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Adaptation Economics

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1. Key points

- Traditional economic appraisal techniques such as cost-benefit analysis face significant challenges when assessing policies and measures where there is a high degree of uncertainty.
- Decision-making around policies and measures to adapt to the impacts of climate change – adaptation – is fraught with uncertainty.
- In such cases with high uncertainty, alternative appraisal methods exist that may address the challenge of evaluating economic costs and benefits more effectively.
- Adaptation should focus on robust actions that perform well under a range of future climates, and which often increase resilience to the current climate.

2. Introduction

With the growing challenges posed by climate change, options for adaptation are becoming increasingly necessary. Following on from the first Climate Change Risk Assessment (CCRA) published in 2012, which identified the main climate risks and opportunities for Scotland, the Scottish Government is developing the first statutory Scottish Adaptation Programme. Decision making around how to implement the policies and proposals contained in the Programme needs to be informed by economic analysis that allows robust weighing of the costs and benefits of actions.

An understanding of the likely costs and benefits of adaptation is important in order to:

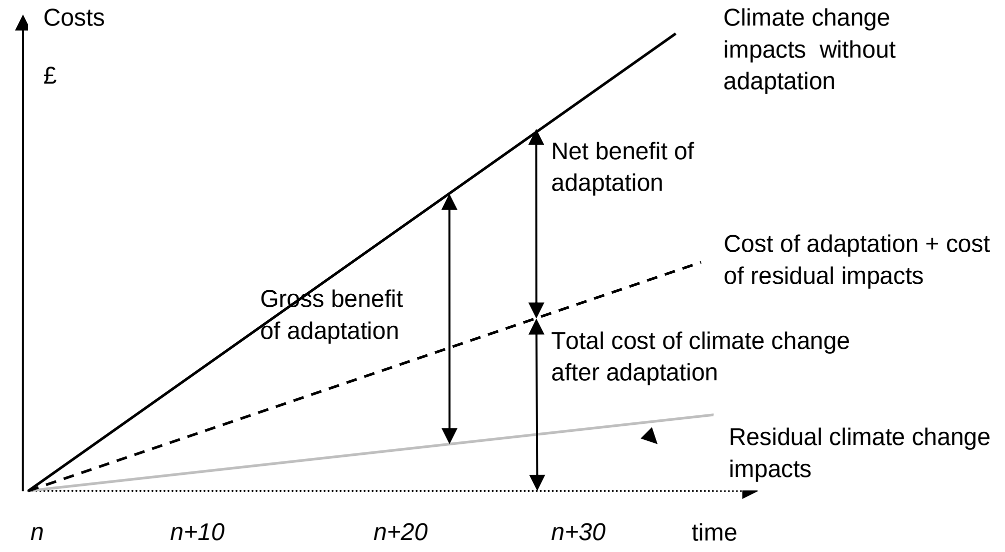
- prioritise action with limited resources,
- understand the consequences and costs of not adapting,
- avoid over- and under-spend in adaptation,
- plan the best approach that also leaves options available in future.

This brief introduces the concept of adaptation economics and then reviews the main approaches, providing examples of their application.

3. Basic principles

The traditional way to think about adaptation economics is portrayed in figure 1. This figure shows the costs of climate change impacts in the absence of any adaptation - the solid black line. These costs are reduced through adaptation actions, shown by the dashed line. The grey line illustrates the baseline costs of "weather" and socio-economic change in the absence of climate change, highlighting that there will always be some level of weather-related damage. As the value of exposed assets increases over time (through for example, increased property development in exposed areas, as well as inflation), these costs will increase even without climate change. These costs are also known as "residual" costs, and it is important to remember that adaptation will never eliminate all weather and climate-related damage. The level of residual cost will vary between societies and possibly over time.

The benefits of adaptation are essentially the avoided climate damages, minus the residual cost.



Source: Adapted from Stern (2006)

Figure 1: impacts, adaptation and residual impacts

Costs of adaptation can be calculated in a number of different ways depending on the purpose. For example, several large scale studies have attempted to calculate the investment and financial flows required for global adaptation (e.g. World Bank 2006; Oxfam 2007; UNFCCC 2007; Project Catalyst 2009; World Bank 2010). For national and/or sector assessments the most common approach to date is based on climate impact/risk assessments, where the costs and benefits of a range of individual adaptation options are calculated.

4. Challenges

There are several challenges confronting adaptation economics. Possibly the most difficult to resolve are those centred around **uncertainty**. Because of the inherent uncertainty in the climate projections (such as UKCP09), there is also uncertainty around the benefits of adaptation. Benefits are uncertain and accrue sometime in the future, while costs are often immediate and certain. This makes 'robust' decision-making vital when considering climate change actions. Robust actions are those which will perform well under a range of climate futures, and often increase resilience to the current climate. Robust adaptations generally have the following attributes (Hallegatte 2009):

- allow for **flexibility or reversibility** as climate impacts become more certain, avoiding being locked-in to a certain path that may no longer be appropriate if the climate does not change as expected
- create benefits in the current climate as well as future climates ('no-regrets', or 'win-win')
- allow enough room for worst case climate scenarios ('safety margins') (see Thames Estuary example below)
- 'soft' strategies such as changes in management, education, timing of operations, rather than 'hard' engineering strategies where possible

- begin with adaptations that address shorter term climate impacts – uncertainty clearly increases further into the future. Where adaptations do have long time horizons and need to begin now, it is especially important that other criteria are met
- positive interaction with mitigation and other environmental outcomes. Adaptations are known as 'maladaptations' if they increase emissions or lead to other negative outcomes, and should be avoided where possible.

Other challenges to quantifying the economics of adaptation relate to defining the **baseline**, i.e what are we comparing the costs and benefits to - what would the impacts of weather variability be in the absence of climate change, and how might these change over time? How much adaptation is already occurring autonomously and becomes incorporated into the baseline?

Further challenges relating to the economic valuation of adaptation arise, some of which are common to other aspects of environmental valuation, including:

- the choice of time horizon and **discount rate** – future costs and benefits are converted to present day values using a discount rate, the choice of which can have significant implications on the outcome
- the **non-monetary costs and benefits** – many of the costs and benefits will occur in areas that do not have a traditional market, particularly environmental goods and services, requiring the use of non-market valuation tools
- the valuation of **non-renewable** resources – some of the resources affected by climate change may be non-renewable, such as peatland, and the extinction of plant and animal species. Should this non-renewability characteristic be valued differently?
- and the **ancillary costs and benefits** – many of the adaptations may have indirect costs and benefits, which also need to be captured in the analysis

Adaptation is much more than a series of discrete technical measures. It is an on-going process of building capacity, reviewing evidence, evaluating effectiveness, and many of the most appropriate actions will be "soft" actions, such as changes in management and education, rather than "hard" engineering solutions. Valuing these also poses signification challenges.

5. Methods

The most appropriate method for appraising the costs and benefits of adaptation will depend on the scale and nature of the adaptation being proposed. Many of the global assessments look at the financial and investment flows required to adapt in global regions. However, most of the adaptation decisions in the UK are at a project or regional level.

The most common approaches to estimate the economics of adaptation projects are cost benefit and cost-effectiveness analysis. However these approaches have considerable limitations and interest is growing in alternative techniques that may handle some of the challenges better. Some of these methods are introduced below. But first we present a summary of the more traditional methods of cost benefit and cost-effectiveness analysis.

Cost-benefit analysis (CBA)

CBA remains the default approach for valuing adaptation despite the challenges discussed above, which CBA is generally unable to cope with. CBA is designed to help identify whether the total benefits of an adaptation project are greater than the total costs, over a defined time-span (e.g. to the end of the century). CBA requires that all the benefits and costs are provided in monetary values, and should ideally account for non-market as well as market values, as well as ancillary benefits and costs.

CBA is most useful when:

- climate risk probabilities are known
- sensitivity to the climate is likely to be small compared to the total costs/benefits
- good quality data exists for major cost/benefit components

The steps involved in a CBA for adaptation are: identify the climate impact of interest and value this (both market and non-market values) in monetary terms over a defined time period; value the impact following the adaptation option; find the difference between these, which provides the benefits of adaptation. The costs of the adaptation must also be estimated over the same time period. The stream of benefits and costs over time are discounted[1] to present values, and a net present value (NPV) is calculated by subtracting the net costs from the net benefits. A positive NPV generally indicates the project should proceed.

Cost-effectiveness analysis (CEA)

CEA compares the costs of alternative actions to deal with the same impact, identifying the least cost outcomes, and does not require the benefit values to be monetised. It is most useful in the same circumstances as CBA, where there is an agreed objective for the sector or issue, and when the benefits are difficult to quantify in monetary terms.

Real-options analysis (ROA)

ROA extends the principles of CBA to allow for learning about the climate change impacts over time. This learning is incorporated by estimation of the value associated with providing information that reduces uncertainty. ROA looks at each and every possible event that might occur in the future and indicates what to do in any of these contingent events. By doing this, ROA analyses whether it is worth waiting for more information given the uncertainty surrounding climate change instead of possibly over- or underinvesting in the present.

Real Option Analysis is most useful:

- As an alternative to standard CBA
- When uncertainty decreases over time
- Where large cost projects are considered for which over- or underinvestment matters
- Where there is an opportunity cost to waiting - otherwise waiting is always the preferred option.

The method has been applied in a study minimising lifetime cost for a drainage system in West Garforth, England (Gersonius et al., 2013). Drainage systems may have to cope with more frequent heavy rainfall events in the future that can lead to urban flooding. In the study, ROA estimates the value of constructing a flexible drainage system by asking whether it is worth spending more money on technical flexibility to expand the system if needed in the future instead of choosing a strategy that might be cheaper in the present but cannot be easily adapted in the future.

Portfolio Analysis (PA)

Portfolio Analysis (PA) is akin to combining different stock market shares in a portfolio to reduce risk by diversification. A basket of adaptation options is determined by maximising adaptation benefits (returns) given the decision maker's attitude to risk. Alternatively, given a defined benefit (return) of the adaptation options, risk is minimised across all adaptation options for different climate change scenarios. Thus, PA allows an explicit

[1] The Treasure Green Book provides guidance on discount rates to be used http://www.hm-treasury.gov.uk/data_greenbook_index.htm

trade-off to be made between the return and the uncertainty of the return of alternative combinations of adaptation options, under alternative climate change projections. PA is most useful when:

- As for CBA
- A number of adaptation options are likely to be complementary in reducing climate risks by performing differently under the same climate change scenario.

The method has been applied in a study analysing which portfolio of wetland habitats for waterfowl should be chosen across the US under a range of different climate change projections (Ando and Mallory, 2011). The different wetland habitats are adaptation options and their benefits the breeding ground quality for waterfowl.

Robust Decision Making (RDM)

RDM can be applied if decision makers have to deal with conflicting or incomplete probabilities on climate change. First, possible robust strategies are developed and in a second step, computer simulation results are created to identify the vulnerabilities of these strategies in different scenarios that describe future conditions where strategies fail to meet their goals. Accordingly, RDM does not as traditionally done predict uncertainty and then rank alternative strategies. Instead RDM characterizes uncertainty in the context of a specific decision. It determines the most important combinations of uncertainties to the choice among alternative options in different plausible futures. Finally, trade-off curves compare alternative strategies rather than providing any conclusive and unique ordering of options. In RDM a strategy that performs well over a range of plausible futures might be chosen over a strategy that performs optimally under expected conditions, thus robustness is the criterion to assess alternative strategies, not optimality. Often, RDM is used in an iterative process together with stakeholder engagement in particular when stakeholders cannot agree on probabilities.

RDM is most useful when:

- The uncertainty is deep with probabilities being unclear
- A large set of decision options exists
- The decision process is complex and simulation models can help to understand the potential consequences of strategies over many scenarios.

RDM has been applied to water management strategies in the U.S in the context of climate change (Lempert and Groves, 2010). The study analysed which strategy will ensure sufficient water supply considering that precipitation and temperature patterns might change significantly however the exact impact and timing are unknown. The analysis showed that the current policy might lead to high future water provisioning costs and established strategies including expanding groundwater banking programs and implementing water recycling programmes that are robust in the sense that they eliminate more than 80 % of the initially identified high cost outcomes.

Flexible pathways

This is less of an economic approach, but is included here as an important example of how uncertainty can be addressed in practice, particularly in large scale projects involving significant uncertainty. Variously termed adaptive management, flexible pathways, adaptive pathways, decision pathways – these options build flexibility into the design of the adaptation, in a less formalised way than ROA. The best-known example of this is the Thames Estuary 2100 (TE2100) project[2]. By sequencing the implementation of different measures over time, the system adapts to climate over time, but options are left open to deal with a range of possible different future

[2] See also Moss and Martin (2012) for a CXC brief on flexible adaptation pathways.

climates and decisions are made at various points along the process as more information becomes available. High level route-maps are used to identify response options (Reeder and Ranger 2010).

6. Conclusion

There are a number of methods available for appraising adaptation decisions. While it is often attractive to obtain 'simple' CBA values, it has to be understood that the assumptions and simplifications necessary to perform a CBA for adaptation may make the final numbers less meaningful. Other options may be more appropriate, particularly under uncertainty (which most climate decisions involve), although it should be noted that some of the alternatives can be very computationally demanding.

7. References

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