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Public concern over global warming correlates negatively with national wealth

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Abstract It has been shown previously that the awareness and concern of the general public about global warming is not only a function of scientific information. Both psychological and sociological factors affect the willingness of laypeople to acknowledge the reality of global warming, and to support climate policies of their home countries. In this paper, I analyse a cross-national dataset of public concern about global warming, utilising data from 46 countries. Based on earlier results at the national and regional level, I expect concern to be negatively correlated to national measures of wealth and carbon dioxide emissions. I find that gross domestic product is indeed negatively correlated to the proportion of a population that regards global warming as a serious problem. There is also a marginally significant tendency that nations' per capita carbon dioxide emissions are negatively correlated to public concern. These findings suggest that the willingness of a nation to contribute to reductions in greenhouse gas emissions decreases with its share of these emissions. This is in accordance with psychological findings, but poses a problem for political decision-makers. When communicating with the public, scientists ought to be aware of their responsibility to use a language that is understood by laypeople.

1 Introduction

Research on climatic change is driven by at least two motivations. The epistemological one, the desire to answer questions about the world, is shared with all other sciences. The second motivation is to provide guidance for society in order to prevent adverse affects of climatic change on humanity and biological diversity. The latter goal, however, cannot be achieved by scientific information alone. It requires the participation of political decision-makers and the general public. Decision-makers and other citizens are influenced by many forces, of which information about scientific findings is only one. Other relevant factors are psychological and sociological in nature. This is taken into account by a growing literature

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on the psychology and sociology of climatic change, as can be witnesses for instance by several interdisciplinary special issues and special sections in diverse scientific journals (Int J Psychol 1991; Int Sociol 1998; Risk Anal 2005; Oppenheimer and Todorov 2006b; cf. Moser and Dilling 2007).

A necessary precondition for decision-makers to take action is that they and possibly the general public understand that climatic change poses serious problems. Several authors have studied factors that influence the amount of public concern about global warming, and have identified a number of important psychological (Krosnick et al. 2006; Lorenzoni and Pidgeon 2006; Moser 2007) and sociological correlates (O'Connor et al. 2002; Leiserowitz 2005, 2006, 2007; Hersch and Viscusi 2006; Zahran et al. 2006). So far, most of these studies have considered situations at the national or regional level. The few studies that utilised data from more than one country did not account for cross-national differences (Dunlap 1998; Brechin 2003; Hersch and Viscusi 2006; Lorenzoni and Pidgeon 2006; but see Zahran et al. 2007). In this paper, I investigate cross-nationally whether geo-economic variables can explain the variation in concern of populations of different countries.

My expectation is that countries that contribute more to global warming have populations that are more sceptical to the reality of global warming. This expectation is based on earlier findings from national or regional surveys on the psychology and sociology of denial of "uncomfortable truths". Individuals (or regions) with higher incomes and/or higher carbon dioxide emissions can expect higher transition costs when policies are designed to reduce anthropogenic greenhouse gas emissions (O'Connor et al. 2002; Zahran et al. 2006, 2007). The wish to not incur these costs can explain the cognitive tendency to disregard global warming as a fact or at least as a problem (Norgaard 2006; Moser 2007). The expectation is tested using data on public concern about global warming, wealth and CO_2 emissions from 46 countries.

2 Material and methods

2.1 The dependent variable

Public concern about global warming was used as the dependent variable. This measure was taken from a global online survey on consumer attitudes towards global warming (cf. ACNielsen 2007), in which respondents from 46 different countries were asked how serious a problem (on a scale from 1 to 5) they thought global warming was. The five possible answers were "not at all a serious problem", "not a very serious problem", "not a serious problem", "a fairly serious problem", and "a very serious problem." Respondents could also answer that they were "not sure."

The nation-wise replies were obtained directly from ACNielsen (personal communication). The concern variable was defined as the proportion considering global warming to be either "a fairly serious problem" or "a very serious problem" (the sum of the two highest scores). These proportions were logit-transformed prior to analysis in order to ensure an approximately normal distribution.

The base of the proportions was the sample of respondents that had previously answered positively on the question, "Have you heard or read anything about the issue of global warming?" The sample sizes in the different countries were between 330 and 988 (median, 480). The national results were reported to be representative for the population with access to internet within error margins of three to four percentage points (ACNielsen, personal communication). The countries represented were, Argentina (AR), Australia (AU), Austria

(AT), Belgium (BE), Brazil (BR), Canada (CA), Chile (CL), China (CN), Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (GR), Hong Kong (HK), Hungary (HU), India (IN), Indonesia (ID), Ireland (IE), Italy (IT), Japan (JP), Latvia (LV), Lithuania (LT), Malaysia (MY), Mexico (MX), the Netherlands (NL), New Zealand (NZ), Norway (NO), the Philippines (PH), Poland (PL), Portugal (PT), Russian Federation (RU), Singapore (SG), South Africa (ZA), South Korea (KR), Spain (ES), Sweden (SE), Switzerland (CH), Taiwan (TW), Thailand (TH), Turkey (TR), the United Arab Emirates (AE), UK (GB), USA (US), and Vietnam (VN).

2.2 Continuous explanatory variables

Two proxies of economic wealth and one proxy of responsibility for global warming were considered as explanatory variables. The first variable was the 2005 per capita gross domestic product (GDP) based on purchasing power parity in 1,000 US$. The second variable was the annual growth rate of the former parameter, averaged over the period 2000–2004. The nation-wise values of these two variables were obtained from the International Monetary Fund (IMF 2006) and the World Bank (2006), respectively.

The third explanatory variable was the 2003 national per capita emission of carbon dioxide from fossil fuels in metric tons of carbon. The figures were obtained from the Carbon Dioxide Information Analysis Center of the US Department of Energy (Marland et al. 2006).

2.3 Categorical explanatory variables

As the dataset is cross-national, possible patterns may be masked by systematic differences between geographical, geopolitical or geo-economic regions. I therefore defined two auxiliary categorical variables, termed “continent” and “region”. The continent variable had the six levels Africa, Asia, Europe, Latin America, North America and Oceania, and assignment of countries was fairly straightforward (RU was assigned to Europe, TR to Asia, and MX to Latin America).

The region variable had four levels, mirroring current geo-economic status. The countries were assigned in the following manner, Developing countries: AR, BR, CL, CN, IN, ID, MY, MX, PH, ZA, TH, TR, VN; Eastern Europe: EE, HU, LV, LT, PL, RU; Middle and Far East: HK, JP, SG, KR, TW, AE; Western countries: AU, AT, BE, CA, CZ, DK, FI, FR, DE, GR, IE, IT, NL, NZ, NO, PT, ES, SE, CH, GB, US. These groupings are of course disputable, however they were assigned prior to analyses and followed simple and general, if arbitrary, rules. Neither the division of European countries into “West” and “East”, nor of Asian countries into “Far East” and “Developing” was trivial, however. In both cases, the division was based on whether the country’s per capita GDP was above or below 17,500 US$. For Asian countries, this divide coincides with the distinction between developed countries (including the newly industrialised “East Asian Tigers” and oil-exporting countries) and developing ones (IMF 2007). The resulting ranking also agrees with the Human Development Index (HDI) for both European and Asian countries (UNDP 2007).

2.4 Analysis

The data were analysed using analysis of covariance. Analysis started from the full model including all variables. Omission of parameters was based on Akaike’s (1973) Information Criterion corrected for small sample sizes (Sugiura 1978; Burnham and Anderson 2002),

AIC_C. Lower AIC_C values indicate better models. Models are compared with the best model using ΔAIC_C, i.e. the difference between the two models' AIC_C values. After having arrived at an optimal model, two-way interactions were tested one at a time by adding them to the optimal model.

The final set of models was tested for robustness by applying a modified concern variable and a modified region variable. (Concern: proportion answering "a very serious problem" and *half* the proportion answering "a fairly serious problem". Region: "Organisation for Economic Co-operation and Development " vs "Eastern Europe" vs "Developing"; and "West" vs "former Warsaw Pact countries" vs "Developing country with a HDI above 0.8" vs "Developing country with a HDI below 0.8".) Results of these modified tests are not reported unless they differ from the main results.

All analyses were carried out in the R environment (R Development Core Team 2005). Probabilities are reported as two-tailed.

3 Results

The best model and its neighbourhood is summarised in Table 1. The best model incorporates two continuous and one categorical variable, viz. gross domestic product (Fig. 1), per capita CO_2 emissions (Fig. 2) and region (model 1 in Table 1). Of those variables, CO_2 emission was only marginally significant ($p=0.082$). The second best model (model 2), without CO_2 emission, was more parsimonious (i.e. required one less parameter) and achieved a ΔAIC_C of less than unity. This model might thus be preferred over the one with the lowest AIC_C. All modifications of these two models resulted in markedly increasing AIC_C values. This is valid both of the addition of further variables (e.g., models 3 and 6), the omission of gross domestic product or region (models 4, 5, 8 and 9), or replacement of region with continent (model 7).

The estimates of the two continuous explanatory variables were negative, i.e. public concern decreased with increasing gross domestic product (Fig. 1) and increasing national

Table 1 Models explaining cross-national variation in public concern over global warming and their parameter estimates

	GDP	CO_2 emission	Economic growth	Region	Continent	r^2	ΔAIC_C
1	−0.052±0.022*	−0.125±0.070$^+$	–	×***	–	0.52	0.00
2	−0.060±0.022*	–	–	×***	–	0.48	0.80
3	−0.065±0.023*	–	−0.057±0.060	×***	–	0.49	2.49
4	–	−0.158±0.072*	–	×***	–	0.46	3.18
5	–	–	–	×***	–	0.39	5.69
6	−0.062±0.025*	–	–	×$^+$	×	0.51	10.54
7	+0.003±0.014	–	–	–	×*	0.11	14.69
8	−0.028±0.012*	–	–	–	–	0.11	18.53
9	−0.023±0.014	−0.066±0.087	–	–	–	0.12	20.27
10	–	–	–	–	–	0.00	21.54

The best model and its neighbourhood are presented. Models are sorted by their ΔAIC_C (the AIC_C of the best model is 109.68). Estimates of continuous parameters are given with their standard errors, asterisks indicating significance levels (from *t* tests; $0.1 > p^+ \geq 0.05 > p^* \geq 0.01 > p^{**} \geq 0.001 > p^{***}$). Crosses indicate the inclusion of categorical variables (region has four levels, continent five; significance levels are based on *F* tests). See text for definition of the parameters.

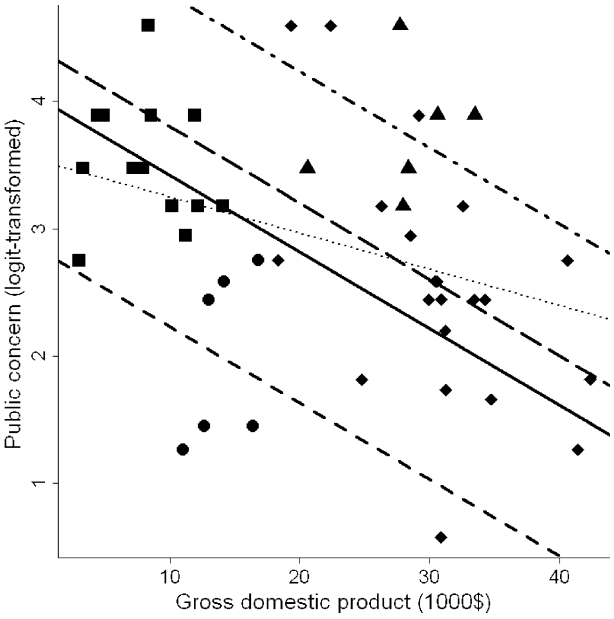

Fig. 1 The proportion of a country's population that conceives global warming as a serious problem decreases with increasing gross domestic product. *Data points* are nations. The regression lines are estimated from model 2 in Table 1, i.e. a model which only includes GDP and region as variables, both of which are significant. Symbols and line types indicate regions: *triangles* and *dot dashed line*, Middle and Far East; *diamonds* and *long dashed line*, Western economies; *squares* and *solid line*, developing countries; *circles* and *dashed line*, Eastern Europe. The *thin dotted line* is the regression line if differences between regions are ignored. All slopes are significantly negative ($p<0.03$)

per capita CO_2 emissions (Fig. 2). As regards the geo-economical regions, the intercepts of developing countries and Western countries did not differ from each other. Citizens of Eastern European countries were significantly less concerned than in the former regions ($p=0.0062$). On the other hand, the populations of Asian and Arab developed economies were significantly more concerned than those of all other regions ($p=0.0062$).

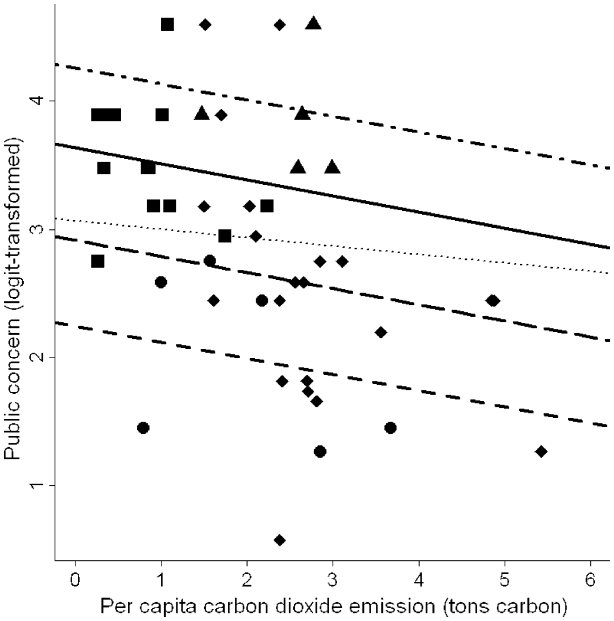

Fig. 2 The proportion of a country's population that conceives global warming as a serious problem decreases with increasing carbon dioxide (CO_2) emissions. *Data points* are nations. The regression lines are estimated from model 1 in Table 1, i.e. a model which includes gross domestic product, CO_2 emission and region as variables. Symbols and line types indicate regions, see legend of Fig. 1. The slopes are not significantly negative, although the *bold* ones are marginally so ($p=0.082$). One extremely high value (United Arab Emirates) is omitted from the figure (but included in the analyses)

The slopes did not differ among regions, i.e. there was no interaction between gross domestic product and region (p=0.21, ΔAIC_C=3.51). No other interactions were significant either. If the region variable is omitted from the model (models 8 and 9), the effect of gross domestic product and of CO_2 emission are weakened (Figs. 1 and 2), but the former remains significant and better than the null model (model 10 in Table 1).

When using modified variables of concern and region (see "2.4"), the effect of CO_2 emission was weakened, i.e. rendered insignificant. The remaining results and significance levels were unaffected.

4 Discussion

The findings support the initial hypothesis that public concern is negatively related both to measures of national wealth and to a measure of responsibility for global warming. The results are the first to demonstrate such a pattern cross-nationally, but they are in accordance with earlier studies on the national or regional level.

The strongest effect was found for per capita GDP. On the other hand, the growth of the per capita GDP did not reach significance, although the sign was in the expected direction. This may not be especially surprising, since economic growth does not have any necessary relation to current wealth. Finally, a nation's CO_2 emission had a weak negative effect on public concern. Because this variable does not reach significance ($0.10<p<0.05$) and was further weakened if the dependent or region variable were modified, this effect is somewhat ambiguous. However, its sign is compatible with the expectation that it is harder to accept global warming as a fact and as a problem the more the respondent feels responsible for it. This is also in accordance with (marginally significant) findings in a national survey of US residents, were the CO_2 emission of the state (rather than nation) was weakly negatively correlated to the public support for climate change policies (Zahran et al. 2006).

As regards the effect of wealth, here approximated by GDP, previous findings have been equivocal. In some regional studies, the effect of household income was far from significant (Zahran et al. 2006). O'Connor et al. (2002) showed that willingness to carry out some voluntary actions (e.g., "drive less with a private car") to reduce greenhouse gas emissions was negatively correlated with income, while it was uncorrelated for other such actions. This contrasts with the "conventional wisdom [...] that environmental concern is a luxury affordable only by the economically secure" (O'Connor et al. 2002:3). To my knowledge, no such positive relationship has been found regarding climatic change. It is also absent in several other contexts (Dunlap and Mertig 1995; Brechin 1999), including ratification of the Kyoto protocol (Zahran et al. 2007). The reason may lie in human cognition and psychology. "Uncomfortable truths" can be met by an array of psychological responses (Leiserowitz 2006): flat denial, conspiracy theories, assumptions of hype, or believe in alternative explanations. As Norgaard (2006, p. 366) points out, "Citizens of wealthy nations who fail to respond to the issue of climate change benefit from their denial in short-run economic terms. They also benefit by avoiding the emotional and psychological entanglement and identity conflicts that may arise from knowledge that one is doing 'the wrong thing' [in a social context]." Viewed this way, the denial of global warming is an instance of the tragedy of the commons (Hardin 1968). Nobody profits directly from bearing the costs of climate policies, while all benefit if others bear these costs. The higher the costs an individual has to bear (relative to all others), the lower is her or his motivation. Logically, the costs are perceived to be higher for well-off people. Since the data used are on a national rather than individual level, they do not permit conclusive judgement about

personal motivation. However, the findings are clearly compatible with the psychological mechanisms invoked at lower levels.

Obviously, the current study has not identified all factors relevant to public concern about climate change. Several factors are better studied—and have been studied—on lower levels, such as effects of age, education and gender (O'Connor et al. 2002; Hersch and Viscusi 2006; Krosnick et al. 2006; but see Zahran et al. 2007). I also acknowledge that the GDP is a disputed measure of wealth, even though it is a widely used proxy. A further source of uncertainty is the way the dependent variable has been sampled: national samples are generally small (<1,000) and only representative for the part of the population with access to internet. While this decreases the representativeness of the national rates as such, especially in the lesser-developed countries, and precludes the inclusion of many developing countries altogether, it may at the same time remove a confounding factor in the cross-national analysis.

A further very relevant explanatory variable, in addition to cognitive, demographic and economic correlates, is the respondents' first-hand experience of meteorological phenomena related to climate change. Krosnick et al. (2006) and Zahran et al. (2006) found that people experiencing high recent local temperature increases were more likely to be concerned over global warming and to support costly climate policies. The latter also found a similar relationship for respondents having experienced extreme weather events. Likewise, Lorenzoni and Pidgeon (in Oppenheimer and Todorov 2006a: fig. 2) found a positive correlation between public concern about global warming and average temperature in July across 15 European countries. It would have been illuminating to tests for these affects also in the present cross-national dataset. However, the scale is probably too large and the data to coarse to define a suitable variable. In the press release that announced the cross-national variation in public awareness and concern, ACNielsen (2007) remarked that the Czech Republic and France had recently experienced extreme meteorological events (floods and heat, respectively), and that both countries score quite high in perceiving global change as a serious problem. While the assumption of an underlying correlation between those findings may be correct, it is hard to test it in a rigorous manner.

It is also noteworthy that the single European country that is threatened by loosing more than 25% of its total area if sea levels continue to rise, viz. the Netherlands, is at the very bottom of the concern survey (64% vs. a cross-national mean of 91%). Counterintuitive as this finding might be, it is mirrored by Zahran et al.'s (2006, p. 783) finding that, in the US, "respondents living within 1 mile of the nearest coastline at negative relative elevation to the coast are less (not more) likely to support government-led climate initiatives." Both findings would make sense if they are viewed in a "wishful thinking" context (Leiserowitz 2006): the more severe and seemingly unsolvable a problem is, the more "tempting" is it to cognitively suppress its reality (cf. Norgaard 2006; Moser 2007).

5 Conclusions

The cognition of our species is biased in a way that enables us to suppress "uncomfortable truths". In accordance with this premise, many studies have shown that public concern about global warming correlates negatively, not positively, with factors that—strictly logically speaking—should suggest high, not low, concern: wealth (here measured by gross domestic product), responsibility (here measured by CO_2 emissions), and direct future threats (e.g. danger of flooding, not measured here). The current study is the first to document effects in these directions using a cross-national dataset. The pattern was especially strong with regard to national wealth.

While the mass media may have part of the responsibility for this situation (Corbett and Durfee 2004; Dunwoody 2007), also scientists should be better aware of how to communicate findings related to climatic change. Helpful suggestions on how to communicate the threats of global warming are available (Moser and Dilling 2007; see especially Dunwoody 2007; McCright 2007; Moser 2007). It is our moral obligation to make the general public understand—even if this requires using a language with which scientists may be both unfamiliar and uncomfortable (Mahlman 1998).

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