

Happiness in the tropics: climate variables and subjective wellbeing

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ONLINE APPENDIX

Marginal Willingness to Pay (MWTP) for climate conditions: review of estimates in the literature and comparisons by income and education levels

Other studies show similar values for MWTP for climate conditions, although the evidence focuses on developed countries. For instance, Albouy *et al.* (2016) project a decrease in welfare by the end of the century in the US measured by a MWTP of 2 per cent of average income. According to this study, although the effect of warmer winters is positive (2.16 per cent on average), the negative effect associated with warmer summers (4.5 per cent on average) dominates the effect of increases in temperature on welfare (Albouy *et al.*, 2016). Sinha *et al.* (2018) also find differences in MWTP when temperature increases during winter and summer, although their estimates are slightly smaller than in Albouy *et al.* (2016). For older households (i.e., 55 years and older), MWTP for a temperature change is 0.9 and 1 per cent of average family income in winter and summer, respectively, whereas the MWTP of younger households is 1.5 and 2 per cent of average family income in winter and summer, respectively. In Italy, MWTP for a change in temperature varies by city and season. However, the average MWTP across five cities (i.e., Milan, Rome, Naples, Cagliari and Palermo) represents 2 and 4 per cent of the expected after-tax labor income net of housing costs for winter and summer, respectively (Maddison and Bigano, 2003). MWTP can also vary by education level. As a percentage of the median monthly wage, Zheng (2016) shows that the average MWTP is 3.5 per cent, ranging from 2.8 per cent for people with less than high school or college to 3.9 and 4 per cent among people with high school or some college.

Figure A1 shows MWTP at different temperature levels relative to the turning point of the relationship between temperature and overall and health happiness. For example, the effect of temperature on overall happiness for an individual living in the highlands with an average temperature of 15°C is equivalent to a reduction in average family income of 28 per cent or

US\$120 (i.e., the average monthly family income in the sample is US\$424) when compared to the temperature level associated with the highest happiness (i.e., 22°C). The effect of temperature on health happiness for the same individual is equivalent to a reduction in family income of 23 per cent or US\$98, compared to a temperature of 21°C that maximizes happiness. Individuals living in warmer places (e.g., locations with a temperature of 25°C, which is the average temperature in the lowlands) require an increase in income of 9 per cent or US\$ 39, and of 31 per cent or US\$131 to reach the maximum overall and health happiness, respectively. For the minimum and maximum values of average temperature, the monetary compensation to maintain happiness at its maximum is 47 per cent and 17 per cent of the average family income for overall happiness and 50 and 41 per cent for health happiness, respectively.

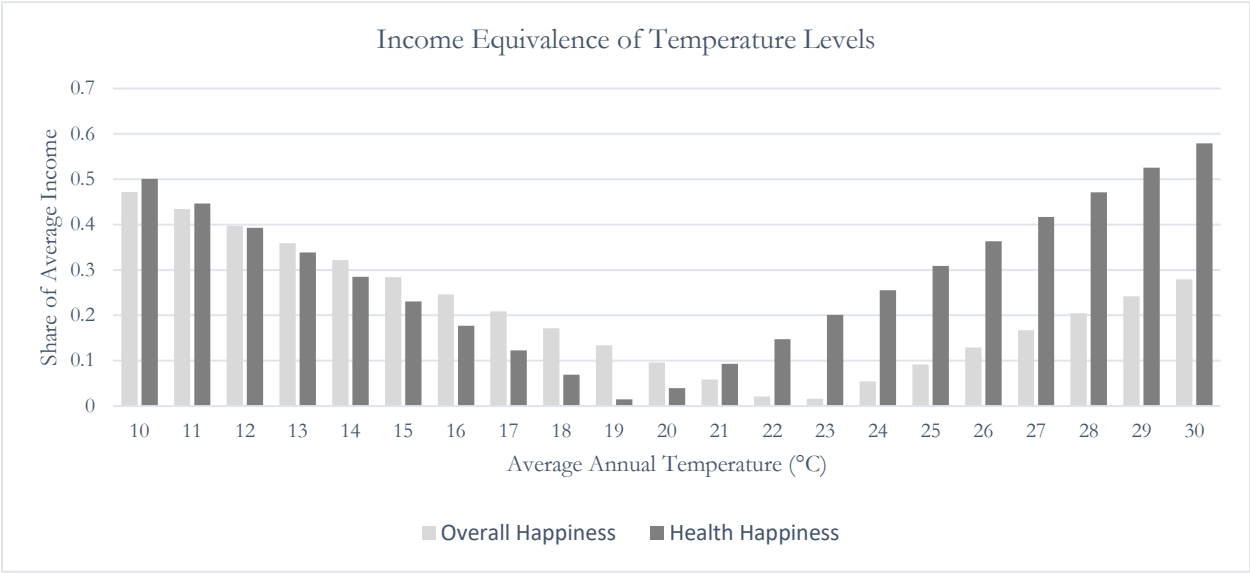


Figure A1. Income equivalence of the effect of climate on happiness.

More generally, individuals living in colder places relative to the overall happiness-maximizing temperature require, on average, more monetary compensation than individuals living in warmer places (i.e., 26.5 per cent of average family income vs. 14 per cent). The opposite is true when

the monetary compensation refers to health happiness, where individuals living in warm places require more compensation than those in cold locations (i.e., 33.6 per cent of average family income vs. 23.8 per cent).

We also identify remarkable differences in MWTP across groups defined by income and education levels. Table A1 shows the average MWTP for a change of 1°C as a percentage of the country's average family income (i.e., column 'Comparison', row 'Sample') and average family income within each of the groups (i.e., column 'Comparison', row 'Group'). The most important patterns that follow from the group comparison are the following: 1) MWTP is higher with average maximum temperature than average temperature. 2) MWTP is higher when overall happiness measures wellbeing than when health happiness does. 3) When MWTP is measured as a percentage of the country's average family income, the differences across income and education groups are small. However, when MWTP is expressed as a percentage of the average family income within each group, the differences become noticeable large with low-income families' MWTP as high as 27 per cent of the average income within this group and as small as 2.5 per cent for high-income families. Furthermore, although the differences by education level are smaller than by income, MWTP for less-educated individuals is higher than that for more-educated individuals in the country. These findings also suggest that the wellbeing of families with lower income and less education is affected disproportionately more than families with higher income and education levels.

Table A1. MWTP by income group and education level (% of average family income)

		Overall happiness		Health happiness		
		Comparison	Average temperature	Average high temperature	Average temperature	Average high temperature
Income	Low	Sample	5.9	6.1	4.6	5.6
		Group	27.5	26.1	21.4	23.8
	Middle	Sample	5.1	6.2	4.4	5.8
		Group	8	9.8	6.9	9.2
	High	Sample	7	7.4	4.8	5.7
		Group	3	3.2	2.1	2.5
Education	Primary	Sample	5.7	6.5	4.5	5.6
		Group	8.6	9.8	6.7	8.4
	Secondary	Sample	2.3	8.7	5.1	6.5
		Group	1.9	7.5	4.4	5.7
	Higher	Sample	6.2	7.1	4.2	5.3
		Group	2.7	3.1	1.8	2.3

Explaining the relationship between climate conditions and overall and health happiness

To explore potential channels through which climate conditions affect overall and health happiness, we identify the relationship between climate variables and a set of economic and social outcomes. These outcomes include individual-level variables, such as income, individual optimism/pessimism (binary variable), work satisfaction (four-category variable), individual illiteracy (binary variable), and institutional factors, including access to health insurance and whether the individual works in the informal sector of the economy (binary variables). We employ econometric models according to the nature of the dependent variable.

The results in table A2 suggest that climate variables, primarily average high temperature, are positively or negatively related to social and economic outcomes. Concretely, temperature is positively related to income and working in the formal sector of the economy and negatively related to pessimism, the level of work satisfaction, illiteracy rates, and being covered by health

insurance. Although we cannot claim that the relationships are causal, they shed some light on how climate conditions may affect outcomes associated with individual happiness.

Table A2. Relationship between climate variables and social and economic outcomes

Variables	Dependent variable						
	Income (OLS)	Optimism (Probit)	Pessimism (Probit)	Work satisfaction (Oprobit)	Illiteracy (Probit)	Have insurance (Probit)	Informal economy (Probit)
Average high temperature	0.025 * (0.011)	0.008 (0.006)	-0.016 ** (0.005)	-0.029 *** (0.008)	-0.019 * (0.009)	-0.032 *** (0.050)	-0.019 * (0.008)
Precipitation	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Humidity	0.008 (0.004)	0.001 (0.002)	-0.007 * (0.002)	-0.010 * (0.004)	-0.002 (0.003)	0.002 (0.002)	-0.003 (0.004)
Ovservations	54,541	54,148	54,148	34,325	34,325	54,541	54,541

Standard errors in italics. Legend: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Controls: income gap, gender, age, age square, family size, unemployed, marital status, migrated, and province and year dummies.

References

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