Valuing Climate Change

THE ECONOMICS OF THE GREENHOUSE

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interested in when aiming at a valuation of the amenity costs (or benefits) of climate change. It is possible to split yC into two parts. First, people need to be compensated for the additional cooling expenditures they undertake in order to mitigate the most adverse effects – the distance AB in Figure 3.1. Second, they need to be compensated for the remaining, unmitigated temperature increase DO′. To avoid double counting, we should in this section only be interested in the second aspect, ie the distance yC – AB. The costs of adaptation have already been assessed in the section on energy.

Unfortunately, estimating this remaining area proved impossible with the currently available information. The monetary value of a benign climate is still largely unknown, although attempts towards a valuation can be found in Hoch and Drake (1974) and Gyourko and Tracy (1991). A careful distinction between winning and losing regions would further require fairly accurate information about regional and seasonal temperature patterns.

Morbidity and mortality

Human beings are very capable of adjusting to climatic variations and, as opposed to most other species, can live in more or less every climate on earth. Nevertheless, climate change will have its impacts on human morbidity and mortality. The literature on the health effects of global warming (eg Haines and Fuchs, 1991; IPCC, 1990b; Weihe and Mertens, 1991; WHO, 1990) predicts an increase in climate-related illnesses such as cardiovascular, cerebrovascular and respiratory diseases. Summer mortality from coronary heart disease and strokes may increase and is likely to offset the reduction in winter mortality. Particularly at risk are individuals with 'immature regulatory systems, such as infants and children, and [...] those with reduced adaptive regulatory functions, such as the elderly and physically handicapped' (WHO, 1990, p 17).

In addition to these direct effects there may be changes in the occurrence of communicable diseases and an aggravation of air pollution (see the following section). The risk areas of communicable diseases like malaria or yellow fever may shift as their vectors adjust to new climate conditions. WHO (1990) fears that, for example, the so far disease-free highlands of Ethiopia, Indonesia and Kenya may be invaded by vectors. Although vector-borne diseases occur predominantly in developing countries, impacts need not be restricted to these areas. A spreading of vector-borne diseases has, for example, also been predicted for the United States and Australia (see eg Haines and Fuchs, 1991; and Smith and Tirpak, 1989). Much will, of course, depend on adaptation and the precautionary measures taken. Although not cost free, precautionary action is likely to be a major aspect of the cost-efficient response. Many projects, like improvements in the hygiene standards of poor countries, are more than likely to be worthwhile in their own right. For a proper assessment of the morbidity damage, however, much more research is still required.

Some, albeit controversial, estimates exist on the warming-induced change in mortality. In a case study carried out for EPA, Kalkstein estimated the change in mortality in 15 American cities (see Smith and Tirpak, 1989; Kalkstein, 1989). He concluded that without acclimatization the number of summer deaths in the observed area would rise by 6,246 in absolute terms, corresponding to a further 294 casualties per million inhabitants. Winter mortality, on the other hand, would decrease by nine deaths per million. The estimates were achieved by feeding $2xCO_2$ climate data into a statistical model regressing mortality on climate variables.

In a second estimate Kalkstein uses analogues to estimate the impacts under full acclimatization, including biological and behavioural adjustments as well as changes in the physical structure of a city (different architectonic style, more reflecting materials, etc). With acclimatization the increase in summer mortality falls to 49 deaths per million, and the decrease in winter mortality becomes four deaths per million. Because of the different methods used, the two pairs of estimates are not directly comparable and are partly contradictory (eg one would expect the decrease in winter mortality to be higher with acclimatization than without). The detailed Kalkstein figures underline the importance of acclimatization, showing that cities already accustomed to a warmer climate are far less affected by a further warming than cities with a moderate climate.[16] Whether, and if so to what extent and how quickly, a society will acclimatize is, however, a fiercely debated issue. It is mainly for this matter that the climate impacts on mortality remain a controversial question (see Kalkstein, 1989; and Cline, 1992a).

Nevertheless, we will take Kalkstein's more moderate estimate including acclimatization as a basis for a rough mortality estimate. Adjusted to 2.5°C it corresponds to a net increase of 27 deaths per million people. This figure may still be rather on the high side. Smith (1992), for example, reports an annual average of about 500 heat-related deaths in the US between 1936 and 1975. Following Mearns et al (1984) in assuming a two to sixfold increase in heatwaves, this would imply an increased mortality of at most 17 deaths per million (assuming an average population of 180 million between 1936 and 1975; after World Resources Institute, 1990). The discrepancy may partially be explained by the fact that Kalkstein's estimates are entirely based on urban areas, which tend to pose a greater risk (Smith, 1992). Although the 15 city studies exhibit some differences according to climate zones, the average net mortality increase of 27 deaths per million is assumed to hold in each region. The increase in mortality for each region is shown in Table 3.11.

To arrive at a monetary valuation the number of casualties has to be weighted by the value of each life. It seems worthwhile to elaborate a bit

16 This to an extent that some of Kalkstein's estimates actually show a *decrease* in summer mortality, the negative effects from warming being more than offset by the better acclimatization in the chosen analogue.

Table 3.11 Damage from increased mortality

	Increased mortality (deaths)	*Loss from increased mortality (m$)*
EU	8,775	13,163
USA	6,642	9,963
Ex-USSR	7,722	2,317
CHINA	29,376	2,938
OECD	22,923	34,385
WORLD	137,727	49,182

Source: see text.

further on this potentially controversial issue. A first crucial point to note is that we do not attempt to measure the value of an (individual) life as such. There is no such figure. What is measured is the amount of money needed to compensate people for an additional risk of death, that is the value of safety. Multiplied by the change in the risk of death, this yields a figure which is often called the value of a *statistical* life. For example, if in a town with 50,000 inhabitants residents are willing to accept $15 to tolerate an increased risk of death of 1/50,000, then the increased risk results in one statistical death. The value of that statistical life is then $15 × 50,000 = $750,000.

Various methods exist to estimate the value of a statistical life. The main distinction is between the human capital or gross output approach, which values the net present value of lost future output, and the willingness to pay approach, which estimates people's willingness to pay for increased safety. Estimates based on the latter method, all for developed countries, range from about $200,000 up to over $16 m, with an average of around $3 m (Pearce et al, 1991; Viscusi, 1993). The results suggest that a statistical life should not be valued at less than $700,000 and should plausibly be at least $1.5 m (Pearce et al, 1991). For developed regions we thus assume $1.5 m, still a fairly conservative value. A low value is, however, preferred to counterbalance the rather high quantity estimate.

People's valuation of the good safety is case-specific and depends on a variety of factors, such as the type of hazard encountered. Some risks are more acceptable than others, eg those connected to leisure activities. Values also depend on people's income level, in the same way as their willingness to pay for market goods does. We should therefore expect the value of a statistical life in poorer countries to be lower than in rich nations. This of course does *not* mean that the life of, say, a Chinese is worth less than that of a European. It merely reflects the fact that the *willingness to pay* for increased safety (a lower mortality risk) is higher in developed countries.

Unfortunately few value-of-life studies exist concerning the less developed world. We therefore used an arbitrary value of $300,000 for middle income and \$100,000 for low income countries. The willingness to pay in each region to prevent an increase in mortality is given in column 2 of Table 3.11.

Air pollution

Given the wide concern about air quality and air pollution it is surprising how little attention this aspect has gained in the context of global warming so far. Global warming will affect the quality of the air in two ways.

The first has to do with what is called *secondary benefits*. Because no economical CO_2-removal technologies currently exist, all attempts to limit CO_2 emissions concentrate on cutting down the use of fossil fuels. All CO_2 abatement will, therefore, also lead to a reduction in the emission of major pollutants such as SO_2, CO and NO_x (Ayres and Walter, 1991; Pearce, 1992). However, since secondary benefits are related to *emissions abatement*, rather than *atmospheric concentration levels*, they are not relevant in the present context. We prefer to interpret them as a (negative) part of the abatement costs, and will come back to them in Chapter 6.

Many chemical reactions also depend on temperature, and this is the second way in which global warming will affect air quality. Scientists predict a warming-induced increase in the emissions of hydrocarbons (HC), nitrogen oxides (NO_x) and sulphur oxides (SO_x). In addition the formation of acidic materials could increase. The effect on acid depositions is nevertheless unclear, because of changes in clouds, winds and precipitation. More certain is an increase in the tropospheric ozone level, brought about through the increase in NO_x and HC emissions as well as through a higher reaction rate (see Smith and Tirpak, 1989). Two case studies carried out for the US EPA predict a change in O_3 concentration of –2.4 to 20 per cent. As a consequence the exposure to concentrations above the US threshold of 120 ppb (measured in people-hours) would increase by 60 to 210 per cent (Smith and Tirpak, 1989). Adjusted from the assumed 4°C warming to 2.5°C we can thus expect an average increase of 5.5 per cent in ozone concentration and 80 per cent in exposure.

For simplicity we suppose that the increase in O_3 concentration is fully due to the increase in NO_x and HC emissions, ie we assume an increase in NO_x emissions of 5.5 per cent. This may look like an overestimate, given that part of the O_3 increase is caused by a higher reaction speed. To achieve a monetary estimate the assumption seems appropriate, however, as the damage from an increased O_3 concentration is fully attributed to NO_x in all available estimates. For SO_2 we assume a rise in emissions of 2 per cent. The emissions increase in absolute terms is shown in the first two columns of Table 3.12, based on the regional estimates of the World Resources Institute (1990).

The monetary value of air pollution damage has been estimated by several authors, including Alfsen et al (1992), PACE (1990) and Pearce (1994b). The estimates for NO_x range from about \$0.10 to \$15 of damage per kg