducted for domestic and international tourists, so as to test the differences in the preferences among these distinct groups (or types of demand). Estimation results show the impact of climate change on tourist flows appears to vary significantly among destinations depending on the kind of attractions they offer, and those areas that host the main artistic and historical sights, affecting predominantly the domestic rather than the international tourists.

Keywords: domestic tourists, international tourists, municipalities, maximum and minimum daily temperature, dynamic model, temperature demand elasticity, GMM

JEL: C23, D01, L83

1. Introduction

The appeal of a tourist destination and its suitability for a variety of recreational activities depend to a considerable extent on its climate (Lohmann and Kaim 1999, Gallarza et al. 2002). That clear skies and warm weather are crucial assets for sun and sand tourism is so obvious, that politicians from touristic areas have occasionally made claims that 'wrong' forecasts of rain were damaging their constituencies (e.g., Brambilla 2010). Yet, even though the importance of climate as a determinant of tourist destination choice has been acknowledged in the scientific literature ever since the 1960s (Scott et al. 2005), there was little interest in evaluating how tourist flows respond to changing climatic conditions until recently, when the notion that climatic resources are fixed had to be dismissed as climate change emerged as an issue.

During the past decade, an increasing number of studies have attempted to assess the impact on the tourism industry and the economy of generalized temperature increases and modifications in the frequency of extreme events. A range of methodological approaches has been used. One strand of work employs climatic indices – such as Mieczkowski's (1985) Tourism Climate Index – to evaluate how the climatic appropriateness for tourism of a given area would be affected in a climate change scenario (e.g. Scott et al. 2004, Amelung et al. 2007). Other studies (Bigano et al. 2005, Hamilton et al. 2005a) take advantage of variation over time or in space to estimate empirical relationships between tourism flows and weather indicators (typically, measures of temperature and precipitation). This type of approach has also been used to estimate the optimal climatic conditions for a holiday destination. Maddison (2001) finds that British tourists are attracted to climates that deviate little from an average daytime maximum temperature of 30.7ºC. According to Lise and Tol (2002), climatically optimal destinations for OECD tourists have average temperatures in the warmest month around 21ºC. Bigano et al. (2006) estimate that, irrespective of their country of origin, tourists tend to prefer holiday destinations with average annual temperatures around 16ºC. A third strand of the work on the tourism impacts of climate change has used techniques grounded in economic theory to derive estimates of the welfare effects involved (Loomis and Crespi 1999, Mendelsohn and Markowski 1999). In this context, the present paper explores how tourist flows respond to varying climatic conditions in Tuscany, one of Italy's twenty administrative regions. The type of hot summers and warm winters that are likely to become increasingly common with climate change appear capable of producing considerable effects on tourist inflows, in particular for some kinds of tourists and destinations. Our analysis relies on an original 8-year panel dataset with a high degree of spatial disaggregation to estimate how arrivals of both international and domestic tourists are affected by the weather conditions at key moments of the year.

The paper is organized as follows section 2 presents and characterizes the study area. Section 3 discusses the analytical framework that is proposed for investigating the tourism flows in Tuscany. Section 4 describes the data set that is explored for the proposed econometric estimation exercises. Section 5 concludes.

2. Setting the scene

Existing impact assessment studies are as varied in geographical focus as they are from a methodological point of view: some are concerned with a single destination, such as a national park (Richardson and Loomis 2004), or type of tourism, for example winter tourism in the Alps (Elsasser and Bürki 2002); others deal with entire countries (Harrison et al. 1999, Hein et al. 2009), or take a global perspective (Berrittella et al. 2005, Hamilton et al. 2005b).

Overall, this literature supports the notion that, under projected climate change, the area that is climatically optimal for tourism is likely to shift towards higher latitudes and altitudes (Scott et al. 2004, Hamilton et al. 2005b, Amelung et al. 2007) – although impacts differ among destinations, types of tourism and recreation activities. Yet, existing studies of the impacts of climate change on tourism have sometimes been criticized for implicitly treating the temperature increases associated with climate change as if they took place linearly over time, whereas in practice climatic conditions fluctuate considerably from one year to another (Gössling and Hall 2006). While unusually hot summers are projected to increase in frequency, they will still alternate with unexceptional summers. In this respect, Gössling and Hall suggest that, in the short run, weather extremes may not have much of an effect on tourism.

The area we examine is Tuscany, in central Italy. For the most part, this region is a popular destination for both international and domestic tourists. In a typical year, it is responsible for more than one tenth of Italy's total tourist arrivals (ISTAT 2010), with the tourism industry accounting for around 8% of regional GDP (Regione Toscana 2010). While its most celebrated spots are a handful of world-renowned destinations for cultural and historical tourism, such as Firenze, Pisa and Siena, Tuscany is quite varied in terms of tourist attractions, as it also hosts popular sea and mountain resorts. Tourist flows to hilly and rural areas are also significant.

The region is characterized by a complex topography ranging from flat areas near the coastline and along the principal river valleys, to hilly and mountainous zones towards the Apennine chain. The climate ranges from typically Mediterranean to temperate warm or cool, according to the altitudinal and latitudinal gradients and the distance from the sea. The annual average temperature ranges from 12°C in the northern mountainous region, to 15°C in the southern coastal region. The coldest month is January, whilst the warmest are July and August. Annual rainfalls range from 600mm to 2400mm and are mainly concentrated in autumn with a secondary peak during spring.

During the last 60 years, increasing and significant trends in annual and seasonal temperature were detected over the entire region. Maximum air temperature has warmed especially in spring and summer and in the eastern hilly area, while minimum temperature has increased in particular in the north of the region and during spring and summer. The last 20 years have been the warmest since 1950 with annual temperature values almost always higher than the long-term average (based on the 1961-1990 period) (Ferrise et al.).

The impact on tourist flows to Tuscany of such climate modifications is not obvious. On the one hand, it is conceivable that, even as maximum temperatures rise above the levels perceived by tourists as comfortable, visitation rates to the main artistic and historical destinations may not be affected much. On the other, it seems plausible that most other parts of the region may exhibit the same type of vulnerability to climate change as many parts of the Mediterranean do (Perry 2000, Amelung and Viner 2004).

3. Analytical framework

There exist a variety of conceivable mechanisms through which climatic factors could affect the flows of tourists to a given destination. A convenient distinction can be made between direct and indirect effects, as in Simpson et al. (2008). On the one hand, climate determines the suitability of a location for a number of tourist activities (snow and skiing, sun and sea, and so forth). ‘Good’ or ‘bad’ weather can by itself make a destination more or less attractive, what we refer to as a *direct effect*. On the other hand, as the climate modifies, the quality of the amenities available at a given location is also likely to be affected. For example, the visual appeal of landscapes may change as a result of changes in the vegetation – whether these changes are spontaneous or induced by farmer's production choices – or higher sea levels and beach erosion could reduce the attractiveness of a sea resort. We refer to the effects of climate change on tourism arising as a consequence of environmental change (e.g. biodiversity loss, beach erosion, agricultural production) induced by modifications of the climate as *indirect effects*. Morris and Walls (2009) review this type of potential climate change impacts with a focus on outdoor recreation resources in the United States.

Our approach to assessing the potential effects of climate change on tourism flows to Tuscany is based on observing how the two evolved in a set of destinations over an 8-year period of time. In practice, we conduct our analysis in a standard panel data framework:

$$y_{it} = \mathbf{x}_{it}'\boldsymbol{\beta} + u_i + \varepsilon_{it} \tag{1}$$

where i and t index destinations and years, respectively; y_{it} denotes the natural logarithm of tourist arrivals; $\mathbf{x}_{it}$ is a vector of climatic variables (e.g. temperatures and lags); u_i is an unobserved time-constant individual effect; ε_{it} is an idiosyncratic error; and $\boldsymbol{\beta}$ is the parameter vector that we aim to estimate.

Clearly, this approach is better suited for estimating the direct effect of varying climatic conditions than for evaluating their indirect consequences emerging through changes in amenities. That any indirect effects could be detected in 8 years of data seems extremely unlikely, as such phenomena typically take place slowly, and a relatively long period of time has to pass before they reach an extent that potential visitors may notice.

On the other hand, the direct effect, which our analysis is expected to capture, is likely to have different intensity depending on the extent to which tourists are able to take the climate into account when they make their choices (e.g. weekend trips as opposed to long-planned vacations) and on the type of attractions they seek (e.g. outdoor activities as opposed to art exhibitions). For this reason, we conduct separate analyses for domestic and international tourists. Indeed, preliminary examination of the data suggests that a majority of foreigners visiting Tuscany are drawn primarily by historical and artistic sights. (For example, in a typical year, the single municipality of Florence accounts for more than a third of all foreign tourist arrivals to the entire region. Domestic incoming flows, on the other hand, are remarkably more dispersed among locations and destination types.) Furthermore, we speculate that potential visitors from closer places of origin may have access to more information about a destination's climatic conditions or enjoy more flexible travel arrangements. Indeed, evidence from German tourists suggests that, although the large majority of people gather climate information before traveling abroad, they usually do so shortly before their trip rather than at the time the trip is booked (Hamilton and Lau 2004). Finally, average length of stay is longer for international (5.2 days; s.d.: 3.1) than for domestic tourists (3.9 days; s.d.: 2.7), and it has been observed that short breaks tend to be more responsive than main holidays to unusual climatic conditions (Agnew and Palutikof 2001).

Rather than using the annual average temperature to characterize the climatic conditions that prevail during the year, we model tourist inflows as a function of temperature extremes, which are more likely to be perceived by tourists. Furthermore, the time of the year when the climatic conditions are most relevant to the annual performance of the tourist sector is arguably at the peak of the season. Since a major share of all overnight stays in the region takes place in the four months from June to September (Regione Toscana 2008), the key climatic explanatory variable used in the analysis of the following sections is the average of maximum daily temperatures during the summer (T.MAX.S). The first lag of T.MAX.S also appears in the model. In addition, in order to account for the importance of climatic conditions during the winter for the ski resorts in the mountainous part of the region, the average of minimum daily temperatures during the winter (T.MIN.W) is also included in the regression and its effect is allowed to differ between the 47 municipalities located in mountain areas and other municipalities.

Typically, empirical analyses of tourist flows control for key economic determinants such as income of potential tourists, travel cost, prices at destination relative to the prices at the place of origin, and quality of destination (Lim 1997). While in the present application no data on these variables are available at the appropriate level of geographic disaggregation, macroeconomic conditions and the prices of substitutes are the same for all municipalities in Tuscany in each given year, and can therefore be accounted for through a set of year dummies, which are duly incorporated in the analysis.

In addition to its climate and economic accessibility, factors that can contribute to making a destination more alluring include the presence of specific attractions (e.g. sea, sights, parks, events, etc.) and cultural appeal (history, tradition, cuisine, lifestyle, renown, etc.). In the short run, such variables are largely time-constant and can therefore be dealt with easily in a standard panel data framework. It is, however, likely that the unobserved effect u_i is correlated with some of the variables in $\mathbf{x}_{it}$. For example, if places with nicer climates were developed as tourist destinations earlier than places with less friendly climates, (unobserved) renown may be correlated with climate. Also, over centuries, historical settlements, culture or cuisine may have developed more in areas with higher agricultural productivity than in poorer areas, so that 'attractions' or 'cultural appeal' in u_i are going to be correlated with the climate variables. Spatial variation in price levels could also reflect the general pleasantness of local climates. All this suggests that a reasonable approach would be to use an estimator for equation (1) that does not require u_i and the regressors to be uncorrelated, such as the fixed effects (FE) estimator.

In fact, many unobserved economic variables – most notably prices – cannot be plausibly assumed to be time invariant. To circumvent these issues, a dynamic version of the model is also estimated:

$$y_{it} = \rho y_{i,t-1} + \mathbf{x}_{it}'\boldsymbol{\beta} + u_i + \varepsilon_{it} \qquad (2)$$

This approach enables us to compute both short-run and long-run elasticities of tourist inflows to changes in climatic conditions. Using the standard approach, equation (2) is estimated by killing u_i by first differencing and then estimating the differenced equation with a two-step GMM procedure, using older lags of y as instruments under a sequential exogeneity assumption (Arellano and Bond 1991; Wooldridge 2002). Until recently, only few analyses of tourism demand have taken dynamic panel data approaches (Song and Li 2008), some exceptions being Ledesma-Rodríguez et al. (2001), Garín-Muñoz (2006), Brida and Risso (2009), none of which is concerned with climate related issues.

4. Data

The dataset used in the analysis is a panel of 254 municipalities (*comuni*) located in Tuscany which are observed annually over the period 2000-2007, amounting to a total of 2,032 observations[1]. Information on annual tourist arrivals was obtained from Tuscany's regional bureau of statistics (Sistema Statistico Regionale – Regione Toscana 2010). Tourism data are available separately for domestic and foreign visitors, even though the countries of origin

[1] In fact, Tuscany is comprised of 281 municipalities, but because some of them are very small, for privacy reasons in some cases official statistics are only released for aggregates of municipalities.

of the latter are unknown. Data limitations have often meant that empirical analyses of the association between tourist flows and climate had to be conducted at coarse levels of spatial disaggregation. In many cases, entire countries have been used as observational units, a country's climate having to be measured by means of arguably imprecise proxies such as temperatures in the capital city (as in Maddison 2001 and Lise and Tol 2002). In this study, the availability of panel data at the municipality (i.e., town) level reduces concerns about measurement error and spurious associations, and enables us to obtain more spatially detailed results. These data were combined with a detailed meteorological dataset produced by Chiesi et al. (2007), which consists of 1 Km interpolated daily observed data for maximum and minimum temperature and precipitation for the period 1999-2007. For the purpose of this study, the meteorological data were aggregated at municipal level. Basic summary statistics for the variables that appear in the analysis are reported in Table 1.

Table 1: Summary statistics

		Mean	Min	Max	SD	SD (BG)	SD (WG)
Tourism inflows:							
L.DOM	Log arrivals of domestic tourists	8.42	0	13.6	1.69	1.66	0.34
L.FOR	Log arrivals of foreign tourists	7.96	0	14.5	1.93	1.89	0.37
Climatic variables:							
T.MAX.S	Avg. daily max summer temperatures (ºC)	27.0	14.9	32.3	2.53	2.31	1.03
T.MIN.W	Avg. daily min winter temperatures (ºC)	2.6	-4.0	8.2	1.94	1.29	1.46
	n = 254;	T = 8;		n×T = 2,032			

SD: standard deviation; BG: between groups; WG: within groups

The spatial distribution of the 2000-2007 averages of the maximum summer temperature and the minimum winter temperature – the two climatic indicators used as explanatory variables – is represented in figure 1 and figure 2, respectively.

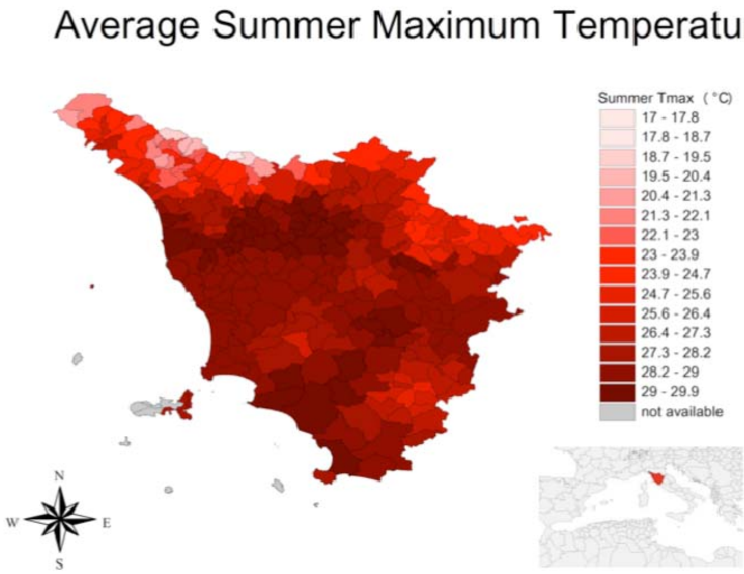

Figure 1: 2000-2007 average maximum summer temperature in the municipalities of Tuscany

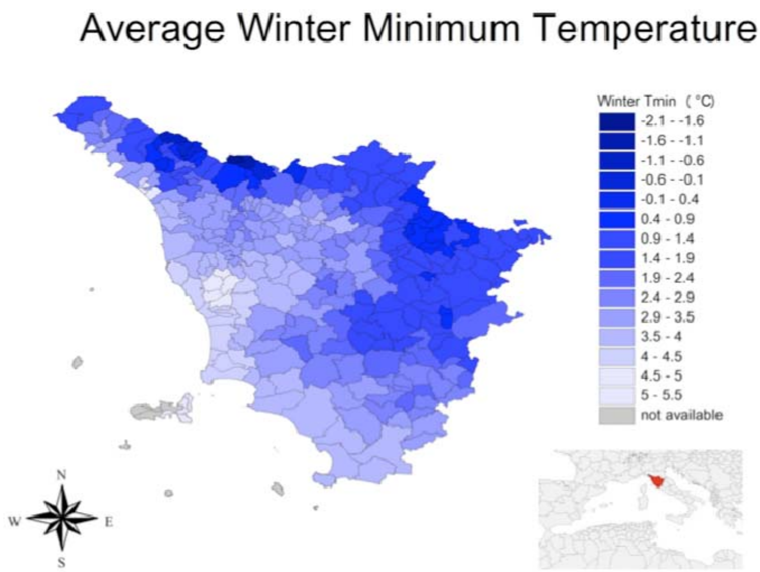

Figure 2: 2000-2007 average minimum winter temperature in the municipalities of Tuscany

5. Results

As mentioned above, tourist flows to Tuscany and their responsiveness to the local climatic conditions were examined separately depending on whether those flows originated from Italy or from abroad. In either case, both a static and a dynamic version were estimated of a model that relates annual tourist arrivals to the average maximum summer temperature in the current and in the previous year, and on the average minimum winter temperature in the current year, allowing the effect of the latter variable to differ between municipalities located in the mountainous part of Tuscany and other municipalities. Table 2 reports the key results of the estimation. As the dependent variable is expressed on a logarithmic scale and temperatures appear in levels (ºC), the estimated coefficients can be interpreted as semi-elasticities. Each regression also included a full set of year dummies, even though for brevity the corresponding coefficients are not reported.

Table 2: Estimation results (robust standard errors in brackets)

	Domestic		Foreign	
	Static	Dynamic	Static	Dynamic
	(1)	(2)	(3)	(4)
$T.MAX.S_t$	–0.006 (0.023)	–0.028* (0.015)	–0.033 (0.023)	–0.018 (0.019)
$T.MAX.S_{t–1}$	–0.097** (0.038)	–0.046** (0.018)	–0.036 (0.027)	0.010 (0.023)
$T.MIN.W_t$	–0.009 (0.016)	–0.022 (0.015)	–0.016 (0.023)	–0.015 (0.020)
$T.MIN.W_t$ × MOUNTAIN	–0.018* (0.010)	–0.027*** (0.010)	0.015 (0.016)	0.006 (0.016)
$y_{t–1}$		0.589*** (0.091)		0.514*** (0.093)
p-value of model	<.001	<.001	<.001	<.001
p-value for climate coefficients all zero	0.010	<.001	0.440	0.788
N	1,778	1,524	1,778	1,524

Legend: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

In the model for domestic tourist arrivals, the climatic variables are jointly significant both in the static ($F(4, 253) = 3.42$, $p = 0.010$) and in the dynamic specification ($\chi^2(4) = 20.98$, $p < 0.001$). In the latter, neither the Arellano–Bond test for serial correlation in first differenced errors (the z-statistics on the 1st and 2nd order autocorrelation are –2.48 and 0.91, respectively), nor the Sargan test of overidentifying restrictions give evidence of any model misspecification ($\chi^2(10) = 6.86$, $p = 0.739$).

The fixed effects estimates of column 1 suggest that a 1ºC increase in T.MAX.S, while producing no significant effect in the current year, reduces annual arrivals of tourists originating from Italy by 9.7% (95% confidence interval: ± 7.5%) in the following year. As expected, higher minimum winter temperatures tend to diminish tourist inflows, but only in mountain areas.

The results from the estimation of the dynamic model in column 2 are consistent with the estimates from the static specification. Again, lagged T.MAX.S has a negative effect on tourist arrivals from domestic origins. Higher maximum summer temperatures also have a significant negative effect on tourist flows in the current year. Tourist flows to mountain municipalities are adversely affected by higher minimum winter temperatures. The inclusion of lags of T.MIN.W in the regression was considered, but is not backed by the data in either the static or the dynamic model.

After imposing the theoretically plausible and empirically well-supported restriction that the leading coefficient on T.MIN.W be zero (as expected, this has virtually no impact on the remaining coefficients), the dynamic model was used to predict the impact of permanent and temporary changes in the climate on tourism flows to Tuscany. Using this approach, the predicted effect of a permanent 1ºC increase in average maximum summer temperatures on the long-run equilibrium is an approximate 20.6% (95% c.i.: ± 14.5%) decrease in annual domestic arrivals. On the other hand, average minimum winter temperatures higher by 1ºC would lead to a 7.2% (95% c.i.: ± 6%) reduction in annual domestic tourist arrivals in mountainous municipalities.

With the frequency of climate anomalies expected to grow in the future, it is also interesting to examine the effects of temporary changes in climatic variables. The impact of a temporary marginal change in T.MAX.S and T.MIN.W on domestic tourism to Tuscany is represented in figure 3 and figure 4, respectively. If in the summer of year t maximum temperatures are higher by 1ºC on average and subsequently revert to their initial value in each of the following years, this is predicted to reduce domestic tourist arrivals by 3.4% in year t, 7% in year $t + 1$, and 4.2% in year $t + 2$, and 2.5% in year $t + 3$. In mountain areas, an analogous temporary increase in minimum winter temperatures produces declines in annual domestic arrivals by 2.9%, 1.7%, and 1% in the years from *t* to *t* + 2.

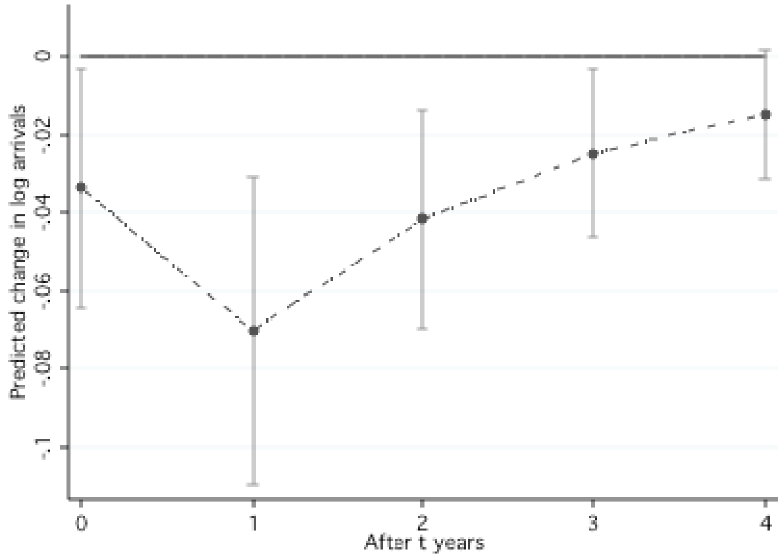

Figure 3: Marginal effect of a temporary increase in maximum summer temperatures on domestic tourist arrivals with 95% confidence intervals

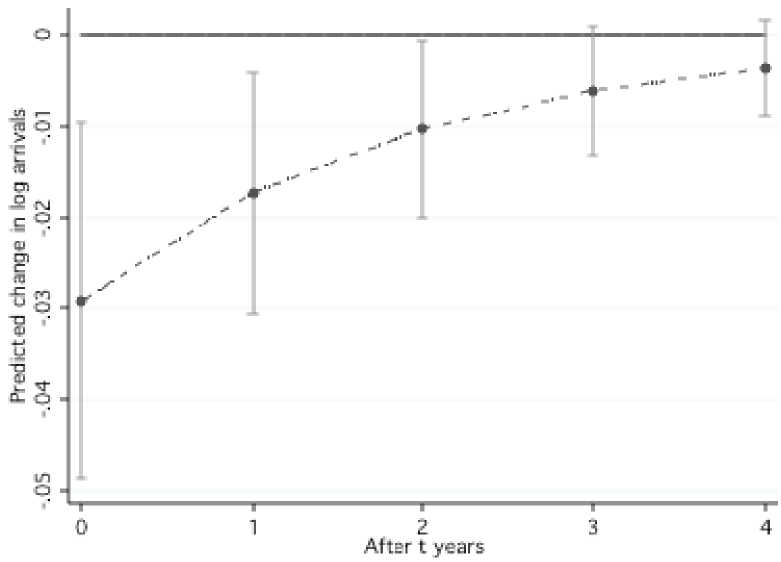

Figure 4: Marginal effect of a temporary increase in minimum winter temperatures on domestic tourist arrivals in the mountain areas with 95% confidence intervals

These results make for a striking comparison with those obtained from the analysis of the flows of visitors originating from abroad, reported in columns 3 and 4. The arrivals of foreign tourists look remarkably insensitive to the meteorological conditions, with the climatic variables turning up statistically insignificant both individually and jointly in either the static or the dynamic model specification.

The different results obtained for foreign and domestic arrivals may suggest, tourism inflows driven by different motivations are likely to be affected by climate change in different ways. Even in a relatively small area such as Tuscany, the effects of modified meteorological conditions on incoming tourism may vary from one location to another depending on the type of attractions available. An example of such differentiated effects is our finding that, in mountain areas, arrivals tend to decrease with higher minimum winter temperatures, which however appear to have no effect on tourism to other types of destinations. Indeed, further informal exploration of the data suggests that the impact of the climatic variables on tourist inflows may vary among locations in several other ways and that the climatic conditions in intermediate seasons also play a role. Yet, using the kind of annual tourism data that are available to us, conducting a formal analysis of these types of phenomena is difficult. Data on a finer time resolution would also allow a better understanding not only of how climatic factors influence the number of tourists that choose to visit a location in one year, but also of how the time of the year when those visits take place is affected. Indeed, patterns of tourism seasonality in the Mediterranean are expected to change remarkably as a result of climate change. Tourist flows are predicted to shift from what is currently the midsummer peak to the spring and the fall, traditionally the shoulder seasons (Perry 2000, Amelung and Viner 2007). However, even if climate change results in a redistribution of the visitation rate to the intermediate seasons, the results of our analysis suggest that this effect will be accompanied by a decline in overall inbound tourism, mostly due to a reduction in (mostly short) trips by tourists from domestic origins.

6. Discussion and conclusions

As the suitability of a location for a variety of activities is determined to a meaningful extent by its meteorological conditions, areas with sizable tourism sectors have grown increasingly concerned about the effects that impending climate change may produce on their economies.

This paper described an empirical investigation of how tourism flows to Tuscany, in central Italy, are affected by fluctuations of the climatic conditions. An 8-year panel dataset of the region's 254 municipalities was assembled and used to examine how the arrivals of domestic and foreign visitors respond to variation in selected climatic variables. As the area enjoys a fairly mild Mediterranean climate, our analysis focused on temperature extremes at key times of the tourist season. The two types of econometric setups that were used – fixed effects estimation of a static specification and system GMM estimation of a dynamic model – produced results that are encouragingly consistent with each other.

Separate econometric analyses are conducted for domestic and international tourists, so as to test the differences in the preferences among these distinct groups (or types of demand). Estimation results show that permanent increases in maximum temperature during the peak season can lead to a sizable decline in the number of domestic tourists visiting the area. In this context, the increasing occurrence of the extreme climate anomalies, such as heat waves, have the potential to result in significant declines in domestic tourism flows to Tuscany. Second, for the international tourists sub-sample, this estimation results less significant and therefore signaling a higher resilience of this type of demand to change in the temperature. Third, the impact of climate change on tourist flows appears to vary significantly among destinations depending on the kind of attractions they offer, and those areas that host the main artistic and historical sights, and cater predominantly to international tourists may be affected to a lesser extent. We can interpret these results as signaling the fact that international visitors, when compared to domestic, may be exposed to less information about the current climatic conditions at a potential destination, and/or need to make travel arrangements well ahead of time and thus limiting their ability to take those conditions into account. Furthermore, in the case of Tuscany, domestic and foreign tourists appear to be drawn by different types of attractions. While the large majority of foreigners concentrate in a handful of renowned artistic and historical sights (e.g. Florence, Pisa or Siena) whose appeal may be influenced only marginally by the climate, a significant share of domestic tourism is accounted for by sea, mountain and other destinations. Finally, it is likely that the choice about if and what to visit is affected by the climatic conditions not only at the potential destinations, but also at the tourist's place of origin. As domestic tourists typically come from comparatively nearby areas, climatic conditions at the two locations will be similar, and their effects are more easily confounded. Yet, at small distances the practical significance of the distinction between climate at destination and climate at origin fades. In any case, the finding that short trips from close origins – an option by far more commonly available to domestic than to international tourists – tend to be more sensitive to unappealing climatic circumstances than longer visits from farther points of origin seems consistent with the observation by Agnew and Palutikof (2001) that, during a particularly hot summer, people are more likely to change their plans for day trips and short breaks than for their main holiday.

In conclusion, the estimation results suggest that in Tuscany the climate change can represent a significantly negative impact on tourism flows, especially in the domestic segment. In this context, extreme climate change events, such as heat waves, that are expected to become increasingly common in the next few decades will be associated to a significant decline in domestic tourist arrivals and therefore signal the potential for the development of *in loco* mitigation policies and therefore supporting the lemma “global climate change and local policy” approach.

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References

Agnew, M. D. and J. P. Palutikof (2001). Climate impacts on the demand for tourism. In: A. Matzarakis and C. R. de Freitas (eds.) *International Society for Biometeorology Proceedings of the First International Workshop on Climate, Tourism and Recreation*. Available online at: http://www.mif.uni-freiburg.de/isb/ws/report.htm, accessed: May 2011.

Amelung, B., S. Nicholls and D. Viner (2007). Implications of global climate change for tourism flows and seasonality. *Journal of Travel Research 45*, 285–296.

Amelung, B. and D. Viner (2007). The vulnerability to climate change of the Mediterranean as a tourist destination. In: Amelung, B., K. Blazejczyk and A. Matzarakis (eds.), *Climate change and tourism. Assessment and coping strategies*, pp. 41–54.

Arellano M. and S. Bond (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations, *Review of Economic Studies 58*, 277–297.

Berrittella, A. A. Bigano, R. Roson, R. S. J. Tol (2006). A general equilibrium analysis of climate change impacts on tourism. *Tourism Management 27*, 913–924.

Bigano, A., A. Goria, J. Hamilton and R. S. J. Tol (2005). The effect of climate change and extreme weather events on tourism. *Nota di Lavoro FEEM* 30.2005.

Bigano, A., J. M. Hamilton and R. S. J. Tol (2006). The impact of climate on holiday destination choice. *Climatic Change 76*, 389–406.

Brambilla, C. (2010). "Troppe nuvole sulle nostre terre". La Lega vuole il meteo federalista. Repubblica June 17th, 2010. Available online at: http://www.repubblica.it/cronaca/2010/06/17/news/zaia_metro-4910395/, accessed: May 2011.

Brida, J. G. and W. A. Risso (2009). A dynamic panel data study of the German demand for tourism in South Tyrol. *Tourism and Hospitality Research 9*, 305–313.

Chiesi, M., F. Maselli, M. Moriondo, L. Fibbi, M. Bindi and S.W. Running (2007). Application of BIOME-BGC to simulate Mediterranean forest processes. *Ecological Modelling 206*, 179-190, 2007.

Elsasser, H. and R. Bürki (2002). Climate change as a threat to tourism in the Alps. *Climate Research 20*, 253–257.

Ferrise R., G. Brandani, C. Dibari, and M.Bindi. Information sheet on observed climate indicators for the CIRCE rural case studies: Tuscany. In: Agnew M. and Goodess C. (Eds.), *Information sheet on the RL11 rural case study*, Deliverable D11.4.2 of the CIRCE Project (Climate Change and Impact Research: the Mediterranean Environment", EU VI Framework Programme), available at: http://www.cru.uea.ac.uk/projects/circe/Tuscany.html, accessed: May 2011.

Gallarza, M. G., I. G. Saura and H. C. García (2002). Destination image: Towards a Conceptual Framework, *Annals of Tourism Research 29*(1), 56–78.

Garín-Muñoz, T. (2006). Inbound international tourism to Canary Islands: a dynamic panel data model. *Tourism Management 27*, 281–291.

Garín-Muñoz, T. and L. F. Montero-Martín (2007). Tourism in the Balearic Islands: A dynamic model for international demand using panel data. *Tourism Management 28*, 1224–1235.

Gössling, S. and C. M. Hall (2006). Uncertainties in predicting tourist flows under scenarios of climate change. *Climatic Change 79*, 163–173.

Hamilton, J. M., and M. A. Lau (2004). The role of climate information in tourist destination choice decision-making. Working Paper FNU-56. Available online at: http://www.fnu.zmaw.de/fileadmin/fnu-files/models-data/htm/climinfo.pdf, accessed: May 2011.

Hamilton, J. M., D. J. Maddison and R. S. J. Tol (2005a). Climate change and international tourism: a simulation study. *Global Environmental Change 15*, 253–266.

Hamilton, J. M., D. J. Maddison and R. S. J. Tol (2005b). Effects of climate change on international tourism. *Climate Research 29*, 245–254.

Harrison S. J., S. J. Winterbottom and C. Sheppard (1999). The potential effects of climate change on the Scottish tourist industry. *Tourism Management 20*, 203–211.

Hein, L., M. J. Metzger and A. Moreno (2009). Potential impacts of climate change on tourism; a case study for Spain. *Current Opinion in Environmental Sustainability 1*, 170–178.

ISTAT (2010). *Capacità e movimento degli esercizi turistici – anno 2008*. Available online at: http://www.istat.it/dati/dataset/20100305_00, accessed: May 2011.

Ledesma-Rodríguez, F. J., M. Navarro-Ibáñez and J. V. Pérez-Rodríguez (2001). Panel data and tourism: A case study of Tenerife. *Tourism Economics 7*, 75–88.

Lim, C. (1997). Review of international tourism demand models. *Annals of Tourism Research 24(4)*, 835–849.

Lise , W. and R. S. J. Tol (2002). Impact of climate on tourism demand. *Climatic Change 55*, 429–449.

Lohmann, M. and E. Kaim (1999). Weather and holiday destination preferences image, attitude and experience, *Tourism Review 54*(2), 54–64.

Loomis, J. and J. Crespi (1999). Estimated effects of climate change on outdoor recreation activities in the United States. In: R. Mendelsohn and J. E. Neumann (eds.), *The impacts of climate change on the United States economy*. Cambridge University Press.

Maddison, D. (2001). In search of warmer climates? The impact of climate change on flows of British tourists. *Climatic Change 49*, 193–208.

Mendelsohn, R. and M. Markowski (1999). The impact of climate change on outdoor recreation. In: R. Mendelsohn and J. E. Neumann (eds.), *The impacts of climate change on the United States economy*. Cambridge University Press.

Mieczkowski, Z. (1985). The tourism climate index: a method for evaluating world climates for tourism. *The Canadian Geographer 29*, 220–233.

Morris, D. and M. Walls (2009). Climate change and outdoor recreation resources. Resources for the Future. Washington, DC.

Perry, A. (2000). Impacts of climate change on tourism in the Mediterranean: adaptive responses. *Nota di Lavoro FEEM* 35.2000.

Regione Toscana (2008), Toscana in cifre 2007, available at: http://ius.regione.toscana.it/cif/pubblica/tic2007/indic2007.htm, accessed: June 2010.

Regione Toscana (2010), available at: http://www.regione.toscana.it/turismo/guida/, accessed: June 2010.

Richardson, R.B. and J.B. Loomis. (2004). Adaptive Recreation Planning and Climate Change: A Contingent Visitation Approach. *Ecological Economics 50*, 83–99.

Scott, D., G. McBoyle and M. Schwartzentruber (2004). Climate change and the distribution of climatic resources for tourism in North America. *Climate Research 27*, 105–117.

Scott, D., G. Wall and G. McBoyle (2005). The evolution of the climate change issue in the tourism sector. In: J. E. S. Higham (ed.), *Tourism, recreation and climate change*, Chapter 3, pp. 44–60.

Song, H. and G. Li (2008). Tourism demand modeling and forecasting – A review of recent research. *Tourism Management 29*, 203–220.

Wooldridge, J. M. (2002). *Econometric analysis of cross-section and panel data*, MIT press.

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