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Abstract

Tourism, being volatile and situation-specific, is responsive to climate change. A cross-section analysis is conducted on destinations of OECD tourists and a factor and regression analysis on holiday activities of Dutch tourists, to find optimal temperatures at travel destination for different tourists and different tourist activities. Globally, OECD tourists prefer a temperature of 21ºC (average of the hottest month of the year) at their choice of holiday destination. This indicates that, under a scenario of gradual warming, tourists would spend their holidays in different places than they currently do. The factor and regression analysis suggests that preferences for climates at tourist destinations differ among age and income groups.

Keywords: tourist demand, climate change, factor analysis, regression analysis, cross-section analysis.

JEL Classification: D12, R19, Q26.

Non-technical summary

Tourism, being volatile and situation-specific, is responsive to climate change. Data on destinations of OECD tourists and holiday activities of Dutch tourists are analysed with the help of statistical techniques to find optimal temperatures at travel destination for different tourists and different tourist activities. Globally, OECD tourists prefer a temperature of 21ºC (average of the hottest month of the year) at their choice of holiday destination. This indicates that, under a scenario of gradual warming, tourists would spend their holidays in different places than they currently do. The statistical analysis further suggests that preferences for climates at tourist destinations differ among age and income groups.

1. Introduction

Tourism has become the biggest industry in the world (The Economist, 1999), a fact that is not reflected in the attention research pays to it. O'Hagan and Harrison (1984) blame the lack of adequate data and the special nature of tourism demand. While climate is obviously important for international tourism, only a few tourism studies make a link with climate change. Many tourists find it important to have a high chance on sunny and warm weather at their holiday destination, in order to relax by swimming, sunbathing and sight seeing in foreign places. Yet, it is not known just how important climate is for the destination choice of tourists.

The larger part of the literature on tourist destination choice (see Crouch, 1995, Lim, 1997, and Witt and Witt, 1995, for surveys) takes the climate of tourists' homes and destinations for granted, focusing on factors such as prices and expenditures, and sociological and psychological considerations. In addition, these studies have a short time horizon, assuming that the climate at the tourist destinations is constant. In the longer term, however, climate is not constant. Climate is expected to change at an accelerating pace due to human activities, particularly fossil fuel combustion (Houghton *et al.*, 1996). The tourism industry is accustomed to rapid change, due to, amongst others, political stability, price changes, fashion and social trends. Nevertheless, climate change could have major implications for the tourist industry, for instance, by making currently popular areas less attractive and bringing new competitors to the market. This paper investigates the sensitivity of tourists in their choice of destination with respect to climate among tourist destinations in order to draw conclusions for the possible impact of climate change in the long term. First, a general picture is obtained of the link between tourist demand and temperature. Next, this general picture is unravelled with a case study of Dutch tourists to study the link between tourist activities during holiday trips and temperature. Finally, we briefly discuss adaptation of tourist suppliers.

The analysis of this paper is based on data sets on two levels. On the macro level, time-series on tourist numbers, destinations, and expenditures at the aggregate, national level are readily available, from sources such as the OECD (World Bank, the Organisation for Economic Cooperation and Development) and national statistical services. Climate data are obtained from various sources, including IIASA's (International Institute for Applied Systems Analysis) global climatology as well as tourist guides. In addition, on the micro level, data were purchased from the CVO (Foundation for Continuous Vacation Surveying). The micro-data consist of over 6,000 trips of Dutch tourists who are asked for their tourist destination and about their activities during their visits. The data include characteristics such as age-cohort, income-cohort, total holiday cost, departure date, destination-code and duration of stay. These micro-data cover only 1988 and 1992. Because of research budget constraints, we could not obtain more or more recent data.

This paper assumes that tourists have complete information about the climatic conditions at the travel destination in general and about the temperature in specific. This assumption is intuitive as tourists are becoming better informed through internet, experience and friends who travelled to their intended travel destination.

This paper is organised as follows. Section 2 briefly reviews the literature on tourist destination choice, and the few studies that look into the relationship between climate and tourism. The paper then continues with a statistical analysis at two levels. More specifically, Section 3 analyses international tourist flows, to explore the sensitivity of tourism to climate in general. Firstly, all tourist arrivals are pooled country-wise to study a general global trend. Secondly, eight individual countries of tourist origin and their travel destination are considered to verify to which extent tourist destination choice is country specific. Finally, a more detailed analysis is performed to explore whether the demand for Dutch tourists differs from that for British tourists. The CVO data are studied at the individual level with a factor and regression analysis (Section 4). It turns out to be a fruitful way to study independent choice situations by converting binary choice variables into continuous variables. Moreover, Section 4 studies the link between tourist activities and climate change by comparing winter and summer tourists, to see whether there are any differences in their choice behaviour, using a factor and regression analysis. Section 5 concludes by highlighting the main findings from both the macro- and the micro analysis and placing these in the context of global climate change.

2. Literature survey

2.1 Tourist demand

The number of studies devoted to tourist demand is vast, (Lim, 1997, Martin and Witt, 1989, Smeral and Witt, 1996, and Witt and Witt, 1995) with a general focus and (Bakkal and Scaperlanda, 1991, Divisekara, 1995, Eyemann and Ronning, 1997, Hannigan, 1994, Melenberg and Van Soest, 1996, Opperman, 1994, Pack, Clewer and Sinclair, 1995) with a regional focus, but the impact of climate and climatic change on tourism has received remarkably limited attention. This section focuses on tourist demand alone, to point out which factors other than climate affects the choice of tourist destination. This is important because the effect of climate effects depends on these other factors as well.

Witt and Witt (1995) have made a survey of empirical research on tourism demand to conclude that ‘it is not possible to build a single model which is appropriate for all origin destination pairs’ (Witt and Witt, 1995, pg. 469). Their finding is confirmed by Crouch (1995) who concludes from his meta-analysis that tourism demand is indeed situation-specific. The analysis of this paper confirms this conclusion although, at the same time, some remarkable generalities are found.

Lim (1997) has reviewed existing studies on tourism demand which use regression techniques. Most models are based on yearly data time series, which are linear or loglinear, mainly including economic variables. The lack of sufficient data is seen as a clear limitation of these models. Usage of yearly data does not capture the volatile character of the tourism sector; even the length of time series cannot compensate for this. Alternatively, cross section data could be used to focus on linkages between tourist choices and economic and climate data, which is the approach of this paper.

Ryan (1991) has argued that time series on tourism are susceptive to variation in macroeconomic growth which may lead to heteroscedasticity: in times of recession tourism appears to be income inelastic, while in times of growth tourism becomes income elastic. Ryan (1991) has provided a qualitative approach to tourist choices. The choice to travel and its destination is not a fixed and stable process. Tourism is a fast changing industry, which has come about recently and is now a major industry. Within tourism there are many interlinked processes such as economic demand and social demand. Psychological factors, such as time availability and the need to escape from the daily routine in an organised versus adventurous manner, also play an important role. Psychological considerations can explain a great deal of recent changes in tourist considerations and is according to Ryan the most important aspect for explaining tourism demand. Quantitatively, a factor analysis can be used to analyse data sets on psychological responses for tourist actions at holiday destinations (see Section 4.1).

2.2 Climate and tourism

Within studies on tourist destination choice, some authors have stressed the need for and incorporated climate factors in their analysis. Barry and O'Hagan (1972) have studied British tourist expenditure in Ireland and included a weather index in the descriptive variable list, which turns out to be always insignificant.

Syriopoulos and Sinclair (1993) have studied the choice of British, German, American, French and Swedish tourists for a destination in a Mediterranean country: Greece, Spain, Portugal, Italy and Turkey using the AIDS (almost ideal demand system) model. They use time series from 1960-87 and consider several types of costs. They study price elasticities between tourists from 'cold' countries to 'warm' countries, which are typical climate considerations.

Various authors have looked at the impact climate change would have on tourism and recreational industry. UKCCIRG (1991, 1996) has qualitatively discussed the impact of climate change on tourism in Great Britain. Mendelsohn and Markowski (1999) and Loomis and Crespi (1999) have investigated the impact of climate change on outdoor recreation in the USA. Agnew (1997) has looked at the quantitative impacts of weather variability on tourism in the UK. Wall (1988) has looked at the impact of climate change on skiing in Canada. Gable (1997) has looked at the implication of climate change and sea level rise for tourism supply in the Caribbean.

In the knowledge of the authors of this paper, Maddison (1998) is the only quantitative study that looks at tourist destination choice in the context of climate change. Using a pooled travel-cost model, Maddison estimates the importance to British tourists of climate at the holiday destination. Maddison (1998) also calculates the change in consumer surplus for certain climate changes. Maddison's model is adapted for Dutch tourists in Section 3.3.

3. Sensitivity of international tourist demand to climate

This section discusses the sensitivity of destination choices by international tourists to climate. We investigate this relationship using three data-sets. The first data-set is crude but covers almost the whole world. The third data-set is very detailed but covers only Dutch tourists. The second data-set is somewhere in between, covering selected OECD countries with some detail. Our analyses of the three different data-sets are necessarily mutually inconsistent; we simply cannot include the same explanatory variables in all regressions. Nonetheless, the analyses are constructed such that climate parts are comparable.

3.1 Global perspective

To study the sensitivity of tourist demand to climate at the international level, data from the World Development Indicators CD-ROM (World Bank, 1998) on the total numbers of tourist arrivals and departures per country are used. The origins and the destinations, respectively, of these tourists are not provided, however. As a result, travel distances and costs are unknown. Nevertheless, these data can be used to estimate which factors are decisive for making a country of destination popular (high number of visitors). Climate is represented by the average temperature of the warmest month over the last 30 years, using the IIASA database for mean monthly values of temperature on a global terrestrial grid by Leemans and Cramer (1991). The climate of the capital of a country is assumed to be representative for the entire country. The crudeness of the analysis is compensated by the fact that there are data for 17 years (1980-1996) for 210 countries. All data are pooled together and treated as cross-section data, which leads to 1730 observations.

The estimated model is:

$$\begin{aligned} \text{LN}ARRIVALS = \beta_0 + \beta_1 YEAR + \beta_2 AREA + \beta_4 POPDENS + \beta_5 COAST + \\ \beta_6 GDPPC + \beta_7 TW + \beta_8 TW^2 + \text{error} \end{aligned} \tag{3.1}$$

Table 1 defines the variables.

The variable *YEAR* is included to filter out all unexplained trends. The variable *AREA* incorporates that bigger countries can receive more tourists. This is only true in a limited sense, as a lot of tourists can be accommodated in a small place. The variable *COAST* captures the potential for beach holidays. The variable *GDPPC* captures destination price levels as well as tourist's dislike for poverty. *TW* is the climate. Table 2 present the results.

Not surprisingly, the explanatory value of the model is low (an R^2 of 0.49). The results are convincing, because the (statistically significant) estimates of the parameters of major interest (temperature) are plausible (see below), stable over the sample, and robust to variations in the model specification.

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The inclusion of both temperature and temperature-squared implies that there is an optimal summer temperature for tourism. The optimal temperature (T^{opt}) follows from:

$$T^{opt} = \frac{-\beta_7}{2\beta_8} \tag{3.2}$$

Its standard deviation ($\sigma_{T^{opt}}$) is approximated with its first-order Taylor expansion:

$$\sigma_{T^{opt}}^2 \approx \frac{1}{4\beta_8^2}\sigma_{\beta_7}^2 + \frac{\beta_7^2}{4\beta_8^4}\sigma_{\beta_8}^2 - \frac{\beta_7}{2\beta_8^3}\sigma_{\beta_7,\beta_8} \tag{3.3}$$

It turns out that the optimal temperature is about 21°C, with a standard deviation of 2°C; see Table 2. This is reasonable. Recall that this is the average over day and night temperatures (*TW*). The optimal temperature corresponds to the present temperatures found in northern Spain, southern France, northern Italy, the former Yugoslavia and Uganda. The first three are well-known tourist resorts, former Yugoslavia used to be, and Uganda may become one. Using different climate indices, Maddison's (1998) climate optimum (for the British) is also found in the European part of the Mediterranean.

The optimal temperature occurs in countries with many beaches. It may be that tourists care more about the presence of the beach than about the climate. The implications of climatic change would then be dramatically different. To test this, we excluded the explanatory variable *COAST* from the regression. The variable *AREA* then becomes significant – there is a high correlation (0.56) between *AREA* and *COAST* – so we also ran regression with neither *AREA* nor *COAST* and with only *COAST*. Table 2b displays the results. Table 2 shows that the estimated influence of temperature on international tourist arrivals is independent of whether *AREA* or *COAST* is used as an explanatory variable. The optimal holiday temperature varies between 20.6°C and 21.1°C, a difference that is not statistically significant. In fact, the correlation between coastal length and temperature is quite low (0.03). Both beaches and a nice climate attract tourists.

Besides climate, tourists' choices are determined by other factors. The number of arrivals increased significantly over time. Larger countries attract more tourists, but this effect is only barely significant. More densely populated countries attract significantly more tourists; tourists prefer a certain level of provision of services (transport, hotels, museums, etc) that cannot be found in lightly populated regions. Countries with long coastlines attract significantly more tourists, as do countries with a higher per capita income; the explanation for the latter is that poverty apparently deters tourists, even though holidays in poor countries are cheap.

3.2 Different origin countries

The above model gives a general picture about the sensitivity of tourist demand to climate at the international level for tourists of all origins. It may be, however, that tourists from different nationalities have different tastes for the climate of and the distance to their holiday destination, as is indeed found by Crouch (1995) and Witt and Witt (1995). For verifying the difference in tastes among tourists from different nations, appropriate data are a real constraint. The OECD publishes data on tourist destinations and origins for selected countries. Their 1997 report (OECD, 1997) is used, which has data for the period 1984-1995, for the countries listed in Table 3. For the Netherlands, the more detailed internet-database of the Central Bureau of Statistics is used (http://www.cbs.nl), covering 1970 to 1995 and more European countries (the destinations Canada and Japan are added from the OECD data). The data are the total, annual number of, for example, Germans or Italians arriving in, for example, France or the Netherlands. There are many missing observations; some countries report on the basis of residence, others on nationality; and some countries only count visitors whereas others count tourists separately. Data so crude only allow for a simple model to be estimated. As before, the purpose is to test whether there is an optimal temperature by treating the time-series as cross-section data.

The estimated model per origin country is:

$$\begin{aligned}\mathrm{LN}ARRIVALS = \beta_0 + \beta_1 YEAR + \beta_2 AREA + \beta_4 POPDENS + \beta_5 COAST + \\ \beta_6 GDPPC + \beta_7 TW + \beta_8 TW^2 + \beta_9 DIST + \text{error}\end{aligned} \tag{3.4}$$

Table 1 defines the variables.

Table 2 presents the estimated parameters and a summary of the results. The estimated optimal temperatures for the individual countries do not deviate significantly from the world estimate of 21.2ºC. The optimal temperature varies between Americans who prefer 21.0°C and Dutch who prefer 23.5°C at their country of holiday destination. This difference, however, is not significantly different from zero. Standard deviations vary between 1°C and 2°C, except for the French, who are rather single-minded about their optimal holiday climate; the French go *en masse* to Italy and Spain.

If the number of arrivals (rather than its natural logarithm) is used as a dependent variable, the estimated climate optimum is somewhat different, but not significantly so. Note that, in the linear model, the climate optimum for tourists from Canada and Japan cannot be estimated with any accuracy.

The other explanatory variables tell a more diverse story. Tourist numbers significantly increased over time, except for Canada and the USA, where the number of international trips remained constant. Distance, or perhaps travel cost, deters tourists. Dutch and US tourists prefer to travel to large countries, Canadians have the same tendency but are largely indifferent, whereas other Europeans and Japanese prefer to travel to small countries. All other things equal, small countries may attract proportionally more OECD tourists because frequent international travellers prefer to visit as many countries as possible in their life. The findings for North America may be explained by the distance factor; Canadians take holidays in the US, while US Americans travel to Canada. Many Dutch people spend their holidays in nearby Germany. French, German, Italian and UK tourists prefer lightly populated countries (recall that this dataset contains travel within the OECD only), whereas Canadian, Japanese, Dutch and US American tourists rather visit densely populated places. Tourists of all nationalities rather travel to countries with long coastlines, except for the Dutch. Again, the Dutch popularity of Germany (for tourism!) may be an explanation. Tourists of all nationalities prefer to travel to richer countries; this is surprising, as there is little absolute poverty in the OECD; apparently, relative poverty deters too, and is stronger than the cost of living effect.

Since the results of the macro analysis are quite crude, it is useful to undertake a more detailed analysis with micro data. Therefore, aggregated Dutch micro data are at the basis of the analysis in the next section.

3.3 Dutch tourists

In order to refine the analysis of tourist demand a pooled travel cost model is estimated for the particular case of Dutch tourists. The choice for this model is to compare our results with an earlier study (Maddison, 1998) on tourism demand for British tourists, to show the difference in tastes of tourists for climate originating from two different countries. This comparison is possible by aggregating the purchased CVO data set into quarterly data per destination. After deleting all destination countries with missing data, and by considering four seasons, and two years (1988 and 1992), 187 observations remain.

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Each destination has a number of climatic characteristics, like temperature, rainfall and hours of sunshine. The climate data (maximum temperature, precipitation and sun) were obtained from http://traveleshop.com/menus/weather.shtml, a standard source of such data for tourists and tourist operators, comprising 30 year averages over major cities in the world. Climate data are quarterly (January-February-March, April-May-June, July-August-September, October-November-December).

Each destination has also a number of non-climatic characteristics, like distance and airfare to reach that destination. Following Maddison (1998), the distance between Amsterdam and the capital of the country of destination is based on the great circles distance (see http://www.indo.com/distance/). The CVO data only contains a variable on the total travel expenditure, that travel costs plus expenditures at the holiday destination. Expenditure at destination are approximated by subtracting the travel cost. The cheapest airfare to a destination is taken as a proxy for the travel cost (see http://www.airfair.nl). Travel cost itself is excluded from the analysis because of its high correlation to distance. It is assumed that each person, either travelling in a group or alone, pays the same (minimum) airfare. Neglecting travellers who are prepared to pay more for travelling, it also neglects that tourist destinations can also be reached by other modes of transport. It is also assumed that the travel cost cannot exceed 80% of the total expenditure on a holiday. This last assumption is required, because in some exceptional cases the calculated travel cost can exceed the total expenditure on a holiday.

Table 3 shows the countries that are included in the analysis. Table 1 defines the variables that are included in the analysis.

The following tourist demand equation is estimated to find which variables contribute most to the number of tourists a certain country attracts. This model is also known as the pooled travel cost model.

$$\begin{aligned}&\mathrm{LN}VISITS_d = \beta_0 + \beta_1 GDPPC_d + \beta_2 POP_d + \beta_3 POPDEN_d + \beta_4 COAST_d + \\ &\beta_5 PDAY_d + \beta_6 DIST_{d-o} + \beta_7 TQ_d + \beta_8 PRECIP_d + \beta_9 Q1 + \beta_{10} Q2 + \beta_{11} Q3 + \\ &\beta_{12} INCOME_o + \beta_{13} AGE_o + \text{error}\end{aligned} \tag{3.4}$$

Subscript *d* denotes that the observation is at the tourist destination; subscript *o* represents the origin (i.e. the Netherlands). This model is slightly different from Maddison's:

$$\begin{aligned}&\mathrm{LN}VISITS_d = \beta_0 + \beta_1 FARE_{d-o}(-) + \beta_2 GDP_d(+) + \beta_3 POP_d(+) + \\ &\beta_4 POPDEN_d(-) + \beta_5 COAST_d(+) + \beta_6 PDAY_d(-) + \beta_7 DIST_{d-o} + \\ &\beta_8 T_d(+) + \beta_9 T_d^2(-) + \beta_{10} PRECIP_d + \beta_{11} Q1 + \beta_{12} Q2 + \beta_{13} Q3 + \text{error}\end{aligned} \tag{3.5}$$

Significant coefficients have their signs in brackets.

To avoid multicolinearity, temperature squared and travel costs are omitted. The gross domestic product per capita is used instead of the gross domestic product, as the latter is highly correlated with the population in a country (see Table 4). Age and income are added to the descriptive variable list as suggested by Maddison in his conclusions. These changes in the model improved the estimation result considerably.

Table 5 summarises the main statistics of the estimated equations.

Comparing our results with Maddison's, population density and the beach length have become insignificant, while distance has become negatively significant. This indicates that the amount of beaches and the population density does not matter for Dutch tourists, while it matters for British tourists. Further, the regression result indicates that Dutch tourists prefer a shorter distance to the holiday destination, while British tourists do not have such a preference. The signs of *GDPPC*(+), *POP*(+), *PDAY*(–) and *TQ*(–) are significant and the same for Dutch and British tourists. This indicates that Dutch and British tourists prefer to spend their holidays in richer, more populous and cheaper countries, while they prefer to avoid very high temperatures.

4. Sensitivity of Dutch tourist activities to climate

4.1 Behaviour of Dutch winter and summer tourists in 1988 and 1992

The behaviour of Dutch tourists in the winter and summer season is analysed with a factor analysis on the set of twenty-five dummy variables concerning the choice of activity during a holiday, to reduce this set into independent activity-choices and to indicate the priorities. Factor loadings greater than or equal to 0.5 in absolute terms, are called dominating factors; these factors symbolise the main considerations within a decision (Harman, 1967). When the dominating factor loading is negative the indicator works the other way around. For example, a negative factor loading for using a car means that not using a car is an important consideration. Table 6 and 7 show the dominating factors of each principal component for winter (from October until April) and summer tourist (from May until September) in 1988 and 1992. The rotated factor matrix is used here to maximise the factor loadings, so that the most possible distinct choice patterns is obtained in each case. A factor analysis helps in determining the main and independent considerations for going on a holiday, while comparing a normal winter (1992) with a mild winter (1988) and a normal summer (1988) with a hot summer (1992) gives an indication of the possible impact of climate change. Table 8 shows the weather characteristics for these specific years. Table 9 shows that the data set consists of two thirds of summer tourists. Business trips are excluded from the data set.

There is a great similarity in behaviour of Dutch summer tourists in 1988 and 1992. Factor 1, 2, 6 and 9 are the same. Hence, in both years the most important activity for Dutch summer tourists is sunbathing. After that, sightseeing has the highest priority. Water sports gets the sixth priority, while walking gets the ninth priority. There is also a great similarity between factor 3, 4 and 7. The third priority is given to leave the car home and travel by other means of transport; in 1988 this is accompanied by a café visit. The fourth priority is given to visiting an attraction; in 1988 this is combined with horse riding. The seventh priority is given to skiing; in 1988 this is combined with tennis and in 1992 it is combined with a café visit. The main change in behaviour between 1988 is factor 5 on travelling by car without cycling, which activity has disappeared in 1992. Instead tennis and mini-golf has given the fifth priority in 1992. Finally, the combination of factor 8 in 1988 (golf and sauna) resembles factor 10 in 1992 (with visits of theatres added). Hence, the behaviour of summer tourists does not change much between a hot summer (1992) and a normal summer (1988). In indicates for both years that sunbathing, sightseeing and travelling are the three most important activities during a holiday for Dutch tourists. That the effect of Dutch summer weather on tourists is limited can also be demonstrated by data on total tourist numbers (domestic and abroad) for the period 1969-1995. These data suggest that a summer which is 1ºC warmer than average, increases the number of domestic holidays in the same year by 4.7% (standard deviation: 2.2%), and increases the number of foreign holidays in the following year by 3.1% (standard deviation: 1.5%) (Tol *et al.*, 1999). There are two possible explanations for this. Firstly, Dutch tourist may expect a bad summer to follow a good one. This mistrust is unwarranted, as the correlation coefficient between successive summers is a positive 0.52. CBS (1993) finds that snowfall in popular ski-resorts in this season is a good predictor for next season's visitor numbers. An alternative explanation is that the money saved on a cheap domestic holiday for this year is spent on a more expensive foreign trip next year.

While tourist activities in summer are not very sensitive to weather conditions, winter tourists are. They have just one factor that fully corresponds in both years: tourists who go for warmer weather during the winter season (factor 2 on sunbathing). A striking result is the change in the first factor. In 1988, the first factor is dominated by visiting a monument or a museum. In 1992, the first factor contains the same indicators, but is added by travelling in public transport and visiting a theatre. This means that travelling in winter is becoming more packed, stuffing more and more activities into a holiday. From table 7 can be seen that a number of factors appear both in 1988 and 1992, but with different priorities, for instance:

- Factor 3 in 1988 resembles factor 5 in 1992 (visiting a sauna, swimming).
- Factor 4 in 1988 resembles factor 8 in 1992 (out in the city: visiting a restaurant or café).
- Factor 5 in 1988 (tennis, mini-golf, golf) almost resembles factor 7 in 1992 (tennis, golf).
- Factor 7 in 1988 resembles factor 4 in 1992 (sailing, surfing).

Finally, factor 6 (driving the car and no walking), factor 8 (cycling), factor 9 (fishing) and factor 10 (visiting a luna park, horse riding) in 1988 have been interchanged by factor 3 (car driving), factor 6 (horse riding), factor 9 (no cycling, skiing) and factor 10 (walking).

4.2 Sensitivity of Dutch tourist activities to other factors

To obtain the sensitivity of the choice for activity during a holiday to climate and other variables, the calculated factors of the last subsection can be used for a regression analysis on the total data set. As a first step in a regression analysis, an appropriate dependent variable needs to be chosen. There are many possibilities for that (Hsieh and O'Leary, 1997; Mendelsohn and Markowski, 1999):

- Activities during a holiday;
- Destination (home/abroad, hot/warm/medium/cold);
- Duration of the holiday;
- Number of visits; or
- Cost of stay.

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In order to establish a logical link to the last subsection, the first variable is most meaningful. This dependent variable gives the driving factors behind tourist activities during a holiday, where the sensitivity to climate can be studied as well.

As a second step in a regression analysis, consider the descriptive variables to be included. As before the CVO data set is used altered with information from other sources, to study the sensitivity of tourist activities to climate. Thereupon, the square of temperature is included in the variable list to find a significant estimate for both coefficients, so that the optimal temperature can be derived.

Given the available data it is possible to estimate the following ordinary linear regression model:

$$\text{Factor } i = \beta_0 + \beta_1 TQ + \beta_2 TQ^2 + \beta_3 PRECIP + \beta_4 SUN + \beta_5 PDAY + \beta_6 DIST + \beta_7 DUR + \beta_8 PERSON + \beta_9 INCOME + \beta_{10} AGE + \text{error} \tag{4.1}$$

Initially, this equation is estimated for 9 to 10 different factors, for summer, winter and all tourists, and for 1988 and 1992; in total, 57 regressions (Lise and Tol, 1999). In order to have a manageable number of regression, only those cases where β_1 and β_2 are statistically significant are presented. Table 10 shows the results. The adjusted R^2 is low in each case, indicating that tourist destination is far more complicated than our model assumes; nonetheless, we do obtain significant relationships.

Equation 4.1 contains 3 climatic variables and 6 socio-economic variables. Let use first interpret the signs of the socio-economic variables. The coefficient for *AGE* is generally negative, except for sight-seeing. This indicates that all considered activities are preferred by younger people except for sight-seeing. While this pattern holds for the 57 regressions, mentioned above, it is also confirmed by table 10. The positive signs for *DIST* and *DUR* indicate that a tourists who go further away for a longer time undertake more activities. The significant estimates for *PDAY* indicate that the daily expenditure is low for car-travellers and high for travellers who go out in the city and play tennis/use the sauna.

While the optimal temperatures are almost constant for the country-wise tourists flows, more variation is found when tourist activities are considered; cf. Table 10. Clearly, sport activities (sailing, surfing, horse riding and tennis) are preferably undertaken in cold weather ($TQ^{opt} \approx 10°\text{C}$). There is a great difference in optimal temperatures between similar activities, namely outing in the city (9°C), visiting an attraction park (20°C) and sight-seeing

(25°C). This low temperature for outing in the city is clearly caused by a sole focus on winter tourists. An optimal temperature of 24°C for winter tourists is more difficult to explain, but it indicates that car driving is preferred under an as high as possible temperature, as there are only two tourist destination with temperatures above 24°C, namely Australia (25°C) and Indonesia (31°C). Most activities are more likely to take place with lower amounts of rain, except for indoor activities as visiting a monument or a museum. The negative sign for the number of sun hours for car driving and sight-seeing shows that these activities are preferred in milder climates.

5. Discussion and conclusions

The analysis of this paper leads to the conclusion that climate is an important consideration for tourists' choice of destination. This should not surprise anyone. However, this paper finds that climate matters in a *regular* way that can be *quantified*. We find that an average temperature of about 21ºC is the ideal for the large bulk of international tourists. This preference is largely independent of the tourist's origin. This implies that climate change will have a strong effect on tourism demand. However, we cannot simply say that the currently popular tourist resorts will travel polewards with global warming.

This is because only the broad patterns are regular, not the details. We find small differences in behaviour of Dutch tourists from 1988 to 1992. Age and income are important explanatory variables, suggestive of significant trends in the behaviour of Dutch tourists over longer periods of time. Unfortunately, the limitations of the data (or rather our budget to purchase data) do not allow further exploration. The factor and regression analysis show that different dominant holiday activities imply different preferences for holiday climates. Younger and richer people do different things during their vacations than do older and poorer tourists. This suggests that preferences for climates at tourist destinations differ among age and income groups. It also suggests that, however regular the macro-preferences may be, there is little reason to assume that current aggregate preferences will resemble future aggregate preferences.

To assess future aggregate preferences would require quite detailed projections. Obviously, the micro-study reported here would need to be replicated for more years and many more countries. In that process, other relevant climate indicators should be included as well to get a more complete picture on the sensitivity of tourist demand to climate change.

This study suggests that people's preferred vacation activities are largely independent of climate. Instead, people purchase a climate that suits their holiday plans. A gradual warming would thus induce tourists to seek different holiday destinations, or travel at different times during the year. Climate change is therefore likely to lead to drastic changes in tourist behaviour. However, one cannot predict such changes without scenarios of preferred vacation activities in the future.

Although very responsive, tourists probably do not care much about climate change. They substitute one destination for another, or one travel date for another.

Some people have the freedom to take a holiday whenever they want, but others do not, and the ratio between the two will be different in the future. Vacation periods are often tied to seasons of the home climate, national and school holidays, and agreements at work. Changes in economic structure, demography, and air conditioning could loosen these ties. Because of this, and the reasons indicated above, it is very hard to predict changes in tourist behaviour due to climate change.

Whereas tourist can readily change their behaviour if climate changes, suppliers of tourism services cannot always. Tour operators can rapidly change their product. It does not matter much whether they sell a ticket to A or to B. The competition in the tourist sector is such that the profit margins are low anyway. Competition also guarantees that novel consumer preferences, because of climate change or otherwise, are rapidly catered for. Owners of hotels and resorts are less flexible. However, the tourist industry changes so fast that most investments have a very short pay back period. Currently, the tourist industry consists of many small and medium-size players. However, consolidation is ongoing, including vertical integration (e.g., travel agencies operating aircraft and hotels). This would reduce the flexibility of the sector as a whole, but would probably lead to an increase of professionalism. The impact on vulnerability is unclear.

Although tourists and probably tourist operators are adaptable enough to cope with climate change, the same cannot be said of local providers of tourist services and local economies dependent on tourism revenues. They would see the attractiveness of their region to tourists change beyond control. Some would benefit and some would lose, but local losses may be dramatic, particularly in regions with little alternatives and a culture of immobility.

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Collection of Tables

Table 1 Definition of the variables used.

Variable	Description
AGE	Average age of the interviewed tourists (years)
AREA	Land surface area per country (km^2)
COAST	Total length of the coast of a destination country (km)
DIST	Distance (as the crow flies) between capitals (km)
DUR	Number of days spent on holiday (number)
GDPPC	Country-wise PPP-based per capita income (US $ per year)
INCOME	Average income of the interviewed tourists (Dutch guilders per year)
LN*ARRIVALS*	Natural logarithm of the number of international tourist arrivals per country per year
LN*VISITS*	Natural logarithm of the number visits to a destination country by a Dutch tourist
PDAY	Average daily expenditure per person (Dutch guilders per day)
PERSON	Number of persons travelling (number)
POP	Total population (number)
POPDEN	Population density (number per square km)
PRECIP	Mean precipitation in the quarter of travelling (inch per month)
*Q*1	Dummy for the first quarter (winter)
*Q*2	Dummy for the second quarter (spring)
*Q*3	Dummy for the third quarter (summer)
SUN	Mean sun hours in country of destination in the quarter of traveling (hours per day)
TW	Mean temperature of the warmest month per country (^oC)
TQ	Mean temperature in the quarter of traveling (^oC)
YEAR	Year of observation

Table 2 Regression results for the global and national tourist destination models.[a]

	World	Canada	France	Germany	Italy	Japan	Netherlands	UK	USA
Constant	-1	5	-52*	-151***	-161***	-132***	-55***	-100***	12
	(1)	(30)	(40)	(37)	(41)	(28)	(11)	(34)	(28)
YEAR	0.4***	-0.6	1.7	7.1***	7.4***	6.2***	1.8***	4.4**	-0.5
10^{-2}	(0.1)	(1.5)	(2.0)	(1.9)	(2.1)	(1.4)	(0.6)	(1.7)	(1.4)
DIST		-2.3***	-3.5***	-2.7***	-3.2***	-2.8***	-6.8***	-1.7***	-2.5***
10^{-4}		(0.1)	(0.1)	(0.1)	(0.1)	(0.6)	(0.4)	(0.1)	(0.1)
AREA	0.4*	0.5*	-3.6***	-2.9***	-2.1***	-0.5*	1.7***	-3.5***	1.3***
10^{-7}	(0.2)	(0.4)	(0.5)	(0.4)	(0.4)	(0.3)	(0.3)	(0.4)	(0.3)
POPDENS	0.2**	2.1**	-9.8***	-7.9***	-7.4***	4.5***	2.4***	-12.8***	3.5***
10^{-3}	(0.1)	(1.0)	(1.7)	(1.3)	(1.3)	(1.0)	(0.6)	(1.5)	(0.9)
COAST	7.3***	12.2***	5.7***	7.3***	6.3***	9.5***	-2.3***	3.7***	13.0***
10^{-5}	(0.7)	(1.0)	(1.1)	(1.1)	(1.1)	(0.8)	(0.7)	(1.0)	(1.6)
GDPPC	2.1***	0.5***	2.1***	1.1***	1.5***	1.8***	1.1***	1.6***	0.4***
10^{-4}	(0.1)	(0.2)	(0.3)	(0.2)	(0.2)	(0.2)	(0.1)	(0.2)	(0.1)
TW	0.45***	1.88***	3.16***	2.34***	2.53***	1.93***	2.03***	2.39***	1.24***
	(0.04)	(0.12)	(0.22)	(0.15)	(0.16)	(0.11)	(0.22)	(0.13)	(0.12)
TW^2	-1.1***	-4.4***	-7.4***	-5.4***	-5.9***	-4.3***	-4.3***	-5.3***	-2.9***
10^{-2}	(0.1)	(0.3)	(0.5)	(0.4)	(0.4)	(0.3)	(0.5)	(0.3)	(0.3)
Optimal *TW*	21.2***	21.1***	21.5***	21.7***	21.4***	22.4***	23.5***	22.5***	21.0***
	(1.8)	(2.1)	(0.2)	(1.0)	(1.0)	(2.2)	(2.5)	(1.1)	(1.9)
# Observations	1700	158	156	170	140	145	376	157	159
R^2	0.49	0.91	0.88	0.85	0.88	0.92	0.64	0.83	0.85

[a] Regression of the natural logarithm of the number of arrivals in a country, either from all other countries (world) or from a particular country (Canada to USA). Standard deviations are given in brackets.

Table 2b The effect of area and coastal length on the optimal temperature

Area	Coast	Opt. TW		# Obs	R^2
No	No	21.1	(1.6)	1731	0.41
Yes	No	20.6	(1.8)	1731	0.44
No	Yes	21.2	(1.8)	1700	0.49
Yes	Yes	21.2	(1.8)	1700	0.49

Table 3 The countries which are included in the analysis.

Both in 1988 and 1992	Australia, Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Indonesia, Ireland, Israel, Italy, Luxembourg, Malta, Morocco, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Spain, Sweden, Switzerland, Tunisia, Turkey, United Kingdom
Only in 1988	Bulgaria
Only in 1992	Iceland, New Zealand, Slovenia

Table 4 Important correlation coefficients in the aggregated data set.

Variables	World	1988	1992
AREA & *COAST*	0.559		
COAST & *TW*	0.030		
TW & TW^2	0.987		
GDP & *POP*		0.603	0.709
DIST & travel cost		0.777	0.831
TQ & TQ^2		0.961	0.950

Table 5 Log-linear regression of climate on the number of visitors in a country.

	Coefficient	Standard deviation	t-ratio	Significance
Constant	0.139597	0.951941	0.146645	0.883584
GDPPC	0.000171	2.53E-05	6.773807	1.77E-10
POP	1.82E-08	3.08E-09	5.893514	1.95E-08
POPDEN	0.000578	0.000587	0.984058	0.326469
COAST	-3.1E-05	2.77E-05	-1.1111	0.268077
PDAY	-0.00863	0.002156	-4.00163	9.33E-05
DIST	-0.00022	5.66E-05	-3.87231	0.000153
TQ	0.174901	0.058731	2.977981	0.003321
TQ^2	-0.00253	0.001726	-1.46527	0.144672
PRECIP	-0.05301	0.091412	-0.57994	0.562714
Q1	0.114659	0.318192	0.360347	0.71903
Q2	-0.59666	0.348849	-1.71036	0.089003
Q3	-0.41715	0.371711	-1.12225	0.263319
INCOME	-3E-06	1.41E-05	-0.21543	0.829688
AGE	-0.0204	0.011247	-1.81412	0.071402
Adjusted R^2		0.430		
# observations		187		

Table 6 Component matrix: choice of Dutch summer tourists.

	1988									1992									
Factor	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	10
Car driving			-x		x							-x							
Cycling					-x														
Other transport			x									x							
Boating																			
Walking									x									x	
Luna park				x									x						
Zoo				x									x						
Cultural		x									x								
Monument		x									x								
Museum		x									x								
Restaurant																			
Theatre																			x
Café			x													x			
Sun	x									x									
Beach	x									x									
Sauna								x											x
Swimming	x									x									
Sailing						x									x				
Surfing						x									x				
Fishing																			
Tennis							x							x					
Mini-golf														x					
Golf								x											x
Horse riding				x													x		
Skiing							x									x			
% explained	9.0	7.5	6.0	5.3	4.7	4.5	4.3	4.2	4.1	8.5	7.4	5.9	5.5	4.7	4.5	4.4	4.1	4.1	4.1

Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalisation. Dominating factors are displayed as “x”, negative dominance is displayed as “-x”.

Table 7 Component matrix: choice of Dutch winter *tourists and some factors for all tourists.*

	1988										1992										All tourists 1992		
Factor	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	2	4	7
Car driving						x							x										
Cycling								x											-x				
Other transport											x												
Boating																							
Walking						-x														x			
Luna park										x												x	
Zoo																						x	
Cultural																							
Monument	x										x										x		
Museum	x										x										x		
Restaurant				x														x					
Theatre											x												
Café				x														x					
Sun		x										x											
Beach		x										x											
Sauna			x												x								x
Swimming			x												x								
Sailing							x							x									
Surfing							x							x									
Fishing									x														
Tennis					x												x						x
Mini-golf					x																		
Golf					x												x						
Horse riding										x						x							
Skiing																			x		-x		
% explained	9.7	7.1	5.9	5.2	4.8	4.8	4.7	4.6	4.4	4.0	9.6	8.2	5.8	5.4	5.0	4.8	4.5	4.4	4.3	4.1	7.8	5.2	4.3

Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalisation. Dominating factors are displayed as “x”, negative dominance is displayed as “-x”.

Table 8 Weather characteristics in the Netherlands.

	Winter	Summer	Year
Sunshine (hours, cumulative)			
1987	143	444	1312
1988	113	447	1293
1991	192	587	1566
1992	172	620	1599
Precipitation (mm, cumulative)			
1987	161	325	927
1988	283	226	887
1991	144	228	716
1992	137	294	957
Temperature (degree Celsius, average)			
1987	1.5	15.6	8.9
1988	5.0	15.8	10.3
1991	2.2	16.6	9.5
1992	3.9	17.8	10.5

Impact of climate on tourist demand

Table 9 Number of observations for winter and summer tourists.

Year	Summer tourists	Winter tourists	All tourists	Total data set
1988	3504 (68%)	1622 (32%)	5126	6659
1992	3763 (67%)	1839 (33%)	5602	6757

Table 10 Regression results for the micro model for choice of holiday activity in 1992.[a]

	Winter tourists				All tourists		
	Factor 3	Factor 4	Factor 6	Factor 8	Factor 2	Factor 4	Factor 7
Meaning of factor	Car driving	Sailing, surfing	Horse riding	Outing in city	Sight-seeing, no skiing	Visit atttraction	Tennis, sauna
Constant	-3.3	-2.1	-1.8	-1.4	-5.7	-1.4	0.60
	(0.6)	(0.6)	(0.7)	(0.7)	(0.4)	(0.4)	(0.36)
TQ	0.12	0.059	0.058	0.042	0.19	0.035	0.023
	(0.02)	(0.018)	(0.020)	(0.020)	(0.01)	(0.011)	(0.010)
TQ^2	-0.0025	-0.0028	-0.0028	-0.0025	-0.0037	-0.00088	-0.0011
	(0.0007)	(0.0008)	(0.0009)	(0.0009)	(0.0004)	(0.00036)	(0.0003)
PRECIP			-0.057	-0.10	-0.12	0.10	
			(0.032)	(0.03)	(0.02)	(0.01)	
SUN	-0.12				-0.17		
	(0.02)				(0.02)		
PDAY	-0.0014			0.0026			0.00085
	(0.0004)			(0.0004)			(0.00024)
DIST		0.00028	0.00017	9.6E-05	5.60E-05		
		(0.00002)	(0.00003)	(2.7E-05)	(1.7E-05)		
DUR					0.021	0.014	0.0077
					(0.002)	(0.002)	(0.0024)
PERSON	-0.016				-0.013		0.0073
	(0.003)				(0.002)		(0.0025)
INCOME	4.3E-06				4.2E-06		-2.2E-06
	(1.8E-06)				(1.0E-06)		(1.1E-06)
AGE		-0.0050	-0.0058	-0.0040	0.0079	-0.0081	-0.0075
		(0.0013)	(0.0014)	(0.0014)	(0.0007)	(0.0008)	(0.0008)
Optimal *TQ*	24.1	10.5	10.4	8.6	24.8	20.1	10.2
	(5.1)	(3.0)	(3.5)	(3.6)	(2.1)	(7.1)	(3.8)
# Observations	1310	1310	1310	1310	4301	4301	4301
Adjusted R^2	0.08	0.12	0.04	0.04	0.13	0.06	0.03

[a] Regression on holiday activity as expressed by a factor. Standard deviations are given in brackets.