Climate and Happiness

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Abstract

Climate is an important input to many human activities. Climate affects heating and cooling requirements, determines clothing and nutritional needs and limits recreational activities. As such it is to be expected that individuals will have a preference for particular types of climate. These preferences have indeed been observed using a variety of approaches including regional analyses of wage rates and land prices, the propensity to migrate, and analyses based on household consumption patterns.

Mindful of existing research this paper analyses a panel of 67 countries attempting to explain differences in self-reported levels of happiness by reference to amongst other things temperature and precipitation. Various indices are used for each of these variables including means, extremes and number of months with a particular climate like the number of hot and cold months.

Using a panel-corrected least squares approach the paper demonstrates that, even when controlling for a range of other factors, climate variables have a particularly powerful effect on self reported levels of happiness. Furthermore there is a correspondence between the findings that emerge from this analysis and earlier studies with respect to what constitutes a preferred climate.

The relationship between climate and self reported happiness is of particular interest because of the much discussed threat of anthropogenically induced climate change. Differential patterns of warming along with a changed distribution of rainfall promises to alter dramatically the distribution of happiness between nations with some countries moving towards a preferred climate and others moving further away. We find that higher mean temperatures in the coldest month increase happiness, whereas higher mean temperatures in the hottest month decrease happiness. Precipitation does not significantly affect happiness. In particular high latitude countries included in our dataset might benefit from temperature changes. Countries already characterized by very high summer temperatures would most likely suffer losses from climate change.

Keywords: amenity value, climate change, happiness, well-being

JEL Classification: R19, Q29

1 Introduction

The impacts of the enhanced greenhouse effect are many and diverse (Smith *et al*., 2001; Tol, 2002). Tackling the problem of future climate change is one of the most challenging issues of this century and has major implications for policies of development and environmental management. Efforts to reduce greenhouse gas emissions are perceived to be very costly. However, little is known about people's preferences for a particular climate or their willingness to pay to avoid negative impacts of climate change. This paper tries to address this problem from a new perspective.

Climate affects humans through a variety of channels. Weather and climate influence societal (e.g. civilization, culture and migration), psychological (e.g. aggression, cognition and mental illness), physiological (e.g. allergies, diet and nutrition) and economic conditions (e.g. energy production, manufacturing or labour demand).[1] Climate change would affect these conditions.

Research work on the economic consequences of climate change has generally focused on changes in productivity in sectors such as agriculture, energy and tourism. Although Adam Smith already stressed the significance of climate as one of the most important factors for the wealth of a country, little attention has been drawn to climate as an input to household activities. Climate influences human health, determines housing requirements and constrains recreation activities. In general, the effects of a changing climate might be positive or negative, depending on time and place.

In order to determine, if climate change is good or bad or more precisely how good or bad, indicators are needed. So far, measurements of the value of climate as a direct input to human welfare were mainly derived by using environmental valuation techniques such as the hedonic price approach or the household production function approach. Both methods derive the preferences for environmental goods through studies of related markets or goods. However, both methods have some major shortcomings and their applications to the amenity value of climate are scarce.[2]

This paper proposes a different approach by analysing a panel of 67 countries to explain differences in self-reported levels of well-being. Mindful of existing research a number of explanatory variables were included to capture economic, cultural, institutional and demographic circumstances in addition to climate. Climate is represented by country-averaged temperature and precipitation. This is the first study using cross-national data on self-reported happiness to evaluate the amenity value of climate and to put it in the context of climate change.

The paper is organized as follows. Section 2 starts with a brief literature review of studies into the determinants of happiness and the amenity value of climate. In Section 3 the data employed for the research are discussed. Section 4 reports on the econometric results of the analysis. In Section 5 the econometric estimates are used to calculate the impact of climate change for two different time slices, 2010-2039 and 2040-2069. Section 6 concludes.

[1] There is a vast number of studies in each discipline. For an overview of some hundred studies see Parker (1995).

[2] The different approaches are discussed in more detail in Section 2.2.

2 Literature review

2.1 Happiness in economics

In standard economic theory, utility is measured objectively, derived from observations of choices between goods and services (within budget constraints). As higher income levels enable individuals to satisfy more needs, additional goods and services can be consumed. This supposedly leads to higher levels of well-being. Consequently, economic growth has to be one of the major objectives of economic policy in any country. However, there is growing evidence that happiness not income is the ultimate objective of most people.[3] Income explains only a low proportion of variations in happiness among people (Easterlin, 1995; Oswald, 1997).

Much of this evidence is derived from the growing literature on the determinants of life-satisfaction and subjective well-being, also conceived as happiness or overall enjoyment of life.[4] In contrast to the concept of objective utility, happiness is not only subjective to the questioned individual, it is an assessment by the individual of all parts of his or her life including circumstances and comparisons to others, past experience and expectations of the future. Although it is completely left to the individual to explain his level of subjective well-being there seems to be correspondence in what makes people happy, nationally and internationally, which makes comparisons possible.

The research on the determinants of happiness has developed for more than a century.[5] Since the 1960's, it has been subject to increasing empirical research and has been intensively investigated by philosophers, psychologists and other social scientists. Richard Easterlin (1974) was one of the first economists empirically studying reported levels of happiness. Since the late 1990's, the research on the determinants of happiness increased substantially in economics, indicating economists awareness of the importance of this area of research. Only recently, a book edited by Easterlin (2002) containing articles of the most cited authors in this field was published. Frey and Stutzer (2002a) wrote the first 'textbook' reporting on the state of happiness research in micro- and macroeconomics.[6] Furthermore, a recent issue of the Journal of Economic Behaviour & Organization (45, 2001) was entirely devoted to the theme.

There is a long history of discussion whether subjective well-being is measurable. Decades of validation research proved that indications of individuals' evaluation of their life satisfaction or happiness can be measured by asking questions of subjective well-being. The indicators of happiness were evaluated by criteria such as reliability, validity, consistency and comparability across nations.[7] Today there is the general belief, that data on subjective well-being are valid and can be used for formal analyses.[8]

Empirical work of the last decades has shown that happiness is not a purely personal issue, but that economic conditions, like unemployment, inflation, and income, have a strong impact

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[3] Among others see e.g. Ng (1997).

[4] As is generally done we use the terms happiness, well-being and life satisfaction interchangeably throughout this study. See Veenhoven (2000) for the specific meanings of the terms. Kahnemann *et al*. (1997) explore the term experienced (subjective) utility.

[5] A bibliography containing several hundred studies on happiness, well-being and life satisfaction is available on the internet, see http://www.eur.nl/fsw/research/happiness/hap_bib/src_sub.htm. Triandis (2000) presents an extensive overview of many factors that might influence subjective well-being on an individual and national level.

[6] Frey and Stutzer (2002b) review the development of happiness research and its importance for economics.

[7] The aspect of comparability across nations is generally discussed in Veenhoven (1997).

[8] Discussed e.g. in Di Tella *et al*. (forthcoming).

on people's subjective well-being.[9] One of the most investigated economic indicators for happiness is income.[10] Although there is convincing evidence that there is a relationship between income and happiness, the findings differ according to place and time. On average, people living in richer countries tend to be happier than those living in poor countries. However, the relationship between happiness and income seems to be non-linear indicating diminishing marginal utility with absolute income. Interestingly, over time happiness appears to be relatively stable and flat with growing income. Even substantial real per-capita income growth over the last decades in rich countries led to no significant increases in subjective well-being.[11] Those findings have been explained by the relative or aspiration theory. On the one hand, subjective well-being depends on ones relative position compared to others. Therefore, "raising the income of all, does not increase the well-being of all", because in comparison to others, income has not changed (Easterlin, 1995). On the other hand, subjective well-being is determined by the gap between aspiration and achievement. However over time aspiration adjusts in proportion to higher income levels (see e.g. Easterlin, 2001). Among others, Daly (1987) used Easterlin's findings of the cancelling effect of growth on welfare over time to claim for a change in social priorities. He defined the 'Easterlin Paradox' as one of the ethicosocial limits to growth next to biophysical limits.

More recently, economists investigated the influence of unemployment and inflation on subjective well-being. Clark and Oswald (1994), among others, showed that unemployed people are significantly less happy than those with a job.[12] Next to income loss, non-pecuniary effects like psychic and social costs reduce happiness notably. Those findings contradict the hypothesis of voluntary unemployment, raised by some economists in the last years. Instead, as e.g. Oswald (1997) claimed, policy in rich societies should aim to reduce joblessness instead of raising incomes.

Inflation was also found to have a statistically significant negative effect on happiness, another trade off between inflation and unemployment (see Di Tella *et al*., 2001). In a further analysis, Di Tella *et al*. (forthcoming) derived a measure of the costs of an economic downturn from happiness surveys and found that losses from recessions are large and exceed the actual fall in income in a recession.

Recent economic studies include alternative variables to test their influence on happiness. The political, economic and personal freedoms of a country have been found to be an additional determinant of happiness. Frey and Stutzer (2000) found direct democracy and federal

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[9] Personal issues are e.g. personality (like optimism, extraversion and self-esteem) and demographic factors (like age, gender and marital status). These factors have been extensively investigated by psychologists. See e.g. Diener *et al.* (1999). See e.g. Frey and Stutzer (2002b) for an overview of the determinants of both personal issues and economic factors on self-reported well-being.

[10] A recent example is Easterlin (2001).

[11] Consequently Frank (1997) argues, if consuming goods and services have little if any effect on subjective well-being in the long term, the same resources should be used differently to raise subjective well-being enduringly.

[12] They explored and rejected the hypothesis that unemployment is voluntary because of too generous financial aid using data for Britain from 1991. Winkelmann and Winkelmann (1998) confirmed those findings using a longitudinal data-set for Germany. They found that non-pecuniary effects are much larger than those from income loss. This finding was also confirmed by a study using individual data for 12 European countries over the period 1975-91. See Di Tella *et al*. (2001). Most recently, Ouweneel (2002) rejected the hypothesis that unemployed in nations with a generous social security system are happier than those in non-welfare states containing data on 42 nations for 1990. In line with the above studies is Van Praag and Ferrer-i-Carbonell (2002). They investigated on the differences between Germans with and without a job.

structure being positively related to individual's well-being in Switzerland.[13] In addition, differences in environmental quality were discovered to determine happiness. Van Praag and Baarsma (2001) studied the external effects due to aircraft noise nuisance at the Amsterdam Airport Shiphol and found a trade-off ratio between income and exposure to noise. Also, air pollution was found to reduce happiness (Welsch, 2002).

2.2 The amenity value of climate

So far, measurements of the value of climate to individuals or households were mainly derived by using environmental valuation techniques such as the hedonic price approach or the household production function approach. We discuss both approaches in some detail and put them into the context of this paper.

The hedonic price approach is based on the assumption that perfectly mobile individuals would locate where they could maximize their net benefits. Living in climatically different regions would then mean consuming different types of goods supported by the respective climate. Since people are attracted to those regions offering preferred combinations of amenities, these regions should have both compensating house price and wage differentials. If a household wishes to enjoy e.g. less monthly precipitation or more hours of sunshine, it will have to buy a house in such an area and pay a premium for it. Consequently, Rosen (1974) and Roback (1982), chief proponents of the hedonic price approach, argue that the value of marginal changes of amenities in general can then be derived from property price and wage regressions.[14]

Rosen (1974) provided the theoretical basis of the hedonic approach. He described a model of market behaviour in a market with differentiated goods and illustrated how the willingness to pay for an environmental improvement can be derived from the relationship between property prices and their attributes: structural characteristics, location specifics and the quality of the environment. Since then the hedonic approach has been widely applied to estimate the economic value of non-market goods, but only very few studies were set out to measure the amenity value of climate to individuals or households.

Although Hoch and Drake (1974) were one of the first who analysed wage differentials, Roback (1982) was the first to investigate the effects of climate on both wages and house prices. Others drawing upon the work of Roback (1982), but using more detailed data were Blomquist *et al.* (1988). Since then some researchers have analysed the amenity value of climate to households. Englin (1996) investigated the amenity value of rainfall and found households would prefer less rainfall and greater seasonal variation. Other studies are Nordhaus (1996), Cragg and Kahn (1997 and 1999). Nordhaus estimated the impact of an equilibrium CO_2 doubling on climate amenities. The estimates show a disamenity premium of about 0.17 percent of GDP. Cragg and Kahn estimated the demand for climate amenities regarding the determinants of population migration decisions. One of the few studies for Europe is Maddison and Bigano (forthcoming). They found that Italians would prefer a drier climate during the winter months, but higher summertime temperatures are shown to reduce welfare.

[13] The psychologist Veenhoven (1999) found a positive relationship between individualization and quality of life in nations. The more individualistic the nation, the more citizens enjoy their life. Similar Ahuvia (2002) who proposes that economic development leads to higher levels of national average subjective well-being not by increasing consumption, but by creating more individualistic cultures.

[14] For an overview of the hedonic price approach see e.g. Palmquist (1991) or Freeman (1993).

The number of studies using the hedonic approach to reveal the amenity value of climate is quite limited and mainly applied to the US. One of the reasons is the basic assumption that no barriers to mobility exist. Individuals would locate where they could maximize their net benefits and would move whenever conditions and prices change in order to raise their net benefits again. However, climate variables are often relatively stable over large distances. It is therefore likely that cultural differences, country boundaries or institutional differences restrict mobility. This might prevent the net benefits related to a particular climate from being eliminated (Maddison, forthcoming). One of the few exceptions is the US.

An alternative approach to make cross-country comparisons possible is the household production approach.[15] In general, this method investigates changes in the consumption of commodities that are substitutes or complements for the environmental good or service. By observing changes in the quantities of the complements the value of a change in the quality is estimated. The method assumes that households combine marketed goods and environmental amenities by using a given 'production technology'.[16]

So far, only very few studies used the household production approach to valuing climate amenities.[17] Shapiro and Smith (1981) used per capita consumption data from different counties in California and included four different environmental amenities (temperature, precipitation and two air-pollution variables). Kravis *et al.* (1982) investigated per capita consumption data from 34 different countries. Climate variables were included as annual average temperature and precipitation. Only recently Maddison (forthcoming) investigated the role of climate in determining differences in consumption patterns for 88 different countries. Annual range in temperature and deviation was found to increase both prices of food and clothing. Also, rainfall increases prices for clothes. It is the first paper explicitly addressing the impacts of climate change (defined as a 2.5°C increase in globally averaged mean temperature) by using the household production approach. Maddison (forthcoming) found that high latitude countries benefit from limited climate change whereas low latitude countries would suffer significant losses. All the studies hold on the not testable assumption of demand dependency, see Bradford and Hildebrandt (1977).

With respect to climate as an additional determinant of subjective well-being one related study exists in economics using 'hypothetical equivalence scales'. Fritjers and Van Praag (1998) estimated the effects of climate on both welfare and well-being in Russia.[18] They also explored the costs and benefits of climate change measured as an increase of one, two or three degrees in temperature combined with an overall increase in precipitation of 5% or 10%. They find climate to be one important determinant of households standard of living in Russia.

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[15] For an overview of this approach see e.g. Smith (1991).

[16] Becker (1965) provides a framework for investigating environmental amenities by using the household production approach. He described how individuals make time allocation decisions in terms of a household production process.

[17] A survey of studies using the household production approach to investigate variations in cross-country patterns in consumption in general is provided by Selvanathan and Selvanathan (1993).

[18] The climate variables entered as temperature (January, July, annual average and difference between maximum and minimum in a calendar year), precipitation (annual average, averages in summer and winter), wind (annual average, January), average annual number of rainy days and hours of sunshine. Also, some cross products were inserted. This work is based on an earlier approach by Van Praag (1988).

3 Empirical Analysis

The data on self-reported levels of happiness (well-being) are provided by the World Database of Happiness (Veenhoven, 2001). This database contains information on the average level of well-being for different countries and years. It is obtained from surveys asking for the level of self-reported happiness in a particular country. Our dataset contains data on a four item response category and includes 185 observations obtained in 67 different countries.[19] Also available were observations for a three and five item response category. However, the number of observations for the five item response category was limited to only very few observations (44 observations for 27 countries). Observations for the three item category were restricted by its relevance to the present. The most recent observation was obtained in 1984.

The least happy countries tend to be Eastern European ones. The least happy country was Bulgaria in 1996 and Moldova in 1996 with a score of 2.33 and 2.40 followed by Russia with a score of 2.41 in 1998. The happiest countries tend to be Western European ones and in particular Iceland. The happiest countries were Venezuela in 1996 with a score of 3.47, Iceland in 1996 and the US in 1995 both with a score of 3.40 followed by the Netherlands with a score of 3.39 for 1990.

Turning to the dependent variables, the empirical model includes GDP per capita in 1995 USD converted using market exchange rates as well as a variable measuring the shortfall in income. This variable indicates whether and to what extent past income has been above the level reached in the survey year. Further economic variables like the annual growth rate in GDP, the percentage of unemployed as well as the inflation rate were included. To measure cultural differences the proportions of different religions are included: Buddhist, Hindu, Muslim, Christian and Orthodox as well as an index of freedom measured as political rights and civil liberty.[20] The index ranges from 1 (low level of freedom) to 7 (high level of freedom). Demographic differences are included as life expectancy as a measure of health status along with literacy rates as a measure of education. Furthermore, population density, the proportion of the population living in urban areas as well as the proportion of the population over 65 and under 15 years.[21]

Various indices are used to describe climate. We experiment with:

- annually averaged mean of precipitation
- annually averaged mean of temperature
- mean temperature of the coldest month
- mean temperature of the hottest month
- mean precipitation of the driest month
- mean precipitation of the wettest month
- the number of cold months
- the number of hot months
- the number of dry months
- the number of wet months.[22]

[19] The replies are ranked from one to four as follows: ‘not at all happy’ = 1, ‘not very happy’ = 2, ‘quite happy’ = 3, ‘very happy’ = 4. See Veenhoven (2001).

[20] The data on proportion of different religions was taken from "World Religions" Infoplease.com. See http://www.infoplease.com/ipa/A0855613.html. The freedom index was provided by Freedom House (2002).

[21] Data on GDP per capita is taken from World Resources Database as well as the data on population, population density, urban population, population above 65 and under 15 years, literacy and life expectancy. The data on the rate of unemployment comes from the International Labour Office. Inflation rates and annual growth rates are obtained from World Development Indicators 2001.

[22] Cold or hot months are those with average mean temperature below freezing or above 20°C. Wet or dry months are those with average mean precipitation above 100mm or below 30mm. These concepts were chosen

Figure 1 shows the most recent score of happiness and the mean temperature of the coldest month for the countries included in the dataset. The clear positive relationship indicates that higher temperatures in the coldest month increase peoples happiness (see section 4 for the regression estimates).

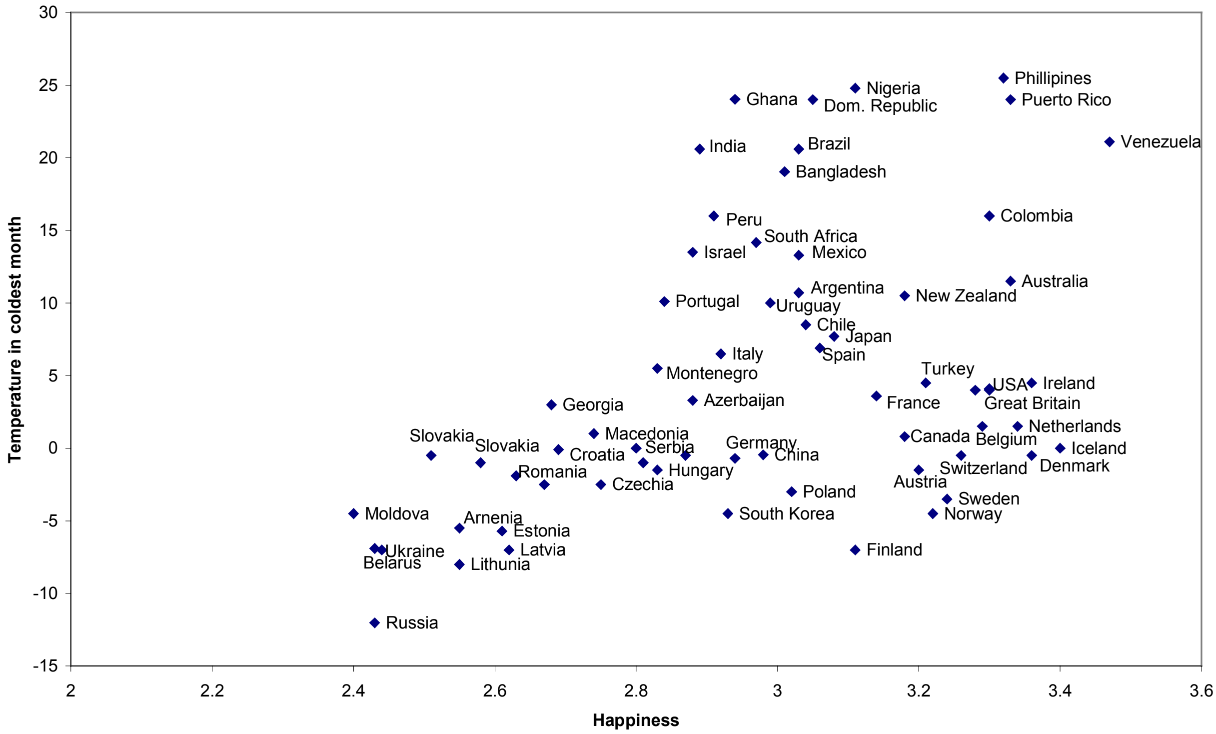

Figure 1: Relationship between temperature in the coldest month (°C) and happiness

Monthly records for temperature and precipitation for each country's major city (or cities) are taken from Landsberg (1969), Pearce and Smith (1994) and miscellaneous Internet sources for some smaller countries. For some cities the data was population weighted to obtain one record per country.[23] Table A1 in the appendix reports the climate records as well as the population weights if applicable. Although, other climate data representing the average climate of a country is available it does not take into account to what extent particular areas of a country are populated. This is especially important for large and climatically different countries like Canada, the US or Russia. By using this data, one would assume that it is equally likely for a Canadian to live within the arctic circle as close to the US border.[24]

The (absolute) latitude of the country is included to account for the variation in the hours of daylight across the seasons.[25] The time trend is included to test whether there are any autonomous changes in reported happiness over time. The data are presented in table 1. Note that some missing values have been imputed using first order regression techniques. In total 185 observations are available for analysis drawn from 67 different countries. The range of the variables, their means and standard deviations are presented in table 2.

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following the calculated means for the coldest/hottest as well as driest/wettest month for all 185 observations. See table 2.

[23] Others applying this method are e.g. Maddison (forthcoming).

[24] More appropriate would have been using climatically homogenous areas rather than countries. So far, most data is not available on this basis.

[25] Latitude refers to the capital city of the particular country. The information is taken from World Gazetteer. See http://www.world-gazetteer.com/home.htm.

Table 1. Definition of the variables

Variable	Definition
HAPPY	Average score of self-reported happiness
GDPCAP	GDP per capita in 1995 USD converted using market exchange rates
GROWTH	Annual GDP growth rate (%)
GDPMAX	Shortfall in income
INFLATION	Annual inflation rate (%)
UNEMPLOYED	Annual rate of unemployment (%)
YEAR	Calendar year of the survey
POPDEN	Population density in persons per square kilometre
POP65	Proportion of the population over 65 years
POP15	Proportion of the population under 15 years
URBAN	Percentage of the population living in urban areas
LIFEEXP	Life expectancy in years
LITERATE	Percentage of the adult population who are literate
FREEDOM	Index of personal freedoms
BUDDHIST	Proportion of the population who are Buddhists
HINDU	Proportion of the population who are Hindu
MUSLIM	Proportion of the population who are Muslim
CHRIST	Proportion of the population who are Christian or Jewish
ORTHODOX	Proportion of the population who follow Orthodox religions
LATITUDE	Absolute latitude in degrees
ANNTEMP	Annually averaged mean temperature (°C)
MAXTEMP	Average mean temperature in hottest month (°C)
MINTEMP	Average mean temperature in coldest month (°C)
HOT	Months when average mean temperature exceeds 20°C
COLD	Months when average mean temperature is below 0°C
ANNPREC	Annually averaged mean precipitation (mm)
MAXPREC	Average mean precipitation in wettest month (mm)
MINPREC	Average mean precipitation in driest month (mm)
WET	Months when average mean precipitation exceeds 100mm
DRY	Months when average mean precipitation is below 30mm

Source: See text.

Table 2. Summary of the data

Variable	Mean	Std. Dev.	Minimum	Maximum
HAPPY	2.99	0.28	2.33	3.47
GDPCAP	13529.11	11874.23	284	46821
GROWTH	2.37	4.19	-11.89	14.91
GDPMAX	104.66	341.63	0.00	2109.48
INFLATION	32.51	109.22	-0.09	1061.59
UNEMPLOYED	7.89	6.91	0.1	69.8
YEAR	1991.70	6.05	1972	2000
POPDEN	115.63	115.03	2	839
POP65	0.11	0.039	0.03	0.18
POP15	0.23	0.07	0.15	0.45
URBAN	70.70	15.47	18.88	97.05
LIFEEXP	72.23	5.58	48.21	79.96
LITERATE	92.42	15.40	1	100
FREEDOM	2.28	1.49	1	7
BUDDHIST	0.02	0.13	0.00	0.84
HINDU	0.01	0.09	0.00	0.83
MUSLIM	0.06	0.16	0.00	0.98
CHRIST	0.66	0.33	0.00	1.00
ORTHODOX	0.09	0.23	0.00	0.98
LATITUDE	44.69	12.95	4.63	64.14
ANNTEMP	11.59	5.64	3.9	27.2
MAXTEMP	20.45	3.78	11.5	31.3
MINTEMP	2.51	8.58	-12.0	25.5
HOT	2.18	3.35	0	12
COLD	1.31	1.61	0	5
ANNRAIN	66.99	27.83	3.6	181.2
MAXRAIN	112.44	73.46	8.0	515.4
MINRAIN	36.04	17.62	0	79
WET	1.43	2.61	0	10
DRY	1.16	2.16	0	12

Source: See text.

4 Results

Including too many specifications of climate at once leads to problems of multicollinearity. Therefore, three different specifications were tested each containing four different climate variables. In the first model, mean temperature in the hottest and coldest month were included as well as mean precipitation in the wettest and driest month (model 1). The second specification includes the number of hot, cold, wet and dry months as counts (model 2). The third specification contains annually averaged temperature and precipitation along with their squared values (model 3). Including squared terms enables us to test whether people prefer a mild climate rather than one characterized by extremes.[26]

[26] See e.g. Maddison and Bigano (forthcoming).

The following model is estimated over all *i* countries and all *t* periods and were performed as follows:[27]

$$HAPPY_{it} = \alpha + \beta_1 \times GDPCAP_{it} + \beta_2 \times GDPCAP_{it}^2 + \ldots + \varepsilon_{it}$$

The explanatory variables are all included in their levels, apart from GDP per capita included as a linear and a quadratic variable in order to capture any possible curvature with respect to the dependent variable. In view of the fact that observations are repeatedly drawn from the same countries the model is estimated using panel-corrected least squares. The standard errors are corrected for heteroscedasticity. As the number of observations per country varies sampling weights were used to give countries with fewer observations higher weights compared to countries with more observations.

Although the hypothesis of zero slopes is easily rejected for all specifications and the equations also pass the RESET test for functional form, model 1 was found to be most appropriate and obtained the highest R^2 compared to other model specifications. Table 3 contains the results. These findings are in line with Cushing (1987), who investigated the determinants of population migration decisions by using different specifications of temperature. He found temperature extremes being the best description of climate whereas annual temperature being the least preferred.

Deferring discussion of the other variables, it is seen that the climate variables are jointly significant for all model specifications. In model 1 higher mean temperatures in the coldest month increase happiness, whereas higher mean temperatures in the hottest month decrease happiness. Both variables describing differences in precipitation are not significant (on its own as well as jointly). When specifying a model with rather extreme climate conditions (model 2) more months with very little precipitation are found to reduce happiness significantly.[28]

Elsewhere in the equations GDP per capita is statistically significant. Its square has the expected sign, but is not significant. The variable measuring the shortfall in income has the expected sign, but is not significant. The variables describing the proportion of religions are significant for model 2 and 3 for Buddhist, literally indicating that this religion makes populations unhappy relative either to atheism or alternative religions. Serving as a proxy for health status, life expectancy is significant for model 2 indicating that better health greatly improves happiness. It is also seen that happiness increases as the proportion of individuals under the age of 15 increases (significant for model 2 and 3). The variable describing political rights and personal freedoms is not significant but there is little evidence that greater civil liberties significantly increase happiness (see e.g. Welsch, 2002). Unemployment, inflation, population density, literacy rates, urban populations and latitude do not significantly influence self-reported happiness. There is no significant autonomous change in happiness over time.

[27] We also tested the possibility of different functional forms, semi-log and logistic transformation. The results obtained are similar to those of the linear specification.

[28] A sensitivity analysis on the specification of the climate variables of model 2 revealed, that the results are fairly stable. Temperature was altered by 1°C, precipitation by 10mm. Increasing temperature by 1°C for cold months, this variable becomes significant and shows the expected sign. Other temperature deviations are not significant. Reducing precipitation in dry months by 10mm, the estimated coefficient is still significant. Instead, when increasing precipitation by 10mm for dry months the variable becomes insignificant. The estimates for wet months are always insignificant.

The admittedly limited number of studies using country average data on self-reported subjective well-being report the same findings.

Table 3. Regression results

	Model 1		Model 2		Model 3	
Variable	Coefficient	T-statistic	Coefficient	T-statistic	Coefficient	T-statistic
CONSTANT	1.08E+01	2.33	8.37E+00	1.90	8.60E+00	1.89
GDPCAP	2.37E-05	3.24	2.21E-05	2.54	2.70E-05	3.56
$GDPCAP^2$	-2.25E-10	-1.51	-2.00E-10	-1.17	-2.96E-10	-1.90
GROWTH	5.25E-03	1.57	2.34E-03	0.59	3.90E-03	0.97
GDPMAX	-5.81E-05	-0.99	-2.57E-05	-0.41	-4.76E-05	-0.70
INFLATION	7.55E-05	0.71	6.76E-05	0.62	8.40E-05	0.76
UNEMPLOYED	3.20E-03	1.33	3.79E-04	0.20	1.11E-03	0.47
YEAR	-4.37E-03	-1.92	-3.56E-03	-1.60	-3.67E-03	-1.61
POPDEN	-4.60E-05	-0.33	1.00E-04	0.92	-4.01E-05	-0.23
POP65	-1.59E+00	-1.77	-1.32E+00	-1.41	-6.27E-01	-0.58
POP15	6.22E-01	0.84	1.68E+00	2.45	1.84E+00	2.28
URBAN	9.70E-04	0.59	1.56E-03	1.11	2.33E-03	1.50
LIFEEXP	1.07E-02	1.57	1.77E-02	2.52	1.38E-02	1.81
LITERATE	2.95E-04	0.25	-5.83E-04	-0.49	-7.86E-04	-0.59
FREEDOM	1.29E-02	0.85	1.49E-02	1.00	6.34E-03	0.39
BUDDHIST	-3.72E-01	-1.74	-3.39E-01	-2.46	-5.17E-01	-3.68
HINDU	-1.83E-01	-0.75	6.28E-02	0.31	6.03E-03	0.03
MUSLIM	1.33E-01	0.79	1.05E-01	0.83	1.19E-01	0.92
CHRIST	-5.85E-02	-0.36	1.18E-02	0.10	-3.21E-02	-0.26
ORTHODOX	-1.51E-01	-0.95	-2.17E-01	-1.77	-2.10E-01	-1.65
LATITUDE	1.42E-03	0.50	-1.59E-03	-0.60	-3.47E-03	-0.91
MAXTEMP	-1.81E-02	-2.05				
MINTEMP	1.39E-02	2.81				
MAXRAIN	4.16E-04	1.73				
MINRAIN	7.05E-04	0.65				
COLD			-2.50E-02	-1.47		
HOT			9.37E-04	0.11		
DRY			-2.24E-02	-3.02		
WET			-5.44E-03	-0.62		
ANNTEMP					4.74E-03	0.35
$ANNTEMP^2$					-4.08E-04	-0.75
ANNRAIN					2.89E-03	1.59
$ANNRAIN^2$					-4.61E-06	-0.35
No. Obs.	185		185		185	
Zero Slopes F(23,66)	31.48		43.60		26.743	
R-Squared	0.7918		0.7871		0.7718	
F-Test (P>F)[a]	0.0011		0.0081		0.0070	
RESET Test (P>F)	0.0822		0.4479		0.1469	

[a] F-Test for joint significance of climate variables.

Source: See text.

5 The influence of climate change

In this section we use the regression equation estimated earlier to calculate the change in GDP per capita necessary to hold happiness at its current levels in the face of predicted changes in climate for two different time slices (2010-2039 and 2040-2069).[29] The calculations are limited to the countries represented in the data set to avoid the risks associated with out of sample prediction. The predictions for temperature and precipitation change (deviations from 1961-1990) are available on a monthly basis and indicate that the majority of the warming is expected to occur during winter months and in high latitude countries. Very warm summers will become more frequent and very cold winters will become increasingly rare. Geographically differences in rainfall are likely to become more pronounced with increased precipitation in high latitudes. Also, rainfall is expected to become more seasonal with drier summers and wetter winters. The changes in mean temperature in the hottest and coldest month as well as the changes in mean precipitation in the wettest and driest month for the two time slices are presented in table A2 in the appendix.

In table 4 the calculations for two different specifications of model 1 are displayed. The first two columns show the calculations for predicted changes in temperature only. The last two columns display the calculations for changes in temperature as well as precipitation. A negative sign indicates that income has to be reduced in order to compensate for the change in climate (that is climate change increases happiness).

Examining the first two columns of table 4 shows that most countries would lose from climate change as temperature is expected to increase over time. Only very few countries in high latitudes like Canada, Norway, Finland, Sweden or Iceland are likely to gain from limited changes in temperature. Also, there are some countries in Eastern Europe and Middle East like Armenia, Azerbaijan, Georgia or Ukraine for which the expected change in minimum temperature is more pronounced than the changes in maximum temperature and which might gain from small changes as well.

Turning to the last two columns, the calculations including changes in temperature as well as precipitation show that the gains and losses are generally more pronounced for countries with either very low temperatures in the coldest month or very high temperatures in the hottest month compared to the first two columns. Also, more countries might benefit from limited climate change. These are in particular countries in Northern Europe like Denmark, Great Britain and Ireland. Countries for which precipitation is expected to increase in dry months like Peru, Venezuela or India are also likely to gain from limited climate change.

The results also indicate that the calculations are rather sensitive to the predicted climate change. A country like Bangladesh is likely to lose out when looking at the calculations for changes in temperature (first two columns of table 4). When adding changes in precipitation pattern Bangladesh might gain especially in the second time slice (fourth column of table 4). This gain occurs because precipitation in the driest month is predicted to recover to today's level as well as precipitation in the wettest month is predicted to increase significantly (see table A2 in the appendix). If precipitation in the driest month would decrease further compared to the first time slice, Bangladesh would still lose out.

Depending on the climate model estimates applied and the time slices used, the impacts of an enhanced greenhouse effect differ for the countries covered by the analysis. However, the

[29] The data was projected by Larry J. Williams and Michael E. Schlesinger and is calculated as the average of 14 general circulation models. It is scaled to the global mean temperature (0.620°C for the first time slice and 1.024°C for the second).

overall results, that countries in high latitudes are the ones expected to gain, find support in the literature (e.g. Maddison, forthcoming).[30]

Table 4. The predicted impact of climate change

	Constant happiness change in GDP per capita (1995 USD) Changes in temperature		Constant happiness change in GDP per capita (1995 USD) Changes in temperature and precipitation	
Country	2039	2069	2039	2069
Argentina	155.93	263.10	138.58	233.85
Armenia	-36.23	-67.89	-75.89	-135.27
Australia	89.53	147.46	78.12	128.00
Austria	166.51	286.01	123.35	247.42
Azerbaijan	-51.45	-77.16	-74.63	-116.75
Bangladesh	68.82	115.74	-17.25	-79.69
Belarus	-36.23	-67.89	-64.94	-116.33
Belgium	65.02	116.58	15.66	32.88
Bosnia-Hercegovina	210.55	363.28	158.89	276.68
Brazil	46.43	94.18	58.26	114.05
Bulgaria	257.17	444.92	244.03	421.09
Canada	-261.80	-445.37	-354.08	-591.61
Chile	142.81	233.43	102.21	163.55
China	45.17	74.74	1.14	-0.14
Colombia	82.77	148.31	12.36	29.12
Croatia	241.06	417.26	219.44	380.28
Czechia[1]	121.66	206.31	89.95	151.70
Czechoslovakia[1]	121.66	206.31	89.95	151.70
Denmark	3.86	-1.85	-81.79	-147.89
Dom. Republic	78.54	126.73	65.02	103.48
Estonia	4.94	-3.16	-31.93	-65.78
Finland	-246.26	-424.45	-356.60	-612.47
France	150.43	254.62	123.77	210.12
Georgia	-36.23	-67.89	-86.01	-152.52
Germany[1]	68.40	116.16	12.70	21.61
Ghana	104.32	168.62	71.36	119.54
Great Britain	56.15	87.41	-26.87	-53.56
Hungary	195.30	336.09	158.89	273.71
Iceland	-87.27	-152.52	-188.69	-323.90
India	43.48	78.54	-28.52	-43.86
Ireland	74.31	121.66	-28.35	-53.14
Israel	254.62	427.90	241.48	401.53
Italy	187.25	309.77	203.77	337.37
Japan	25.24	40.23	-81.79	-142.00
Latvia	-36.23	-67.89	-88.11	-155.47
Lithuania	-36.23	-67.89	-76.73	-136.53

[30] He used predicted changes in climate for a 2.5°C increase in global mean temperature to calculate the percentage change in the cost of living for 88 different countries. He also found high latitude countries likely to benefit from global temperature increases whereas countries located in the tropics would have to expect large increases in the cost of living.

Macedonia	241.06	417.26	253.78	440.66
Mexico	142.39	243.60	166.08	283.89
Moldova	111.93	182.17	65.02	102.63
Montenegro	241.06	417.26	272.43	470.46
Netherlands	49.81	80.23	-4.73	-12.02
New Zealand	95.87	156.35	38.54	59.10
Nigeria	154.23	259.71	180.48	304.25
Northern Ireland	82.34	144.93	17.68	34.86
Norway	-168.09	-286.98	-271.45	-463.11
Peru	17.81	24.77	-60.30	-66.20
Philippines	46.86	72.62	12.53	14.47
Poland	87.84	141.54	26.08	36.51
Portugal	199.96	350.11	218.17	368.38
Puerto Rico	63.33	103.90	37.86	60.37
Romania	247.84	414.29	233.85	389.63
Russia	-36.23	-67.88	-75.89	-127.69
Serbia	241.06	417.26	219.44	395.15
Slovakia	121.66	206.31	136.46	230.89
Slovenia	241.06	417.26	189.37	328.87
South Africa	138.58	238.51	158.04	272.01
South Korea	-17.72	-27.97	-95.27	-160.09
Spain	232.16	393.88	268.19	453.43
Sweden	-169.77	-282.79	-272.29	-457.92
Switzerland	163.12	286.43	146.19	258.02
Turkey	277.10	466.20	298.31	500.27
USA	69.24	132.66	24.60	57.42
Ukraine	-36.23	-67.89	-74.63	-133.16
Uruguay	163.97	289.40	147.04	260.14
Venezuela	59.10	101.36	-33.07	-55.25

Source: See text.

[1] The climate and the predicted climate change for East and West Germany are so similar to those for Germany (reunified) that the calculated change in GDP is equivalent. The same holds for Czechia and Czechoslovakia.

6 Conclusion

This study has demonstrated that climate variables can be used to investigate differences in self-reported subjective well-being. People seem to be concerned with very low and high temperatures as well as very little rain. The estimates suggest that people living in very cold regions would prefer higher mean temperatures in the coldest month whereas those living in regions with very high temperatures would prefer lower temperatures in the hottest month. In a different model specification we found people living in regions with a lot of dry months per year preferring more precipitation. Modest global warming with higher winter temperatures would increase peoples happiness particularly for those living in the North. Those living in regions already characterized by very high temperatures would lose out. Calculations including both predicted changes in temperature as well as precipitation make those differences for some countries even more pronounced. In general, our results support findings that high latitude countries benefit from limited climate changes whereas low latitude countries would suffer losses.

It is remarkable that climate variables were found significant although the number of observations is restricted and the number of included variables is quite large. However, empirical results are never unimpeachable, the choice of independent variables is not predetermined and always arbitrary. Moreover, the selection depends to a certain extent on data availability. In general, the impact of climate change on happiness appears to be rather sensitive to the extent a country will have to expect changes in precipitation.

The limited number of studies investigating the amenity value of climate make comparisons to other research work difficult. As this is the first study relating differences in self-reported levels of happiness to climate conditions, our findings cannot be compared directly. However, the results are in line with those of other studies using different approaches.

This analysis needs to be extended in several ways. The analysis has been restricted to the country level. However, climate and climate change differ not only between countries, but also within countries. It would be interesting to see how this would affect people's happiness in the different climate regions of a country. Second, there are other consequences of climate change apart from changes in temperature and precipitation, which are likely to have an effect on people's happiness. These are, for example, indirect effects like the increase of extreme weather events. These have not been taken into consideration in this analysis. Furthermore, we did not look into the time it would take people to adapt to a new climate and the discomfort this may cause. All this is deferred to future research.

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Table A1: Records Used to Compute Climate Record

Name	Climate Record	Population (x 1000)
Argentina	Buenos Aires	10,728
	Cordoba	1,055
	Rosario	1,016
Armenia	Yerevan	
Australia	Sydney	3,531
	Melbourne	2,965
	Brisbane	1,125
	Perth	1,083
	Adelaide	1,013
Austria	Vienna	
Azerbaijan	Baku	
Bangladesh	Dacca	4,770
	Chittagong	1,840
Belarus	Minsk	
Belgium	Brussels	
Bosnia-Hercegovina	Sarajevo	
Brazil	Sao Paulo	16,832
	Rio de Janeiro	11,141
	Belo Horizonte	3,446
	Recife	2,945
	Porto Alegre	2,924
	Salvador	2,362
Bulgaria	Sofia	
Canada	Toronto	3,427
	Montreal	2,921
	Vancouver	1,381
Chile	Santiago	
China	Shanghai	12,320
	Beijing	9,750
	Tianjin	5,459
	Shenyang	4,285
	Wuhan	3,493
	Guangzhou	3,359
	Chongquing	2,832
	Harbin	2,668
	Chengdu	2,642
Colombia	Bogota	4,185
	Medellin	1,506
Croatia	Zagreb	
Czechia	Prague	
Czechoslovakia	Prague	

Denmark	Copenhagen	
Dom. Republic	Santo Domingo	
Estonia	Tallinn	
Finland	Helsinki	
France	Paris	8,510
	Lyon	1,170
	Marseilles	1,080
Georgia	T'Bilisi	
Germany East	Berlin	
Germany West	Berlin	2,075
	Hamburg	1,594
	Munich	1,189
Germany	Berlin	3,301
	Hamburg	1,594
	Munich	1,189
Ghana	Accra	
Great Britain	London	
Hungary	Budapest	
Iceland	Reykjavik	
India	Calcutta	9,194
	Bombay	8,243
	Delhi	5,729
	Madras	4,289
	Bangalore	2,922
	Ahmadabad	2,548
	Hyderabad	2,546
Ireland	Dublin	
Israel	Haifa	
Italy	Rome	2,817
	Milan	1,464
	Naples	1,203
Japan	Tokyo	11,829
	Yokohama	2,993
	Osaka	2,636
	Nagoya	2,116
Latvia	Riga	
Lithuania	Vilnus	
Macedonia	Skopje	
Mexico	Mexico City	18,748
	Guadalajara	2,587
	Monterrey	2,335
	Pueblo	1,218
Moldova	Chisinau	
Montenegro	Podgogica	

Netherlands	De Bilt	
New Zealand	Auckland	
Nigeria	Lagos	1,097
	Ibadam	1,060
Northern Ireland	Belfast	
Norway	Oslo	
Peru	Lima-Callao	
Philippines	Manila	
Poland	Warsaw	
Portugal	Lisbon	1,612
	Oporto	1,315
Puerto Rico	San Juan	
Romania	Bucharest	
Russia	Moscow	8,967
	St. Petersburg	5,020
	Novgorod	1,438
	Novosibirsk	1,436
Serbia	Belgrade	
Slovakia	Bratislava	
Slovenia	Ljubljana	
South Africa	Cape Town	1,912
	Johannesburg	1,762
South Korea	Seoul	
Spain	Madrid	3,123
	Barcelona	1,694
Sweden	Stockholm	
Switzerland	Zurich	
Turkey	Istanbul	5,495
	Ankara	2,252
	Izmir	1,490
USA	New York	18,120
	Los Angeles	13,770
	Chicago	8,181
	San Francisco	6,042
	Philadelphia	5,963
	Detroit	4,620
	Dallas	3,766
	Boston	3,736
	Washington	3,734
	Houston	3,642
	Miami	3,001
	Cleveland	2,769
	Atlanta	2,737
	Saint Louis	2,467
	Seattle	2,421

	Minneapolis	2,388
	San Diego	2,370
	Baltimore	2,343
	Pittsburgh	2,284
	Phoenix	2,030
Ukraine	Kiev	
Uruguay	Montivideo	
Venezuela	Caracas	3,247
	Maracaibo	1,295

Source: Philip's Atlas of the World (1992).

Table A2. Predicted changes in temperature and precipitation

	Change in minimum temperature (°C)		Change in maximum temperature (°C)		Change in minimum precipitation (mm)		Change in maximum precipitation (mm)	
Country	2039	2069	2039	2069	2039	2069	2039	2069
Argentina	0.63	1.07	0.69	1.17	0.62	1.05	-0.07	-0.11
Armenia	0.93	1.58	0.67	1.13	0.56	0.95	1.31	2.23
Australia	0.60	1.02	0.58	0.98	0.85	1.44	-0.79	-1.35
Austria	0.78	1.33	0.82	1.40	2.28	2.70	-1.41	-2.39
Azerbaijan	0.93	1.57	0.65	1.11	0.10	0.17	1.16	1.97
Bangladesh	0.57	0.97	0.53	0.90	-1.46	-0.83	7.38	12.54
Belarus	0.93	1.58	0.67	1.13	0.91	1.54	0.10	0.17
Belgium	0.81	1.37	0.71	1.21	1.99	3.39	-0.57	-0.97
Bosnia-Hercegovina	0.68	1.16	0.80	1.37	1.56	2.61	0.29	0.49
Brazil	0.53	0.89	0.47	0.81	-1.05	-1.79	1.12	1.90
Bulgaria	0.64	1.09	0.83	1.42	1.06	1.81	-1.06	-1.80
Canada	1.25	2.12	0.62	1.05	2.01	3.18	1.87	3.17
Chile	0.60	1.03	0.65	1.10	0.46	0.79	1.54	2.63
China	0.74	1.26	0.63	1.07	0.65	1.11	1.40	2.38
Colombia	0.43	0.72	0.44	0.75	0.13	0.22	3.78	6.42
Croatia	0.68	1.16	0.84	1.44	1.14	1.94	-0.70	-1.19
Czechia	0.83	1.40	0.80	1.35	1.72	2.93	-1.10	-1.87
Czechoslovakia	0.83	1.40	0.80	1.35	1.72	2.93	-1.10	-1.87
Denmark	0.81	1.39	0.63	1.07	2.45	4.17	0.74	1.26
Dom. Republic	0.45	0.77	0.45	0.76	-0.40	-0.67	1.45	2.46
Estonia	0.86	1.47	0.67	1.13	0.91	1.54	0.56	0.95
Finland	1.21	2.06	0.61	1.03	1.85	3.15	3.20	5.44
France	0.73	1.24	0.76	1.29	1.77	3.00	-1.50	-2.55
Georgia	0.93	1.58	0.67	1.13	0.91	1.54	1.31	2.23
Germany	0.83	1.41	0.73	1.24	2.26	3.84	-0.66	-1.13
Ghana	0.51	0.88	0.53	0.90	1.06	1.58	0.07	0.12
Great Britain	0.76	1.29	0.66	1.11	1.63	2.77	1.97	3.35
Hungary	0.77	1.31	0.85	1.45	0.07	0.12	1.96	3.34
Iceland	1.03	1.75	0.68	1.15	1.61	2.74	3.05	5.18

India	0.60	1.02	0.52	0.89	0.08	0.14	3.97	6.75
Ireland	0.69	1.18	0.63	1.07	1.90	3.24	2.64	4.48
Israel	0.54	0.92	0.75	1.27	0.50	1.00	-0.08	-0.15
Italy	0.68	1.16	0.77	1.30	-0.91	-1.54	0.62	1.05
Japan	0.67	1.15	0.55	0.94	1.09	1.86	4.26	7.25
Latvia	0.93	1.58	0.67	1.13	1.41	2.39	0.56	0.95
Lithuania	0.93	1.58	0.67	1.13	1.03	1.75	0.56	0.95
Macedonia	0.68	1.16	0.84	1.44	-0.60	-1.08	0.29	0.49
Mexico	0.51	0.87	0.58	0.99	-0.77	-1.31	-0.04	-0.07
Moldova	0.51	0.87	0.54	0.91	1.62	2.75	-0.08	-0.14
Montenegro	0.68	1.16	0.84	1.44	-1.22	-2.08	0.29	0.49
Netherlands	0.81	1.38	0.69	1.17	2.01	3.41	-0.31	-0.52
New Zealand	0.55	0.94	0.55	0.93	1.39	2.36	0.91	1.54
Nigeria	0.49	0.83	0.58	0.98	0.01	0.01	-1.50	-2.55
Northern Ireland	0.69	1.18	0.64	1.10	1.90	3.24	0.45	0.76
Norway	1.09	1.85	0.62	1.05	2.53	4.30	1.62	2.76
Peru	0.54	0.93	0.44	0.75	2.09	1.45	0.90	2.72
Philippines	0.40	0.68	0.37	0.62	1.66	2.82	-0.86	-1.46
Poland	0.81	1.38	0.74	1.25	2.25	3.83	-0.30	-0.52
Portugal	0.62	1.04	0.74	1.26	-0.06	-0.09	-0.93	-0.88
Puerto Rico	0.45	0.77	0.43	0.73	-0.40	-0.67	2.12	3.61
Romania	0.72	1.23	0.88	1.49	0.51	0.87	-0.05	-0.08
Russia	0.93	1.58	0.67	1.13	1.28	1.91	0.10	0.17
Serbia	0.68	1.16	0.84	1.44	1.14	1.44	-0.70	-1.19
Slovakia	0.83	1.40	0.80	1.35	0.16	0.27	-1.10	-1.87
Slovenia	0.68	1.16	0.84	1.44	1.56	2.66	0.29	0.49
South Africa	0.62	1.06	0.66	1.13	-0.64	-1.09	-0.02	-0.04
South Korea	0.73	1.24	0.54	0.92	0.53	0.91	3.53	6.00
Spain	0.63	1.07	0.79	1.34	-0.61	-1.03	-1.01	-1.71
Sweden	1.08	1.83	0.61	1.04	2.19	3.73	2.15	3.66
Switzerland	0.76	1.29	0.80	1.37	1.58	2.68	-1.72	-2.92
Turkey	0.58	0.99	0.81	1.37	-1.09	-1.85	0.65	1.10
USA	0.79	1.33	0.70	1.20	0.36	0.61	1.92	3.26
Ukraine	0.93	1.58	0.67	1.13	0.96	1.64	0.56	0.95
Uruguay	0.59	1.00	0.67	1.15	-0.17	-0.29	1.26	2.14
Venezuela	0.47	0.80	0.44	0.75	0.79	1.34	3.91	6.65

Source: See text.