THE IMPACT OF CLIMATE ON HOLIDAY DESTINATION CHOICE

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Abstract

The holiday destination choice is analysed for tourists from 45 countries, representing all continents and all climates. Tourists are deterred by distance, political instability and poverty, and attracted to coasts. Tourists prefer countries with a sunny yet mild climate, shun climes that are too hot or too cold. A country's tourists' aversion for poverty and distance can be predicted by that country's average per capita income. The preferred holiday climate is the same for all tourists, independent of the home climate. However, tourists from hotter climates have more pronounced preferences.

Key words

Climate change, impacts, adaptation, acclimatisation, domestic tourism, international tourism

JEL Classification

L83, Q25

1. Introduction

Tourism is one of the largest economic sectors in the world. Tourists are sensitive to climate and to climate change (Maddison, 2001; Lise and Tol, 2002 and Hamilton, 2003). This combination makes tourism potentially one of the largest market impacts of climate change. Indeed, Berritella *et al.* (2004) find large impacts of climate change on tourism already by 2050. However, previous estimates of the relationship between climate and tourist destination choice suffer from two major drawbacks. Firstly, tourists from only a few countries are analysed. This potentially biases the results. Secondly, domestic tourism is not explicitly included. The potential bias of this is larger, as domestic tourism is about 5 times as large as international tourism. This paper seeks to overcome these two drawbacks by looking at the destination choice of tourists from 45 countries from all levels of development and all climates. The tourists travel to 200-odd countries, including the home country.

Previous papers on climate change and tourism have focussed on biophysically constructed comfort indices (see, for example, Scott and McBoyle, 2001; and Amelung and Viner, in press), and on potential impacts and adaptation of particular tourism resorts (see, for example, Gable, 1997; Harrison *et al.,* 1999; Perry, 2000; Lohmann, 2001; and Elsasser and Bürki, 2002). Other papers, which include destination characteristics, are closer to the analysis presented here. Maddison (2001), Lise and Tol (2002), and Hamilton (2003) use micro-data of UK, Dutch and German tourists, respectively, to statistically estimate the relationship between destination choice, various climate indices and a range of other explanatory variables. In the paper by Hamilton, the origin country, Germany, was included in the destination choice set. See Hamilton and Tol (2004) for an extensive review of the literature on the impacts of climate change on tourism.

Compared to international tourism, there are relatively few studies on domestic tourism. There are some studies, however, that examine the trends in domestic tourism for particular countries: for example, Australia (Faulkner, 1988), China (Wen, 1997) and Germany (Coles, 2003). In some developing countries, domestic tourism has been increasing rapidly (Wen, 1997 and Ghimire, 2001), whereas in developed countries such as Australia and Germany domestic tourism is relatively stable. The geographical spread of domestic tourists is different from international tourists and domestic tourists and from domestic holidaymakers and those visiting friends and relatives (see, for example, Seaton and Palmer, 1997 and Seckelmann, 2002). Some studies argue that tourists behave differently on a domestic holiday compared to an international holiday (see Carr, 2002). Few attempts have been made to estimate demand functions for domestic tourism. In a study carried out for the North East of England, the demand function is restricted to the price of tourism in the region, the price of substitutes and the income of tourists (Seddighi and Shearing, 1997). Typically, demand estimation studies do not include destination characteristics (Morley, 1992).

Besides a detailed analysis of Dutch tourists, Lise and Tol (2002) also report a statistical analysis of aggregate data of tourism flows between selected OECD countries. It is this analysis that we extend here to include more origin countries and many more destination countries. As the analysis is at the aggregate level, many details are lost. In return, we obtain comprehensiveness.

The paper proceeds as follows. Section 2 presents the data. Section 3 shows the results for the 45 countries, as well as the consolidated results. Section 4 discusses and concludes.

2. The data

International tourism

International tourism data for each country are taken from the World Tourism Organisation (WTO) (2003). Where available, we use Table 1: international arrivals of tourists by *country of residence*. If not available, we use the alternative Table 1: international arrivals of tourists by *nationality*. If this is also not available, we instead use Table 4: international arrivals of tourists in *all establishments*. In the current study, no distinction is made between residence and nationality. If there is no Table 4 either, we use Table 3: international arrivals of tourists in *hotels*.

WTO (2003) reports the annual number of tourist arrivals for 1997-2001. We use the average of these five years, smoothing out annual variability.

Germany generates the most international tourists (72 mln), followed by the USA (57 mln), the UK (53 mln), the Netherlands (24 mln) and France (22 mln). These numbers are not in proportion to population size, nor to per capita income. The high numbers for the three northwest European countries probably has to do with the unreliable summer weather and, for the Netherlands, the small country size.

France is the most popular destination for international tourists (72 mln), followed by the USA (48 mln), Spain (40 mln), Italy (37 mln) and Mexico (20 mln). The popularity of France, Spain and Italy is explained by their proximity to Germany, the UK and the Netherlands, while Mexico profits from being close to the USA.

Domestic Tourism

For most countries, the volume of domestic tourist flows is derived using 1997 data contained in the Euromonitor (2002) database. For some other countries, we rely upon data from alternative sources, such as national statistical offices, other governmental institutions or trade associations. For some very small states (mostly city states[1]), we assumed that the number of domestic tourists is zero. Data are mostly in the form of number of trips to destinations beyond a non-negligible distance from the place of residence, and involving at least one overnight stay. For some countries, data in such a format was not available, and we resorted to using either the number of registered guests in hotels, campsites, hostels etc., or the ratio ofthe number of overnight stays to the average length of stay. The latter formats underestimate domestic tourism by excluding trips to friends and relatives; nevertheless, we included such data for completeness, relying on the fact that dropping them did not lead to any dramatic change. See Bigano *et al.* (2004) for a more extensive discussion and listing of sources.

In general, the number of domestic tourists is less than the national population; however, in 22 countries, residents took a holiday within their national borders more than once per year. Many factors may concur to explain this behaviour and a systematic analysis of them falls into the scope of the next sections. However, a preliminary look at the characteristics of countries, which display a marked domestic tourist activity, shows that these are in general rich countries, large (or at least medium-sized), and endowed with plenty of opportunities for domestic tourism. This definition fits in particular to the Scandinavian countries (4.8 domestic tourists per resident in Sweden) but also Canada, Australia, and the USA.[2]

In the USA, the combination of a large national area, a large number of tourist sites, high income per capita and the willingness to travel long distances contribute to explain why, on average, each American took a domestic holiday 3.67 times in 1997. The distance from the rest of the world is also important, and this is most probably the case for Australia and New Zealand, where there are plenty of opportunities for domestic tourism and it may take a very long journey to reach almost every international tourist destination. Table 1 shows the 10 most active and the 10 least active countries in terms of domestic tourism, for which we were able to collect data. For the 10 least active countries, the poverty of the vast majority of the population, probably combined with the lack of infrastructure and perhaps with cultural factors, make tourist travel a luxury for the lucky few.

[1] Andorra, Malta, Monaco and San Marino. Data were available for Hong Kong, Macau, Singapore and Liechtenstein.

[2] Poland, ranking 8th, is particularly active notwithstanding substantially lower per capita income than the rest of the top 10 countries.

Other data

A number of explanatory variables are used in the regressions reported below. Per capita income is taken from WRI (2002), temperature from New *et al.* (1999), world heritage sites from UNESCO (2004), area and coastline length from the CIA (2004) and the index of political stability from Kaufmann et al. (1999). The distance between countries is calculated from the great circles distance between the capital cities, the longitude and latitude of which were taken from the Times Atlas (1994).

3. Results

Preliminary findings

We estimate the following relationship for all countries of origin:

$$\begin{aligned} \ln(A_i^j) &= c^j + \delta_d^j + \delta_h^j + \delta_a^j + \\ &\alpha_1^j (1 - I_{i=j}) \ln(D_i^j) + \alpha_2^j \ln(y_i) + \alpha_3^j T_i + \alpha_4^j T_i^2 + \alpha_5^j H_i + \alpha_6^j C_i + \alpha_7^j A_i + \alpha_8^j S_i \end{aligned} \quad (1)$$

where A_i^i denotes the arrivals in country *i* from country *j*; D_i^j is the distance between the two countries (the range of t-statistics for the 45 regressions is –8.96 to 1.29); y_i is per capita income in the destination country (range of t-statistics 0.09 to 4.90); T_i is the annual average temperature in the destination country (range of t-statistics, linear –2.10 to 4.61, quadratic –4.36 to 2.16); H_i is the number of world heritage sites per million square kilometers in the destination country (range of t-statistics –2.57 to 2.30); C_i is the length of the coast line of the destination country (range of t-statistics –2.36 to 3.31); A_i is the land area of the destination country (range of t-statistics –0.91 to 3.77); and S_i is an index of the political stability of the destination country (range of t-statistics -0.49 to 3.00); besides the constant *c*, we also estimate three dummies, viz. whether the tourists stay in their home country (*i=j*) (range of t-statistics –5.66 to 4.59), whether the destination country reports only tourists arriving in hotels (range of t-statistics -2.38 to 2.15), or in all tourism establishments (range of t-statistics –3.01 to 0.57); the default reporting is for tourists arriving at the border.

Table A1 shows the results. Distance has a clear negative effect: destinations that are further away are less popular. Distance is significant at the 5% for all countries except Brazil, Switzerland and the USA. Per capita income in the destination country has a positive effect; tourists, particularly tourists from richer countries, do not like to witness poverty. Per capita income is significant at the 5% level for the Americas and Europe, except the Czech Republic, Germany, Hungary, and the Netherlands but is not significant for Africa, Asia and Australasia, except for Australia, China, India, Japan, and the Philippines. Temperature has a significant effect. The temperature parameters are jointly significant at the 5% level in all countries except Congo, Germany and Russia and the relationship, between temperature and the number of tourists, has the expected inverted-U shape in all countries except Germany and the Netherlands. Coast length has a positive effect or has no effect on tourist numbers; the coast length parameter is positive and significant in about half of the countries, without a pattern that can be easily interpreted. The Netherlands is the only country with a negative and significant relationship. The number of world heritage sites has a *negative* effect or has no effect, depending on the country of origin. The parameter is positive and significant for Indonesia and the Netherlands but it is negative and significant for Algeria, China, Germany, Saudi Arabia, Tunisia, and the USA. Area has a positive effect: larger countries attract more tourists. This parameter is insignificant for Argentina, New Zealand and the countries of Europe, apart from Greece, Poland and Russia. Political stability has a positive effect: the more stable the country, the more tourists it attracts. Stability is significant at the 5% level for Canada, the Czech Republic, Egypt, Hungary, Indonesia, Kenya, Malaysia, Mexico, South Africa, Sweden, Thailand and Turkey.

The regression results conform to our expectations, with two exceptions. The attitude of tourists from the Netherlands towards climate and coast is peculiar. It is odd that the world heritage sites appear to deter tourists. However, some peculiarities are to be expected with one standard regression for 45 different countries.

Interpretation

Figure 1 shows the relationship between the optimal holiday temperature and the temperature in the country of origin. This relationship is largely absent. This is confirmed by a regression analysis. Figure 2 shows the relationship between α_4, the parameter of the temperature squared in Equation (1), and the temperature in the country of origin. Here, there is a clear relationship. Weighted least squares, using the inverse of the standard error of the parameter estimates as weights, shows that this parameter falls by 2.5 (0.9) 10^{-4} for every degree increase in temperature.[3] Although people from hot countries prefer the same climate as people from cold countries, they are much more particular about their preferences, and have a greater dislike of tourist destinations that are too hot or too cold.

The distance elasticity of arrivals falls with per capita income in the country of origin, with 5.4 (1.2) 10^{-5} per additional dollar. This is as expected: travel expenses are less relevant to the better-off. Poverty aversion, α_2 in Equation (1), increase with per capita income in the home country, with 1.3 (0.5) 10^{-5} per additional dollar. This is as expected: people from poor countries are less deterred by poverty.

Consolidated results

We separately estimate the relationships that describe the behaviour of tourists from 45 countries. We find that there is a meta-structure in the parameters. That is, additional information, that is not considered in the first regressions. In order to use this information, we run the following procedure: One by one, we omit each country from the analysis above. Based on the original parameter estimates for the remaining 44 countries, we predict the parameter value for the 45th country. We combine this prior information with the likelihood information of the original regression of the 45th country to form the posterior for the 45th country. The equations are

(2) $$\Sigma = (\mathrm{T}^{-1} + \Upsilon^{-1})^{-1}$$

and

(3) $$\beta = \Sigma(\mathrm{T}^{-1}\alpha + \Upsilon^{-1}\gamma)$$

where β is the new vector of parameter estimates for Equation (1) and Σ is its covariance matrix; α is the original vector of parameter estimates for Equation (1) and T is its covariance matrix; and γ is the vector of predicted parameter values and Y is its covariance matrix. For γ, we use a zero if no prediction is available; the corresponding diagonal element in Y is set to infinity. The off-diagonal elements of Y are all set to zero. The classical equivalent of this Bayesian procedure is mixed estimation by Theil and Goldberger (1961). If we just use the average of the parameter values of the other countries (rather than the average adjusted for

[3] Figure 2 suggests that the relationship is quadratic, that is, the parameter first falls and then rises. However, temperature squared does not significantly affect the parameter (and its coefficient is in fact of the wrong sign).

temperature or per capita income), this procedure would correspond to a panel data analysis with random effects. With the adjustments for temperature and per capita income, this corresponds to a panel data analysis with cross-terms and random effects.

Table 2 shows the results for adding information on the optimal holiday temperature, the curvature of the temperature/attractiveness curve (the temperature squared parameter), the distance elasticity, and the poverty aversion. Results are as expected. The estimated optimal holiday temperature per country are shrunk to the global mean optimal holiday temperature, which is 16.2 (0.5)˚C. This is no surprise, as the uncertainty about the global mean optimal holiday temperature is much smaller than the typical uncertainty about the country optimal holiday temperature. The standard deviations of the latter vary between 0.8˚C and 11.4˚C.

Similar things happen with the other parameters, but in these cases, the estimates are not shrunk to the global mean, but rather to the predicted value, conditional on per capita income or temperature. With regard to the curvature of the temperature / attractiveness relationship, the predictions dominate the initial estimate. As a result, the noise of Figure 2 is considerably reduced, both in terms of country-to-country comparisons, and in terms of uncertainty about the estimated parameters. Germany and the Netherlands initially had positive estimates; the consolidated estimates are negative, as expected.

For the distance elasticity, the predicted parameter values are less dominant, but nonetheless do reduce both types of noise. For poverty aversion, the predicted parameter values dominate.

4. Discussion and conclusion

The following results emerge from the above analysis. People from any country prefer the same climate for their holidays. The optimal holiday destination has an average annual temperature of 16.2±2·0.5ºC. Mediterranean countries fall in this range. This conclusion is remarkable. People from Canada, Russia and Sweden prefer to be in the same climate as do people from Bangladesh, Brazil and Nigeria. This suggests that people's climate preferences are driven by basic biological processes, with limited or no acclimatisation to the climates in which they live.

However, this conclusion does not carry over to the second moment. People from warmer climes have sharper preferences, are more particular about their choices than are people from colder climes. For example, a Swede would prefer to spend her holiday in the Provence, but would not really object to a holiday in Denmark; an Italian would similarly prefer the Provence, but would feel bad if he ends up in Denmark instead. This result is as remarkable as the first one. As preferences are assumed to be symmetrical around the optimum climate, it suggests that people from colder climes have got used to unpleasant weather, and therefore think less of it. The surprising part is not that they do not mind the cold, but they also do not mind heat. People from hot places avoid cold places for their holidays, as expected, but similarly avoid places that are too hot. Perhaps people from cold climes know they can handle cold but cannot imagine heat, while people from hot places can imagine cold. Another explanation is that the assumed symmetry is not real. Introducing asymmetries into the analysis is not trivial, however, and would require a larger number of observations.

The wider implications for adaptation to climate and climate change readily follow. It has long been argued that people adapt to extreme rather than mean weather. Here, we find that there is evidence of adaptation in the extremes of behaviour, but not in the mean.

The implications for the impacts of climate change on tourism are also clear. Climate change would drive tourists up the mountains and towards the poles. Although not analysed here, climate change would also induce people to avoid July and August, and have holidays in June and September instead (in the Northern Hemisphere). Tourists from warmer climates would respond more strongly than tourists from colder places. This implies that tourist resorts in places that are likely to become too hot, should strengthen the loyalty of their visitors from cold places but not from hot places. Potential tourist resorts that are likely to become sufficiently warm, should also target tourists from cold countries. Only resorts with a near perfect climate should target tourists from hotter places. Another implication, as the bulk of the future growth of tourism is bound to originate from hotter countries, is that tourism as a whole is likely to become more sensitive to climate change as time passes.

Future research should look into the asymmetries sketched above. It should also study tourist destination choice paying greater attention to spatial and temporal resolution (national and annual is probably not good enough) and to tourist characteristics. A crude study such as this one yields sufficiently interesting results to warrant further research.

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References

Amelung, B. and D. Viner, in press. The vulnerability to climate change of the Mediterranean as a tourist destination. In: *Climate Change and Tourism: Assessment and Coping Strategies* [Amelung, B., K. Blazejczyk, A. Matzarakis and D.Viner (eds.)]. Kluwer Academic Publishers, Dordrecht, the Netherlands.

Berritella, M., A. Bigano, R. Roson and R.S.J. Tol, 2004: A general equilibrium analysis of climate change impacts on tourism. Research Unit Sustainability and Global Change Working Paper FNU-49, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg, Germany.

Bigano, A., J.M. Hamilton, M. Lau, R.S.J. Tol and Y. Zhou (2004), *A global database of domestic and international tourist numbers at national and subnational level*, Research unit Sustainability and Global Change **FNU-54**, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg.

Carr, N., 2002: A comparitive analysis of the behaviour of domestic and international young tourists. *Tourism Management,* **23**, 321-325

CIA, 2002: *The World Factbook 2002*. Central Intelligence Agency, Washington, D.C., USA. Retrieved from http://www.cia.gov/cia/publications/factbookColes, T., 2003: The emergent tourism industry in eastern Germany a decade after unification. *Tourism Management*, **24**, 217-226

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

Euromonitor 2002: Global Market Information Database, http://www.euromonitor.com/gmid/default.asp

Faulkner, B., 1988: Tourism demand patterns-Australia. *International Journal of Hospitality Management*, **7(4),** 333-341

Gable, F. J., 1997: Climate change impacts on Caribbean coastal areas and tourism. *Journal of Coastal Research,* **27**, 49-70.

Ghimire, K.B. 2001: *The Native Tourist*. Earthscan, London, UK

Hamilton, J.M., 2003: Climate and the destination choice of German tourists. Research Unit Sustainability and Global Change Working Paper FNU-15 (revised), Centre for Marine and Climate Research, Hamburg University, Germany.

Hamilton, J.M. and R.S.J. Tol (2004), *The Impacts of Climate Change on Tourism and Recreation,* Research Unit Sustainability and Global Change **FNU-52**, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg.

Harrison, S.J., S.J. Winterbottom and C. Shephard, 1999: The potential effects of climate change on the Scottish tourist industry. *Tourism Management*, **20**, 203-211.

Kaufmann, D., A. Kraay & P. Zoido-Lobaton, 1999: Governance Matters. Policy Research Working Paper 2196. World Bank, Washington, USA.

Lise, W. and R.S.J. Tol, 2002: Impact of climate on tourism demand. *Climatic Change*, **55(4)**, 429-449.

Lohmann, M., 2001: Coastal resorts and climate change. In: *Tourism and Hospitality in the 21st Century*, [Lockwood, A. and S. Medlik (eds.)]. Butterworth-Heinemann, Oxford, UK, pp. 284 – 295.

Maddison, D., 2001: In search of warmer climates? The impact of climate change on flows of British tourists. In: *The Amenity Value of the Global Climate*, [Maddison, D. (ed)]. Earthscan, London, UK, pp. 53-76.

Morley, C.L., 1992: A microeconomic theory of international tourism demand. *Annals of Tourism Research*, **19**, 250-267.

Nakicenovic, N. and R.J. Swart, 2001: *IPCC Special Report on Emissions Scenarios*. Cambridge University Press, Cambridge, UK.

New, M., Hulme, M. and P.D. Jones, 1999: Representing Twentieth Century Space-Time Climate Variability, Part I: Development of a 1961-1990 Mean Monthly Terrestrial Climatology. *Journal of Climate*, **12**, 829-856.

Perry, A., 2000: Impacts of climate change on tourism in the Mediterranean: Adaptive responses. Nota di Lavoro 35.2000, Fondazione Eni Enrico Mattei, Milan, Italy.

Scott, D. and G. McBoyle, 2001: Using a "Tourism Climate Index" to examine the implications of climate change for Climate as a Tourism Resource. In: *International*

Society of Biometeorology Proceedings of the First International Workshop on Climate, Tourism and Recreation. [Matzarakis, A. and C. de Freitas (eds.)]. Retrieved from http://www.mif.uni-freiburg.de/isb/ws/report.htm

Seaton, A.V. and C. Palmer, 1997: Understanding VFR tourism behaviour: the first five years of the United Kingdom tourism survey. *Tourism Management,* **18(6)**, 345-355.

Seckelmann, A., 2002: Domestic tourism – a chance for regional development in Turkey. *Tourism Management,* **23**, 85-92.

Seddighi, H.R. and D.F. Shearing, 1997: The demand for tourism in North East England with special reference to Northumbria: an empirical analysis. *Tourism Management*, **18(8),** 499-511.

Smith, J.B., H.-J. Schellnhuber, M.M.Q. Mirza, S. Fankhauser, R. Leemans, E. Lin, L. Ogallo, B. Pittock, R.G. Richels, C. Rosenzweig, R.S.J. Tol, J.P. Weyant and G.W. Yohe , 2001: Vulnerability to climate change and reasons for concern: a synthesis. In: *Climate Change 2001: Impacts, Adaptation, and Vulnerability* [J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White (eds.)]. Cambridge University Press, Cambridge, UK, Chapter 19, pp. 913-967.

The Times Atlas of the World (1994), 9th Comprehensive Edition, Harper Collins, London.

UNESCO, 2004: *World Heritage List*. UNESCO, Paris, France. Retrieved from http://whc.unesco.org.

Wen, Z., 1997: China's domestic tourism: impetus development and trends. *Tourism Management*, **18(8),** 565-571.

WRI, 2002: *World Resources Database 2002-2003*. World Resources Institute, Washington, D.C., USA

WTO, 2003: *Yearbook of Tourism Statistics*. World Tourism Organization, Madrid, Spain.

Table 1. Domestic tourism in the 10 most active and in the 10 least active countries[4]

Least active countries	Domestic tourists / residents	GDP per Capita 1997	Area (sq km)	Most active countries	Domestic tourists /residents	GDP per capita 1997	Area (sq km)
Congo	0.00778	815	342000	Sweden	4.79903	26766	449964
Togo	0.00406	349	56785	Finland	4.41692	26888	337030
Nicaragua	0.00399	521	129494	New Zealand	4.12968	16834	268680
Albania	0.00362	785	28748	United States	3.67587	28651	9629091
El Salvador	0.00318	1702	21040	Australia	3.52266	20843	7686859
Senegal	0.00285	570	196190	Canada	2.67469	20225	9976140
Kenya	0.00231	338	582650	United Kingdom	2.28203	20025	244820
Mali	0.00224	262	1240000	Poland	2.24071	3482	312685
Niger	0.00037	206	1267000	Ireland	1.87281	21083	70280
Chad	0.00014	224	1284000	Norway	1.42087	36389	324220

[4] GDP per Capita is expressed in 1995 constant US Dollars. The entry for Nicaragua refers to 1996.

Table 2. Consolidated regression results (standard deviations in brackets).

	Optimal temperature		Temperature squared		Distance		Per capita income	
Kenya	16.2	(0.5)	-0.0141	(0.0014)	-2.3232	(0.2158)	0.5565	(0.0908)
Congo	16.2	(0.5)	-0.0142	(0.0014)	-2.2678	(0.2361)	0.5572	(0.0926)
Algeria	16.2	(0.5)	-0.0138	(0.0014)	-2.1888	(0.2350)	0.5997	(0.0955)
Morocco	16.3	(0.5)	-0.0129	(0.0014)	-2.2289	(0.2372)	0.5754	(0.0933)
Tunisia	16.2	(0.5)	-0.0130	(0.0014)	-2.1186	(0.2390)	0.6176	(0.0967)
South Africa	16.2	(0.5)	-0.0130	(0.0013)	-1.8102	(0.2032)	0.6500	(0.0984)
Nigeria	16.2	(0.5)	-0.0147	(0.0014)	-2.2784	(0.2210)	0.5400	(0.0914)
Canada	16.4	(0.5)	-0.0074	(0.0013)	-0.9420	(0.2419)	0.7975	(0.1254)
Mexico	16.2	(0.4)	-0.0141	(0.0013)	-1.7785	(0.2066)	0.6985	(0.0991)
USA	16.2	(0.5)	-0.0099	(0.0013)	-0.2168	(0.1568)	1.0695	(0.1520)
Argentina	16.0	(0.5)	-0.0124	(0.0014)	-1.7020	(0.2538)	0.7279	(0.1094)
Brazil	16.2	(0.5)	-0.0149	(0.0014)	-0.6997	(0.1688)	0.6797	(0.0959)
China	16.2	(0.5)	-0.0098	(0.0013)	-2.2219	(0.2114)	0.6063	(0.0920)
Japan	16.3	(0.5)	-0.0113	(0.0013)	-2.0108	(0.2999)	0.9763	(0.1315)
Korea	16.3	(0.5)	-0.0114	(0.0014)	-1.8209	(0.2795)	0.7645	(0.1194)
Indonesia	16.2	(0.5)	-0.0149	(0.0014)	-2.3915	(0.2178)	0.5660	(0.0924)
Malaysia	16.2	(0.5)	-0.0146	(0.0013)	-2.3561	(0.2226)	0.6675	(0.1027)
Philippines	16.2	(0.5)	-0.0147	(0.0013)	-2.2751	(0.2009)	0.6051	(0.0919)
Thailand	16.1	(0.5)	-0.0147	(0.0014)	-2.3322	(0.2205)	0.6345	(0.0969)
Australia	15.8	(0.5)	-0.0139	(0.0013)	-1.8335	(0.3240)	0.8106	(0.1305)
New Zealand	15.8	(0.5)	-0.0114	(0.0013)	-1.6265	(0.3081)	0.7441	(0.1205)
Czechia	16.1	(0.5)	-0.0100	(0.0015)	-1.8838	(0.2416)	0.7009	(0.1088)
Hungary	15.9	(0.5)	-0.0110	(0.0014)	-1.8694	(0.2223)	0.6770	(0.1041)
Poland	16.0	(0.5)	-0.0106	(0.0013)	-1.9749	(0.2141)	0.6599	(0.0976)
Russia	16.2	(0.5)	-0.0066	(0.0015)	-2.0755	(0.2337)	0.6529	(0.0972)
Denmark	16.2	(0.5)	-0.0098	(0.0013)	-1.1639	(0.2800)	0.8624	(0.1393)
Sweden	16.2	(0.5)	-0.0087	(0.0013)	-1.2839	(0.2708)	0.8280	(0.1300)
UK	16.3	(0.5)	-0.0102	(0.0013)	-1.0734	(0.2157)	0.8674	(0.1210)
Greece	16.1	(0.5)	-0.0121	(0.0014)	-1.5406	(0.2477)	0.7737	(0.1182)
Italy	16.3	(0.5)	-0.0113	(0.0013)	-1.1965	(0.2317)	0.8901	(0.1235)
Portugal	16.1	(0.5)	-0.0122	(0.0013)	-1.3620	(0.2464)	0.7877	(0.1153)
Spain	16.2	(0.5)	-0.0116	(0.0013)	-1.0104	(0.1712)	0.8113	(0.1202)
Austria	16.2	(0.5)	-0.0097	(0.0014)	-1.3686	(0.2641)	0.8710	(0.1400)
France	16.2	(0.5)	-0.0106	(0.0013)	-1.1833	(0.2460)	0.8213	(0.1311)
Germany	16.2	(0.5)	-0.0097	(0.0014)	-1.6439	(0.2880)	0.7688	(0.1387)
Netherlands	16.1	(0.5)	-0.0096	(0.0014)	-1.4463	(0.2857)	0.8296	(0.1443)
Switzerland	16.0	(0.5)	-0.0101	(0.0013)	-0.1217	(0.2189)	0.9372	(0.1473)
Israel	15.8	(0.5)	-0.0133	(0.0014)	-1.0848	(0.2326)	0.8203	(0.1256)
Turkey	16.0	(0.5)	-0.0114	(0.0014)	-2.0203	(0.2187)	0.6057	(0.0959)
Saudi Arabia	16.2	(0.5)	-0.0144	(0.0014)	-1.9063	(0.2590)	0.6697	(0.1041)
Egypt	16.3	(0.5)	-0.0142	(0.0014)	-2.0963	(0.2130)	0.5667	(0.0925)
Bangladesh	16.3	(0.5)	-0.0144	(0.0014)	-2.5053	(0.2086)	0.5722	(0.0915)
India	16.2	(0.5)	-0.0133	(0.0014)	-2.2618	(0.2080)	0.6032	(0.0903)
Iran	16.2	(0.5)	-0.0126	(0.0014)	-2.1556	(0.2352)	0.6145	(0.0967)
Pakistan	16.3	(0.5)	-0.0131	(0.0014)	-2.2949	(0.2175)	0.5810	(0.0919)

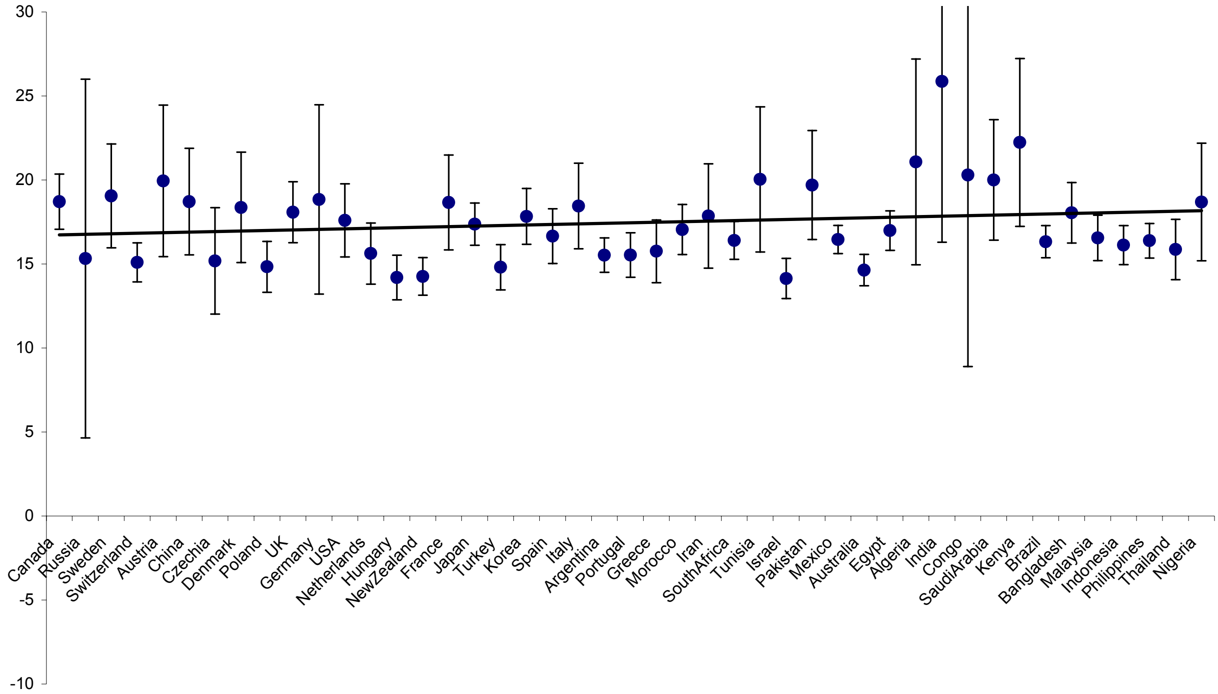

Figure 1. The optimal temperature for all countries of origin in the sample; the countries of origin are ranked according to their temperature.

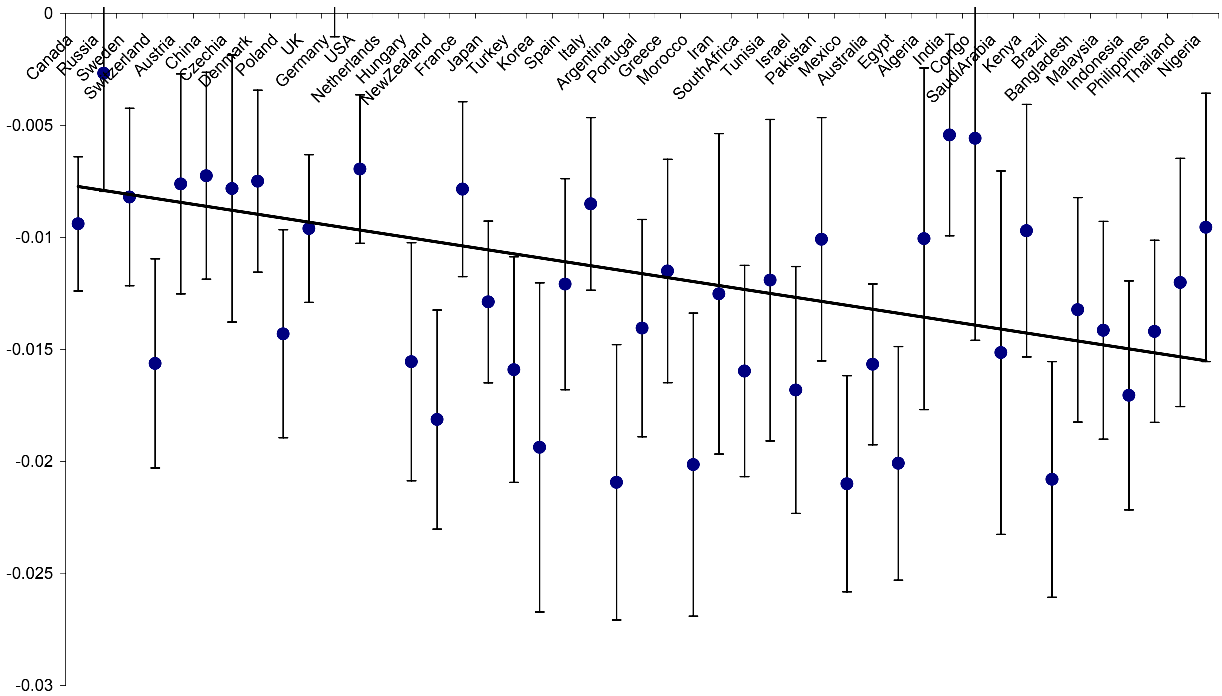

Figure 2. The coefficient of temperature squared in Equation (1) for all countries of origin in the sample; the countries of origin are ranked according to their temperature.

Table A1a. Regression results per country (standard deviations in brackets).

	Optimal temperature		Temperature squared		Distance		Income per capita	
Kenya	22.2	(5.0)	-0.0097	(0.0056)	-2.45	(0.45)	0.45	(0.38)
Congo	20.3	(11.4)	-0.0056	(0.0090)	-1.76	(0.87)	0.52	(0.75)
Algeria	21.1	(6.1)	-0.0101	(0.0076)	-2.89	(0.62)	0.05	(0.56)
Morocco	17.1	(1.5)	-0.0201	(0.0068)	-2.74	(0.79)	0.11	(0.54)
Tunisia	20.0	(4.3)	-0.0119	(0.0072)	-2.75	(0.64)	0.28	(0.53)
South Africa	16.4	(1.1)	-0.0160	(0.0047)	-1.68	(0.31)	0.57	(0.38)
Nigeria	18.7	(3.5)	-0.0096	(0.0060)	-2.11	(0.51)	0.17	(0.45)
Canada	18.7	(1.6)	-0.0094	(0.0030)	-0.89	(0.31)	0.64	(0.22)
Mexico	16.5	(0.8)	-0.0210	(0.0048)	-1.64	(0.32)	1.13	(0.36)
USA	17.6	(2.2)	-0.0070	(0.0033)	-0.20	(0.16)	1.14	(0.24)
Argentina	15.5	(1.0)	-0.0209	(0.0061)	-1.81	(0.51)	1.00	(0.50)
Brazil	16.3	(1.0)	-0.0208	(0.0053)	0.29	(0.22)	1.65	(0.43)
China	18.7	(3.2)	-0.0072	(0.0046)	-2.35	(0.40)	0.85	(0.38)
Japan	17.4	(1.3)	-0.0129	(0.0036)	-3.41	(0.47)	1.28	(0.26)
Korea	17.8	(1.7)	-0.0194	(0.0073)	-3.03	(0.61)	1.00	(0.66)
Indonesia	16.1	(1.2)	-0.0171	(0.0051)	-3.01	(0.46)	0.18	(0.47)
Malaysia	16.6	(1.3)	-0.0141	(0.0049)	-3.38	(0.38)	0.45	(0.44)
Philippines	16.4	(1.0)	-0.0142	(0.0041)	-2.48	(0.34)	0.77	(0.36)
Thailand	15.9	(1.8)	-0.0120	(0.0055)	-3.21	(0.42)	0.70	(0.52)
Australia	14.6	(0.9)	-0.0157	(0.0036)	-3.91	(0.64)	0.65	(0.29)
New Zealand	14.3	(1.1)	-0.0181	(0.0049)	-3.28	(0.90)	0.41	(0.39)
Czech Rep.	15.2	(3.2)	-0.0078	(0.0060)	-2.35	(0.43)	0.49	(0.45)
Hungary	14.2	(1.3)	-0.0155	(0.0053)	-2.05	(0.36)	0.47	(0.40)
Poland	14.8	(1.5)	-0.0143	(0.0046)	-2.10	(0.36)	0.71	(0.34)
Russia	15.3	(10.7)	-0.0027	(0.0053)	-2.55	(0.51)	0.77	(0.39)
Denmark	18.4	(3.3)	-0.0075	(0.0041)	-1.34	(0.39)	0.78	(0.32)
Sweden	19.1	(3.1)	-0.0082	(0.0040)	-1.43	(0.40)	0.78	(0.32)
UK	18.1	(1.8)	-0.0096	(0.0033)	-1.04	(0.26)	0.92	(0.22)
Greece	15.8	(1.9)	-0.0115	(0.0050)	-1.69	(0.38)	0.79	(0.37)
Italy	18.4	(2.5)	-0.0085	(0.0039)	-1.22	(0.30)	1.06	(0.25)
Portugal	15.5	(1.3)	-0.0140	(0.0049)	-1.12	(0.40)	1.17	(0.40)
Spain	16.7	(1.6)	-0.0121	(0.0047)	-0.87	(0.20)	1.05	(0.36)
Austria	19.9	(4.5)	-0.0076	(0.0049)	-1.66	(0.36)	0.85	(0.35)
France	18.7	(2.8)	-0.0078	(0.0039)	-1.28	(0.32)	0.68	(0.27)
Germany	18.8	(5.6)	0.0060	(0.0070)	-2.40	(0.44)	0.04	(0.43)
Netherlands	15.6	(1.8)	0.0159	(0.0073)	-1.93	(0.42)	0.39	(0.52)
Switzerland	15.1	(1.2)	-0.0156	(0.0047)	0.12	(0.25)	0.99	(0.31)
Israel	14.1	(1.2)	-0.0168	(0.0055)	-0.85	(0.32)	1.16	(0.47)
Turkey	14.8	(1.3)	-0.0159	(0.0050)	-2.07	(0.41)	0.16	(0.40)
Saudi Arabia	20.0	(3.6)	-0.0151	(0.0081)	-2.66	(0.73)	0.35	(0.53)
Egypt	17.0	(1.2)	-0.0201	(0.0052)	-1.89	(0.41)	0.09	(0.42)
Bangladesh	18.0	(1.8)	-0.0132	(0.0050)	-3.08	(0.39)	0.75	(0.44)
India	25.9	(9.6)	-0.0054	(0.0045)	-2.29	(0.39)	1.00	(0.34)
Iran	17.9	(3.1)	-0.0125	(0.0072)	-2.82	(0.58)	0.18	(0.59)
Pakistan	19.7	(3.2)	-0.0101	(0.0054)	-2.42	(0.46)	0.87	(0.47)

Table A1b. Regression results per country (continued).

	Coast		Area		Stability		World heritage		R^2	N
Kenya	1.1E-05	(1.2E-05)	5.3E-07	(1.5E-07)	1.08	(0.54)	0.00	(0.00)	0.68	32
Congo	1.9E-06	(1.9E-05)	5.3E-07	(2.2E-07)	-0.16	(1.11)	-0.64	(0.53)	0.23	26
Algeria	1.7E-05	(1.6E-05)	4.7E-07	(2.0E-07)	0.96	(0.71)	-2.57	(0.02)	0.57	31
Morocco	3.0E-05	(1.5E-05)	4.2E-07	(1.9E-07)	1.05	(0.68)	-1.57	(0.13)	0.68	33
Tunisia	2.2E-05	(1.5E-05)	5.1E-07	(1.9E-07)	0.81	(0.69)	-2.25	(0.04)	0.62	30
South Africa	2.5E-05	(1.0E-05)	2.4E-07	(1.0E-07)	0.99	(0.43)	-1.89	(0.07)	0.63	46
Nigeria	1.4E-05	(1.2E-05)	4.5E-07	(1.3E-07)	0.51	(0.71)	-1.34	(0.19)	0.47	34
Canada	5.5E-05	(1.8E-05)	1.6E-07	(7.7E-08)	0.60	(0.26)	-1.68	(0.10)	0.68	82
Mexico	2.5E-05	(1.0E-05)	3.3E-07	(9.8E-08)	0.90	(0.43)	0.65	(0.52)	0.78	50
USA	2.1E-05	(8.4E-06)	1.8E-07	(9.5E-08)	0.13	(0.29)	-1.97	(0.05)	0.64	85
Argentina	2.4E-05	(1.4E-05)	2.2E-07	(1.3E-07)	0.44	(0.62)	-1.72	(0.09)	0.58	49
Brazil	2.4E-05	(1.2E-05)	3.4E-07	(1.5E-07)	-0.24	(0.49)	0.06	(0.95)	0.68	50
China	1.1E-05	(1.0E-05)	2.7E-07	(1.1E-07)	0.52	(0.43)	-2.06	(0.05)	0.73	52
Japan	2.4E-05	(8.8E-06)	2.4E-07	(8.3E-08)	0.47	(0.33)	-1.71	(0.09)	0.73	76
Korea	4.1E-05	(1.5E-05)	2.7E-07	(1.4E-07)	0.33	(0.73)	0.60	(0.55)	0.52	48
Indonesia	2.6E-05	(1.1E-05)	4.0E-07	(1.1E-07)	1.57	(0.59)	2.23	(0.03)	0.83	38
Malaysia	2.8E-05	(1.0E-05)	3.3E-07	(1.1E-07)	1.00	(0.49)	0.86	(0.40)	0.80	42
Philippines	2.6E-05	(8.7E-06)	2.6E-07	(8.7E-08)	0.15	(0.44)	0.70	(0.49)	0.80	41
Thailand	2.2E-05	(1.1E-05)	2.9E-07	(1.2E-07)	1.33	(0.60)	1.57	(0.13)	0.81	37
Australia	2.8E-05	(8.3E-06)	1.5E-07	(8.0E-08)	0.61	(0.34)	-0.38	(0.70)	0.64	56
New Zealand	2.9E-05	(1.1E-05)	1.4E-07	(1.1E-07)	0.85	(0.50)	-0.79	(0.43)	0.50	53
Czech Rep.	8.2E-06	(1.2E-05)	2.9E-07	(1.6E-07)	1.24	(0.56)	-1.50	(0.14)	0.71	41
Hungary	2.1E-05	(1.1E-05)	2.0E-07	(1.2E-07)	1.23	(0.52)	-1.59	(0.12)	0.77	48
Poland	1.5E-05	(1.0E-05)	3.3E-07	(1.4E-07)	0.69	(0.44)	-1.57	(0.12)	0.80	52
Russia	-1.3E-05	(1.2E-05)	6.1E-07	(1.6E-07)	0.08	(0.49)	-0.16	(0.88)	0.62	47
Denmark	1.5E-05	(9.5E-06)	1.5E-07	(1.0E-07)	0.57	(0.38)	-1.03	(0.31)	0.59	68
Sweden	1.8E-05	(9.6E-06)	9.9E-08	(9.6E-08)	0.76	(0.39)	0.00	(0.00)	0.55	69
UK	2.3E-05	(8.0E-06)	9.9E-08	(8.0E-08)	0.42	(0.27)	-0.50	(0.62)	0.64	83
Greece	1.1E-05	(1.0E-05)	4.1E-07	(1.2E-07)	0.61	(0.47)	-1.53	(0.13)	0.69	55
Italy	1.9E-05	(9.1E-06)	9.9E-08	(9.2E-08)	0.25	(0.33)	-1.36	(0.18)	0.60	84
Portugal	1.5E-05	(1.1E-05)	3.2E-07	(1.1E-07)	0.10	(0.47)	-0.78	(0.44)	0.64	60
Spain	1.4E-05	(1.1E-05)	1.7E-07	(1.1E-07)	0.45	(0.43)	-1.78	(0.08)	0.54	71
Austria	1.7E-05	(1.0E-05)	2.0E-07	(1.1E-07)	0.56	(0.42)	-1.29	(0.20)	0.60	66
France	2.4E-05	(9.6E-06)	9.9E-08	(9.6E-08)	0.18	(0.34)	-0.80	(0.43)	0.51	86
Germany	-1.4E-05	(1.7E-05)	-1.5E-07	(1.6E-07)	0.96	(0.56)	-1.98	(0.05)	0.51	86
Netherlands	-6.4E-05	(2.7E-05)	1.0E-06	(5.9E-07)	0.23	(0.59)	2.30	(0.03)	0.36	66
Switzerland	2.7E-05	(1.1E-05)	-7.4E-08	(1.1E-07)	0.58	(0.43)	0.00	(0.34)	0.51	75
Israel	1.7E-05	(1.2E-05)	3.3E-07	(1.3E-07)	0.14	(0.55)	0.00	(0.23)	0.60	52
Turkey	1.4E-05	(1.1E-05)	3.4E-07	(1.5E-07)	1.62	(0.54)	0.00	(0.06)	0.74	51
Saudi Arabia	3.8E-05	(1.6E-05)	3.9E-07	(1.8E-07)	1.29	(0.74)	0.00	(0.05)	0.48	40
Egypt	3.4E-05	(1.1E-05)	4.0E-07	(1.4E-07)	1.34	(0.54)	0.00	(0.08)	0.66	42
Bangladesh	2.4E-05	(1.1E-05)	4.0E-07	(1.4E-07)	0.51	(0.48)	-1.52	(0.00)	0.75	35
India	1.3E-05	(1.1E-05)	4.1E-07	(1.4E-07)	0.70	(0.42)	-1.93	(0.00)	0.74	46
Iran	2.4E-05	(1.5E-05)	4.3E-07	(1.9E-07)	0.98	(0.72)	-1.72	(0.00)	0.50	38
Pakistan	8.0E-06	(1.2E-05)	4.8E-07	(1.5E-07)	0.06	(0.52)	-1.10	(0.00)	0.64	40

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Schneider, U.A. and B.A. McCarl (2003), *Measuring Abatement Potentials When Multiple Change is Present: The Case of Greenhouse Gas Mitigation in U.S. Agriculture and Forestry*, **FNU-23** (submitted)

Zhou, Y. and Tol, R.S.J. (2003), *The Implications of Desalination to Water Resources in China - an Economic Perspective*, FNU-22 (*Desalination*, **163** (4), 225-240)

Yetkiner, I.H., de Vaal, A., and van Zon, A. (2003), *The Cyclical Advancement of Drastic Technologies*, **FNU-21**

Rehdanz, K. and Maddison, D. (2003) *Climate and Happiness*, **FNU 20** (submitted to *Ecological Economics*)

Tol, R.S.J., (2003), *The Marginal Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties*, **FNU-19** (forthcoming in *Energy Policy*).

Lee, H.C., B.A. McCarl, U.A. Schneider, and C.C. Chen (2003), *Leakage and Comparative Advantage Implications of Agricultural Participation in Greenhouse Gas Emission Mitigation*, **FNU-18** (submitted).

Schneider, U.A. and B.A. McCarl (2003), *Implications of a Carbon Based Energy Tax for U.S. Agriculture*, **FNU-17** (submitted).

Tol, R.S.J. (2002), *Climate, Development, and Malaria: An Application of* FUND, **FNU-16** (submitted).

Hamilton, J.M. (2003), *Climate and the Destination Choice of German Tourists,* **FNU-15** (revised and submitted).

Tol, R.S.J. (2002), *Technology Protocols for Climate Change: An Application of* FUND, **FNU-14** (forthcoming in *Climate Policy*).

Rehdanz, K (2002), *Hedonic Pricing of Climate Change Impacts to Households in Great Britain*, **FNU-13** (submitted to *Climatic Change*).

Tol, R.S.J. (2002), *Emission Abatement Versus Development As Strategies To Reduce Vulnerability To Climate Change: An Application Of* FUND, **FNU-12** (submitted to *Environment and Development Economics*).

Rehdanz, K. and Tol, R.S.J. (2002), *On National and International Trade in Greenhouse Gas Emission Permits*, **FNU-11** (submitted).

Fankhauser, S. and Tol, R.S.J. (2001), *On Climate Change and Growth*, **FNU-10** (forthcoming in *Resource and Energy Economics*).

Tol, R.S.J.and Verheyen, R. (2001), *Liability and Compensation for Climate Change Damages – A Legal and Economic Assessment*, **FNU-9** (*Energy Policy*, **32** (9), 1109-1130).

Yohe, G. and R.S.J. Tol (2001), *Indicators for Social and Economic Coping Capacity – Moving Toward a Working Definition of Adaptive Capacity*, **FNU-8** (*Global Environmental Change*, **12** (1), 25-40).

Kemfert, C., W. Lise and R.S.J. Tol (2001), *Games of Climate Change with International Trade*, **FNU-7** (*Environmental and Resource Economics*, **28**, 209-232).

Tol, R.S.J., W. Lise, B. Morel and B.C.C. van der Zwaan (2001), *Technology Development and Diffusion and Incentives to Abate Greenhouse Gas Emissions*, **FNU-6** (submitted to *International Environmental Agreements*).

Kemfert, C. and R.S.J. Tol (2001), *Equity, International Trade and Climate Policy*, **FNU-5** (*International Environmental Agreements*, **2**, 23-48).

Tol, R.S.J., Downing T.E., Fankhauser S., Richels R.G. and Smith J.B. (2001), *Progress in Estimating the Marginal Costs of Greenhouse Gas Emissions*, **FNU-4**. (*Pollution Atmosphérique – Numéro Spécial: Combien Vaut l'Air Propre?*, 155-179).

Tol, R.S.J. (2000), *How Large is the Uncertainty about Climate Change?*, **FNU-3** (*Climatic Change*, **56** (3), 265-289).

Tol, R.S.J., S. Fankhauser, R.G. Richels and J.B. Smith (2000), *How Much Damage Will Climate Change Do? Recent Estimates*, **FNU-2** (*World Economics,* **1** (4), 179-206)

Lise, W. and R.S.J. Tol (2000), *Impact of Climate on Tourism Demand*, **FNU-1** (*Climatic Change*, **55** (4), 429-449).