Appendix 5: Greenhouse gas emissions and the carbon price

Climate change is an important policy issue for many countries. Despite considerable uncertainty regarding the extent, timing, intensity or frequency of expected changes in climate and extreme weather events, it has become commonplace in economic appraisals to include a monetary value for the greenhouse gas emissions generated by a project. The value is treated as a negative externality in cost-benefit analyses (CBA).

There has not, however, been work done to resolve some of the problems inherent in using any particular value. The purpose of this appendix is to raise issues that should be addressed in establishing consistent valuation of the so-called 'carbon price'.

A5.1 Consistency in measurement

The range of greenhouse gases includes, among others, water vapour, carbon dioxide, methane and nitrous oxide and ozone. The radiative forcing effect of each of these is measured with respect to the reference gas, carbon dioxide. The total effect of any emission scenario is therefore expressed in the common unit of carbon dioxide equivalents, CO_2(e). Nevertheless CBA reports are rarely clear on which greenhouse emissions have been included. It is generally not the practice, for example, to include water vapour, which is a potent greenhouse gas. An obvious area for harmonisation is to establish a common set of gases to be considered, thus allowing projects to be considered on a comparable basis.

The change in radiative forcing caused by greenhouse gas emissions is a function of their addition to the atmospheric concentration of all greenhouse gases. This fact is often overlooked, which leads to the inappropriate measurement of the volume of emissions of greenhouse gases and the attribution of some negative 'carbon price' annual value to a project's 'bubble' of emissions. The additional externality cost will in theory differ each year as the atmospheric concentration of greenhouse gases changes. Given the difficulty of forecasting future global concentration levels, it may be necessary to develop an adjustment factor for future project emissions, perhaps based on the representative concentration pathways (Moss et al., 2008) adopted in the *Fifth Assessment Report* of the Intergovernmental Panel on Climate Change.

Even less tractable is the joint nature of climate change cost due to an increase in emissions in a particular project. In cases where the standing of the project is defined as being national, it is not clear how much of any global change in climatic conditions should be attributed to a local project. Nor is it clear whether there may be a risk of exaggeration in current estimates of carbon prices if they are determined on the basis of damage cost avoided on a global basis.

As well as these conceptual issues, there are four main methods that are currently used to estimate the 'cost of carbon'. Each has advantages and disadvantages.

A5.1.1 Damage cost avoided approach

The 'damage cost estimate' aims to measure the present value of the stream of future damages associated with a marginal increase (e.g. a tonne) in CO_2 emissions. In other words, this approach aims to measure the social cost of CO_2 emissions. The damages considered typically include both market and non-market aspects, covering health, environment, crops and other property damage potentials (e.g. due to increased flood risk or adverse weather patterns) and wider social aspects (e.g. United States Government, 2013).

A frequent problem with the damage cost avoided approach is its reliance on the so-called 'dumb farmer' assumption: that farmers or other actors will not adapt in some way that will reduce or limit the assumed damage incurred. Some of the adaptation framing issues are canvassed in Dobes et al. (2014), including the more realistic modelling approach by Kurukulasuriya and Mendelsohn (2008) to estimating damage to agricultural production.

Estimating the total or marginal damage cost of greenhouse gas emissions involves estimating how they contribute to atmospheric concentrations and hence on associated climatic effects. Integrated assessment models (IAM) have been developed to assess the damage impacts of an increase in global greenhouse gas concentrations, based on different assumptions. Their complex 'black box' nature, however, can mean that the level of transparency around how these models work is generally not particularly high. Pindyck (2013) provides a summary of their key characteristics:

> Most economic analyses of climate change policy have six elements, each of which can be global in nature or disaggregated on a regional basis. In an IAM-based analysis, each of these elements is either part of the model (determined endogenously), or else is an exogenous input to the model. These six elements can be summarized as follows:
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> 1. Projections of future emissions of a CO_2 equivalent (CO_2e) composite (or individual GHGs) under 'business as usual' (BAU) and one or more abatement scenarios. Projections of emissions in turn require projections of both GDP growth and 'carbon intensity', i.e. the amount of CO_2e released per dollar of GDP, again under BAU and alternative abatement scenarios, and on an aggregate or regionally disaggregated basis.
> 2. Projections of future atmospheric CO_2e concentrations resulting from past, current, and future CO_2e emissions. (This is part of the climate science side of an IAM.)
> 3. Projections of average global (or regional) temperature changes — and possibly other measures of climate change such as temperature and rainfall variability, hurricane frequency, and sea level increases — likely to result over time from higher CO_2e concentrations. (This is also part of the climate science side of an IAM.)
> 4. Projections of the economic impact, usually expressed in terms of lost GDP and consumption, resulting from higher temperatures. (This is the most speculative element of the analysis, in part because of uncertainty over adaptation to climate change.) 'Economic impact' includes both direct economic impacts as well as any other adverse effects of climate change, such as social, political, and medical impacts, which under various assumptions are monetized and included as part of lost GDP.

5. Estimates of the cost of abating GHG emissions by various amounts, both now and throughout the future. This in turn requires projections of technological change that might reduce future abatement costs.
6. Assumptions about social utility and the rate of time preference, so that lost consumption from expenditures on abatement can be valued and weighed against future gains in consumption from the reductions in warming that abatement would bring about.

IAMs are typically developed for assessing the outcomes of mitigation options to inform related policy decisions, rather than to determine the damage cost of CO_2 emissions. For models that provide such cost estimates, the range is typically high. For example, in the United States the estimates of the social cost of CO_2 ranged from US$11 to US$109 per tonne of CO_2 in 2015, increasing to between US$26 and US4$220 per tonne of CO_2 by 2050 (US Government, 2013).

Key limitations of the damage cost approach include the uncertainty in predicting climatic impacts, as well as assumptions about adaptation, mitigation measures and feedback processes, the discount rate and the robustness of the damage functions used in the assessment process (Pindyck, 2013; OECD, 2015). For global models that look at the effects of climate change on different countries or regions, the weighting used to aggregate the cost estimates and the assumptions around whether decision-makers are altruistic towards other countries can also affect the final results (Anhoff & Tol, 2010).

A5.1.2 Abatement cost estimate

Another approach to costing greenhouse gas emissions is 'abatement cost'. This approach aims to measure the marginal cost of achieving a given level of CO_2 emission reduction (either target based or individual mitigation policy based), rather than estimating the social cost of CO_2.

The abatement cost approach essentially involves estimating how much emissions and costs will change over time, with and without a specific mitigation policy. Its major limitation is its inability to measure the social cost due to climate change. It is, therefore, used primarily to compare the cost-effectiveness of different policy options for achieving target levels of emission reductions. Its use in CBA is correspondingly limited.

According to a review conducted by the Organisation for Economic Cooperation and Development (OECD), countries that use the abatement cost approach include France, United Kingdom, Norway and the Netherlands. In the United Kingdom, the abatement cost estimate of CO_2 ranged from £30 to £91 per tonne of CO_2 in 2015, increasing to £110 to £329 by 2050 (OECD, 2015).

A5.1.3 Market price of carbon

The market price of carbon is sometimes used to inform policy decisions. If the market price of carbon truly reflected the social cost of carbon emissions, it could potentially offer an effective means of incorporating it into CBA. However, carbon market prices are affected by a range of political and other considerations that control the emission allowances and exemptions for certain sectors or industries.

For example, in the past year, the traded carbon price in New Zealand was below NZ$10 per tonne of CO_2(e). This low value may not represent the social cost of climate change due to emissions.

A5.1.4 Willingness-to-pay estimates

Predicting the future climate at local levels is constrained by the lack of knowledge of the extent, timing, intensity or frequency of expected changes in climate and extreme weather events. Equally problematic is prediction of the effect of current mitigative actions on future climatic change. These problems make valuing the social cost of carbon emissions extremely difficult.

Stated preference techniques typically involve asking respondents directly about their willingness to pay (WTP) (or accept) a good or services (or for the removal of a good or services) under a hypothetical situation. For example, Veldhuizen et al. (2011) conducted a pilot choice experiment in Australia to understand how people trade off the type and amount of a tax or levy they would be willing to pay for specific 2050 emission outcomes expressed in terms of CO_2(e) concentration levels.

Another approach is to impute WTP from market data (e.g. using vehicle-purchasing decisions to impute WTP for lower fuel consumption). Market-based estimates of damage due to climate change, such as lower agricultural production due to changes in temperatures and rainfall, could be gained using hedonic pricing (Howard, 2014 p. 16). However, hedonic pricing requires market data, and these are only available for contemporary or past situations; application to future conditions would require subjective judgement or extrapolation.

Since climate change due to carbon dioxide and related emissions can affect different sectors and have different impacts, integrated assessment models are sometimes used to combine WTP estimates for different impacts to establish the overall impact.

A5.1.5 Current practice

Table A5.1 presents estimates of the social cost of carbon dioxide equivalent emissions that are used in different countries.

Table A5.1: Current international valuation practice for carbon dioxide equivalent emissions

Jurisdiction	Department	Method	Mid-range value per tonne of CO_2(e)	PPP USD 2013	Remarks
Australia	Transport	Abatement cost	€25 (or A$34.75)	22.8	Source: Austroads (2014)
New Zealand	Transport	Damage costs	NZ$40	27.2	
	Health and Environment	Carbon prices	NZ$6.5 (March 2015)	4.4	For cost effectiveness analysis
France	Transport	Abatement costs	€42.40 (2010 € for 2015)	51.1	Source: OECD (2015)
Germany		Damage and abatement cost approach	€80 (2010 € for years to 2030)	105.6	
Japan		Damage cost approach	US$25.70 (2013 $)	25.7	
The Netherlands		Abatement costs	€78 (2010 € for 2015)	96.5	

Jurisdiction	Department	Method	Mid-range value per tonne of CO_2(e)	PPP USD 2013	Remarks
Norway	Transport	Abatement costs	NOK210 (2013 NOK for 2014)	22.8	Source: OECD (2015)
Sweden		Fuel tax on CO_2	SEK1.08 per kg (2010 SEK for 2015)	126.6	
UK	All departments	Abatement costs	£61 (non-traded) (2013 £ for 2015)	92.2	
US	All departments	Damage cost approach	US$11 (2007 $ in 2015)	12.1	

Note: CO_2(e) values for Australia and New Zealand were first inflated to 2013 prices in domestic currency using GDP deflators and then converted to USD using PPP conversion factors. GDP deflators and PPP data are sourced from The World Bank. Other CO_2(e) estimates were sourced from OECD (2015). The Austroads (2014, table 5.3) figure is based on estimates of European Union data by CE Delft et al. (2011).

Source: compiled by Joanne Leung from the sources cited

A5.2 Harmonisation

Due to the uncertainty surrounding the nature of future climate change and its effects, it is difficult to establish a robust social cost for greenhouse gas emissions. Any attempt at strict harmonisation of a value for a 'carbon price' would be contentious, given the wide range of values that are shown in Table A5.1.

If jurisdictions consider it acceptable to include in CBA studies values that reflect the social cost of greenhouse gas emissions, despite the deep level of inherent uncertainty, then it would be desirable to initiate early discussion about the best method of estimating an acceptable value, or range of values.

This text is taken from *Social Cost-Benefit Analysis in Australia and New Zealand: The State of Current Practice and What Needs to be Done*, by Leo Dobes, Joanne Leung and George Argyrous, published 2016 by ANU Press, The Australian National University, Canberra, Australia.