Background Paper: Reflections on Cross-cutting issues in Impact Assessment

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Introduction

Recent research which I, along with others, have undertaken for the UK Climate Impacts Programme[1] and the UK Defra[2] has provided an opportunity to reflect on a number of the issues that arise in the "bottom-up" assessment of climate change impact costs - and therefore the potential benefits of local, regional and national adaptation policies, as well as the national benefits of international mitigation efforts. In some senses, then, this paper comprises of a number of lessons learnt. Whilst the context of this – and much of the other work referred to herein- has been UK-focussed the literature suggests that many of the generic issues discussed would be common to bottom-up assessments in other countries and world regions.

Purpose

Our work has arisen from the premise that the development of appropriate climate change policies at a national and international level may benefit from the use of information regarding the costs of the impacts of climate change. For example, since climate change adaptation and mitigation decisions at any level inevitably involves making trade-offs concerning the use of scarce resources. These trade-offs might include, for example, comparing the costs of adaptation responses taken now with the future damages that would result from inaction; or contrasting the national costs of reducing GHG emissions with the national benefits (as well as costs, where relevant). The impact costs ensure that the mitigation and adaptation decisions are linked in the following way (after Evans et. al 2004):

$$C^{UK}{}_{T}\,(e^{UK}, e^{ROW}, a^{UK}) = C^{UK}{}_{I}\,(e^{G} a^{UK}) + C^{UK}{}_{A}(a^{UK}) + C^{UK}{}_{M}\,(e^{UK})$$

Where: C_T = Total Costs; e = greenhouse gas emissions; a = adaptation measures implemented; C_I = Climate Impact Costs; C_A = Climate Adaptation Costs; C_M = Mitigation costs of greenhouse gas emissions; UK superscript = United Kingdom; ROW superscript = Rest of World and G = Global. Welfare-efficient optimisation policy therefore aims to minimise the total costs associated with climate impacts, adaptation and mitigation measures. Whilst policy is of course not evaluated according to economic efficiency alone, information related to these trade-offs may still be of some value. However, it seems likely that the informational priorities of the mitigation and adaptation communities regarding impact cost/benefit assessments differ in a number of ways, with implications for future work in this area. Two main differences are:

A) **Time periods of interest**. Whilst mitigation decisions are made in the context of avoiding dangerous climate change, with time-scales of 50-200 years being of most interest, the longest term decisions that relate to adaptation – primarily in infrastructure investment - consider time-scales of 50-100 years; most adaptation measures are likely to have significantly shorter lifetimes.

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[1] Case study applications (in Metroeconomica, forthcoming) of Metroeconomica (2004). *Costing the impacts of climate change on the UK: overview of guidelines*. UKCIP Technical Report. UKCIP, Oxford.

[2] Project E: Quantifying the costs of impacts and adaptation, led by Metroeconomica Ltd. For Defra: Climate Change Impacts and Adaptation: Cross-Regional Research Programme

B) **Geographical scale and depth of analysis**. The informational needs of those charged with making decisions relating to adaptation are greater than those that could be realistically expected by those making mitigation decisions at the global scale. For example, work for UKCIP on costing the impacts of summer road subsidence in Cambridgeshire, UK, has demonstrated that the complexity of data analysis relating, in particular, to future climate temperature and precipitation patterns, together with the level of interpretation of regional socio-economic scenarios required to generate estimates sufficiently credible for local government to consider adaptation responses is extremely resource intensive. And yet the appropriate scale is the local one and the context-specific features of the region suggest that transferability between (domestic) regions is an inadequate basis on which to make adaptation decisions. The only context in which such transferability is appropriate is likely to be in a national impact/adaptation scoping exercise where an indication of which impacts and regions are likely to be most vulnerable is sought.

Date needs: Historical analogues and Scenarios

The preceding paragraph highlighted the fact that for climate change adaptation decisions to be seriously contemplated the output of impact assessment exercises need to have a certain level of sophistication to generate sufficiently credible results. The sophistication lies in the use of impact assessment embedded in historical experience combined felicitously with sets of plausible climate and socio-economic scenarios.

The first data need is therefore to have some basis on which to think climate change is having, or will have, an impact. This therefore requires either an established link between a climate variable mean value and a resource impact – such as the relationship between domestic energy use for heating purposes – or the impact(s) associated with an extreme weather event from climate variable variability. In the case of weather event extremes, it is only possible to identify impacts if a weather event such as that projected to occur under climate scenarios either has occurred, (e.g. summer heatwaves), or can be credibly simulated in models (e.g. rivering flooding); other events are likely to be omitted from the analysis. Neither approach is likely to predict well threshold effects in climate conditions outside of current climate variability. Future impact assessment will certainly benefit from the use of probabilistic-based, down-scaled, climate scenarios.

As the above implies, coverage of climate change impacts relating to changes in both climate variable means and variability puts an increased demand on climate data and its interpretation. For example, in the case of extreme weather events, expected annual average impact can be calculated only as long as probabilities of the particular weather event under climate scenarios are known.

The challenge in the use of socio-economic scenarios – assuming that they exist and have a degree of compatibility with the climate scenarios – is to interpret these in as sufficiently detailed way as possible to allow a credible reference case to be constructed for each scenario, without over-interpreting the largely qualitative story-lines developed for the individual scenarios. An additional issue is how to express the results in the most meaningful way – e.g. the need, or not, to inflate impact estimates by GDP/capita income elasticities and whether to adjust values based on projections in preferences. Inflating by GDP/capita accounts for changing values over time, given GDP growth assumptions, but reduces the ability of the results to describe the future impact relative to today's climate event impacts. The approach we have adopted is illustrated in Box 1 for the example of property subsidence.

Box 1. Climate Change Impact Assessment in the UK: Property subsidence example

Stage 1. We identify a particular climate event known to have impacted on the sector and region of interest - in this case excess insurance claims due to domestic property subsidence. The assumption is that the resulting impacts are typical of that event at that location in the UK. The Summer 2003 analysis led us to use a monthly mean temperature value of 18.3°C as a proxy for the subsidence impact in that year. This event, and the associated excess claims over and above an average year, will have a specific return-period (annual probability of occurrence) based on historical data, or correspond to a specific climate parameter. Once the insured losses are converted to economic damages, we have an estimate of the cost of a weather event – in this case the warm, dry summer of 2003, of a specified return period or temperature/precipitation anomaly.

Stage 2. We interpret the UKCIP (2001) socio-economic scenarios (SESs), up-dated by the BESEECH report, to estimate the stock vulnerability in future time periods. In this example, the resulting estimates are driven solely by the information given in these scenarios relating to population and household size. GDP growth is not included. Thus, only the physical stock at risk is affected by socio-economic change; the unit value of the stock at risk is assumed constant. Other socio-economic factors that may be expected to determine vulnerability of domestic property to subsidence risk are interpreted in qualitative terms in order to give an indication of the likely net effect of the individual factors on the quantitative estimates.

Table 1: Qualitative indicators of effect of other socio-economic factors on total number of subsidence-prone properties under alternative socio-economic scenarios

Socio-economic factor	*Socio-economic scenario*			
	GS	NE	LS	WM
Planning Policy	- ve	+ ve	- ve	+ ve
Building Design	- ve	+ ve	+ ve	- ve
Insurance policy	+ ve	?	?	- ve
Overall net effect	- ve	+ ve	Same	- ve

+ve - increase numbers of subsidence cases; -ve – decrease numbers of subsidence cases
Socio-economic scenarios: LS = Local Stewardship; GS = Global Sustainability; NE = National Enterprise; WM = World Markets

Stage 3. Analysis of the UKCIP02 climate data produced the frequencies of such months in three future time-slices centred on the 2020s, 2050s and 2080s. Results for the 2080s are presented in Table 2.

Table 2. Frequency of hot summer months for Central England in climate change scenarios (2080s)

2080s	1961-90	Low	M-L	M-H	High
Probability of summer month ≥ 18.3°C	0.03	0.03	0.03	0.03	0.03

(mean monthly temp.) Ref. case					
Probability of summer month ≥ 18.3°C (mean monthly temp.) CC scen.	0.03	0.48	0.61	0.74	0.79
Net CC attributed prob.	0	0.45	0.58	0.71	0.76

Stage 4. Combining the climate (reference and climate change) and socio-economic data allows us to identify the net climate change impacts under a set of consistent socio-economic – climate change (emission) scenario combinations, presented in Table 3.

Table 3. Undiscounted net climate change induced subsidence costs in the UK (£m)

	Emission scenarios			
	Low	M-L	M-H	High
2020s	6	5	6	15
2050s	26	41	119	185
2080s	162	114	213	316

Uncertainty

The forms of uncertainty in climate change impact assessment are outlined in the taxonomy developed by Yohe (2003). Here, I briefly discuss the high degree of *contextual uncertainty* that is attached to one impact category in the health sector in the UK context: mortality valuation. In country-focussed impact assessment it is not necessary to consider the lengthy equity-related discussions that have been a feature of the treatment of this impact in global impact assessments (e.g. in IPCC SAR, 1995). The issues – in the UK context alone – revolve around the appropriate metric and the uncertainty in the measurement of premature mortality risk. The results in the following two tables show the estimated annual physical and monetary impact (benefit), respectively, of warmer winters, in the 2080s-centred time-slice in the UK. Clearly, the choice of physical impact metric – attributable deaths or number of life years is very significant, with the former resulting in totals 100+ times the size of the latter totals.

Table 4. Annual Deaths and life years saved from warmer winters in UK, 2080s

Metric	Low	High
Attributable Deaths	4285	7822
Life-years	2964	4464

Table 5. Annual value of deaths and life years saved from warmer winters in UK, 2080s (£m)

Metric	Low	High
Attributable Deaths (VSL)	5142	9386
Life-years value (VOLY)	44	67

VSL=Value of a Statistical Life; VOLY=Value of a Life-Year

In considering the three components (resource costs, opportunity costs and disutility) of welfare costs associated with the premature mortality impact, the uncertainties related to measurement of resource and opportunity costs are likely to be trivial compared to those associated with the valuation of the disutility component. In this case, there are no market prices to use; instead we are obliged to derive values from use of other non-market valuation techniques such as wage-risk studies (where different levels of workplace risk are related to wage levels to identify wage premiums associated with different risk levels), or survey-based approaches where respondents are asked to value a change in the risk of suffering e.g. premature death. Valuation of health disutility has historically been made in transport and work safety contexts, and more recently in the air pollution context, where the use of the life year metric has recently gained more currency.

To date, findings of these studies have informed the selection of values used in social cost of carbon estimates (see e.g. Fankhauser 1995). However, in addition to the methodological limitations associated with these studies, further uncertainty is attached to transferring values between risk contexts. Contextual differences include: the absolute size of the risks; ex-ante knowledge of the risks; level of involuntariness associated with exposure to the risks; socio-cultural determinants of preferences relating to risk, different causes of death, etc. There is also, of course, the uncertainty derived from transferring over time i.e. preferences may be expected to change over time, independent of income.

The table below summarises some key sources of uncertainty in health values and their use in the climate change context. One conclusion that the table highlights is that uncertainty in both the original study application and contextual transfer are significant and will remain so at least until we have greater experience with the application of non-market valuation techniques in the climate context in a range of world regions.

Table 6. Taxonomy of uncertainty in valuation of premature mortality

Origin of uncertainty
Knowledge of product e.g. Δ in risk of death, Δ in life expectancy?
Context – climate change - appropriate size of risk change
Study design features
Relevant populations & sample sizes in study?
Choice of econometric methods & treatment of data
Interpretation of results
Validity of spatial transfer e.g. socio-cultural differences

Endogeneity: Scenarios, Impacts and Adaptation

A further potentially important methodological challenge in climate change impact assessment is the endogeneity that is likely to exist between the measurement of climate change impacts and the incorporation of adaptation. One example of this is implicit in Box 1 above where the extreme weather event (a month where the mean temperature >18.3^{o}C) has a probability of 3% occurrence in 2003 but becomes the normal (67% in the High emissions scenario) in the 2080s time-slice. One would, however, not expect the property subsidence associated with this event in 2003 to occur with a 20 times higher frequency in the 2080s time-slice; preventative adaptation would have been incorporated into building design prior to such a rate of occurrence being reached. The issue for future impact exercises is whether to measure the maximum impact (i.e. with a reference case in which zero adaptation is assumed) – as with the method in Box 1 – or to model up-take of adaptation under alternative socio-economic scenarios, and measurement of both adaptation costs and residual impacts. The answer to this may in part relate back to the purpose of the study. If the purpose of the study is to build a case for the development of an adaptation strategy then the former approach should be seen as the first stage in the process, with the latter constituting part of the adaptation decision-making process. For mitigation policy analysis, the output from the latter exercise is more useful, though clearly reliant on prior micro-scale adaptation analysis being undertaken.

Another form of endogeneity in climate change impact assessment results from the fact that the findings of the studies themselves influence the course of action taken by policy in a sector or sectors, and subsequent socio-economic development path. This has been the case, for example, in the development of flood management policy in the UK Government's strategy paper: Making Space for Water as a result of the findings of the FORESIGHT study (Evans et. al 2004). Of course, this simply demonstrates the effectiveness of well-timed and targeted research. But it also emphasises the importance of the integrity and completeness of such assessments, the latter remaining a significant challenge in many sectors, but particularly health and biodiversity.

Conclusions

This paper has offered some short reflections on a few cross-cutting issues relating to climate change impact assessment. Each of these merits further discussion. Many other issues have not been addressed. Among the issues that we have found important in our UK work are: the treatment of non-marginal impacts and role of macro-economic modelling; the separability of impact and adaptation costs, and; the role of users and stakeholder groups in sectoral & cross-sectoral analysis. In addition, the major gap in our analysis of climate change impacts on the UK is research into the climate change impacts that occur internationally but which are likely to have secondary impacts on the country. Since it is expected that climate change impacts in many other countries and world regions will be more severe any such secondary impacts are likely to have significant political and economic implications for the UK.

References

Ekins 1995
Evans et. al 2004