Environment and Development Economics (2022), **27**, 250–271
doi:10.1017/S1355770X21000267

RESEARCH ARTICLE

Happiness in the tropics: climate variables and subjective wellbeing

Oscar Zapata[1,2]

[1]School of Environment and Sustainability, University of Saskatchewan, Saskatoon, Canada and
[2]Department of Economics, University of Regina, Regina, Canada
Corresponding author. E-mail: oscar.zapata@usask.ca

(Submitted 1 May 2020; revised 30 November 2020, 20 May 2021; accepted 04 June 2021; first published online 9 September 2021)

Abstract

Changes in climatic patterns are expected to have significant effects on health and wellbeing. However, the literature on the effect of climate on subjective wellbeing remains scant and existing studies focus mostly on developed countries or cross-country analyses. This paper aims to identify the relationship between climate conditions on happiness after controlling for individual and social characteristics. Ecuador, a geographically fragmented country with varying climate conditions across municipalities, constitutes an ideal case study to assess the effect of climate variables on happiness. We employ a cross-section analysis to identify the effect of temperature, precipitation and humidity on happiness. The paper shows that climate conditions constitute an important determinant of people's subjective wellbeing. The results also suggest that income and education attenuate the effect of temperature on happiness and that substantial differences are observed depending on whether places are hot/humid or cold/dry.

Keywords: climate; Ecuador; happiness; health; wellbeing

JEL classification: Q54; I310; I150

1. Introduction

The interest in evaluating society's progress and the effectiveness of public policies based on individual wellbeing are increasingly the focus of researchers and governments. Consequently, prevalent measures of happiness or subjective wellbeing have considered determinants of life satisfaction such as income, job conditions, health, environment, human relations (White, 2007; Kahneman and Deaton, 2010; Ferrer-i-Carbonell, 2013; Clark, 2018; Atkinson *et al.*, 2020), and more recently climate variables (Welsch, 2006; Maddison and Rehdanz, 2011; Connolly, 2013; Noelke *et al.*, 2016). The relationship between climate and happiness is a recent contribution to our understanding of climate conditions and human wellbeing. This relationship is even more critical in the context of climate change where rapid changes in climate patterns and drastic economic and social consequences of these changes are expected. Heatwaves and extreme temperatures directly affect human health and mortality (Pal and Eltahir, 2015; Schär, 2016), from heat exhaustion and heat cramps to fatal heat strokes (Becker and Stewart, 2011). The study of happiness and its relationship with extreme climate variables, especially concerning temperature, precipitation and humidity, can provide insights to understand this topic. This paper presents evidence of the relationship between climate variables and people's happiness in Ecuador, a tropical country with various climate conditions.

Ecuador is a country with abundant natural resources and is one of the most geographically-fragmented countries globally, with a geographic fragmentation index[1] of 0.85, compared to an average of 0.3 for OECD countries (Lora *et al.*, 2003). This fragmentation stems from the existence of three natural regions that determine a remarkable variation of climate conditions across local jurisdictions, as follows: the coastal area on the west towards the Pacific Ocean; the highlands in the middle and along the Andean mountains; and the Amazon to the east of the country. To identify the relationship between climate variables and happiness we compare the levels of overall satisfaction (i.e., how satisfied a person is with her life) and health satisfaction (i.e., individual satisfaction with own health status) of individuals across municipalities in the country, while controlling for critical socio-economic characteristics of the population. Although most determinants of happiness can have the same effect on overall and health satisfaction levels, climate variables can affect these two domains of happiness differently. Specifically, higher temperature levels can be associated with higher levels of satisfaction that result from undertaking outdoor or social activities (Keller *et al.*, 2005; Connolly, 2008). In contrast, health status, especially among vulnerable populations such as the elderly and children, can worsen as temperature increases, dehydration occurs (Becker and Stewart, 2011), and the presence of harmful pathogens increases (Vergara *et al.*, 2013).

We look at how climate variables are associated with overall and health happiness separately to determine whether these relationships are different. We provide evidence on the relationship between climate variables and happiness by taking advantage of the 2006–2008 national employment surveys, including extensive information about household characteristics and individual self-reported assessments regarding different domains of happiness. We match information about individuals with information about climate variables at the municipal level. We identify the relationship between climate conditions and happiness by taking advantage of the fact that people sharing the same culture and country characteristics live in municipalities with different climate conditions. We employ a repeated cross-section approach while controlling for marital status, employment status, family size, age, and a self-assessment of the relative income level.

Although climate variables directly affect wellbeing, the combined effect of high temperature and humidity levels determines the heat stress people are exposed to and the subsequent impacts on their health. In the context of climate change, greater exposure to high temperatures is expected worldwide (IPCC, 2013), which is associated with dehydration, kidney diseases, a higher risk of suffering heat strokes, and higher mortality (García-Trabanino *et al.*, 2015). Climate conditions in Ecuador imply that municipalities where temperature and humidity levels are high experience heat stress often. To study the relationship between heat stress and happiness, we calculate a heat index (NOAA, 2009; Anderson *et al.*, 2013) to reflect the combined effect of average maximum temperature and humidity recorded at the municipal level. Heat stress is notably unsafe for human health when temperature and humidity are higher than 30°C and 80 per cent,

[1]The geographic fragmentation index shows the probability of two individuals in a country, chosen randomly, living in different ecological zones. For the case of Ecuador, this probability is 85 per cent.

respectively, which produces a thermal effect of extreme heat equivalent to temperatures above 35°C (Willet and Sherwood, 2012). The share of individuals in the sample living in locations with heat above this risk level represents approximately one-third of the population.

The main findings show that the relationship between climate and happiness is persistent and significant across econometric specifications and after controlling for individual and group characteristics. We explore this relationship by adopting linear and quadratic forms. The relationships between temperature variables and happiness are inverted U-shaped. Overall happiness peaks at an average temperature of 22°C. While the relationship between average temperature and health happiness is an inverted-U peaking at a level of 19°C, the relationship between heat and health happiness is significant only along the decreasing segment of the relationship. However, when looking at regional differences within the country, the relationship between temperature and happiness is mostly positive in cold and dry places, while mostly negative in warm and humid ones. The results suggest that the effect of climate on happiness is large in magnitude in terms of marginal willingness to pay. The effects of socio-economic and personal characteristics on happiness levels are also robust to different econometric specifications.

The evidence on the relationship between climate conditions and individual outcomes is inconclusive. Some research shows that higher temperatures influence people's mood, increase collaborative behavior, and lower anxiety and skepticism (Cunningham, 1979), whereas low temperatures enhance work productivity (Howarth and Hoffman, 1984). Low and high temperatures in cold places are associated with increased respiratory and cardiovascular illnesses (Braga *et al.*, 2002). Although contradictory results exist, the evidence suggests that higher temperatures trigger aggressive behavior and reduce social affection (Eliasson *et al.*, 2007). Similarly, humidity can directly affect people's moods (Cunningham, 1979). Humidity is inversely related to good mood, diminishes physical energy, and reduces the interest in social interaction (Sanders and Brizzolara, 1982). Moreover, high humidity reduces concentration, work productivity and collaborative behavior, and increases sleepiness events (Howarth and Hoffman, 1984). More extended periods of sunshine correlate with optimistic choices and positive evaluations of life satisfaction, and with increases in stock financial returns (Hirshleifer and Shumway, 2003).

The studies on climate conditions and happiness have been mostly limited to generating evidence for developed countries by taking advantage of differences in climate conditions across seasons. Most evidence shows a positive relationship between climate variables and happiness. The cross-country evidence shows that precipitation and temperature patterns are strong predictors of happiness (Rehdanz and Maddison, 2005), and that a negative relationship between pollution and wellbeing exists (Welsch, 2006). Connolly (2013) finds that happiness in summer is higher when the temperature decreases and lower when it increases. Brereton *et al.* (2008) and Cuñado and de Gracia (2013) find similar results from inter-regional analyses in Ireland and Spain, respectively. The economic value of droughts has also been approximated through subjective wellbeing measures (Carroll *et al.*, 2009). However, Lucas and Lawless (2013), studying the relationship between daily climate conditions and subjective wellbeing in the US, find negligible impacts of climate on happiness. Our understanding of the effect of climate on happiness in tropical countries, where climate patterns are different from developed countries and where climate change impacts are expected to be severe, is still scarce. Additionally, unlike countries with four seasons, the effect of climate on happiness in Ecuador corresponds to its inhabitants' long-term adaptation to natural conditions since climatic patterns in the tropics, namely temperature and humidity, are stable throughout the year.

The contribution of the paper is three-fold. First, it identifies the relationship between climate conditions and happiness and addresses the endogeneity in the estimation procedure as follows: (a) climate patterns are exogenous to the individuals and the degree of mobility across municipalities in the country is relatively low where 80 per cent of the individuals in the survey reports to live in the same municipality where they were born. Therefore, the estimation model controls for whether the respondent lives where she was born. (b) Our approach controls for individual characteristics that are usually unobservable and can be important determinants of happiness. These characteristics include personal aspirations (i.e., the difference between the income level that the individual considers as high enough to live well and her current income level). (c) Provincial and year fixed effects and clustered standard errors by municipality and year control for hedonic price differentials across municipalities. Second, the climatic fragmentation in Ecuador makes this country an ideal case to study the effect of climate conditions on economic outcomes. Third, the evidence comes from a country in the tropical region of the world that is expected to suffer significant changes in climatic patterns and where the understanding of the effect of climate on economic outcomes is essential to anticipating changes in wellbeing.

The paper is organized as follows. Section 2 describes the data and the methodology employed in the analysis and section 3 presents different econometric estimation models and discusses the findings on climate conditions, socio-economic variables and happiness. Finally, section 4 concludes.

2. Data and methodology

We use information from the employment survey of Ecuador conducted by the National Institute of Statistics and Census (INEC), the institution responsible for generating the country's official statistics.[2] We specifically employ the survey waves for the years 2006–2008, which include questions about subjective wellbeing regarding different domains of life. Although INEC collects information about employment conditions quarterly, information on happiness was only collected in the surveys conducted in the last quarter. The domains include the household financial situation, job conditions, health, environment, attitudes towards the government, social life, education level, neighborhood and housing conditions, and overall life assessment. The employment survey also includes information about the social, demographic, and economic profile of the population, and employment status and characteristics of the working-age population. The survey is conducted at the household level, covering urban and rural areas in every municipality of the country.[3]

[2]INEC follows a sampling methodology to select a national sample that is representative of the Ecuadorian population. Professional enumerators interview the household head or, in his or her absence, the spouse or an adult living in the household answers the survey. The employment survey serves to elaborate socio-economic measures of the Ecuadorian economy, such as employment and unemployment rates, poverty and extreme poverty levels, and inequality measures.

[3]In the period of study, the survey included ten provinces in the highlands, five provinces in the coastal region, and six provinces in the Amazon region. Currently, the country has 24 provinces; one of the two new provinces is in the highlands and the other on the coast. The Galapagos Islands are not included in the survey.

Table 1. Descriptive statistics of the sample at the household level

Variables	Category (in %)				
Gender	Male 77.55	Female 22.45			
Working status	Employed 82.40	Unemployed 17.60			
Education level	No education 10.90	Primary 51.25	Secondary 24.45	Higher 13.40	
Ethnic group	Indigenous 8.15	White 6.75	Mestizo 79.32	Black 3.45	Other 2.33
Marital status	Single 8.08	Married 49.64	Separated/divorced 11.18	Widow 10.98	Not legally married 20.12
Urban/rural resident	Rural 43.91	Urban 56.09			
Self-assessment	Pessimistic 21.62	Neutral 38.84	Optimistic 39.54		

The sample includes 54,541 households distributed as follows: 17,726 households (32.5 per cent of the sample) in 2006, 18,271 (33.5 per cent of the sample) in 2007, and 18,544 (34 per cent of the sample) in 2008. Descriptive statistics for the main characteristics of respondents are shown in table 1. Household heads are mostly males (77.55 per cent) and were employed (82.36 per cent) on the survey day. Almost 80 per cent of the interviewees described themselves as Hispanic, and nine out of ten reported speaking Spanish exclusively. More than half of the population lives in urban areas (56 per cent of the sample), and married people represent half of the sample, whereas those who have at least completed elementary school represent slightly more than half of the sample. Respondents' ethnic identification and marital status of respondents coincide with the official information generated by the latest population census.[4] Regarding how optimistic or pessimistic people are, almost 40 per cent of respondents are optimistic, 21 per cent pessimistic and 39 per cent neutral about their living conditions.

Questions about the level of satisfaction with different wellbeing domains are of the following form: how satisfied are you with your work /financial situation /health status /environment /government…? The survey adopts a scale from 0 to 10, corresponding to different satisfaction levels, with ten being the highest. People are more satisfied with their marital status, social life and neighborhood characteristics, whereas the financial situation, the government, and education levels achieve the lowest levels of satisfaction. Work condition, health status, leisure, and the environment reach intermediate ranges of satisfaction. For this paper, the focus is on overall life satisfaction (i.e., overall happiness), which is assumed to capture the general self-assessment of happiness and satisfaction with one's own health status (i.e., health happiness). Table 2 shows additional information about individuals' characteristics and climate conditions.

As a measure of climate conditions, we use the monthly average values of temperature, precipitation, and humidity for November and December when the surveys with

[4] At the time of the employment survey, the latest population census corresponded to that of 2001. A new population census was conducted in 2010.

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

Table 2. Descriptive statistics of socio-economic and climatic variables

Variables		Observations	Mean	Std. dev.	Min value	Max value
Monthly family income (US$)		54,541	423	490.2	0	11,562
Age (years)		54,541	49.1	14.8	13	80
Family size (number of people)		54,541	4.2	2.2	1	25
Happiness level (0–10 scale)	Overall	54,541	6.4	2.1	0	10
	Health	54,541	5.8	2.4	0	10
Income gap (US$)		54,541	394	614	0	14,500
Average temperature (°C)						
	Country	654	19.7	5.6	10.4	27.6
	Coast	258	25.1	1.1	20.8	27.6
	Highlands	273	15.2	3.5	10.4	26.2
	Amazon	123	23.3	2.5	10.6	26.8
Average high temperature (°C)						
	Country	654	25.2	5.3	12.5	33
	Coast	258	30.2	1.4	23.9	33
	Highlands	273	20.9	3.4	14.7	30
	Amazon	123	28.9	2.7	18.8	32.9
Heat index (°C)						
	Country	654	28.2	8.4	16.4	48.8
	Coast	258	36.4	3.6	24.3	45.3
	Highlands	273	21.3	3.6	17.5	41.5
	Amazon	123	35.7	7.5	16.4	48.8
Average precipitation (mm)						
	Country	654	139.2	139.9	14.4	900
	Coast	258	148.1	100.7	19.6	509.6
	Highlands	273	121.3	155.3	14.4	900
	Amazon	123	270.6	167.8	60.1	800
Humidity (%)						
	Country	654	79.6	9.1	62	94
	Coast	258	72.6	7.9	62	91
	Highlands	273	84.8	6.1	62	92
	Amazon	123	82.1	3.4	73	94

happiness questions took place. We also employ average maximum temperature levels and a measure of heat stress to identify the effect of temperature extremes on subjective wellbeing. Precipitation, however, is the climate variable exhibiting more variation with

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

high and low peaks in the wet (December to May) and dry seasons (June to November), respectively. Information on climate variables comes from the 2006–2008 annual reports by the National Institute of Meteorology and Hydrology (INHAMI) of Ecuador[5] and the World Bank's Climate Change Knowledge Portal (see table 2 for details on climate patterns in the country).[6] Local climate conditions exhibit a remarkable variation across the country's natural regions, as shown in figure 1 which illustrates average temperature and precipitation levels at the municipal level. The analysis includes information on temperature, precipitation and humidity levels for 218 municipalities of Ecuador (86 in the coastal region, 91 in the highlands and 41 in the Amazon). At the municipal level, the average temperature ranges from 10.4°C to 27.6°C, monthly average precipitation from 14.4 to 900 mm, and average humidity levels from 62 to 94 per cent. Municipalities experiencing high temperature and humidity are primarily in the coastal and Amazon regions, whereas municipalities in the highlands are usually colder and drier. Regarding extreme temperatures, the average high temperatures recorded in the country can exceed 30°C, whereas the heat index can go above 40°C.

The theoretical relationship between climate conditions and individual happiness implies that climate is an external factor to the individual (i.e., a factor that cannot be altered by individual decisions) that is an element of her utility function and provides positive or negative effects on wellbeing (van Praag and Ferrer-i-Carbonell, 2004). This notion of utility refers to the experienced utility that results from hedonic experiences of realized outcomes instead of decision utility inferred from individual choices (Kahneman and Thaler, 2006). Since the substitutability of components of the utility function is assumed (Mas-Colell *et al.*, 1995), it is possible to identify the trade-offs between climate conditions and income at the individual level or the shadow price of climate (van Praag and Ferrer-i-Carbonell, 2004). However, individual or collective (i.e., institutional arrangements) decisions can ameliorate or attenuate the effects of climate conditions on happiness. This element implies that the empirical estimation of the effect of climate on happiness needs to acknowledge both the exogenous nature of climate variables and the individual and social characteristics of populations that can mediate this relationship.

The exogenous source of variation allowing identification of the causal effect of climate on happiness consists of differences in individuals' happiness with similar socioeconomic characteristics and affected by similar policies and institutions, but living in municipalities with different climate conditions. The variation in climate patterns comes mostly from climate differences across municipalities since the variation within municipalities over time is minimal. In terms of econometric methodology, the omitted variables problem ideally requires panel data to eliminate the bias from unobserved individual characteristics (Dell *et al.*, 2014; Hsiang, 2016). Although we employ cross-section observations for three years, we can control for the effect of material aspirations respondents have that may affect their subjective assessment of wellbeing. This variable is the difference between the level of income respondents consider the minimum level for a 'good' life and their actual income level. This difference constitutes the gap between the lifestyle individuals aspire to enjoy and the income level they currently earn (variable 'income gap' in table 2). With this variable, we aim to determine how far individuals are from reaching their material aspirations and how this affects individual wellbeing.

[5]The annual reports are available from the Instituto Nacional de Meteorología and Hidrología del Ecuador, INHAMI, at http://www.inamhi.gov.ec/html/inicio.htm.

[6]More information is available at https://climateknowledgeportal.worldbank.org/.

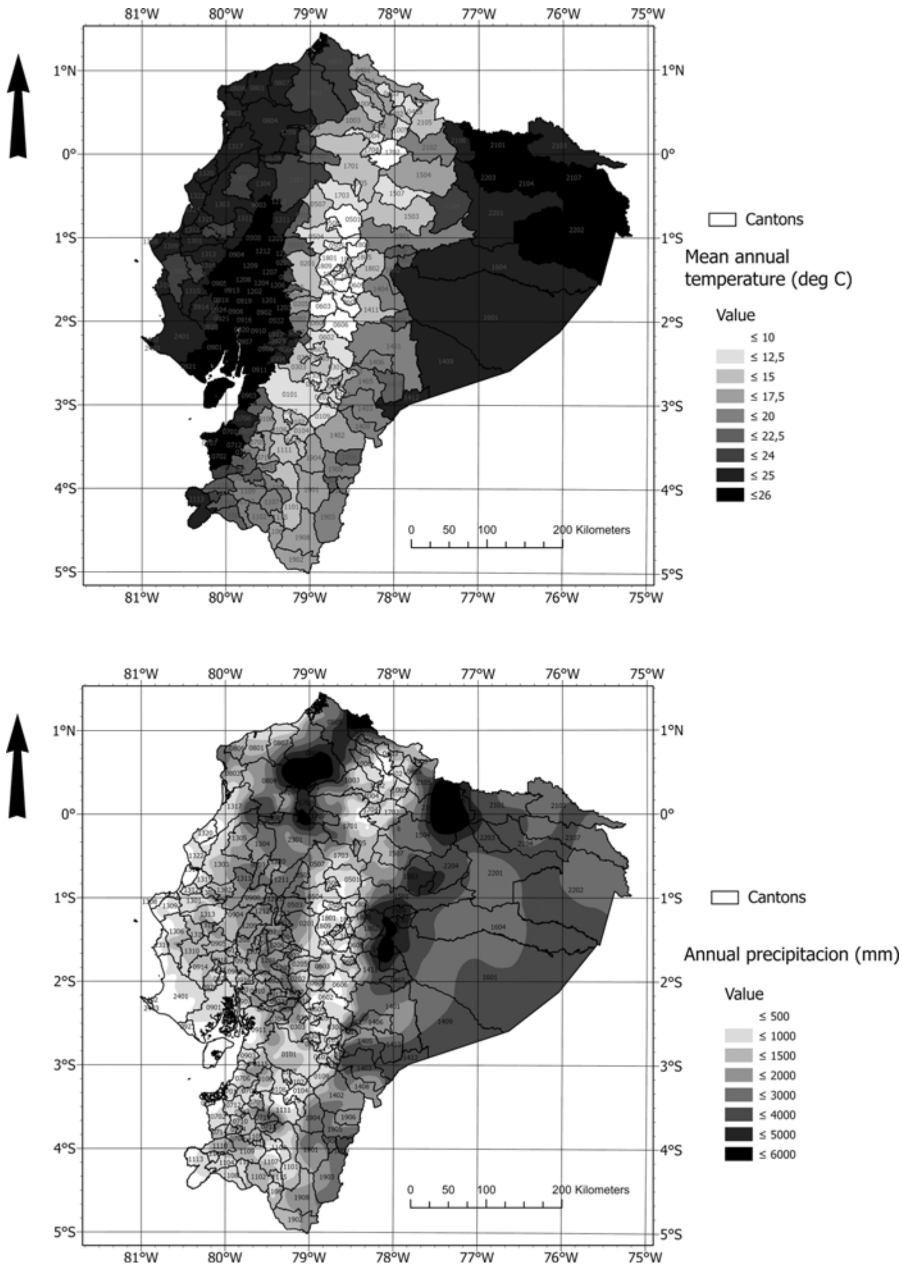

Figure 1. Annual average temperature (top panel) and precipitation (bottom panel) in Ecuador, 2006–2008.

The methodological treatment of answers to subjective wellbeing questions falling into different qualitative or quantitative categories can adopt two approaches: (1) the response of an individual stating being somewhat satisfied (instead of not satisfied or

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

unsatisfied) may reflect an order mentally structured by the interviewee. In this case, respondents' self-reported wellbeing is treated as an ordinal variable that prevents the researcher from making interpersonal comparisons. (2) If the researcher assumes that a numerical scale reflects a quantitative assessment of the respondent's wellbeing, answers can be treated as cardinal variables that allow interpersonal comparisons. Econometrically, ordered logit models are suitable for analyzing ordinal dependent variables, whereas a cardinal probit approach or group-wise regressions are appropriate to treat wellbeing responses as cardinal variables (van Praag and Ferrer-i-Carbonell, 2004; Dolan *et al.*, 2008). Some researchers have suggested other econometric models, such as probit ordinary least squares (OLS) that treats the values of the dependent variable as the conditional expectation of the measure within a wellbeing scale defined by intervals. The empirical evidence shows that these three econometric approaches yield similar results (van Praag and Ferrer-i-Carbonell, 2004). This paper will employ the probit OLS approach that consists of the cardinalization of subjective wellbeing responses based on Maddala's approach (1983).[7] The most common happiness model in the literature adopts an additive functional form (Dolan *et al.*, 2008):

$$\mathrm{SWB}_i = \alpha + \beta_i X_i + \delta_i Z_k + \theta_t T_t + \varepsilon_i,$$

where SWB_i = self-reported measure of individual wellbeing in logarithmic form; X_i = demographic, social and economic factors at the individual level (income gap, age, gender, employment status, family size, marital status, whether people live where they were born); Z_k = climate variables: annual average temperature and maximum temperature, precipitation and humidity, and their variations (linear and square terms, and deviations from averages), at the municipal level; and ε_i = individual differences captured in the error term.

The assumptions for modelling subjective wellbeing are the following: (1) causality runs from the explanatory to the dependent variable; (2) no correlation between unobserved factors and the explanatory variables exists (Dolan *et al.*, 2008); (3) similar responses from two individuals that fall into the same category represent the same level of satisfaction, which implies that ordinal interpersonal comparability is allowed; and (4) the substitutability between explanatory variables is plausible (van Praag *et al.*, 2003). Moreover, the causal relationship between climate and happiness does not suffer from endogeneity problems since climate patterns are exogenous to individuals, and mobility within the country is low. We also control for critical factors such as personal aspirations (measured by the variable 'income gap'), which can be viewed as reference points to self-assess individuals' wellbeing (Kahneman and Krueger, 2006; Rojas, 2007; Clark *et al.*, 2008).

It is also possible that individuals seeking to reach higher levels of happiness move to locations where climate conditions are associated with higher wellbeing, which would bias the regression estimates. To control for location choices, we include a dummy variable indicating whether the person lives where she was born (i.e., variable 'place' = 1, if the person lives in a different municipality, and 'place' = 0 otherwise). Moreover, we control for provincial and municipal level factors (i.e., provincial fixed-effects) in different

[7] Probit OLS similarly describes the happiness function as in Ordered Probit, with the only difference being that the former assumes that this function is approximately normally distributed. Probit OLS, therefore, requires an additional assumption that makes it less generalizable than Ordered Probit (van Praag and Ferrer-i-Carbonell, 2004).

specifications of the regression model. Although institutional quality at the provincial and municipal levels can result from climate conditions (Acemoglu *et al.*, 2001; Dell *et al.*, 2014; Hsiang, 2016), we do this to control the effect of hedonic or price differentials across municipalities in the country. This approach helps control for differences in the cost of living due to climate conditions (e.g., food prices) or exposure to climate events (e.g., seasonal flooding). We cluster standard errors by municipality and year to consider shared characteristics of individuals living in the same jurisdiction, which can also vary over time.

3. Results

As determinants of happiness, we consider socio-economic variables such as gender, age and age squared, family size, employment and marital status, level of income individuals consider enough to live well (i.e., income gap), and whether they currently live where they were born. Although individuals may assess their overall level of happiness (i.e., overall happiness) by taking into account the elements of their lives that are most important to them (Dolan *et al.*, 2008), assessments of happiness for specific domains of life can bring a better understanding of particular aspects of individual wellbeing. Concretely, when individuals assess happiness with their health status (i.e., health happiness), they are expected to evaluate how the environment and their physical condition determine their level of satisfaction. Unlike the effect of climate conditions on overall happiness, happiness with one's health status is assumed to consider the direct effect of climate on respondents' health. Places that experience high or low temperatures combined with high humidity constitute locations where people can suffer from health problems related to respiratory and cardiovascular illnesses and changes in people's aggressiveness and mood (Cunningham, 1979; Braga *et al.*, 2002; Eliasson *et al.*, 2007). To determine whether climate conditions affect overall and health happiness differently, the determinants of these two domains are analyzed separately.

The identification of a causal relationship between climate and socio-economic outcomes is always a methodological concern. Deviations from average levels in climate variables have been suggested to establish this effect because of their random nature (Dell *et al.*, 2014; Hsiang, 2016). To check the robustness of the relationship between temperature and happiness, we consider the deviations in average temperature as the temperature variable in the regression model. We define temperature deviations as the difference between the average temperature in the study years and the average temperature during 1991–2008. Since deviations in average temperatures vary across municipalities and over time, we can control for factors at the municipal level other than climate conditions that affect happiness. For example, these factors may refer to differences in the prices of food or housing, and ultimately the cost of living across municipalities. However, one should be aware that municipal dummies partially capture the effect of climate conditions on happiness, as suggested in the literature (Acemoglu *et al.*, 2001; Dell *et al.*, 2014; Hsiang, 2016).

Results in table 3 provide evidence suggesting a causal relationship between temperature and happiness. Columns 1 and 2 present the results for overall and health happiness as the dependent variables. The relationship between temperature deviations and overall and health happiness shows a positive, statistically significant effect. Specifically, an increase of 1°C in the temperature deviation raises overall and health happiness by 0.013 and 0.018 points, respectively. The results also suggest that women are less happy than men, with an average difference of 4.7 per cent in overall happiness and 11.3 per cent

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

Table 3. Effect of temperature deviations on happiness

	(1) Overall happiness	(2) Health happiness
Temperature deviation (°C)	0.013* (0.006)	0.018*** (0.005)
Average annual precipitation (100 mm)	−0.002 (0.003)	−0.002 (0.003)
Average annual humidity (%)	0.001 (0.003)	0.003 (0.002)
Income gap (log)	−0.007** (0.002)	−0.011*** (0.001)
Female	−0.047** (0.016)	−0.113*** (0.014)
Age (years)	0.007*** (0.002)	−0.011*** (0.002)
Age square	−0.0001*** (0.000)	−0.0001** (0.000)
Family size	−0.011*** (0.002)	−0.001 (0.002)
Unemployed	−0.030* (0.013)	−0.165*** (0.014)
Migrated from a different municipality	0.069*** (0.015)	0.058*** (0.015)
Marital status	Yes	Yes
Province	Yes	Yes
Year	Yes	Yes
Observations	54,541	54,541
R^2	0.100	0.143

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

in health happiness. Age is positively associated with overall happiness and negatively associated with health happiness, while its quadratic term harms both types of happiness. Being unemployed decreases overall happiness by 3 per cent and health happiness by almost 16.5 per cent. Family size is negatively associated with overall and health happiness, but this effect is only statistically significant for the former, whereas people living in places other than their place of birth are generally happier. The variable income gap has a negative coefficient showing that the gap between actual income and what individuals consider an adequate level decreases happiness. Like the effect of unemployment, the income gap decreases health happiness more than overall happiness (elasticity values of 0.011 and 0.007, respectively), suggesting that the financial anxiety captured by this variable taxes the health condition more heavily than overall happiness.

The magnitude of the effect of socio-economic characteristics and its statistical significance are consistent across different econometric specifications and with existing evidence from Ecuador (Pontarollo *et al.*, 2020). Additional controls include marital status and province and year fixed effects. The effect of precipitation and humidity levels on happiness is not statistically significant, suggesting that people perceive temperature at a

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

given time (i.e., whether the day is hot or cold) more easily than precipitation and humidity. Standard errors in the econometric specification are clustered by municipality and year to control for factors affecting individuals living in the same locality, which can vary yearly. The results in table 3 suggest that temperature levels are important determinants of individual happiness even after controlling for shared characteristics of households at the provincial and municipal levels, such as cost of living and institutional quality.

Since the literature identifies a non-linear relationship between climate and happiness (van Praag and Ferrer-i-Carbonell, 2004; Maddison and Rehdanz, 2011; Noelke *et al*., 2016), we first explore the linear relationship between climate variables in levels and happiness and then impose a quadratic relationship to identify the temperature at which happiness reaches its highest peak. The results of the main econometric specifications are presented in tables 4 and 5 and show the relationship between climate variables and happiness while controlling for socio-economic determinants of wellbeing. While table 4 considers the linear effect of climate variables, table 5 introduces the model results, including the quadratic term of these variables. We alternate the temperature variable to consider the effect of annual average temperature (columns 1 and 4), annual average maximum temperature (columns 2 and 5), and heat stress (columns 3 and 6) to capture not only the average effect but also the effect of high peaks of temperature on wellbeing. In both tables, columns 1–3 have models for overall happiness, whereas columns 4–6 include models for health happiness. Table 4 shows that overall happiness is positively related to average temperature and average high temperature, whereas health happiness is negatively related to heat. Increases of 1°C in average and average high temperature are associated with an increase of 1.2 per cent and 1.4 per cent in overall happiness, respectively. The negative effect of heat on overall happiness and the positive effects of average and average high temperature on health happiness are statistically insignificant. The relationship between precipitation and happiness is negative, although statistically insignificant. Humidity and happiness are positively related with a statistically significant effect on health happiness and when the average high temperature is the temperature variable (column 5 in table 4). An increase of one percentage point in humidity levels is associated with an increase of 0.5 per cent in health happiness.

The shape of the quadratic relationships between temperature and happiness (table 5) is an inverted-U. Overall happiness increases as average and average high temperature increase only up to some level, above which it starts decreasing. Overall happiness peaks at an average temperature of 22°C and an average high temperature of 26°C (columns 1 and 2 in table 5). The pattern of this relationship implies that two segments are defining how temperature affects overall happiness. The first segment corresponds to increases in temperature in cold places (i.e., low temperature levels) where people became happier as temperature raises. In our sample, this occurs when average temperature gradually increases from 10.4°C (i.e., the minimum average temperature) to 22°C (i.e., the temperature at which overall happiness is the highest), or when average maximum temperature gradually increases from 12.5°C (i.e., the lowest average maximum temperature) to 26°C (i.e., the maximum temperature at which overall happiness is the highest). The second segment occurs in places already warm (i.e., with an average temperature of 22°C or average maximum temperature of 26°C) where higher temperature levels decrease overall happiness. Regarding the distribution of municipality-year observations, 28,198 observations (51.7 per cent) and 27,343 observations (48.3 per cent) are below and above 22°C, the turning point maximizing happiness. In terms of number, 100 municipalities are below, and 118 above, this temperature level. The relationship between temperature and health happiness exhibits a similar pattern. Health happiness reaches its maximum

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

Table 4. Linear relationship between climate variables and overall happiness

	(1) Overall happiness	(2) Overall happiness	(3) Overall happiness	(4) Health happiness	(5) Health happiness	(6) Health happiness
Average temperature (°C)	0.012* (0.006)			0.005 (0.005)		
Average high temperature (°C)		0.014* (0.006)			0.008 (0.005)	
Heat index (°C)			−0.003 (0.004)			−0.010** (0.003)
Average annual precipitation (100 mm)	−0.002 (0.003)	−0.002 (0.003)	0.002 (0.003)	−0.003 (0.002)	−0.003 (0.002)	0.002 (0.002)
Average humidity (%)	0.005 (0.003)	0.004 (0.003)	0.001 (0.003)	0.004 (0.002)	0.005* (0.002)	0.002 (0.002)
Income gap (log)	−0.006** (0.002)	−0.006** (0.002)	−0.007** (0.002)	−0.011*** (0.001)	−0.011*** (0.001)	−0.011*** (0.001)
Female	−0.046** (0.016)	−0.046** (0.016)	−0.048** (0.016)	−0.112*** (0.014)	−0.111*** (0.014)	−0.115*** (0.014)
Age (years)	0.007*** (0.002)	0.007*** (0.002)	0.007*** (0.002)	−0.011*** (0.002)	−0.011*** (0.002)	−0.011*** (0.002)
Age square	−0.0001*** (0.0000)	−0.0001*** (0.0000)	−0.0001*** (0.0000)	−0.00004** (0.00001)	−0.00004** (0.00001)	−0.00004** (0.00001)
Family size	−0.011*** (0.002)	−0.011*** (0.002)	−0.011*** (0.002)	−0.001 (0.002)	−0.001 (0.002)	−0.001 (0.002)
Unemployed	−0.031* (0.013)	−0.031* (0.013)	−0.030* (0.013)	−0.165*** (0.014)	−0.165*** (0.014)	−0.164*** (0.014)
Migrated from a different municipality	0.067*** (0.015)	0.067*** (0.015)	0.071*** (0.015)	0.059*** (0.015)	0.058*** (0.015)	0.062*** (0.015)
Marital status	Yes	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	54,541	54,541	54,541	54,541	54,541	54,541
R^2	0.100	0.100	0.100	0.143	0.143	0.143

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

when average and average maximum temperature are 19°C and 24°C, respectively. The effect of heat on overall happiness is not statistically significant (column 3), whereas its effect on health happiness is only significant along the decreasing segment of the relationship (column 6). Health happiness decreases in heat for levels higher than 25.5°C. The existence of a temperature level maximizing happiness is consistent with other findings that determine the existence of a comfort range for individual satisfaction (Epstein and Moran, 2006; Budd, 2008).

Although not statistically significant, the association of precipitation and humidity with overall happiness is represented by a U shape, whereas the relationship between

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

Table 5. Linear and quadratic relationship between climate variables and health happiness

	(1) Overall happiness	(2) Overall happiness	(3) Overall happiness	(4) Health happiness	(5) Health happiness	(6) Health happiness
Average temperature (°C)	0.087** (0.032)			0.119*** (0.025)		
Average temperature square	−0.002* (0.001)			−0.003*** (0.001)		
Average high temperature (°C)		0.132*** (0.035)			0.173*** (0.026)	
Average high temperature square		−0.003*** (0.001)			−0.004*** (0.001)	
Heat index (°C)			0.021 (0.023)			0.030 (0.020)
Heat index square			−0.0003 (0.0003)			−0.001* (0.000)
Average annual precipitation (100 mm)	−0.006 (0.007)	−0.005 (0.006)	−0.0001 (0.0006)	−0.010 (0.005)	−0.009 (0.005)	−0.002 (0.005)
Average annual precipitation square	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Average humidity (%)	−0.031 (0.044)	−0.036 (0.044)	−0.029 (0.047)	0.016 (0.037)	0.012 (0.038)	0.016 (0.040)
Average humidity square	0.0002 (0.0002)	0.0002 (0.0003)	0.0002 (0.0003)	−0.0001 (0.0002)	−0.0001 (0.0002)	−0.0001 (0.0002)
Income gap	−0.007** (0.002)	−0.007** (0.002)	−0.007** (0.002)	−0.011*** (0.001)	−0.011*** (0.001)	−0.011*** (0.001)
Female	−0.048** (0.016)	−0.049** (0.016)	−0.048** (0.016)	−0.114*** (0.014)	−0.115*** (0.014)	−0.115*** (0.014)
Age (years)	0.007*** (0.002)	0.007*** (0.002)	0.007*** (0.002)	−0.011*** (0.002)	−0.011*** (0.002)	−0.011*** (0.002)
Age square	−0.0001*** (0.0000)	−0.0001*** (0.0000)	−0.0001*** (0.0000)	−0.00005** (0.00002)	−0.00004** (0.00002)	−0.00004** (0.00001)
Family size	−0.011*** (0.002)	−0.011*** (0.002)	−0.011*** (0.002)	−0.001 (0.002)	−0.000 (0.002)	−0.001 (0.002)
Unemployed	−0.031* (0.013)	−0.033* (0.013)	−0.030* (0.013)	−0.166*** (0.014)	−0.168*** (0.014)	−0.166*** (0.014)
Migrated from a different municipality	0.068*** (0.014)	0.066*** (0.014)	0.070*** (0.014)	0.061*** (0.015)	0.056*** (0.015)	0.060*** (0.015)
Marital status	Yes	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Observations	54,541	54,541	54,541	54,541	54,541	54,541
R^2	0.101	0.102	0.100	0.144	0.145	0.144

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

humidity and health happiness adopts an inverted-U shape. While high humidity levels can be associated with a reduction in physical energy, people's concentration, work productivity and social interaction (Sanders and Brizzolara, 1982; Howarth and Hoffman, 1984), we do not find evidence that this variable affects happiness. The effects of socio-economic determinants on happiness levels in tables 4 and 5 remain similar in direction and magnitude to those discussed above.

The effect of climate on happiness can differentially affect people with specific socio-economic characteristics. To test the effect of climate on happiness among different groups in the country, we modify the main econometric specification to include the interaction between average maximum temperature and income and education levels. We consider family income and education level as variables that may attenuate the effect of temperature on overall and health happiness. We run regressions similar to those in table 5 but include the interaction between average high temperature and individuals' family income and education.[8] The interaction variables correspond to the temperature variable and dummies for income quartiles and education levels (i.e., individuals with no formal education, primary education, and secondary education). Table 6 shows the regression specifications with overall and health happiness as the dependent variables, and average high temperature in levels and in interaction with individual socio-economic characteristics as the main independent variables.

The results in columns 1 and 2 of table 6 show how income attenuates the effect of temperature on happiness. Although the effect of temperature and happiness remains U-inverted-shaped, the interactions between temperature measures and income quartiles suggest that overall and health happiness levels associated with temperature are higher for individuals with higher income. Whereas higher-income individuals are the happiest (i.e., the difference in happiness levels between the fourth quartile and the other three is negative and statistically significant), middle-income individuals are happier than low-income ones (i.e., the difference in happiness levels between the third and the second and the first quartiles is negative and statistically significant).[9] The coefficient of the interaction variables implies that the slope of the relationship between temperature and income is smaller for lower-income levels across the income distribution. The effect of temperature on happiness is larger for the first two income quartiles than for the highest quartile. The negative effect is also significant for those in the third quartile, although the effect size is smaller than for lower-income individuals. Families with higher income levels may cope better with climate conditions, allowing income to attenuate the negative effect of temperature on happiness through access to devices and infrastructure, making living conditions more comfortable. Air conditioning systems, weather monitoring, and construction with improved climatic-isolation mechanisms are just a few examples of affordable devices for people with higher incomes. The results remain persistent when the dependent variable is the average temperature.

[8] Although in table 6 we only present the results of the econometric specifications showing the effect of average high temperature on overall and health happiness and its interactions with income and education, the results are similar when we use average temperature as the model's temperature variable.

[9] The differences across income groups are significant when the excluded interaction between temperature and different income levels, and therefore the comparison group, is alternately changed. Individuals in the fourth and third income quartiles are significantly less affected by climate conditions than individuals in the first and second quartiles. The same analysis applies to the interaction between temperature and education, where differences in happiness are statistically significant between individuals with different education levels.

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

Table 6. Regression models with interaction variables

	(1) (Income) Overall happiness	(2) (Income) Health happiness	(3) (Education) Overall happiness	(4) (Education) Health happiness
Average high temperature (°C)	0.093** (0.033)	0.130*** (0.023)	0.086** (0.033)	0.127*** (0.023)
Average high temperature square	−0.001* (0.001)	−0.002*** (0.000)	−0.001 (0.001)	−0.002*** (0.001)
Average annual precipitation (100 mm)	−0.005 (0.006)	−0.009 (0.005)	−0.003 (0.006)	−0.006 (0.004)
Average annual precipitation square	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Annual average humidity (%)	−0.042 (0.042)	0.005 (0.031)	−0.025 (0.041)	0.030 (0.030)
Annual average humidity square	0.0003 (0.0003)	−0.0002 (0.0002)	0.0002 (0.0002)	−0.0001 (0.0002)
Income gap (log)	0.005* (0.002)	0.002 (0.002)	−0.009*** (0.002)	−0.012*** (0.001)
Female	−0.037* (0.015)	−0.101*** (0.013)	−0.035* (0.015)	−0.117*** (0.014)
Family income	0.000*** (0.000)	0.000*** (0.000)		
1st income quartile * temperature	−0.019*** (0.001)	−0.021*** (0.001)		
2nd income quartile * temperature	−0.015*** (0.001)	−0.014*** (0.001)		
3rd income quartile * temperature	−0.008*** (0.001)	−0.008*** (0.001)		
Years of schooling			0.035*** (0.003)	0.034*** (0.002)
No education * temperature			−0.020*** (0.003)	−0.022*** (0.003)
Primary education * temperature			−0.026*** (0.002)	−0.026*** (0.001)
High school * temperature			−0.014*** (0.001)	−0.015*** (0.001)
Observations	54,541	54,541	54,541	54,541
R^2	0.129	0.176	0.120	0.158

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Additional controls include age, age square, family size, being unemployed, migrated from a different municipality, marital status, province and year dummies.

The results in columns 3 and 4 in table 6 suggest that education also attenuates the effect of temperature on happiness. As with income, individuals with more education have higher overall and health happiness associated with temperature. Again, significant differences in happiness related to the effect of temperature levels exist between individuals with higher education and those with lower levels of education, and between

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

those with primary education and no education and between those with secondary and primary education. Similarly, the coefficients of the interaction variables show that the relationship between temperature and happiness for individuals with less education (i.e., individuals with no education and primary education only) has a smaller slope. Being able to use information about climate and weather conditions and anticipate their risks and effects on health and infrastructure may be associated with higher education levels, which may explain why individuals with more education are happier than those with less education when experiencing the same climate conditions.

Breaking down the data by regions illustrates the effect of weather on happiness in places where climate conditions are noticeably different. For instance, the coastal and the Amazon regions are warm and humid, whereas the highlands are colder and drier. Regression models in table 7, with average maximum temperature as the temperature variable and overall and health happiness as the dependent variables, show the results for the coastal and Amazon regions taken together and the highlands.[10] The results by region show that climate affects individual happiness differently depending on the prevalent climate conditions in each region. In the highlands, cold and dry, the effect of average high temperature on overall happiness is positive and exhibits an inverted-U shape on health happiness. Health happiness peaks when the average high temperature reaches 24°C. In the coastal and Amazon regions, warm and humid, the effect of temperature on overall and health happiness is statistically significant only along the decreasing segment of the inverted-U relationship. Unlike the highlands, where most temperature levels are within a comfortable range and therefore increase happiness, the results by regions reveal that temperature in places already warm and humid harms both overall and health happiness.[11] The effects of precipitation and humidity remain insignificant in model specifications by region. These findings are consistent with the concern that heatwaves constitute a challenge for human health and wellbeing, mainly in tropical areas of the world characterized by high temperature and humidity levels.

To determine the magnitude of the effect of climate variables on happiness, we determine a measure of willingness to pay (MWTP) for climate conditions. To solve endogeneity between income and happiness (i.e., happy people earn more money and a higher income makes people happier), we regress income on a set of individual characteristics and dummy variables by sector of the economy and occupation. We then estimate the predicted income to instrument the income variable in the regressions of happiness on income. We next follow the methodology proposed by Levinson (2012) and Frey *et al.* (2010) to find the income level necessary to compensate individuals for an increase in temperature.[12] The average MWTP for a 1°C change in average and average high temperature for overall happiness is \$22.6 and \$26.5, or 5.3 per cent and 6.2 per cent of average income, respectively. MWTP slightly decreases when we consider

[10] Regression specifications with average temperature as the temperature variable produce similar results to those found when the temperature variable is the average high.

[11] These results hold with heat as the temperature variable and average temperature in the coastal and Amazon regions.

[12] After estimating the econometric specification with the log of income as an explanatory variable, we totally differentiate the estimated equation and set $d\text{SWB} = 0$. The resulting expression determines the marginal rate of substitution between temperature and income: $(\partial Y/\partial T) = ((\gamma/Y) + \theta_1)/2\theta_2$, where γ is the estimator of log of income, Y is average income, and θ_1 and θ_2 represent the linear and quadratic coefficients of temperature, respectively.

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

Table 7. Regression models by natural regions

	(1) (Highlands) Overall happiness	(2) (Highlands) Health happiness	(3) (Lowlands) Overall happiness	(4) (Lowlands) Health happiness
Average high temperature (°C)	0.115* (0.046)	0.178*** (0.035)	0.274 (0.143)	0.232 (0.128)
Average high temperature square	−0.002 (0.001)	−0.004*** (0.001)	−0.005* (0.003)	−0.005* (0.002)
Average annual precipitation (100 mm)	−0.009 (0.013)	−0.008 (0.011)	0.003 (0.001)	0.004 (0.006)
Average annual precipitation square	0.000 (0.000)	0.000 (0.000)	−0.000 (0.000)	−0.000 (0.000)
Average annual humidity (%)	−0.046 (0.077)	0.018 (0.066)	0.014 (0.057)	0.041 (0.044)
Average annual humidity square	0.0003 (0.0004)	−0.0001 (0.0004)	−0.0001 (0.0003)	−0.0002 (0.0003)
Income gap (log)	−0.004 (0.003)	−0.010*** (0.002)	−0.010*** (0.003)	−0.012*** (0.002)
Female	−0.079*** (0.021)	−0.139*** (0.019)	−0.004 (0.024)	−0.074*** (0.020)
Age (years)	0.006** (0.002)	−0.010*** (0.002)	0.007*** (0.002)	−0.012*** (0.002)
Age square	−0.0001*** (0.00002)	−0.0001** (0.00002)	−0.0001*** (0.00002)	−0.00001 (0.00002)
Family size	−0.012*** (0.003)	0.003 (0.003)	−0.011*** (0.003)	−0.005 (0.003)
Unemployed	−0.025 (0.019)	−0.138*** (0.020)	−0.057*** (0.017)	−0.217*** (0.017)
Marital status	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Observations	29,430	29,430	25,111	25,111
R^2	0.110	0.163	0.099	0.130

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

health happiness the measure of wellbeing, with values of \$19.3 and \$24.2, or 4.5 per cent and 5.7 per cent of average income, for a change of 1°C in average and average high temperature, respectively.

The material in the online appendix compares our estimates to those of other studies and expands the calculation of MWTP by income and education levels, offering a perspective of inequitable impacts of climate conditions on wellbeing across the income distribution. We also explore the potential channels through which climate conditions affect overall and health happiness.

https://doi.org/10.1017/S1355770X21000267 Published online by Cambridge University Press

4. Concluding remarks

The paper shows that the relationship between climate conditions and overall and health happiness exists, indicating the direction of the effects and their magnitudes. Ecuador is an ideal case study to identify the effect of climate conditions on socio-economic outcomes because of its geographical fragmentation and its consequent diversity of climate conditions across municipalities. The robustness of the results stems from the fact that different econometric specifications are adopted and that potential confounding effects are controlled for. Personal and socio-economic characteristics are important determinants of happiness levels, confirming the findings in the happiness literature. The effect of climate variables, particularly temperature, on happiness is strong and consistent across econometric specifications. We find an inverted U-shaped relationship between the temperature variable (i.e., average and maximum temperature) and overall and health happiness levels, whereas the relationship between heat and health happiness is only negative. Significant differences regarding the effect of climate on happiness exist across income groups and education levels, and across regions of the country with different prevalent climate conditions. These last results suggest that mitigation and adaptation to changing climate conditions in a warmer world are possible.

The effect of climate or geographical variables on happiness may reflect long-term and short-term effects. The former may include the effect of climate on institutional arrangements (Sokoloff and Engerman, 2000; Acemoglu *et al*., 2001) and might result from human adaptation (Landes, 1998). The latter might be a direct and immediate effect of temperature, humidity or rain on human wellbeing. Moreover, changes in people's mood can result from prevailing climate conditions and impact the self-assessment of wellbeing. If this is the case, climate may have an immediate effect on the short-term evaluation of happiness (Schwarz and Clore, 1983). This paper's findings do not provide a conclusive means to distinguish between the two effects, although the former might be related to provincial level variables given by social conditions and institutional quality. Nevertheless, analyses with panel data and within-year climate variation may contribute to a better understanding of the channels through which the climate directly impacts people's subjective wellbeing.

Additional channels through which climate affects happiness can be identified as well. Geographic conditions can determine the type of crops cultivated and, therefore, the main components of the diet affecting individuals' health. Changing climate conditions may also affect consumption, making people consume more ice cream during hot days, or more alcohol, tobacco and coffee during rainy days; or consumers in a good mood may be willing to spend more money going shopping (Murray *et al*., 2010). These are just a few examples of the importance of further understanding the effect of climate on individual behavior and subjective reports of wellbeing.

More research on how satisfaction domains relate to climate conditions and to each other is needed. For instance, the analysis of the degree of substitutability between domains can shed light on what matters most to people in the tropics, and public policy could be targeted to those aspects related to the most critical domains. Some of the open questions reported in the literature remain unexplained in the case of Ecuador. How climate conditions affect happiness with work conditions, financial situation, the environment, politics, and the neighborhood where the person lives, require further research. Complementarily, how climate-related disasters, such as floods or droughts, affect different domains of subjective wellbeing may also contribute to assessing the damages of disasters in terms of wellbeing and designing policies to help mitigate climate change and adapt to the changing patterns of world climate.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1355770X21000267.

References

Acemoglu D, Johnson S and Robinson JA (2001) The colonial origins of comparative development: an empirical investigation. *The American Economic Review* **91**, 1369–1401.

Anderson GB, Bell ML and Peng RD (2013) Methods to calculate the heat index as an exposure metric in environmental health research. *Environmental Health Perspectives* **121**, 1111–1119.

Atkinson S, Bagnall AM, Corcoran R, South J and Curtis S (2020) Being well together: individual subjective and community wellbeing. *Journal of Happiness Studies* **21**, 1903–1921.

Becker JA and Stewart LK (2011) Heat-related illnesses. *American Family Physician* **83**, 1325–1330.

Braga ALF, Zanobetti A and Schwartz J (2002) The effect of weather on respiratory and cardiovascular deaths in 12 US cities. *Environmental Health Perspectives* **110**, 859–863.

Brereton F, Clinch JP and Ferreira S (2008) Happiness, geography and the environment. *Ecological Economics* **65**, 386–396.

Budd GM (2008) Wet-bulb globe temperature (WBGT) – its history and its limitations. *Journal of Science and Medicine in Sport* **11**, 20–32.

Carroll N, Frijters P and Shields MA (2009) Quantifying the costs of drought: new evidence from life satisfaction data. *Journal of Population Economics* **22**, 445–461.

Clark AE (2018) Four decades of the economics of happiness: where next? *Review of Income and Wealth* **64**, 245–269.

Clark AE, Frijters P and Shields MA (2008) Relative income, happiness, and utility: an explanation for the Easterlin Paradox and other puzzles. *Journal of Economic Literature* **46**, 95–144.

Connolly M (2008) Here comes the rain again: weather and the intertemporal substitution of leisure. *Journal of Labor Economics* **26**, 73–100.

Connolly M (2013) Some like it mild and not too wet: the influence of weather on subjective wellbeing. *Journal of Happiness Studies* **14**, 457–473.

Cuñado J and de Gracia FP (2013) Environment and happiness: new evidence for Spain. *Social Indicators Research* **112**, 549–567.

Cunningham MR (1979) Weather, mood, and helping behavior: quasi-experiments with the sunshine Samaritan. *Journal of Personality and Social Psychology* **37**, 1947–1956.

Dell M, Jones BF and Olken BA (2014) What do we learn from the weather? The new climate-economy literature. *Journal of Economic Literature* **52**, 740–798.

Dolan P, Peasgood T and White M (2008) Do we really know what makes us happy? A review of the economic literature on the factors associated with subjective wellbeing. *Journal of Economic Psychology* **29**, 94–122.

Eliasson I, Knez I, Westerberg U, Thorsson S and Lindberg F (2007) Climate and behaviour in a Nordic city. *Landscape and Urban Planning* **82**, 72–84.

Epstein Y and Moran DS (2006) Thermal comfort and the heat stress indices. *Industrial Health* **44**, 388–398.

Ferrer-i-Carbonell A (2013) Happiness economics. *SERIEs* **4**, 35–60.

Frey BS, Luechinger S and Stutzer A (2010) The life satisfaction approach to environmental valuation. *Annual Review of Resource Economics* **2**, 139–160.

García-Trabanino R, Jarquín E, Wesseling C, Johnson RJ, González-Quiroz M, Weiss I, Glaser J, Vindell JJ, Stockfelt L, Roncal C, Harra T and Barregard L (2015) Heat stress, dehydration, and kidney function in sugarcane cutters in El Salvador – A cross-shift study of workers at risk of Mesoamerican nephropathy. *Environmental Research* **142**, 746–755.

Hirshleifer D and Shumway T (2003) Good day sunshine: stock returns and the weather. *The Journal of Finance* **58**, 1009–1032.

Howarth E and Hoffman MS (1984) A multidimensional approach to the relationship between mood and weather. *British Journal of Psychology* **75**, 15–23.

Hsiang S (2016) Climate econometrics. *Annual Review of Resource Economics* **8**, 43–75.

IPCC (2013) Summary for policy makers. In Stocker TF, Qin D, Plattner G-K, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V and Midgley PM (eds). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK and New York, NY: Cambridge University Press, pp. 3–29.

Kahneman D and Deaton A (2010) High income improves evaluation of life but not emotional well-being. *PNAS* **107**, 16489–16493.

Kahneman D and Krueger AB (2006) Developments in the measurement of subjective wellbeing. *Journal of Economic Perspectives* **20**, 3–24.

Kahneman D and Thaler RH (2006) Utility maximization and experienced utility. *The Journal of Economic Perspectives* **20**, 221–234.

Keller MC, Fredrickson BL, Ybarra O, Côté S, Johnson K, Mikels J, Conway A and Wager T (2005) A warm heart and a clear head. The contingent effects of weather on mood and cognition. *Psychological Science* **16**, 724–731.

Landes D (1998) *The Wealth and Poverty of Nations. Why Are Some So Rich and Others So Poor?* New York: WW Norton.

Levinson A (2012) Valuing public goods using happiness data: the case of air quality. *Journal of Public Economics* **96**, 869–880.

Lora E, Gallup J and Gaviria A (eds) (2003) *Is Geography Destiny? Lessons From Latin America*. Palo Alto, CA: Stanford University Press.

Lucas RE and Lawless NM (2013) Does life seem better on a sunny day? Examining the association between daily weather conditions and life satisfaction judgments. *Journal of Personality and Social Psychology* **104**, 872–884.

Maddala GS (1983) *Limited Dependent and Qualitative Variables in Econometrics*. Cambridge: Cambridge University Press.

Maddison D and Rehdanz K (2011) The impact of climate on life satisfaction. *Ecological Economics* **70**, 2437–2445.

Mas-Colell A, Whinston MD and Green JR (1995) *Microeconomic Theory*. Oxford: Oxford University Press.

Murray KB, Di Muro F, Finn A and Leszczyc PP (2010) The effect of weather on consumer spending. *Journal of Retailing and Consumer Services* **17**, 512–520.

NOAA (National Oceanic and Atmospheric Administration) (2009) National Weather Service Glossary. Available at http://w1.weather.gov/glossary/.

Noelke C, McGovern M, Corsi DJ, Jimenez MP, Stern A, Wing IS and Berkman L (2016) Increasing ambient temperature reduces subjective well-being. *Environmental Research* **151**, 124–129.

Pal JS and Eltahir EAB (2015) Future temperature in southwest Asia projected to exceed a threshold for human adaptability. *Nature Climate Change* **6**, 197–200.

Pontarollo N, Orellana M and Segovia J (2020) Determinants of subjective well-being in a developing country: the Ecuadorian case. *Journal of Happiness Studies* **21**, 3007–3035.

Rehdanz K and Maddison D (2005) Climate and happiness. *Ecological Economics* **52**, 111–125.

Rojas M (2007) Heterogeneity in the relationship between income and happiness: a conceptual-referent-theory explanation. *Journal of Economic Psychology* **28**, 1–14.

Sanders JL and Brizzolara MS (1982) Relationships between weather and mood. *Journal of General Psychology* **107**, 155–156.

Schär C (2016) The worst heat waves to come. *Nature Climate Change* **6**, 128–129.

Schwarz N and Clore GL (1983) Mood, misattribution, and judgments of wellbeing: informative and directive functions of affective states. *Journal of Personality & Social Psychology* **45**, 513–523.

Sokoloff KL and Engerman SL (2000) Institutions, factor endowments, and paths of development in the New World. *Journal of Economic Perspectives* **14**, 217–232.

van Praag BMS and Ferrer-i-Carbonell A (2004) *Happiness Quantified. A Satisfaction Calculus Approach.* New York: Oxford University Press.

van Praag BMS, Frijters P and Ferrer-i-Carbonell A (2003) The anatomy of subjective wellbeing. *Journal of Economic Behavior and Organization* **51**, 29–49.

Vergara A, Rios AR, Galindo LM, Gutman P, Isbell P, Suding PH and Samaniego J (2013) *The Climate and Development Challenge for Latin America and the Caribbean: Options for Climate-Resilient, Low Carbon Development*. Washington, DC: ECLAC, IADB, WWF.

Welsch H (2006) Environment and happiness: valuation of air pollution using life satisfaction data. *Ecological Economics* **58**, 801–813.

White AG (2007) A global projection of subjective wellbeing. a challenge for positive psychology? *Psychtalk* **56**, 17–20.

Willet KM and Sherwood S (2012) Exceedance of heat index thresholds for 15 regions under a warming climate using the wet-bulb globe temperature. *International Journal of Climatology* **32**, 161–177.

Cite this article: Zapata O (2022). Happiness in the tropics: climate variables and subjective wellbeing. *Environment and Development Economics* **27**, 250–271. https://doi.org/10.1017/S1355770X21000267