

The costs of social and environmental degradation in affluent economies

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ABSTRACT

Individuals' attempts to defend from the deterioration of common goods, such as natural and social capital, are a source of defensive growth, that is new economic activity driven by private and public consumption in response to collective problems. We use a compensating differential approach to compute the value of social and environmental degradation. To do so, we conduct a regression analysis of life satisfaction on aggregate consumption levels and various social and environmental externalities (which we refer to as "bads"). Our findings indicate that the welfare equivalent consumption to defend against collective problems is substantial. One standard deviation increase in each bad is worth about \$21,800 per capita, which corresponds to 65% of the observed yearly consumption per capita in our sample. *Ceteris paribus*, if bads could be avoided, consumption would be smaller, the economy would grow less, and individuals would be better-off. In so far as part of economic growth is defensive, only a portion of its expansion reflects true progress.

1. Introduction

Economic growth is commonly considered a measure of progress, despite having been conceived to reflect the productive capacity of a country. Over the course of the twentieth century, it accompanied improvements in health, education, and living standards. However, environmental and social degradation coupled with the lack of long-run improvements in well-being, showed the limits of growth as a measure of progress (Easterlin and O'Connor, 2022; Jansen et al., 2024; World Bank, 2024; Mikucka et al., 2017; Costanza et al., 2009; Fleurbaey, 2009).

Social comparisons and hedonic adaptation are two mechanisms that explain why economic growth and subjective well-being changes are decoupled in the long run (Easterlin, 1974; Clark et al., 2008; Clark, 2016). The idea is that individual well-being depends on previous achievements and on what others, the so-called reference group, have: if the expectations based on previous achievements are not met, subjective well-being does not grow even in presence of economic growth. Similarly, if individual income grows as much as or less than the one of others, subjective well-being will also suffer despite economic growth. The consequences for subjective well-being of social comparisons and

adaptation compound with those of defensive consumption, a third mechanism explaining why subjective well-being can stagnate in growing economies (Sarracino and O'Connor, 2023; Bartolini and Sarracino, 2024).

This mechanism posits that individuals turn to private goods and services to defend themselves against environmental degradation and social fragmentation - a phenomenon known as defensive expenditure (Hirsch, 1976; Daly, 1997) or defensive consumption (Bartolini and Bonatti, 2008). This response creates a feedback loop in which defensive consumption stimulates economic activity and resource use, perpetuating a cycle of growth that feeds on the very social and environmental disruption it helps produce (Antoci and Bartolini, 2004; Bartolini and Bonatti, 2008). The concept of defensive growth is akin to *uneconomic* growth. According to Daly (1998, 1999) growth becomes *uneconomic* when the environmental and social costs it generates exceed its benefits, so that further GDP expansion ultimately reduces net welfare rather than increasing it.

By pushing individuals to consume private goods and services to defend against the depletion of common goods, defensive consumption becomes an engine of economic growth. In fact, the depletion of natural and social capital opens the way to new business opportunities to

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address and buffer their impacts. Air filters and bottled water protect people from pollution; private security and insurance services shield from criminality; home entertainment offers companionship to the lonely; in these examples collective issues become fertile ground for new businesses and stimulate new economic activity which, however, offers an individual patch, without solving the collective problem. What is more, individuals need to work harder to afford the new defensive consumption. As degradation progresses, the need for defensive consumption expands, setting people on a defensive treadmill where the protection they gain from their defensive consumption is lost as the erosion of common goods progresses. The economy thrives by offering market solutions to losses that are collectively endured, and thanks to the increased working efforts to finance the new expenditures. This is how defensive consumption explains why declining environmental sustainability, rising stress and mental disorders, declining social relations, increased loneliness, and flat or negative well-being trends follow economic growth in many affluent societies (Dixon-Decleve et al., 2022; Macchia, 2022; Sarracino and Mikucka, 2017).

The theoretical foundations of defensive growth are well established (Bartolini and Bonatti, 2003; Bartolini and Bonatti, 2008), and various studies provided evidence supporting its hypotheses and expectations (Bartolini et al., 2023). However, we lack estimates of how much consumption and economic output is dedicated to defending well-being against social and environmental degradation. The information typically available in national accounts and social surveys is insufficient to distinguish defensive expenditures from other forms of consumption.

We address this gap by leveraging the relationship between subjective well-being, aggregate consumption, and societal “bads”. Given the difficulty of observing actual consumption behaviour, we adopt a valuation approach based on compensating differentials. Specifically, we estimate the consumption that would be required to maintain well-being constant in presence of increasing social or environmental degradation – what we will refer to in the following as compensating consumption. Compensating consumption captures the shadow cost, akin to the economic concept of marginal rate of substitution, between consumption and public bads. This does not reflect actual expenditures, but rather the amount of consumption needed to maintain subjective well-being unchanged in response to increases in social or environmental disruption. As such, our results give an indication of the extra consumption that individuals would have to adopt to protect their well-being from social and environmental degradation. In a second step, we compare compensating consumption with the compensating income we obtain using the same method, but switching aggregate consumption with aggregate income. We emphasize that this technique does not provide the actual value of defensive consumption, but only the hypothetical worth of a change in a bad.

Our empirical strategy is based on a panel of high-income countries observed between 2009 and 2019. We combine subjective well-being data from the Gallup World Poll with macroeconomic indicators on consumption and a selection of social and environmental variables. These include income inequality, mistrust, distress, lack of prosocial behaviour, PM2.5 air pollution and temperatures of the surface of the earth, measured in °C. We focus on these variables because they represent plausible externalities of economic activity with verifiable effects on well-being and are widely available over time and across countries.

We contribute to the literature in various ways. First, we contribute to the valuation literature (which we discuss in Section 6) by relating our compensatory amounts to observed consumption and GDP per capita, essentially providing a welfare equivalent value of defensive measures. This is different from what has been done in previous studies using compensating differentials. Here, we recognize that the erosion of social and natural resources creates new business opportunities that contribute to “uneconomic” growth. Such growth is undesirable as it arises from social and environmental decay, creates new common degradation, and establishes a self-reinforcing vicious cycle of growth, disruption and new growth. Our estimates are a first step toward the more ambitious goal of

establishing how much is the share of the economy dedicated to defensive consumption. If we could reduce social and environmental degradation, while keeping everything else constant, defensive consumption would decrease; economic activity – and therefore growth – would be smaller, but also better suited to support individuals' well-being.

The second contribution of our work is that we apply the method of compensating differentials to the Gallup World Poll, an internationally harmonized yet underused dataset for this kind of analysis. Third, we estimate compensating differentials with respect to consumption, as well as aggregate income, and discuss the implications of the results we obtain.

Our work further adds to the literature on the limits of GDP as a measure of progress. Establishing whether a significant portion of economic activity is defensive would allow to tell good, creative-led growth from the bad, defensive one, where only the former could contribute to real progress. Recognizing this distinction invites us to rethink policy priorities: toward prevention rather than repair, and investing in public goods rather than inciting private coping. It also calls for a reconsideration of what economic indicators should measure: not merely the quantity of output, but the quality of life they enable and the sustainability with which it is achieved (Sarracino and Slater, 2026).

In the next two sections, we first introduce the data used in our analysis and then we detail the method. In Section 4, we report our main findings, whereas Section 5 shows the robustness of our findings to alternative measures of environmental bads, and to potential endogeneity issues. In Section 6 we compare the magnitude of our results to those from previous studies providing compensatory variations for various kind of bads and at different levels of analysis. The last section summarizes our main findings and discusses their implications.

2. Data

The key variables in our analysis are subjective well-being (SWB), aggregate consumption per capita, and a few social and environmental bads. These data are sourced from various datasets and merged in a single, unbalanced panel dataset, covering high-income countries from 2009 to 2019. The choice of the period of analysis is dictated by the availability of individual level data on SWB and other socio-demographic controls which are sourced from the Gallup World Poll (Gallup, 2024). We limit our analysis to 2019 to exclude the Covid-19 period when the pandemic might have affected the relationship between our variables of interest in unpredictable ways.

The dependent variable is the individual-level Cantril ladder of life satisfaction, which asks “Please imagine a ladder with steps numbered from zero at the bottom to 10 at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time?”

Aggregate consumption per capita is sourced from the Penn World Table and it measures real consumption at constant 2017 national prices (in million 2017 USD). GDP per capita, which we use as an alternative to consumption later in the analysis, is also sourced from the Penn World Table (Feenstra et al., 2015). Data on social and environmental degradation, which we also refer to as “bads”, are derived from multiple datasets and aggregated as follows:

- *Distress*, an index which we construct as the first principal component of three variables: the country-year share of people who feel pain, worry and stress. These are sourced from the Gallup World Poll, which asks respondents to report whether they felt any of the above feelings the day before (with a yes or no answer). We take the weighted average per country-year of the three variables, that is the share of people who answered “yes” to each of the questions, and we construct the index on the three shares.

- *Lack of pro-social behaviour* is the average of the shares of respondents in each country-year answering “no” to each of three variables sourced from the Gallup World Poll: donating money, volunteering, and helping strangers. Each component is assessed through responses to the question: “In the past month, have you done any of the following? A. Donated money to a charity; B. Volunteered your time to an organisation; C. Helped a stranger or someone you didn't know who needed help.”
- *Mistrust* measures the share of people who state they do not think others around them can generally be trusted. The variable comes from the Survey Data Recycling 2.0 (SDR) project, a harmonized dataset of a number of social surveys (Slomczynski et al., 2023). Mistrust is the variable for which we have the least observations, with the series starting in 2009 and ending in 2017. The observations are unbalanced across country-years as the trust question was not asked consistently in all social surveys that compose the SDR, and when asked it is possible it was in different years, with different intervals and in different countries at the time.
- *Gini index of income inequality* is sourced from the Standardized World Income Inequality Database and it measures the Gini of disposable income per country (Solt, 2020).
- *Temperatures of the surface of the Earth*: sourced from Our World in Data,¹ it measures the temperatures of the surface of the earth, expressed in °C.
- *Particulate Matter (PM) 2.5* is a measure of pollution expressed as mean annual exposure (micrograms per cubic meter). Population-weighted exposure to ambient PM2.5 pollution is defined as the average level of exposure of a nation's population to concentrations of suspended particles measuring less than 2.5 µm in aerodynamic diameter, which are capable of penetrating deep into the respiratory tract and causing severe health damage. Exposure is calculated by weighting mean annual concentrations of PM2.5 by population in both urban and rural areas.² PM2.5 is observed from 2010 onwards and sourced from the World Development Indicators of the World Bank (The World Bank, 2024).

3. Methods

We employ the method of compensating differentials to compute the monetary equivalent of social and environmental bads. A widespread literature has used the Wellbeing Approach (WA), or Life Satisfaction Approach (LSA), to derive monetary values of non-marketable goods.³ This method uses subjective well-being measures to derive marginal rates of substitution between non-market goods and measures of income, which can be used to measure the compensating (or equivalent) surplus (Fujiwara, 2013; Frey et al., 2009).

We estimate the compensating surplus in terms of willingness to accept the negative change: compensating surplus is the amount of

money, paid or received, that will leave the individual in his initial welfare position following a change in the good (or bad) (Fujiwara, 2013). In our case, we are interested in how much people should consume to accept the negative change, that is, an increase in social and environmental degradation, to maintain their well-being unchanged. Essentially, by measuring the marginal disutility of social and environmental bads, as well as the marginal utility of consumption, we can determine the trade-off between consumption and the bads, and assign the bads a monetary value. Hence, this approach allows to compute the costs of social and environmental degradation, by monetizing the well-being losses caused by these bads.

To implement this method, we investigate the relationship between SWB, consumption and bads using Ordinary Least Squares (linear probability) to estimate the following equation:

$$SWB_{i,c,t} = \alpha + \beta_1 (Bads_{c,t}) + \beta_2 (\text{Log Consumption } pc_{c,t}) + \beta_3 Controls_{i,c,t} + \beta_4 Controls_{c,t} + \lambda_t + u_{i,c,t} \quad (1)$$

where $SWB_{i,c,t}$ is the subjective well-being of each individual, measured with the Cantril ladder of Life satisfaction, in country c at time t , $\text{Log Consumption } pc_{c,t}$ is the natural logarithm of consumption per capita for each country year, and $Bads_{c,t}$ represents a matrix of the social and environmental variables mentioned above, measured as the level of bad in each country-year. λ_t are time dummies and $u_{i,c,t}$ are standard errors clustered at the country level. We further include a set of controls to account for socio-demographic and country characteristics that might affect the relationship between the bads and subjective well-being. In particular, we include a number of individual level controls sourced from the Gallup World Poll, and a number of country level controls. Individual level controls are: age categories (15 to 25, 26 to 45, 46 to 65, and 66+), whether the respondent is unemployed, educational attainment in categories, a dummy for female gender, household size, marital status in categories, income expressed in quintiles, and whether the respondent resides in a urban or rural area. Country level controls include countries' unemployment rate and inflation rate to account for the state of the economy and lastly, we include macro-region dummies. We estimate the equation using a weighted OLS on pooled micro-data and cluster standard errors at the country level. Our estimates should be interpreted as associations used to recover a monetary valuation of bads under the life satisfaction approach, rather than as causal effects of within-country changes.

We regress individuals' SWB on all social bads (Gini, mistrust, lack of pro-social behaviour and distress) in one equation, and in a separate equation we regress SWB on the environmental variables (temperatures of the surface of the earth in °C and PM2.5). In a robustness test we run a unique regression with all bads included simultaneously (results are qualitatively comparable to the main results, and are available in the appendix, Table A5). We do not use the simultaneous equation as main result because we lose nearly half of our observations in doing so. In the appendix, we also report the results of the six regressions of SWB on each bad independent of the other (Table A6).

To compute the compensating differential, we set $\Delta SWB = 0$, where the Δ can be thought of as the difference between SWB in the “absence” of bad and SWB under an increase in the bad,⁴ and obtain the following formula for the compensating differential (please see Appendix B for the full step by step derivation of this formula):

¹ Data Page: Average annual surface temperature, part of the following publication: Hannah Ritchie, Pablo Rosado, and Veronika Samborska (2024) - “Climate Change”. Data adapted from Contains modified Copernicus Climate Change Service information. Retrieved from <https://archive.ourworldindata.org/20260518-093348/grapher/average-annual-surface-temperature.html> [online resource]

² PM2.5 data were sourced in early 2024 from the World Development Indicators via the world bank function *wbopendata* on STATA but has since been moved to the WDI archives.

³ As examples, the wellbeing approach as a valuation technique has been applied to air pollution (Welsch, 2002, 2006), aircraft noise (van Praag and Baarsma 2005), climate (Rehdanz and Maddison, 2005), terrorism (Frey et al., 2009b), corruption (Welsch, 2008), conflict (Welsch, 2008b), and fear of crime (Moore and Shepherd, 2006). For a thorough review of the method's critiques and comparison to hedonic pricing or contingent valuation methods to value public goods and bads please refer to the papers by Levinson (2012), Welsch (2006) and Frey et al. (2004).

⁴ Note here that for the sake of explaining the formula of the compensating differentials, we set the Δ to be the difference between a situation with no bad to one with a bad. However, in our theoretical framework the bad exists and it increases with economic activity, as per the defensive growth model (Bartolini and Bonatti, 2008).

$$\text{Compensating Differential} = \overline{\text{Consumption}_{pc}} \left(e^{\left(\frac{\beta_1}{\beta_2} SD_{bad} \right)} - 1 \right) \quad (2)$$

where SD_{bad} denotes the standard deviation of each bad, and $\overline{\text{Consumption}_{pc}}$ is the average consumption per capita per year in the sample.

Eq. (2) represents the additional annual consumption per capita, evaluated at sample mean, required to offset the predicted well-being loss associated with a one standard deviation higher level of the bad. This formula then represents the monetary equivalent of the bads, that is, the amount of *compensating consumption* in dollars per capita required to hold well-being constant in presence of a marginal change in any of the bads, accounting for the non-linear relationship between well-being and consumption.

4. Results

Our computations indicate that compensating consumption ranges between \$2381 and \$3341 for social bads, and between \$3933 and \$6287 for environmental degradation. As shown in column 1 of Table 1, consumption per capita should increase by \$3341 per year to maintain subjective well-being levels unchanged in presence of an increase in one standard deviation (SD) in mistrust (which amounts to around 14% in our sample). This is the highest compensating consumption value among the social bads. As for the other social bads, one standard deviation increase in distress is valued at \$2381, the lowest compensating consumption according to our results. A one standard deviation increase in the share of people who do not engage in pro-social behaviours (12.14%) would require an additional consumption of \$2854 per capita per year. Lastly, an increase in inequality, as measured by the Gini index of income, would require \$2045 per person per year to maintain subjective well-being unchanged. Among the environmental variables, the lowest compensating consumption is for the temperatures of the surface of the Earth, around \$3933 per capita per year for one standard deviation, whereas the compensating amount for PM2.5 is 6287 dollars.

In Table 1 we further report the unit cost of each bad, that is the value for one unit of bad. These are obtained by dividing compensating consumption by the observed standard deviation of the bad and are reported to facilitate the comparison with the monetary values of bads from previous studies.

These values are obtained using the compensating differential formula for the willingness to accept a standard deviation increase in the bad, as expressed in Eq. (2), and are based on the coefficients of consumption and bads resulting from regression (1) and reported in Table 2.

The signs of the coefficients in Table 2 suggest that all the considered bads correlate negatively with SWB in a sizeable and statistically significant way. For instance, one standard deviation higher Gini index (around 5.11 points in our sample) correlates with 0.16 points lower SWB ($-0.0315 \times 5.11 = -0.16$). Similarly, one standard deviation higher

Table 1
Compensating Consumption per bad.

	Compensating Consumption	Unit costs
	\$ per capita	\$ per capita
Gini	3045.24	596
Mistrust	3341.99	224
Distress	2381.03	374
No prosocial behaviour	2854.39	235
Temperatures	3933.25	547
PM2.5	6287.67	439

Note: all compensatory amounts are to be interpreted as the monetary value of one standard deviation of each bad, expressed in dollars per capita per year. Column 2 is intended to facilitate the comparison with the monetary valuation of bads from previous literature.

Table 2
regression of subjective well-being on social and environmental bads.

	Cantril ladder of life satisfaction			
	(1)		(2)	
Gini	−0.0315*	(0.0138)		
Mistrust (share)	−0.0118***	(0.00308)		
Distress (share)	−0.0200**	(0.00677)		
No prosocial behav. (share)	−0.0125**	(0.00376)		
Temperatures (°C)			−0.0322**	(0.0109)
PM25			−0.0251***	(0.00467)
Log Consumption	1.792***	(0.229)	2.032***	(0.215)
Constant	−9.925***	(2.494)	−14.62***	(2.301)
Time dummies	Yes		Yes	
Controls	Yes		Yes	
N	258,291		472,135	
Countries	42		46	
R2	0.202		0.169	

Note: *** < 1%; ** < 5%; * < 10%. Standard errors clustered by country are shown in parentheses. Individual level controls include age categories, unemployment and educational attainment, gender, household size, marital status, income in quintiles, whether urban or rural resident; Macro level controls include unemployment rate, inflation rate, and macro-region dummies (Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, North America, Sub-Saharan Africa. East Asia and Pacific is the baseline). Year dummies are included, the period of observation is 2009–2017 in the first sample, and 2010–2019 in the second. The sample is smaller in column 1 as Mistrust is not observed every year. Sample 1 includes 42 countries, sample 2 includes 46 countries. Sample descriptive statistics and country composition are reported in Table A1 in the Appendix.

mistrust correlates with nearly 0.17 points lower SWB. As for the environmental bads, one SD higher temperatures (7.18 °C) correlate with 0.23 points lower SWB, and one standard deviation higher PM2.5 (14.29 micrograms per cubic meter) is associated to 0.36 points lower SWB. Table A1 in the appendix reports the descriptive statistics (including averages and standard deviations) of the two analytical samples, as well as the list of countries included in each.

Consumption per capita attracts high and statistically significant coefficients in both regressions. Partial correlations are 1.79 and 2.032 according to the specification. Thus, a 10% higher consumption correlates with 0.17 points higher SWB on a 0–10 scale ($=1.78 \times \ln(1.10)$) in the social bads specification, and by 0.19 points in the second specification with environmental bads (see column 2 of Table 2).

All control variables mentioned in the previous section are not shown for brevity, but can be found in Table A2 in the appendix. In the first specification, shown in column 1 of Table A2 in which we regress SWB on social bads, we find that the inflation rate attracts a negative and statistically significant coefficient (at 10%), whereas the unemployment rate attracts a very small positive, non-statistically significant coefficient. In the second specification (column 2) both the coefficients on inflation and unemployment are negative, small and insignificant. All other individual level controls attract significant coefficients, with the expected signs, in both specifications. For instance, women, richer and more educated respondents report a higher subjective well-being than others; whereas being separated or widowed, and unemployed correlates to lower SWB.

Typically, compensating valuations are estimated using the marginal rate of substitution between the public good (or bad, as in our case) and income. To align with previous literature, we estimated a variant of Eq. (1) in which we regress SWB on the bads and on the logarithm of GDP per capita, rather than on consumption.

Table 3 reports the compensating income amounts, estimated using Eq. (2). We observe that compensating income - that is, the amount of GDP per capita necessary to accept an increase in the bad - is much larger than compensating consumption.

Our computations show that the lowest compensating income amount is \$6357 for one more standard deviation of distress, and the largest among the social bads is \$11,913 for lack of prosocial behaviours. One standard deviation higher temperature is compensated with an extra \$9418 of total output produced, whereas one SD higher in pollution is valued at \$24,859.

The fact that compensating income is higher than compensating consumption suggests that a large share of responses to degradation operate through savings and investments, rather than contemporaneous consumption.⁵ For instance, many forms of responses to social and environmental degradation (such as healthcare, justice, environmental monitoring and remediation, housing quality or climate change adaptation investments) are undertaken by the public sector through investments, which are part of GDP. Savings and investments, whose benefits materialise over time, allow societies to smooth the impact of the bads and to create protection from future degradation. This is consistent with the finding that income buys, at least in part, hope (Pleeging et al., 2021): higher income not only means higher consumption today, but also the possibility of buying protection against the uncertainty of the future. It is worth noticing that individuals at the low end of the income distribution are particularly vulnerable as their ability to finance defensive consumption is more limited than for others. Finally, we emphasize that our estimates are not actual consumption responses, but rather valuations: the difference between the compensating income and consumption is unrelated to the actual savings or investments.

The coefficients of the regression informing Table 3 are shown in Table A3 in the Appendix. All the coefficients on both social and environmental bads are negative and statistically significant: GDP per capita positively correlates to SWB, with coefficients slightly lower than those of consumption. A 10% higher GDP per capita correlates positively with SWB: 0.086 ($=0.908 \cdot \ln(1.10)$) and 0.113 ($=1.192 \cdot \ln(1.10)$) points according to the specification with the social or environmental bads respectively (see Table A3 in the appendix).

It is difficult to establish how small or large are the compensatory amounts we reported in Tables 1 and 3. We discuss our results firstly by relating them to consumption and GDP per capita, then by computing the compensating amounts by countries using their observed changes in the bads; and, lastly, by comparing them to previous literature in Section 6.

Table 1 indicates that the sum of all compensating consumptions is

Table 3
Compensating Income per bad.

	Compensating Income	Unit Values
	\$ per capita	\$ per capita
Gini	9829.25	1923
Mistrust	9509.91	638
Distress	6357.90	998
No prosocial behaviour	11,913.58	981
Temperatures	9418.51	1310
PM2.5	24,859.33	1738

Note: all compensatory amounts are to be interpreted as the monetary value of one standard deviation of each bad, expressed in dollars per capita per year. Column 2 is intended to facilitate the comparison with the monetary valuation of bads from previous literature.

⁵ In this case we should more correctly speak about defensive investments, rather than consumption.

around \$21,800 per capita. That is, if societies spent the whole amount necessary to defend themselves from one standard deviation of each bad, then they would spend an extra \$11,600 on social bads each year, and \$10,200 on environmental bads. This corresponds to roughly 65% of the observed yearly consumption per capita in our sample.

Total compensating income, the sum of compensating income values from column 1 of Table 3, is larger than total compensating consumption. If societies produced an amount of aggregate output sufficient to defend societies from one full standard deviation in each bad, total compensating GDP would amount to an additional \$72,000 per capita, per year. Of these, approximately \$36,000 would be devoted to compensating for the well-being loss by higher social disruption, and the remaining to compensate from increased temperatures and particulate matter. This corresponds to roughly 150% of the observed yearly GDP per capita.

We report compensating values for a one standard deviation increase in each bad for ease of comparisons of welfare costs across indicators. This should be interpreted as a benchmark normalization, not as a behavioural claim that people completely offset a full standard deviation deterioration in each bad. The extent of defensive responses is likely to differ across bads and may be substantially smaller than one SD. To provide more relatable estimates, we also reported the compensatory values per unit of bad. These values can be scaled to any plausible change in exposure to bads, whereas the SD-based figures provide the most readily comparable summary across domains.

For example, Fig. 1 shows the compensatory amounts computed for the United States given their observed changes in the bads in the considered period. These figures are computed as the unit values of the bads multiplied by the observed deviation in each of the bads. In the US, compensating consumption is around \$6000: this is how much would be needed to compensate individuals from the decrease in subjective well-being associated to increases in inequality, in the share of people in distress and to a decrease in pro-social behaviours. This figure suggests that the equivalent of nearly 12% of total per capita US consumption could be the result of rising social bads. Compensating income instead amounts to around 16,000 US\$ per capita.

5. Heterogeneity

Prior studies documented substantial cross-country heterogeneity in the welfare costs of environmental degradation (e.g., Giannadaki et al., 2018). Although our framework does not allow for country-specific well-being regressions, it is possible to extend the example of the United States to the other countries included in our analysis.

The idea is to keep the marginal utility of consumption and the marginal disutility of the bads constant across countries, essentially assuming a constant marginal rate of substitution, and allowing average consumption and changes in the bads to vary by country.

We thus compute the compensating differential using Eq. (2), where consumption is defined as the country's average consumption, and the standard deviation of each bad is computed by country. Then, to obtain the unit values we divide the compensating differential by the standard deviation. Lastly, we compute the expected compensating consumption as each country's unit value multiplied by the observed change in each bad. This change is the difference between the amount of bad in the first and last year of observation by country.

Fig. 2 shows the distribution of compensating consumption across countries, ranked by consumption equivalent. Unsurprisingly, the countries where bads grow less or decrease exhibit smaller compensatory variations. Compensating consumption is highest in Luxembourg, the Netherlands, Korea and Sweden. Countries with the lowest values are the United Arab Emirates, Cyprus, Estonia, and Bahrain – for which we observe only increases in the environmental bads – as well as the UK, Spain and Slovenia. The estimated consumption necessary to maintain well-being unchanged in presence of the increases in all six social and environmental bads ranges between \$2000 per person, per year, in

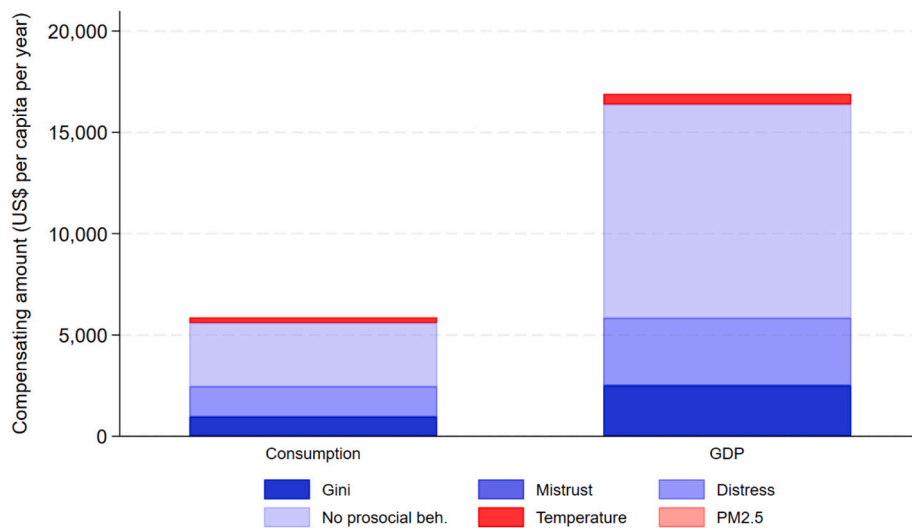


Fig. 1. Estimated compensatory amounts for the United States.

Note: Compensating amounts are computed as the unit values times the observed deviation in each bad over the whole period for which the bads are observed in the country. Eventual negative values, due to decreases in the bads, are set equal to zero as negative compensations variations are meaningless for the willingness to accept a bad. Unit values are obtained from applying Eq. (2) to the US, that is, using their observed consumption per capita and the standard deviation of each bad. Then, displayed compensating amounts are the unit value per bad multiplied by the difference in bad observed between the last and the first period.

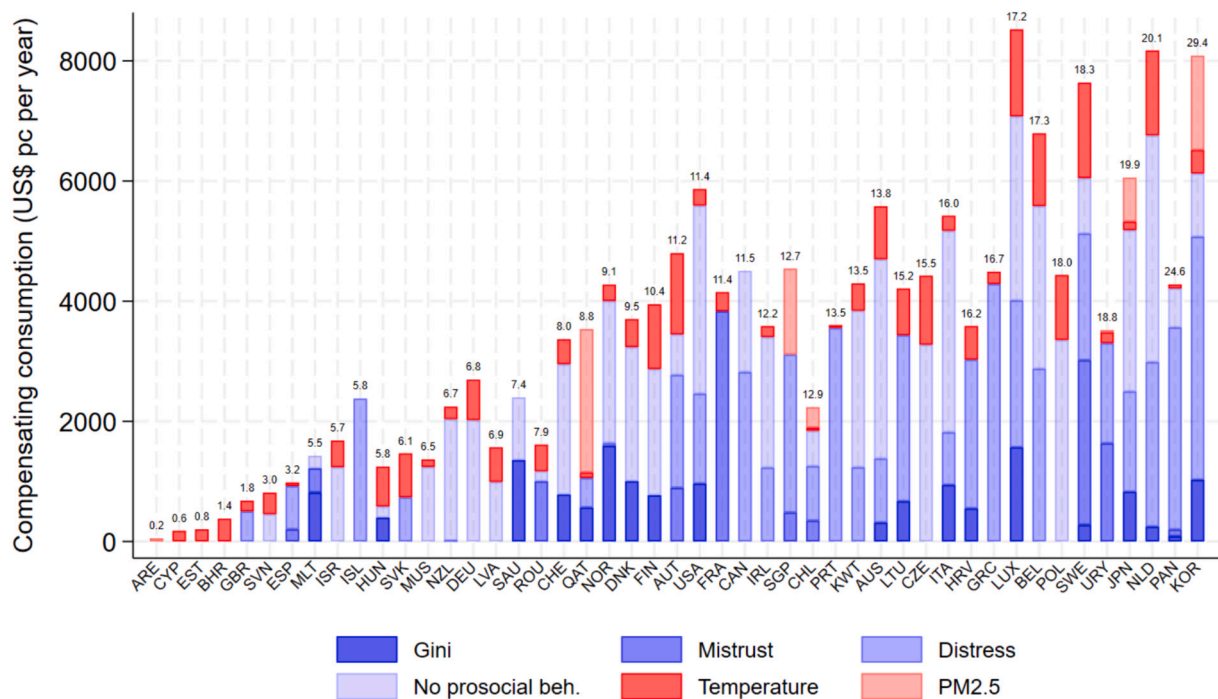


Fig. 2. Estimated compensating consumption by country.

Notes: The figure is ranked by equivalent compensating consumption (displayed over each bar), that is, the value of estimated compensating consumption over observed consumption per capita. Estimated compensating variations are computed as the unit bad multiplied by the observed change in the bads over the period, for each country. Data for social variables are missing for United Arab Emirates and Bahrain; data for environmental variables are missing for Malta. For the rest of the countries, if a bad's value is missing it indicates a decrease in the bad over the observed period.

Switzerland and more than \$8000 in Luxembourg. These are equivalent, respectively, to 12% and 17% of consumption per capita in each country. The figure is ranked by consumption equivalent (reported in black over each country's bar plot) which is the compensating consumption value to total observed consumption. We find that the increases in the bads are worth, on average 10% of actual average consumption per capita, and range between less than 1% and 30%.

Despite their merely hypothetical nature, these figures indicate a

plausible range of within-country variations in compensating consumption. Fig. A1 in the appendix reports the same information for the estimated compensating income by country.

6. Robustness tests

Our selection of environmental bads is constrained by data availability. To test the robustness of our results to alternative specifications,

we estimate the same regression of Eq. (1) using an alternative composite measure of environmental degradation. We construct this variable using data from the Quality of Governance (QoG) Institution,⁶ which sources environmental variables from The Emissions Database for Global Atmospheric Research (EDGAR) - Global Air Pollutant Emissions dataset (Povtchina et al., 2021; Crippa et al., 2019). The QoG data includes harmonized, country level data on various anthropogenic greenhouse gas emissions and air pollutants over time. We derive the composite degradation indicator as the first principal component of nine pollutants contained in the EDGAR dataset. These include SO₂, PM_{2.5}, PM₁₀, OC, NO_x, NMVOC, NH₃, N₂O, CO₂.⁷ The resulting indicator serves as a synthetic measure of the overall burden of anthropogenic emissions.

We did not include this indicator in our main analysis as its components would be highly collinear with environmental bads we used (PM_{2.5} and temperatures) and would introduce double counting.

Table 4 shows the results of the two estimated equations: in column 1, we include the composite environmental degradation indicator as a control along with consumption per capita, whereas in column 2 we control for pollution and GDP per capita. In both specifications, environmental degradation negatively correlates with subjective well-being, whereas both consumption and GDP are associated with higher SWB. Table A4 in the Appendix shows the full table of results, including control variables.

Our figures indicate the compensating consumption values are \$3200 per capita per year, which is slightly less than the value estimated in our main analysis. Compensating income values amount to \$5500, also in this case less than the income valuations estimated earlier.

Our main results may be subject to endogeneity issues. For instance, institutional factors such as quality of infrastructure or the welfare state might be influencing both the social bads and individuals' subjective well-being, making our regression subject to omitted variable bias. Similarly, in the environmental bads equation, PM_{2.5} might be correlated with other polluting factors that also influence well-being. To address endogeneity, we estimate an instrumental variable (IV) specification in which each bad is instrumented using its first and second lags. For more details on the instrumental variable approach, including the discussion of the instruments and their validity, the direction of bias of the IV coefficients compared to the OLS, and for the full tables of results, please see Appendix C.

The results using the IV approach confirm the negative association between bads and subjective well-being. In the regressions with consumption, the coefficients that retain a statistically significant negative effect on subjective well-being are mistrust, lack of prosocial behaviours and PM_{2.5}, whereas consumption attracts positive and significant coefficients, thus confirming the findings from the OLS results. The rest of the bads' coefficients instead lose statistical significance under IV. This attenuation suggests that part of the coefficients in our main analysis may reflect endogenous associations between SWB and the bads. Similar results apply to the equation with GDP, in which mistrust, lack of prosocial behaviours and PM_{2.5} negatively and significantly correlate with SWB.

Compensating amounts computed using IV coefficients remain

qualitatively similar. For the variables that retain statistically significant coefficients, compensating consumption amounts to \$24,000, slightly larger than the total compensating consumption obtained from our main analysis. Of these, \$6000 are for mistrust, \$12,000 for lack of prosocial behaviours and the remaining \$4000 for PM_{2.5}. Total compensating income instead is around \$58,000, about 14,000 less than in the main analysis.

7. Our results in context

The life satisfaction approach provides an alternative to traditional valuation methods such as contingent valuation and hedonic pricing, both of which have been widely used to estimate the monetary value of non-marketable goods and bads. Contingent valuation, a stated preference technique, elicits individuals' willingness to pay (WTP) for an improvement or their willingness to accept (WTA) compensation for a deterioration of a given good by directly asking them through surveys (Mitchell and Carson, 2013). While widely applied in environmental and public economics, this approach is susceptible to hypothetical bias, as respondents may overstate or understate their valuations depending on the framing of questions, strategic incentives, or the difficulty of accurately pricing intangible benefits (Hausman, 2012). Alternatively, the hedonic pricing method infers the value of non-market goods from observed market transactions, such as variations in property prices reflecting differences in environmental quality or exposure to disamenities, and it assumes that perfectly mobile individuals would relocate to better housing with better amenities (Rosen, 1974). This method, however, requires strong assumptions about market efficiency and individuals' ability to perceive and act upon differences in non-market attributes, which may not always hold.

In contrast, the life satisfaction approach overcomes these limitations by leveraging self-reported well-being measures as a proxy for utility. By regressing life satisfaction scores on income and non-market factors of interest (such as environmental quality or social conditions) we can derive implicit monetary valuations based on how changes in these factors correlate with subjective well-being (Frey et al., 2010; Welsch, 2006). This method does not require individuals to explicitly assign a monetary value to non-market goods, reducing the cognitive burden and potential biases associated with contingent valuation surveys. Moreover, it captures individuals' actual experiences rather than their hypothetical choices, making it suitable for assessing public goods and externalities that lack a market.

Despite its advantages, the life satisfaction approach has limitations, as it relies on the assumption that reported well-being accurately reflects true utility and that income has a stable and comparable marginal effect across individuals and contexts (Diener et al., 1999; Frey and Stutzer, 2000; Veenhoven, 1993). Nonetheless, it provides a complement to other valuation methods and enhances our understanding of the welfare costs associated with environmental and social disruptions. Welsch and Kühling (2009) provide a thorough discussion of the life satisfaction approach used in the literature of valuation of non-market goods, as well as a review of the literature.

Many scholars in previous literature adopted the life satisfaction approach to estimate the value of social, non-market goods and bads. Here, we attempt to compare our results to those found in the literature. However, a direct comparison is often complicated by the differences in methods, units of measure of the bads considered, and the level of analysis of each study.

Frey et al. (2009b) estimated that the compensating surplus, or the necessary income to forego terrorism, amounts to \$2150 and \$7641 per capita per year in France and the British Isles, respectively. Similarly, Clark and Oswald (2002) estimated the costs of widowhood at £170,000 per capita per year, while the cost of falling unemployed is significantly higher at £276,000, based on a sample of UK individuals between 1991 and 1997. Using data from the British Household Panel Survey, Powdthavee (2008) found that an increase in social involvement

⁶ <https://www.gu.se/en/quality-government/qog-data/data-downloads/enviromental-indicators-dataset>

⁷ Cronbach alpha of the composite indicator is 0.94, suggesting a good sorting of the variables. Pollutants are: Sulfur dioxide, Fine particulate Matter (10 and 2.5), Carbon Monoxide, Nitrogen Oxides, Non-Methane Volatile Organic Compounds, Ammonia, Nitrus Oxide, Carbon Dioxide. We acknowledge that the mechanisms for which pollutants and greenhouse gases affect well-being are different, as the latter are more detrimental in cumulative terms whereas pollutants are detrimental through contemporaneous exposure and local concentrations. When we remove the greenhouse gases from the indicator (CO₂ and NO₂), the results are qualitatively very similar.

Table 4

Regression of subjective well-being on a composite pollution indicator.

	Cantril ladder of life satisfaction	
	(1)	(2)
Environmental Degradation	−0.000276***	(0.0000469)
Log consumption	2.388***	(0.222)
Log GDP pc		1.195***
Constant	−18.99***	(2.277)
		−7.170**
N	490,828	490,828
N clusters	49	49
R2	0.158	0.140
Controls	Yes	Yes

Note: *** < 1%; ** < 5%; * < 10%. Standard errors clustered by country. Individual level controls include age categories, unemployment and educational attainment, gender, household size, marital status, income in quintiles, whether urban or rural resident; macro level controls include unemployment rate, inflation rate, and macro-region dummies (Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, North America, Sub-Saharan Africa, East Asia and Pacific is the baseline). Year dummies are included - the period of observation is 2009–2019. Environmental degradation is the first principal component of 9 separate pollution variables sourced from the EDGAR dataset. The variables are SO₂, PM₂₅, PM₁₀, OC, NO_x, NMVOC, NH₃, N₂O, CO₂. Alpha coefficient reliability of the indicator is 0.94.

(measured as frequency of meetings with friends and neighbours) has the same SWB value as an additional £85,000 per year. Moreover, [Murtin et al. \(2017\)](#) determined that households would be willing to forgo half of their income (approximately \$2614 in their sample) to avoid a 1% increase in unemployment. Additionally, other findings suggest that the monetary compensation required for increased unemployment is approximately \$200 per capita per year, while inflation costs around \$70 per capita annually ([Di Tella et al., 2003](#)).

The life satisfaction approach has been used to estimate the value of the environment as well. For instance, [Welsch \(2002\)](#) estimated that individuals require \$70 per year per capita to accept a 1-kt per capita increase in nitrogen dioxide emissions. Similarly, [Di Tella and MacCulloch \(2008\)](#) found that an increase of one standard deviation in sulfur dioxide (SO₂) emissions correlates with a decline in happiness equivalent to a 17% reduction in income. Several studies employed happiness measures to value air quality improvements. [Welsch](#) utilized various cross-sectional and country-level panel data, finding that reductions in nitrogen dioxide and lead pollution in Europe from 1990 to 1997 were valued at \$750 and \$1400 per capita, respectively, in 2008 dollars ([Welsch, 2006](#)). [Levinson \(2012\)](#) estimated that the marginal willingness to pay for an increase in PM₁₀ air quality is \$459, which equates to spending \$18 per day to achieve a one standard deviation reduction in PM₁₀ levels. Using Chinese individual level data merged with daily PM_{2.5} data, [Zhang et al. \(2017\)](#) find that people are willing to pay ¥17,934 (approximately \$2900, using the conversion of 2018) per year per person on average for one standard deviation reduction in PM_{2.5}. Interestingly, using the hedonic pricing valuation method on 2020 data for Beijing, [Zhang et al. \(2023\)](#) find that the marginal willingness to pay for 1% improvement in PM₂₅ ranges between 177 and 327\$.

Other studies highlighted the economic burden of social and environmental stressors. [Powdthavee \(2008\)](#) estimated the cost of crime in South Africa at \$240 per month, while [Van Praag and Baarsma \(2005\)](#) determined that the required monthly compensation per household for airport noise in the Amsterdam region ranges between €17 and €57. [Welsch \(2008\)](#) calculated that the average monetary value of corruption is approximately \$900 per capita per year, based on a sample of around 50 countries. Furthermore, [Brown \(2015\)](#) found that the economic cost of ill-health amounts to an annual loss of \$41,650 per capita in a sample of U.S. individuals between 1975 and 2010.

Using our main specification, the compensating consumption amounts for a standard-deviation increase in the bads range from about \$2400 to \$6300 per person per year ([Table 1](#)), while the corresponding GDP-based amounts range from roughly \$6400 to \$24,900 ([Table 3](#)). For ease of comparison with previous studies, our implied unit costs fall between \$224 and \$596 in consumption terms and between \$638 and \$1923 in GDP terms. Hence, our valuations of social degradations are in the same order of magnitude as several life satisfaction valuation benchmarks - e.g., [Frey et al. \(2009b\)](#) report compensating amounts for terrorism on the order of a few thousand dollars per year, and [Welsch \(2008\)](#) estimates corruption costs around \$900 per capita annually. For environmental bads, the comparison is mixed: our PM_{2.5} compensating consumption amount, about \$6300 per year, is close to the valuations implied by [Levinson \(2012\)](#), who reports willingness-to-pay figures of several thousand dollars per year for a standard deviation increase in air-quality, but it is above the Chinese estimates in [Zhang et al. \(2017\)](#) (about \$2900 per year for one SD reduction). This discrepancy could be the result of different willingness to pay for pollution removal in lower and middle-lower income countries.

At the same time, some cross-country studies valuing pollutants (e.g., [Welsch, 2002, 2006](#)) report smaller annual monetary equivalents for specific emissions changes, which come close to our estimates given differences in the pollutant metrics (emissions vs concentrations), exposure mapping, and the level of aggregation. Finally, it is worth noting that within-country panel studies of major life events often deliver much larger compensating income equivalents (e.g., [Clark and Oswald's \(2002\)](#) estimates for unemployment and widowhood; [Powdthavee's \(2008\)](#) large values for social involvement), which likely reflects both the severity and immediacy of those shocks and the fact that micro-level identification tends to capture welfare losses more sharply than cross-country variation in broad macro conditions.

8. Conclusion

In this paper we estimate the monetary valuation of selected social and environmental bads in affluent economies. Using a compensating differential approach, we estimate the per capita consumption required to maintain average well-being unchanged in presence of increased social and environmental bads. In high-income countries individuals would require between \$2300 and \$6200 per year in additional

consumption to offset the well-being loss associated with one standard deviation increase in these bads. These figures reflect a monetary valuation of collective bads and should be interpreted as the compensating consumption necessary to preserve average subjective well-being in deteriorating social and environmental conditions. Under the assumption that individuals consume to defend themselves entirely from the degradation of collective goods, we find compensating consumption in high-income countries is worth about \$21,800 per year. For the sake of comparison, this is equivalent to nearly 65% of total observed consumption.

The idea of defensive consumption is not new: authors have defined defensive consumption as the amount of money people spend on private goods and services to compensate for the degradation of common goods (Antoci and Bartolini, 2004; Bartolini and Bonatti, 2008). When cooperation to address collective problems is difficult, individuals resort to private solutions to protect themselves and their loved ones. Although this theory has been extensively discussed (Bartolini and Bonatti, 2008), estimating the size of defensive consumption has proven a difficult task so far. This is why it is challenging to find a benchmark to assess the validity of our estimates. The Genuine Progress Indicator (GPI) developed by Kubiszewski et al. (2013) accounts for the depletion of natural and social capital as costs, and thus serves as a measure of the welfare-generating component of economic activity. In their study, the authors find that in 2005 the average GPI per capita was approximately 40% of total GDP per capita in their sample. This implies that the remaining 60% of GDP reflects the economic activity that does not contribute to net societal welfare - what could be interpreted as “uneconomic growth” in Daly's (1999) terms, and akin to defensive growth.

Since we do not observe the effective magnitude of social and environmental deterioration from which individuals actually defend themselves, it is impossible to establish a direct comparison between our results and the GDP-GPI gap. If we sum all the unit values obtained in our work, our compensatory income would amount to 15% of yearly GDP per capita, well below the figure by Kubiszewski and colleagues. However, if we multiply the unit values for changes under different scenarios, we obtain some comparable figures: compensatory income would stand at about 75% of yearly GDP per capita in case of half a standard deviation increase in each bad, and about 150% of yearly GDP per capita for a full standard deviation. Compared to Kubiszewski's and colleagues estimate that the GDP-GPI gap is 60%, our figures suggest that the size of the gap is consistent with societies defending themselves from an increase in the bads of about 0.4 of a standard deviation.

Our findings carry significant implications for how we conceptualize economic growth. If a portion of total consumption is defensive then part of economic activity, and therefore of GDP, is also defensive. In this light, GDP can be understood as comprising both non-defensive (creative) and defensive components. Yet only the former benefits well-being, whereas defensive expenditures do not provide durable improvements. This is because any well-being increment due to defensive expenditures is quickly off-set by adaptation, social comparisons and obsolescence. In addition, defensive expenditures require heightened work effort, with consequent pressure on people's private lives, interests and passions, and introduce a trade-off between working and leisure time, with negative consequences on individual's relational lives. Hence, the net effect of defensive expenditures for well-being is questionable, and – at best – temporary. The distinction between non-defensive and defensive components of growth is thus essential for rethinking our understanding of progress.

An economy that grows fast due to increased sales of defensive goods

exhibits high growth rates, while simultaneously failing in terms of well-being, trust, ecological integrity and all that matters for quality of life. A non-defensive growth, even if slower, may be better fit to deliver sustainability and human flourishing; it would emphasize prevention and the maintenance of public goods, rather than private coping mechanisms. Recognizing the defensive dimension of consumption has important policy implications. Rather than relying on market-based private solutions to compensate for degraded environments and fraying social cohesion, public investments in prevention and on public goods such as clean air, social trust and green spaces may be both more efficient and more equitable. These investments can reduce the need for defensive expenditures, freeing up resources for creative, productive, and life-enhancing uses.

Our results are consistent with the view that part of economic activity is driven by the need to defend well-being against rising social and environmental degradation. This may explain unhappiness, social and environmental degradation in affluent and growing economies. If left unaddressed, this pattern stimulates a growth model that is both unsustainable and self-defeating. A new model of progress, one that tracks the quality and sustainability of life, rather than just the quantity of output, is needed.

CRediT authorship contribution statement

Giulia Slater: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Francesco Sarracino:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization.

Declaration of competing interest

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Appendix A

Table A1

Summary statistics.

	Observations	Mean	Std. Dev	Min	Max
Sample 1					
SWB	258,291	6.581353	0.7404609	4.668911	7.788252
Gini	258,291	30.90529	5.116439	22.7067	48.1459
Mistrust (share)	258,291	68.10702	14.94103	0	96.48013
Distress (share)	258,291	31.2325	6.373304	17.4112	52.28193
Lack of pro-social behaviours	258,291	61.1338	12.14833	38.62043	87.145
Consumption pc	258,291	32,340.26	8582.988	13,938.75	50,708.54
GDP pc	258,291	46,481.8	17,907.3	18,877.54	101,391.8
Sample 2					
SWB	472,135	6.602262	2.023676	0	10
Temperatures	472,135	12.53593	7.189679	-4.208109	28.955
PM2.5	472,135	17.70884	14.29993	5.257788	85.96687
Consumption pc	472,135	32,549.15	8465.789	15,170.02	54,900.3
GDP pc	472,135	48,785.81	19,612.4	19,514.69	146,217.3
Sample 3					
SWB	490,828	6.580854	2.034517	0	10
Environmental degradation	490,828	339.52	818.2078	1.029414	5488.893
Consumption pc	490,828	32,339.36	8504.668	13,938.75	54,900.3
GDP pc	490,828	48,686.48	19,910.71	18,877.54	146,217.3

Sample 1: Australia, Austria, Belgium, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Panama, Poland, Portugal, Republic of Korea, Romania, Saudi Arabia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States, Uruguay.

Sample 2: Australia, Austria, Bahrain, Belgium, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Luxembourg, Mauritius, Netherlands, New Zealand, Norway, Oman, Panama, Poland, Portugal, Qatar, Republic of Korea, Romania, Saudi Arabia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Trinidad and Tobago, United Arab Emirates, United Kingdom, United States, Uruguay.

Sample 3: Australia, Austria, Bahrain, Belgium, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Luxembourg, Malta, Mauritius, Netherlands, New Zealand, Norway, Oman, Panama, Poland, Portugal, Qatar, Republic of Korea, Romania, Saudi Arabia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Trinidad and Tobago, United Arab Emirates, United Kingdom, United States, Uruguay.

Table A2

Regression of SWB on bads and consumption pc.

	Cantril Ladder of Life Satisfaction	
	(1)	(2)
Gini	-0.0315*	(0.0138)
Mistrust (share)	-0.0118***	(0.00308)
Distress (share)	-0.0200**	(0.00677)
Lack of pro-social beh. (share)	-0.0125**	(0.00376)
Temperatures °C		-0.0322** (0.0109)
PM2.5		-0.0251*** (0.00467)
Log consumption	1.792***	2.032*** (0.215)
Age (25–45)	-0.632***	-0.561*** (0.0372)
Age (46–65)	-0.778***	-0.695*** (0.0591)
Age (65+)	-0.608***	-0.561*** (0.0795)
Household size	0.195***	0.176*** (0.0141)
Female	0.150***	0.159*** (0.0185)
Married or coupled	0.151***	0.161*** (0.0300)
Separated or divorced	-0.205***	-0.235*** (0.0279)
Widowed	-0.237***	-0.204*** (0.0368)
Secondary education	0.273***	0.350*** (0.0536)
Tertiary education	0.597***	0.660*** (0.0597)
Unemployed	-0.694***	-0.622*** (0.0329)
2nd quintile	0.371***	0.360*** (0.0198)
3rd quintile	0.633***	0.610*** (0.0281)
4th quintile	0.892***	0.863*** (0.0364)
5th quintile	1.224***	1.200*** (0.0484)
Small town or village	-0.0873**	-0.0540 (0.0320)
City	-0.0809*	-0.0546 (0.0368)
City suburbs	-0.128**	-0.0339 (0.0451)
Inflation rate	-0.0420*	-0.0129 (0.0199)
Unemployment rate	0.0135	-0.0198 (0.0113)
Europe and Central Asia	0.147	0.178 (0.254)
Latin America and Caribbean	0.100	-0.0171 (0.224)
Middle East and north Africa	2.080***	1.395*** (0.242)
North America	0.781**	1.268*** (0.263)

(continued on next page)

Table A2 (continued)

	Cantril Ladder of Life Satisfaction			
	(1)		(2)	
Sub-Saharan Africa			0.595*	(0.241)
Constant	−9.925***	(2.494)	−14.62***	(2.301)
N	258,291		472,135	
R2	0.200		0.171	

Note: *** < 1%; ** < 5%; * < 10%. Standard errors shown in parenthesis are clustered at the country level. Year dummies are included, period of observation is 2009–2017 in the first sample, and 2010–2019 in the second. East Asia and Pacific is baseline of the macro-region dummies. Baseline for residency is rural area or farm.

Table A3

regression of SWB on bads and GDP pc.

	Cantril Ladder of Life Satisfaction			
	(1)		(2)	
Gini	−0.0341*	(0.0142)		
Mistrust (share)	−0.0113**	(0.00411)		
Distress (share)	−0.0183*	(0.00757)		
Lack of pro-social beh. (share)	−0.0171***	(0.00451)		
	−0.0341*	(0.0142)		
Temperatures °C			−0.0293*	(0.0125)
PM2.5			−0.0343***	(0.00577)
Log GDP pc	0.908***	(0.218)	1.192***	(0.188)
Age (25–45)	−0.634***	(0.0360)	−0.564***	(0.0366)
Age (46–65)	−0.775***	(0.0675)	−0.682***	(0.0592)
Age (65+)	−0.594***	(0.0876)	−0.536***	(0.0799)
Household size	0.179***	(0.0171)	0.171***	(0.0147)
Female	0.150***	(0.0159)	0.165***	(0.0185)
Married or coupled	0.160***	(0.0270)	0.164***	(0.0306)
Separated or divorced	−0.204***	(0.0319)	−0.231***	(0.0291)
Widowed	−0.260***	(0.0377)	−0.224***	(0.0392)
Secondary education	0.292***	(0.0398)	0.372***	(0.0519)
Tertiary education	0.604***	(0.0509)	0.653***	(0.0640)
Unemployed	−0.689***	(0.0295)	−0.621***	(0.0343)
2nd quintile	0.363***	(0.0253)	0.356***	(0.0203)
3rd quintile	0.619***	(0.0317)	0.605***	(0.0284)
4th quintile	0.875***	(0.0454)	0.857***	(0.0366)
5th quintile	1.200***	(0.0594)	1.194***	(0.0495)
Small town or village	−0.0595	(0.0356)	−0.0205	(0.0377)
City	−0.0631	(0.0393)	−0.0329	(0.0389)
City suburbs	−0.0830	(0.0450)	0.00272	(0.0449)
Inflation rate	−0.0257	(0.0174)	0.00195	(0.0211)
Unemployment rate	−0.0000265	(0.0174)	−0.0191	(0.0101)
Europe and Central Asia	0.488*	(0.182)	0.410*	(0.196)
Latin America and Caribbean	0.279	(0.156)	0.0401	(0.252)
Middle East and north Africa	1.645***	(0.257)	0.904**	(0.262)
North America	0.872*	(0.331)	1.143**	(0.328)
Sub-Saharan Africa			0.484	(0.281)
Constant	−0.799	(2.579)	−6.298**	(2.104)
N	258,291		472,135	
R2	0.191		0.165	

Note: *** < 1%; ** < 5%; * < 10%. Standard errors shown in parenthesis are clustered at the country level. Year dummies are included; the period of observation is 2009–2017 for the first sample, and 2010–2019 for the second. East Asia and Pacific is baseline of the macro-region dummies. Baseline for residency is rural area or farm.

Table A4

Robustness – SWB regression on environmental pollution.

Cantril Ladder of life satisfaction				
	(1)		(2)	
Environmental degradation indicator	–0.000276***	(0.0000469)	–0.000157***	(0.0000409)
Log consumption pc	2.388***	(0.222)		
Log GDP pc			1.195***	(0.201)
Inflation rate	–0.00545	(0.0202)	0.00910	(0.0226)
Unemployment rate	–0.0236	(0.0124)	–0.0277*	(0.0119)
Age (25–45)	–0.587***	(0.0384)	–0.591***	(0.0396)
Age (46–65)	–0.707***	(0.0606)	–0.683***	(0.0625)
Age (65+)	–0.546***	(0.0798)	–0.502***	(0.0822)
Household size	0.150***	(0.0164)	0.130***	(0.0197)
Female	0.171***	(0.0174)	0.182***	(0.0178)
Married or coupled	0.168***	(0.0313)	0.167***	(0.0330)
Separated or divorced	–0.229***	(0.0295)	–0.233***	(0.0336)
Widowed	–0.219***	(0.0389)	–0.276***	(0.0451)
Secondary education	0.379***	(0.0588)	0.427***	(0.0614)
Tertiary education	0.698***	(0.0620)	0.718***	(0.0683)
Unemployed	–0.632***	(0.0362)	–0.641***	(0.0393)
2nd quintile	0.336***	(0.0205)	0.324***	(0.0219)
3rd quintile	0.571***	(0.0294)	0.552***	(0.0312)
4th quintile	0.819***	(0.0387)	0.795***	(0.0417)
5th quintile	1.142***	(0.0509)	1.112***	(0.0555)
Small town or village	–0.108**	(0.0358)	–0.0675	(0.0475)
City	–0.127*	(0.0511)	–0.139*	(0.0627)
City suburbs	–0.0725	(0.0477)	–0.00393	(0.0536)
Europe and Central Asia	0.153	(0.205)	0.320	(0.304)
Latin America and Caribbean	1.491***	(0.215)	0.909**	(0.334)
Middle East and north Africa	0.0357	(0.217)	–0.260	(0.348)
North America	0.734***	(0.199)	1.030***	(0.261)
Sub-Saharan Africa	0.430*	(0.197)	0.322	(0.318)
Constant	–18.99***	(2.277)	–7.170**	(2.211)
N	490,828		490,828	
R2	0.158		0.140	

Note: *** < 1%; ** < 5%; * < 10%. Standard errors are in parentheses, cluster at country level. Year dummies are included; the period of observation is 2009–2019. Environmental degradation indicator is the first principal component of 9 separate pollution variables sourced from the EDGAR dataset. The variables are SO2, PM25, PM10, OC, NOX, NMVOC, NH3, N2O, CO2.

Table A5

Regression of SWB on all bads.

Cantril ladder of life satisfaction		
	(1)	(2)
Gini	–0.0401** (0.0133)	–0.0421** (0.0148)
Mistrust (share)	–0.0102*** (0.00273)	–0.00898* (0.00345)
Distress (share)	–0.0164* (0.00792)	–0.0147 (0.00815)
Lack pro-social behaviours (share)	–0.0137** (0.00394)	–0.0170** (0.00531)
Temperatures °C	–0.00996 (0.00858)	–0.00674 (0.0102)
PM2.5	–0.00179 (0.00565)	–0.0116 (0.00758)
Log Consumption	1.733*** (0.243)	
Log GDP pc		0.867*** (0.238)
Constant	–9.080** (2.623)	–0.149 (2.805)
N	239,977	239,977
N countries	40	40
R2	0.205	0.197

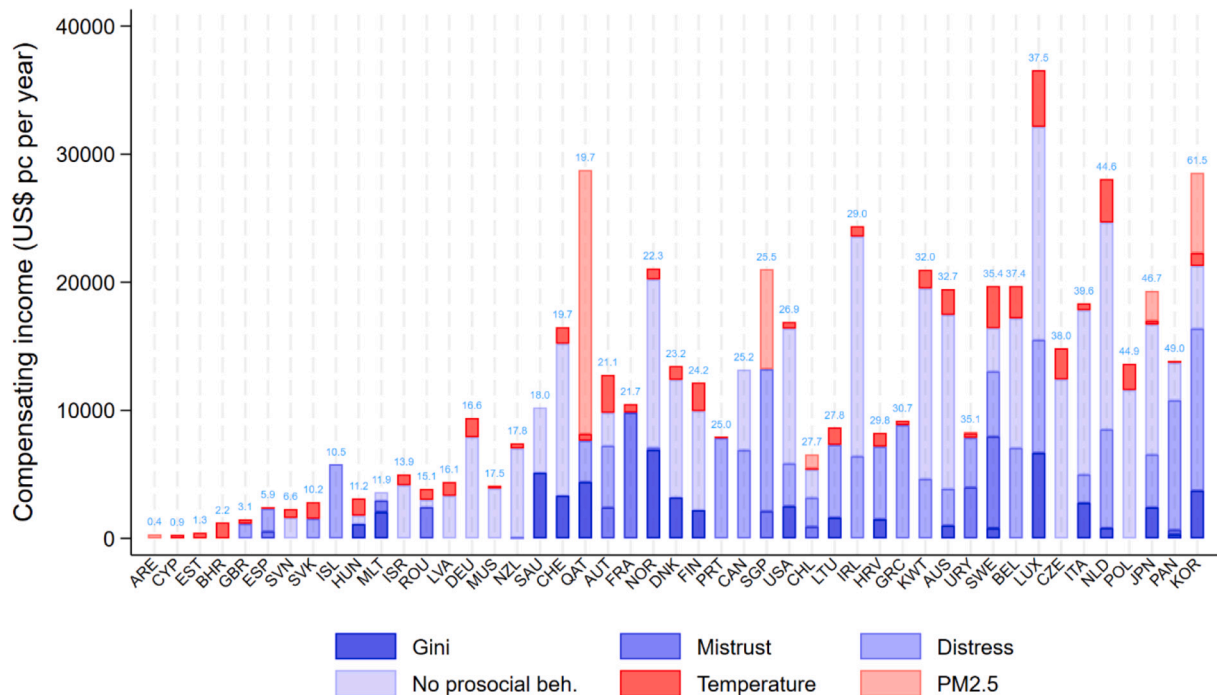
Notes: *** < 1%; ** < 5%; * < 10%. Standard errors in parentheses, clustered at country level. Year dummies included, years of observations from 2010 to 2017. All controls are included in both regressions as in main analysis.

Table A6

Regression of SWB on each bad independently of others.

Cantril ladder of Life Satisfaction						
	(1)	(2)	(3)	(4)	(5)	(6)
Gini	−0.0380*** (0.00994)					
Mistrust (share)		−0.0158*** (0.00331)				
Distress (share)			−0.0220*** (0.00593)			
Lack pro-social beh. (share)				−0.0181*** (0.00441)		
Temperatures °C					−0.0388** (0.0124)	
PM2.5						−0.0209*** (0.00552)
Log Consumption pc	2.193*** (0.207)	2.216*** (0.187)	2.098*** (0.220)	1.703*** (0.231)	2.199*** (0.209)	2.066*** (0.215)
Constant	−15.88*** (2.191)	−16.40*** (1.985)	−15.68*** (2.321)	−10.97*** (2.570)	−16.75*** (2.226)	−15.44*** (2.291)
N	557,759	260,249	677,968	667,586	657,626	488,463
R2	0.158	0.191	0.142	0.144	0.148	0.162

Notes: *** < 1%; ** < 5%; * < 10%. Standard errors in parentheses, clustered at country level. Year dummies included, years of observations from 2010 to 2017. All controls are included in all regressions, as in main analysis.

**Fig. A1.** Estimated compensating income by country.

Notes: The figure is ranked by equivalent compensating income (displayed over each bar), that is, the value of estimated compensating income over observed GDP per capita. Estimated compensating variations are computed as the unit bad multiplied by the observed change in the bads over the period, for each country. Data for social variables are missing for United Arab Emirates and Bahrain; data for environmental variables are missing for Malta. For the rest of the countries, if a bad's value is missing it indicates a decrease in the bad over the observed period.

Appendix B

Derivation of Eqs. (1) and (2)

This appendix provides a step-by-step derivation of Eq. (1) from a theoretical subjective well-being (SWB) function, and the derivation of the compensating differential in Eq. (2). Bads and consumption are observed at the country–year level. We assume the coefficient on the bads $\beta_1 < 0$ and the coefficient on consumption $\beta_2 > 0$.

1. Derivation of Eq. (1)

We start from the theoretical relationship for which subjective well-being is a report of an underlying utility function $U(\cdot)$:

$$SWB_{ict} = U(C_{ct}, B_{ct}, z_{ict}, w_{ct}) + \varepsilon_{ict}$$

where the arguments are Consumption per capita (C), Bads (B), individual level controls (z) and country level controls (w).

To capture diminishing marginal utility of consumption which we typically shows decreasing marginal returns, utility is assumed to depend on log consumption:

$$SWB_{ict} = \tilde{U}(\ln C_{ct}, B_{ct}, z_{ict}, w_{ct}) + \varepsilon_{ict}$$

By linearizing $\tilde{U}$ using a first-order Taylor expansion around a reference point (using the means $\ln C^-$, B^- , z^- , w^-):

$$\tilde{U}(\ln C_{ct}, B_{ct}, z_{ict}, w_{ct}) \approx \tilde{U}(\ln C^-, B^-, z^-, w^-) + \left(\frac{\partial \tilde{U}}{\partial \ln C} \right) (\ln C_{ct} - \ln C^-) + \left(\frac{\partial \tilde{U}}{\partial B} \right) (B_{ct} - B^-) + \left(\frac{\partial \tilde{U}}{\partial z} \right) (z_{ict} - z^-) + \left(\frac{\partial \tilde{U}}{\partial w} \right) (w_{ct} - w^-)$$

and evaluating derivatives at the reference point, and then collecting constants yields the linear approximation, where the β coefficients represent the partial derivatives:

$$SWB_{ict} = \alpha + \beta_1 B_{ct} + \beta_2 \ln C_{ct} + \beta_3 Controls_{ict} + \beta_4 Controls_{ct} + \varepsilon_{ict}$$

Allowing for time fixed effects as per our specification gives Eq. (1):

$$SWB_{ict} = \alpha + \beta_1 Bads_{ct} + \beta_2 \ln(Consumption_{ct}) + \beta_3 Controls_{ict} + \beta_4 Controls_{ct} + \lambda_t + u_{ict}$$

2. Derivation of the compensating differential (Eq. (2))

Holding all other regressors constant, Eq. (1) implies:

$$SWB = \alpha + \beta_1 B_{ct} + \beta_2 \ln C_{ct}$$

Consider an increase in bads $\Delta B > 0$ and a change in consumption from C_0 to C_1 that keeps SWB constant, that is set $\Delta SWB = 0$:

$$0 = \beta_1 \Delta B + \beta_2 (\ln C_1 - \ln C_0)$$

Solving for C_1 shows the consumption individuals will undertake in presence of an increase Δ in the bad B:

$$\ln C_1 - \ln C_0 = -\frac{\beta_1}{\beta_2} \Delta B$$

$$C_1 = C_0 \cdot \exp\left(-\frac{\beta_1}{\beta_2} \Delta B\right)$$

The compensating differential, defined as the difference between consumption at C_1 when the bad has increased, and C_0 when the bad was at its initial level, is therefore:

$$CD(\Delta B) = C_1 - C_0 = C_0 \left[\exp\left(-\frac{\beta_1}{\beta_2} \Delta B\right) - 1 \right]$$

In our main text we call the compensating differential “compensating consumption”, and it is expressed as the extra consumption needed to maintain wellbeing unchanged when bads increase by one standard deviation with respect to a situation in which the bad already exists, and individuals consume some average amount of consumption, denoted *Consumption*.

Then, substituting out C_0 with *Consumption*, and specifying the delta as SD, we obtain:

$$CC = \overline{Consumption} \left[\exp\left(-\frac{\beta_1}{\beta_2} SD_{bad}\right) - 1 \right]$$

Appendix C

As discussed in the text, our main results may be subject to endogeneity issues. For instance, institutional factors such as quality of infrastructure or the welfare state might be influencing both the social bads and individuals' subjective well-being, making our regression subject to omitted variable bias. Similarly, in the environmental bads equation, PM2.5 might be correlated with other polluting factors that also influence well-being. To address endogeneity, we estimate an instrumental variable (IV) specification in which each bad is instrumented using its first and second lags.

Finding appropriate instruments for variables such as trust, inequality and prosocial behaviours is typically difficult, because factors that influence them also likely correlate with subjective well-being. Similarly, in our micro-macro setting, instrumenting environmental bads with potentially well-being exogenous variables (such as wind-speed, as has been done in the context of Chinese counties using geo-coded individual level data (Li et al., 2024)) is likewise unfeasible due to low country level variability. Hence, our choice of instrumenting the bads with their past values is dictated by the

data and lack of other feasible instruments.

Our strategy exploits the predictable component of bads driven by their own past realizations. First stage F-statistics indicate very strong instrument relevance, with Kleibergen–Paap and Cragg–Donald F-statistics well above conventional thresholds, suggesting no weak instrument concerns. Overidentification tests (Hansen J) do not reject the null of instrument validity. While lagged bads cannot fully eliminate all sources of endogeneity, particularly if past degradation exerts direct long-run effects on well-being, they reduce concerns that contemporaneous coefficients reflect reverse causality or omitted variables bias.

The results using 2SLS confirm the negative association between bads and subjective well-being (see [Tables AC7 and AC8](#) below). For social bads, mistrust and lack of pro-social behaviour retain statistically significant negative effects under IV estimation, with coefficients of -0.0104 and -0.0242 respectively. In the OLS estimation, these were -0.0118 and -0.0125 , suggesting that the direction of the bias in the OLS estimation is both upward (for mistrust) and downward (for lack of pro-social behaviours). In other words, the OLS overestimated the effect of mistrust and underestimated the effect of lack of pro-social behaviours. For environmental bads, the coefficient on PM2.5 remains negative and statistically significant. The magnitude decreases from -0.0251 in the OLS results to -0.0163 in the IV, suggesting that part of the OLS estimate may reflect omitted factors that correlate with pollution and SWB. Nonetheless, the coefficient confirms that pollution has a robust adverse association with SWB. In both equations, consumption positively affects well-being with coefficients of 0.935 and 1.591 , respectively in the social and environmental bads equations. Some coefficients lose statistical significance under IV. This attenuation suggests that part of the coefficients in our main analysis may reflect endogenous associations between SWB and the bads.

We repeat the same analysis but with GDP per capita in the place of consumption per capita, and we find the pattern of significance of the coefficients is the same: mistrust, lack of prosocial behaviours and PM2.5 negatively and significantly correlate with SWB, with the same bias directions.

Table AC7

Instrumental variable approach on consumption equation – instruments: lags of endogenous variables.

	(1)	(2)	(3)	(4)	(5) 2 stage	(6)	(7)	(8) 2 stage
	Gini	mistrust	Distress	No PSB	SWB	Temp °C	PM25	SWB
Lag gini	1.000*** (0.0000689)	−0.000189 (0.00106)	−0.000241 (0.000229)	−0.0150 (0.176)				
Lag mistrust	−9.82e-08 (0.00000424)	1.000*** (0.0000964)	−0.0000186 (0.0000133)	−0.00843 (0.0137)				
Lag distress	−0.0000206 (0.0000154)	0.0000347 (0.000242)	1.000*** (0.0000609)	−0.0693* (0.0376)				
Lag lack PSB	−0.00000967 (0.0000162)	0.000471 (0.000321)	0.0000245 (0.0000593)	0.794*** (0.0560)				
Lag 2 gini	0.000154** (0.0000712)	0.000466 (0.00109)	0.000241 (0.000234)	−0.166 (0.182)				
Lag 2 mistrust	−0.00000158 (0.00000254)	−0.0000815* (0.0000476)	0.0000143 (0.0000123)	0.0138 (0.0131)				
Lag 2 distress	0.0000307** (0.0000131)	0.0000107 (0.000211)	0.000118** (0.0000469)	0.00631 (0.0348)				
Lag 2 Lack PSB	0.0000136 (0.0000153)	−0.000378 (0.000280)	−0.0000138 (0.0000603)	0.0880* (0.0486)				
Log Consumption	0.000181 (0.000274)	−0.00805** (0.00379)	0.00132 (0.00108)	−2.092* (1.268)	0.935*** (0.270)	−0.000195* (0.000113)	−0.0000653 (0.000361)	1.591*** (0.287)
Gini					0.0109 (0.0145)			
Mistrust					−0.0104** (0.00407)			
Distress					−0.0157 (0.00965)			
Lack PSB					−0.0242*** (0.00561)			
Lag Temp °C						0.957*** (0.0319)	−0.00725 (0.0161)	
Lag 2 Temp °C						0.0429 (0.0319)	0.00727 (0.0161)	
Lag PM2.5						−0.000153 (0.00127)	1.001*** (0.00115)	
Lag 2 PM2.5						0.000157 (0.00127)	−0.000582 (0.00116)	
Temp °C								−0.000385 (0.0117)
PM2.5								−0.0163*** (0.00494)
N	258,172	258,172	258,172	258,172	258,172	472,059	472,059	472,059
AdjR2					0.0713			0.0610
N clusters	42	42	42	42	42	47	47	47
F					12.40			12.47
Fp					2.43e-10			9.47e-11
j					1.712			1.962
J pvalue					0.789			0.375
jdf					4			2
rkf					364.5			604,132,255.7
C-D F-stat					558,999.2			3.52661e+09
Kleiben-Paap					364.5			604,132,255.7

Notes: *** < 1%; ** < 5%; * < 10%. Standard errors in parentheses, clustered at country level. Year dummies included. Controls are included in all regressions.

Table AC8

Instrumental variable approach on GDP equation – instruments: lags of endogenous variables.

	(1)	(2)	(3)	(4)	(5) 2 stage	(6)	(7)	(8) 2 stage
	Gini	mistrust	Distress	No PSB	SWB	Temp°C	PM25	SWB
Lag gini	1.000*** (0.0000687)	−0.000168 (0.00103)	−0.000194 (0.000210)	−0.0429 (0.178)				
Lag mistrust	−9.40e-09 (0.00000436)	1.000*** (0.0000979)	−0.0000212 (0.0000144)	−0.00857 (0.0147)				
Lag distress	−0.0000204 (0.0000153)	0.0000100 (0.000246)	1.000*** (0.0000624)	−0.0695* (0.0366)				
Lag lack PSB	−0.0000104 (0.0000166)	0.000507 (0.000324)	0.0000204 (0.0000606)	0.802*** (0.0552)				
Lag 2 gini	0.000151** (0.0000706)	0.000490 (0.00105)	0.000168 (0.000212)	−0.115 (0.177)				
Lag 2 mistrust	−0.00000161 (0.00000252)	−0.0000861* (0.0000458)	0.0000119 (0.0000126)	0.0147 (0.0132)				
Lag 2 distress	0.0000309** (0.0000132)	−0.00000649 (0.000209)	0.000116** (0.0000485)	0.00540 (0.0351)				
Lag 2 Lack PSB	0.0000140 (0.0000165)	−0.000438 (0.000292)	−0.0000262 (0.0000618)	0.0870* (0.0495)				
Log Consumption	0.000106 (0.000250)	−0.00757** (0.00298)	−0.000341 (0.000847)	−0.918 (0.935)	0.607*** (0.205)	−0.000139* (0.0000714)	0.0000433 (0.000237)	1.158*** (0.176)
Gini					0.00250 (0.0133)			
Mistrust					−0.00972** (0.00459)			
Distress					−0.0134 (0.00959)			
Lack PSB					−0.0249*** (0.00585)			
Lag Temp °C						0.957*** (0.0319)	−0.00725 (0.0161)	
Lag 2 Temp °C						0.0428 (0.0319)	0.00727 (0.0161)	
Lag PM2.5						−0.000152 (0.00127)	1.001*** (0.00115)	
Lag 2 PM2.5						0.000157 (0.00127)	−0.000581 (0.00116)	
Temp °C								−0.00639 (0.00982)
PM2.5								−0.0234*** (0.00475)
N	258,172	258,172	258,172	258,172	258,172	472,059	472,059	472,059
N clusters	42	42	42	42	42	47	47	47
AdjR2					0.0685			0.0629
F					9.443			9.656
Fp					1.32e-08			5.44e-09
j					1.828			2.009
J pvalue					0.767			0.366
jdf					4			2
rkf					312.1			616,415,373.1
C-D F-stat					520,777.3			3.46019e+09
Kleiben-Paap					312.1			616,415,373.1

Notes: *** < 1%; ** < 5%; * < 10%. Standard errors in parentheses, clustered at country level. Year dummies included. Controls are included in all regressions.

Data availability

Data will be made available on request.

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