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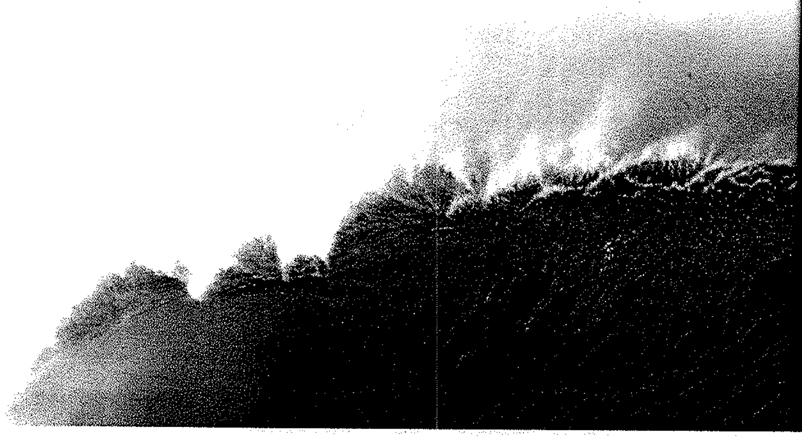
RESPONDING TO CLIMATE CHANGE

Global Experiences and the Korean Perspective



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2. Sustaining growth and mitigating climate change: are the costs of mitigation underestimated?

Stephen Howes

INTRODUCTION

Despite many estimates showing that the costs of mitigation of climate change will be moderate, concerns remain that mitigation will slow and possibly halt economic growth. Take for example the conclusion of Dieter Helm, who, though he supports the "case for urgent action" (Helm 2008:236), argues:

> The happy political message that we can deal with climate change without affecting our standard of living—which is a key implicit message from the Stern Report on which politicians have publicly focused—and do so in a sustainable way, turns out, unfortunately, to be wrong. (Helm 2008:228)

This chapter explores the concerns of those such as Helm in relation to standard and often-used estimates of mitigation costs, and assesses their validity. It begins with a brief survey of mitigation cost estimates, and then outlines and considers a range of issues in relation to them. The aim is to address in particular the apprehensions around whether the standard estimates of mitigation costs are too low. Whereas Weyant (2000) and Barker et al. (2006) explore reasons why different models give different cost estimates, the concern in the discussion below is more with cost considerations that might not be captured by the models from which global cost estimates are derived. The chapter draws in particular on the recent Australian Garnaut Review of Climate Change (Garnaut 2008), the related modelling of the Australian Treasury (2008), and the public debate in Australia in relation to the introduction of an emissions trading scheme. The chapter concludes that the national costs of mitigation may well lie above the commonly estimated range of, say, 1–5 percent of GDP. The two most serious risks are that in some countries the national costs of mitigation will be significantly above the global average—some modelling

Table 2.1 Survey of global mitigation cost estimates for 2050

Modelling exercise	Mitigation cost in 2050 as a percentage of global output
550 ppm CO_2eq stabilization target	
IPCC Fourth Assessment Report (2007a) 535–590	1.3 (slightly negative to 4)
Stern 550 (2007)	1 (−2 to 4)
Australian Treasury GTEM 550 (2008)	2.7
450–500 ppm CO_2eq stabilization target	
IPCC Fourth Assessment Report (2007a) 445–535	(up to 5.5)
Stern 500 (2009)	2
Australian Treasury GTEM 450 (2008)	4.3

Notes: Costs are mean or individual estimates (with ranges in parentheses). Note that the 535–590 ppm CO_2eq range is assessed to hold on the basis of "high agreement, much evidence" (IPCC 2007a:172). The 445–535 ppm CO_2eq range is assessed to hold with "high agreement, medium evidence." There are fewer studies with this more stringent stabilization target, which is also why only a range is presented and no mean.

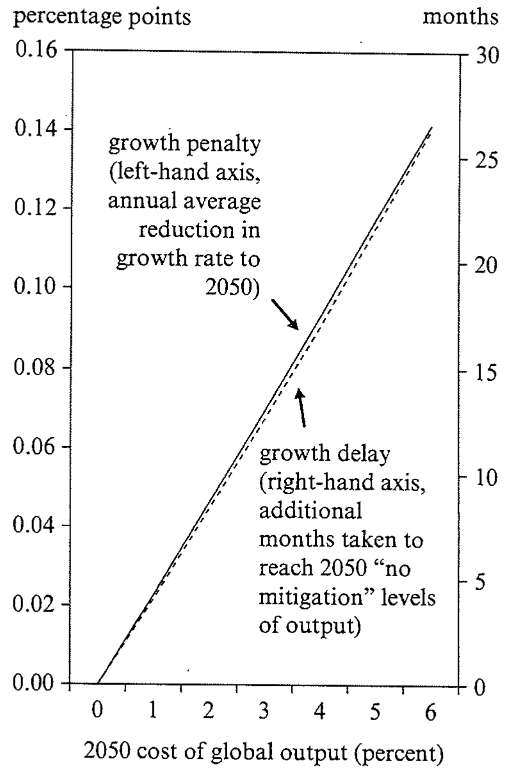
suggests that this is particularly a risk for poor countries—and that policy mistakes will drive up the costs of mitigation. These factors are unlikely to make mitigation not worth undertaking, but could discourage mitigation effort. Policies that are efficient and that assist developing countries to meet some of their mitigation costs will likely have a high environmental return.

Table 2.1 provides a survey of global mitigation costs as a percentage of global output for the year 2050 and for two stabilization targets: about 550 parts per million (ppm) of carbon dioxide equivalent and a more stringent target of about 450 ppm. The table shows the range of results reported in the Fourth Assessment Report of the International Panel on Climate Change (IPCC), the cost estimates from Stern (2007 and 2009, probably the most influential in the global debate), and some recent estimates derived by the Australian Treasury (2008), using the Global Trade and Environment Model (GTEM), which are drawn on later in the chapter.

The best known of these cost estimates is Stern's (2007) 1 percent of global output. Stern (2009) now supports a 2 percent cost estimate to achieve a tougher mitigation target (500 rather than 550 parts per million). Stern's estimates are at the low end of the range of published estimates. The recently published Australian Treasury GTEM results put the cost of global mitigation at twice or more Stern's levels. The Stern review uses a bottom-up model based on cost estimates of different technologies. The Treasury and other general equilibrium modelling exercises derive their estimates from models that have less technological detail but capture second-round effects such as reductions in savings (caused by income losses) and thus declines in investment. Weyant (2000) concludes from his survey that the most important determinants of modelled mitigation costs are the size of the abatement task relative to GDP, and the scope for flexibility allowed in the policy regime. Differences in assumptions about the flexibility of the economy to substitute and about the speed with which new technology develops have a secondary influence. Barker et al. (2006) reach similar conclusions.

In absolute terms, the cost estimates in Table 2.1 are large. Even 1 percent of world output in 2050—measured in 2005 U.S. dollar prices, using purchasing power parities to compare across countries—is US$2.7 trillion or about the size of the Indian economy today. Nevertheless, costs in the range presented in Table 2.1 would have only a minor impact on growth. Their growth impact can be measured (1) as a growth penalty (the difference between annual average growth under the business as usual or no-mitigation scenario and under the mitigation scenario) or (2) as a growth delay (the additional time it will take the world to achieve the no-mitigation level of output). Figure 2.1 shows how the cost of global output translates into growth penalties and growth delays. It illustrates that even relatively large costs—if incurred over a long period of time and in the context of reasonable underlying growth—have only a limited impact on growth rates and impose only moderate delays in achieving given growth targets. Thus, for example, the Stern 1 percent 2050 cost estimate translates into a growth penalty of 0.02 percentage points and to a growth delay of 4 months. Even the Australian Treasury (450 ppm) 4 percent cost estimate amounts to a growth penalty of just under 0.1 percentage points and a growth delay of 17 months.

From Figure 2.1, the growth impact of even a stringent mitigation target costed using more conservative assumptions than Stern appears to be minor. Why then is the cost of mitigation still a contentious issue? There are several possible reasons. First and most important, even if the mitigation cost estimates presented above are accurate, and even if they amount to only a minor tax on growth, they might still not be worth incurring. Second, decisions to mitigate are made at the national not the international level. Such decisions will be based not on global but on national mitigation cost estimates, and these might range widely around the global average. Third and fourth, the standard global cost estimates typically include a number of unrealistic assumptions that push costs



Note: The assumed annual average global growth (without mitigation) from 2005 to 2050 is 3 percent.

Figure 2.1 Growth penalties and growth delays for different 2050 mitigation costs

down, including, respectively, optimal domestic policies and complete global participation.[1] Fifth, modelling exercises also typically neglect short-term transitional costs and the distribution of costs. Finally, there are also counterarguments that mitigation cost estimates are systematically overstated and ignore the potential benefits of climate change policies in driving economic innovation and growth.

The following sections interrogate the standard mitigation cost estimates with respect to these various concerns. As noted earlier, the aim is not to provide an explanation of why different published global cost estimates differ, but rather to consider whether all the estimates might be biased downward (or perhaps upward).

ARE THE COSTS OF MITIGATION WORTH INCURRING?

Frankel (2005) notes that the economic modelling in which he was involved, on behalf of the Clinton administration in the United States, showed that, with heavy reliance on trade in permits, it would cost the United States only 0.1 percent of GDP a year to fulfil Kyoto Protocol commitments. The clear, if unstated, implication is that even this level of costs was testing political support for domestic U.S. mitigation at that time. Indeed, until recently, most economic modelling has supported only a moderate level of mitigation, aiming for targets above 550 ppm (Toll 2006). There have been two reasons for this.

First, economic models have tended to show high levels of climate change damage only in the distant future. The Stern Review gave a best estimate of damages of only about 3 percent of global output in 2100 even when incorporating non-market as well as market impacts as well as catastrophic risk (Stern 2007: Figure 6.5c). Even the 95th percentile damage estimate for 2100 fell below 10 percent of global output. The costs of climate change according to the Stern Review were much larger in the twenty-second century, with the best estimate of damages rising to 14 percent of global output by 2200, and the 95th percentile estimate increasing to 35 percent. Since Stern used a low discount rate, he used these twenty-second century damages to argue for stringent mitigation today, but most economists worked with higher discount rates and thus supported less stringent efforts.

The debate about discounting continues, but more recent projections of emissions under business as usual bring forward the damages of climate change. Stern assumed a temperature increase over the course of the century of about 3.4 degrees Celsius, right in the middle of the IPCC Fourth Assessment Report central range of 2.3 to 4.5 degrees.[2] The Garnaut Review (2008), by contrast, built its no-mitigation emissions projections on the assumption of long-term, rapid developing-country growth. As a result, it derived a business-as-usual temperature increase projection this century of 5.1 degrees Celsius, which is above the IPCC range.

Second, many economic models show relatively limited impacts of climate change, even for high temperature increases. Consider a 5 degree Celsius increase. This is above the range of "tipping points" for seven of the eight catastrophic global events, for which Lenton et al. (2008) present such a range, and at the top end of the range for the eighth.[3] A recent study by the Center for Strategic and International Studies concluded that this extent of climate change

> would pose almost inconceivable challenges as human society struggled to adapt. . . . The collapse and chaos associated with extreme climate change futures would destabilize virtually every aspect of modern life. (CSIS 2007:7, 9)

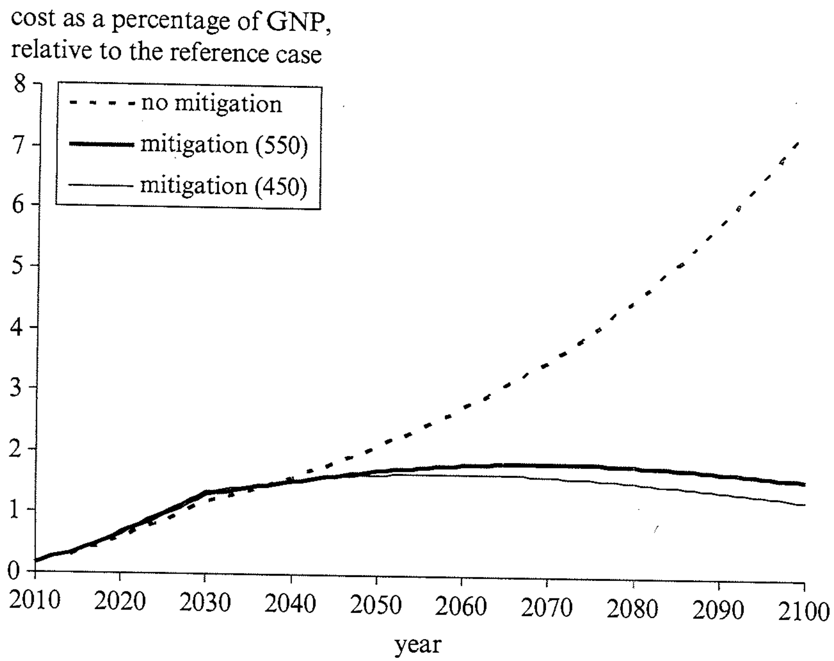
However, the survey of economic models in the IPCC Fourth Assessment Report (2007b) suggests that, for this level of temperature increase, global output would take a hit of somewhere between about 0 and 10 percent (see Figure 20.3 in Chapter 20 of IPCC 2007b): significant, but far from catastrophic, and indeed as Figure 2.1 shows, quite manageable in the context of a century of growth.

Worryingly, this disconnect may be increasing over time. Smith et al. (2009: Figure 1), summarizes how much more risk scientists have come to attach to even moderate levels of climate change between the third (2001) and fourth (2007) IPCC assessment reports. But the survey of aggregate economic costs of climate change given in the IPCC third and fourth assessment reports shows no sign of an upward trend in the relationship between temperature and damage, as is perceived by economists.[4]

A full account of this disconnect is beyond the scope of this chapter. However, it is important to recognize the limits of economic modelling when it comes to estimating climate change impact. Impacts might be catastrophic, and yet be difficult to model simply because they are difficult to quantify. It is obvious that an unmitigated future will be hugely damaging and risky. In the words of Martin Weitzman, a large temperature increase, of the sort that would occur if emissions continue to grow rapidly (Weitzman refers to an average increase of 6 degrees Celsius), would result in

> a terra incognita biosphere . . . whose mass species extinctions, radical alterations of natural environments, and other extreme outdoor consequences of a different planet will have been triggered by a geologically instantaneous temperature change that is significantly larger than what separates us now from past ice ages. (Weitzman 2007:717)

The question then is not whether to mitigate but how much. Here again, the role of modelling might be limited. Modelling carried out by the Garnaut Review suggests that the climate change associated with 450 and 550 ppm levels of mitigation will give rise to roughly similar expected market impacts. Figure 2.2 illustrates by showing not the costs of different levels of mitigation but the costs associated with the climate change associated with these levels of mitigation. There is very little difference between the modelled damage from stabilization at 450 ppm and 500 ppm. Given this, it would only make sense to opt for more stringent (and



Note: These estimates are achieved by "shocking" the reference (no climate change) case with the differing levels of impact associated with the temperatures expected from the three scenarios. There are no costs of mitigation.

Source: Garnaut (2008).

Figure 2.2 Expected, modeled market costs for Australia of unmitigated and mitigated climate change, 2010–2100

therefore more expensive) mitigation for the greater protection it would give against non-market damages and against low probability catastrophic events, both of which are hard to model. The Garnaut Review argued on these (non-quantified) grounds that Australia should support 450 ppm as a global stabilization objective even though this would cost about 1 percent of GNP more (in net present value terms) over the course of the century.

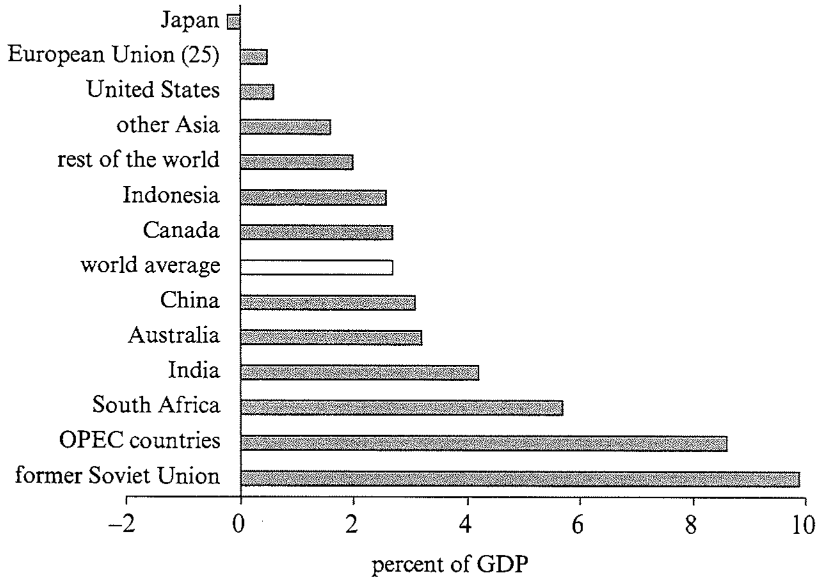
In summary, even if it is not evident from climate change damage estimates based on economic modelling, the sorts of mitigation costs presented in Table 2.1 are certainly modest enough to warrant even stringent levels of mitigation. Whether they can be relied on is the subject of the rest of this chapter.

NATIONAL MITIGATION COSTS

Decisions to mitigate are made not at the international but at the national level. From this perspective, the global mitigation cost estimates surveyed in Table 2.1 are of limited interest. It is well known that climate change damages will vary from region to region, with cold areas even benefiting from limited amounts of global warming. Mitigation costs will also vary from region to region. But modelling exercises typically pay less attention to national than international mitigation costs.

How global mitigation costs are shared around the world depends on burden sharing arrangements. The global mitigation costs presented above assume efficient mitigation, with a single global price on greenhouse gas emissions. A useful benchmark to consider is the national cost of the mitigation that would transpire if each country was subject to the same global carbon price, prior to any international transfers.

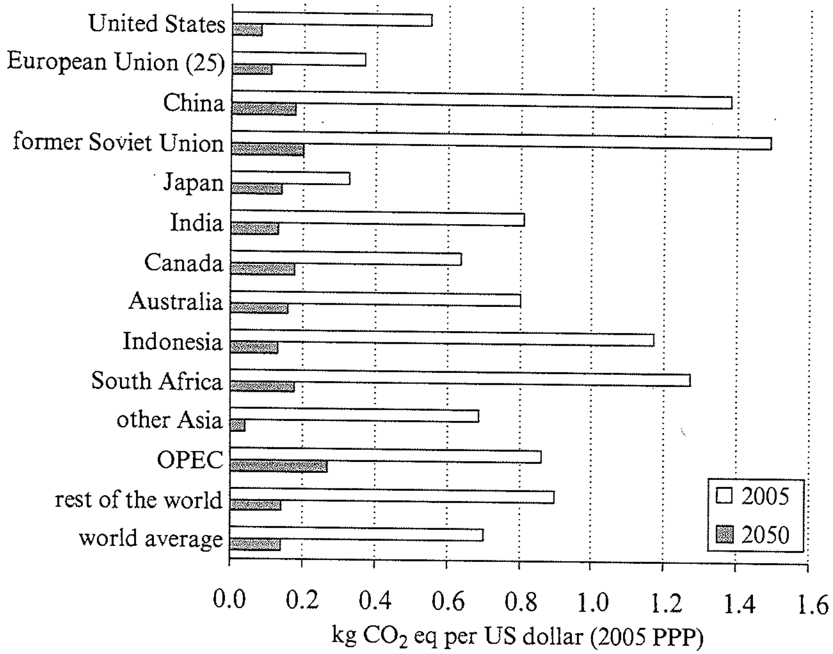
Figure 2.3 shows the great variation in mitigation costs across countries, according to the GTEM model used by the Australian Treasury (2008).



Note: Results were generated using the GTEM model.

Source: Australian Treasury (2008), Table 5.14.

Figure 2.3 GDP costs of mitigation for 2050 under a 550 ppm global mitigation strategy: selected countries and regions



Note: Results were generated using the GTEM model.

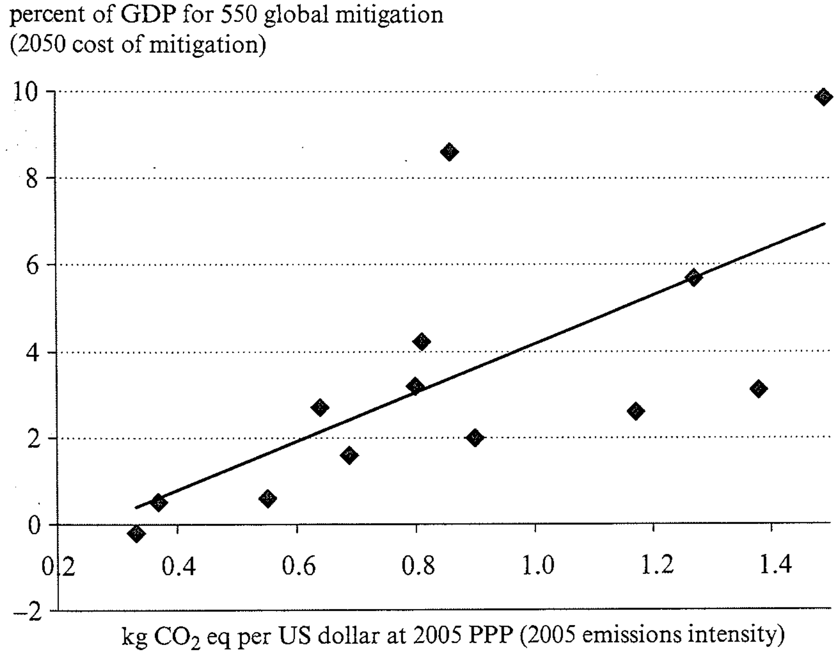
Source: Australian Treasury (2008), Table 5.11.

Figure 2.4 Emissions intensity in 2005 and 2050 under a 550 ppm global mitigation strategy

If we take the 550 target, for which the global average GDP cost in 2050 is 2.8 percent, the cost range for the thirteen GTEM regions is from −0.2 percent (Japan) to 9.9 percent (the former Soviet Union).

A number of factors explain the variation, including terms of trade effects. The reduction in fossil fuel prices benefits fuel importers, such as Japan. The most important determinant, however, is the starting emissions intensity of the economy. As Figure 2.4 shows, with a global carbon price there is by 2050 very little absolute variation in the emissions intensities (ratios of emissions to output) of the world's economies. The units are kg of CO_2 equivalent per U.S. dollar (again using purchasing power parities at 2005 prices). The 2050 range is from 0.04 (other Asia) to 0.27 (OPEC). Compare that to the range today (2005), from 0.33 (Japan) to 1.49 (the former Soviet Union).

At least according to GTEM, a common carbon price will induce all



Note: The results were generated using the GTEM model; see Figures 2.3 and 2.4.

Source: Australian Treasury (2008).

Figure 2.5 Cost of mitigation in 2050 and emissions intensity in 2005

countries to move not only in the same direction but to more or less the same destination emissions intensity. Those with the longest to go to reach this destination incur the highest costs. Figure 2.5 shows the close correlation between initial emissions intensity and the 2050 cost of mitigation.

One striking consequence of this close correlation is that on average developing countries incur the highest mitigation costs. GTEM 2050 global costs for the 550 mitigation strategy, which are 2.8 percent of global output using purchasing power parities, are only 2.2 percent if market exchange rates (which give developing economies a lower weight) are used to aggregate costs across countries. China, India, Indonesia, South Africa, OPEC, and the rest of the world (essentially Latin America and Africa) all have above average initial emission intensities today (Figure 2.4). They also all have above average 2050 mitigation costs, except for Indonesia and the rest-of-the-world category, which evidently find it cheap to reduce deforestation (Figure 2.3).

It remains to be seen whether this result holds across models. The other global model used by the Treasury, G-cubed, also shows significantly higher costs of global mitigation when assessed using purchasing power parities rather than market exchange rates (2.5 percent versus 1.9 percent for the 550 strategy).[5]

This result may appear to be contrary to the received wisdom that mitigation will be cheap in developing countries. For example, Frankel (2005:46) writes: "It is far easier for some countries to cut emissions relative to the BAU [business-as-usual] path than for others." He gives China and the United States as examples of places where it will be, respectively, cheap and expensive to reduce emissions. Many developing countries have low marginal mitigation costs, but this may simply mean that they mitigate a lot, and so still end up with high total mitigation costs.[6] The modelling results reported here do not include the costs of stranded investments, for example mothballed coal-fired power plants. If they were included, the costs of developed country mitigation could go up relative to those in developing countries since the former could have more stranded assets (Stern 2007:275; Frankel 2005). This notwithstanding, these results should clearly caution us against simplistic statements that mitigation will cost developing countries less.

The results also underline the importance of developed countries putting in place generous transfer programs to help compensate developing countries for the costs they will face. This will reduce costs for developing countries, and increase them for developed countries. This in turn will reduce the dispersion in mitigation costs between developing and developed countries, and in general push countries toward the global average.

POOR POLICIES

The cost estimates provided in Table 2.1 assume that the cheapest abatement opportunities are selected. In bottom-up models, mitigation options are simply ranked from cheapest to most expensive, and selected accordingly. In top-down models, a single instrument, a carbon price, ensures that the cheapest abatement opportunities are selected first. The real world is more complex. In practice, countries use a range of policies, in addition to or in place of carbon pricing, including separate targets for renewable energy and for biofuels, government R&D programs, and often separate targets or policies for energy efficiency or product quality regulation (for example automobile efficiency standards).

Both political and economic arguments can be made for this portfolio approach to mitigation policy (Hannemann 2007, 2008). In an environment of political uncertainty, it might make sense to use a diversified approach. For example, a government might not be sure if it can introduce carbon pricing or it might be worried that if carbon price rises too high, political support will be compromised. Such governments will have an incentive to seek overlapping policies in case carbon pricing is unavailable as a policy tool, or to dampen carbon prices.

From an economic perspective, as Bennear and Stavins (2007:111) argue, "under a fairly broad set of circumstances the use of multiple policy instruments can be justified as optimal in a second-best world." For example, while cap and trade worked to reduce sulfur emissions from coal-fired power plants, in that case the technology to respond to the problem at hand was well developed. Some of the technology required for successful mitigation is still under development, and a range of policies may be needed to induce that technology (Grubb 2004).[7] In addition, mitigation can give rise to national first-mover advantages, if, as discussed in the penultimate section, particular countries are the first to display mastery of particular technologies. However, this requires not a dispersed market-based effort, but a focus on particular technologies, supported by a variety of instruments (see the example of Denmark and wind power discussed below).

While these arguments for the use of multiple mitigation policies have some merit, it is also the case that the greater the variety of policies used, the greater the scope for political rent-seeking and the greater the likelihood that really bad policies will be adopted. Policies relating to biofuels are the most egregious example to date. One study of OECD biofuels estimated "costs ranging from US$150 to over US$1,500 per metric tonne of CO_2-equivalent avoided" (Kutas et al. 2007). Other studies have questioned whether biofuel use actually reduces greenhouse gas emissions, noting that some methods of producing biofuels "actually increase global warming due to land conversion and the release of huge amounts of carbon that otherwise would remain in plants and soil" (CGIAR 2008). Biofuel policies have been used to subsidize domestic producers and keep out more efficient foreign producers. The United States imposes a tariff of US$0.54 per gallon on ethanol imports to keep Brazil, the world's lowest-cost producer, out of its market (Smith 2007). The rapid growth of the ethanol industry has pushed up food prices, hurting the poor in developing countries (CGIAR 2008).

Renewable energy mandates are also expensive. A study by the U.K. National Audit Office (2005) found that the United Kingdom's renewable obligation policy (which mandated 10 percent of U.K. electricity to come from renewable sources by 2010) saves greenhouse gas emissions at the high cost of 70–140 euros per tonne of CO_2. The German policy of promoting domestic photovoltaic solar has been criticized as being particularly expensive. The generous feed-in tariff that has supported the expansion of solar photovoltaics in Germany is now being wound back owing to cost pressures.[8]

Policy uncertainty can be another source of cost. Investors will delay decisions if it is unclear which energy policies will be implemented when, and with what vigor. At the extreme, this could compromise energy security and reliability.

Finally, as noted in the next section, the adoption of measures to shield emissions-intensive industries can give rise to rent seeking, as industries clamber to be on the list of protected industries. It could also give rise to trade disputes, if countries seek to penalize those seen to be obtaining an unfair trade advantage through not mitigating.

It is difficult if not impossible to quantify the policy costs likely to be associated with climate change mitigation. Dieter Helm argues that on account of policy costs, among other factors, the "costs of mitigating climate change are likely to be significantly higher than indicated by the Stern Report" (Helm 2008:228). Ross Garnaut (2008:297) estimates that, if handled incorrectly, the special treatment of emissions-intensive trade-exposed industries, discussed further in the next section, could "turn out to be as expensive as the costs of mitigation itself." Nicholas Stern's most recent book emphasizes "the importance of good policy in keeping costs down" (Stern 2009:55).

INCOMPLETE PARTICIPATION

A critical concern for countries considering whether to mitigate is incomplete participation. In the debate in Australia over the introduction of an emissions trading scheme, no issue has received more attention. A speech by the opposition Liberal Party spokesman illustrates the arguments against "going it alone."

> . . . global emissions could actually increase as investments and jobs, especially from major regional centres, leave Australia and go to developing countries where less efficient factories pump out much more CO_2 than in Australia. And without our major competitors engaging in some form of scheme the cost to Australians will be much greater. This cost will be measured in the premature closure of many coal mines, cement works, coal powered generators and fuel refineries and the loss of major investment in new smelters, metal refineries, LNG gas projects, cement works, exploration and much more. (Robb 2009)

A world in which only some countries decide to mitigate makes mitigation less attractive for the mitigating countries for three reasons. First, with incomplete participation, participating countries have to do more to achieve any given global environmental target (Nordhaus 2008). Nordhaus calculates that a participation rate of 50 percent imposes a cost penalty of 250 percent for this reason.

Second, costs for countries subject to national emissions caps, like those in the Kyoto protocol, will rise if the opportunities for trade in permits are limited. This phenomenon has been extensively modelled. Some estimates show costs being halved or more by the introduction of trading—relative to a global mitigation program in which there are national caps but no trades (Stern 2009:164). Brandt and Svendsen (2006: Table 2) present a range of estimates which show that the cost for the United States of achieving its Kyoto target was three to ten times more expensive without trading than with.

Third, and this is the aspect that causes the greatest concern, incomplete participation gives rise to the risk of leakage, that is, an increase in emissions in non-participating countries.[9] This leakage can happen either directly (as emissions-intensive production moves to non-participating countries) or indirectly (as fossil fuel prices fall in non-participating countries owing to reduced global demand). The global environmental benefits of domestic mitigation are thus reduced. It is also often claimed that the unlevel playing field (a result of incomplete participation) will in itself increase the costs of domestic mitigation, but this is not necessarily so. McKibbin and Pearce (2007) consider a carbon tax, and so abstract from the impact of participation on international permit trading. They analyze a carbon tax implemented only in Australia, only in the rest of the world, and then all over the world. The results show that mitigation is actually cheaper in Australia when it is going alone (see McKibbin and Pearce 2007:26, Figure 3.1). This is because of the terms-of-trade effect that international mitigation has: demand from the rest of the world for Australian coal in particular falls. Thus, incomplete participation does not necessarily make domestic mitigation more expensive, but it does make it environmentally less effective.

The likely extent of leakage is very uncertain. The available evidence is surveyed in Chapter 11 (section 11.7) of the report of the Third Working Group of the IPCC's Fourth Assessment Report. This cites a leakage range of 5–20 percent (the ratio of increase in emissions in non-participating countries to decrease in participating countries), but there is little evidence on which to base such a claim, since the so-called participating countries have either not implemented economywide policies or have shielded their trade-exposed emissions-intensive industries. Many analysts suggest that direct leakage will be small, citing experience with other environmental regulations (Aldy and Pizer 2009; Stern 2007: Chapter 11), and the fact that emissions-intensive trade-exposed industries are only a small proportion of total output. In Australia, the ten industries with the highest emissions per unit of revenue in 2001–02 contributed 37 percent of national emissions, 4 percent of national production, 3 percent of employment, and 15 percent of exports (Australian Government 2008:313). The fact that emissions-intensive industries are also capital intensive suggests that relocation is unlikely. Firms establishing new plants will look at many factors; with respect to carbon prices, the prospect of carbon price introduction in the future will deter the establishment of long-lived carbon-intensive projects in countries that currently do not have carbon prices.

Even if direct leakage is an exaggerated and misunderstood problem in the public debate, it is politically salient. In a world with incomplete participation, experience shows that countries will not mitigate without providing some protection to their carbon-intensive, trade-exposed industries. This protection will typically not only involve compensation (which would have no impact on aggregate costs) but also some sort of shielding, that is, the full or partial exemption of the industries concerned from the carbon pricing regime. Shielding will tend to increase costs since it reduces effective coverage. Modelling for the Garnaut Review suggested an additional cost impact of shielding of about 0.2 percent of GNP by 2020 (1.7 percent of GNP cost with shielding versus 1.5 percent without) rising to as much as 0.5 percent of GNP by 2030 (4 percent versus 3.5 percent).[10]

Additional costs from leakage can also arise as a result of rent seeking associated with the policy response, or even potentially as a result of trade disputes. This is a form of the policy costs discussed in the previous section. Ross Garnaut has noted that the "arbitrary nature" of assistance measures to address leakage concerns "will make them the subject of intense lobbying with potential for serious distortion of policy-making processes" (Garnaut 2008:317) and "has the capacity to . . . pervert individual domestic schemes to the point of non-viability" (Garnaut 2008:342).

Finally, experience suggests that incomplete participation will result in participating countries doing less. Incomplete participation discourages action by participating nations, in part because of worries about carbon leakage and competitiveness, and in part because of a perception that climate change mitigation, if limited to a few countries, is both unfair and ineffective. The decision of the "enthusiastic countries" (to use the terminology of Victor 2008) to continue to mitigate, albeit at a lower level, despite incomplete participation is made in response to public pressure, in the hope of encouraging the "reluctant countries" to do more over time, to enable a gradual decarbonization of the economy and avoid sharp adjustments and, as discussed in the next-to-last section below, to gain first-mover advantages.

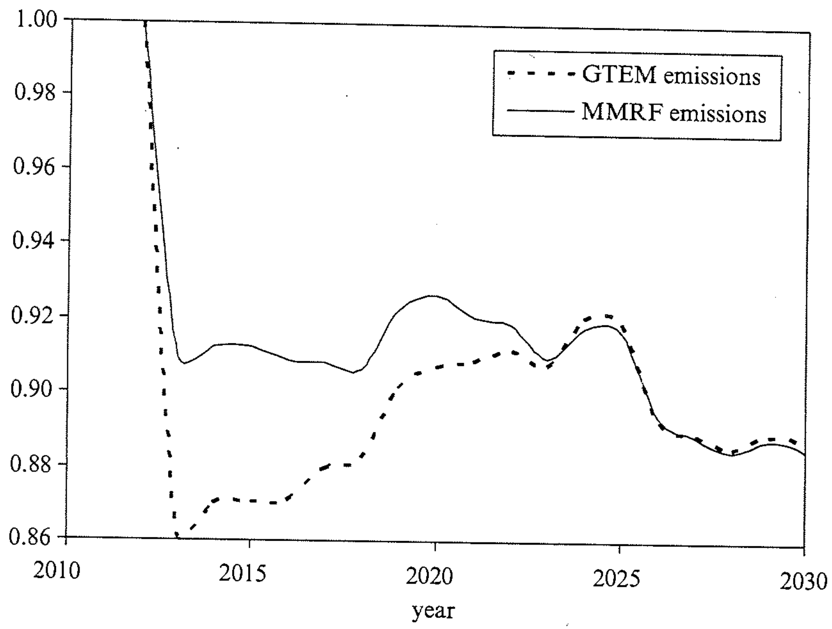
Both the European Union and Australia have formally made conditional and unconditional offers. The European Union has said it will reduce emissions by 20 percent over 1990 levels by 2020 unilaterally, and by 30 percent if there is a global agreement. Australia has said it will reduce emissions by 5 percent by 2020 over 1990 levels unilaterally, and by 15 percent or 25 percent if there is a global agreement (depending on the strength of that agreement). The Garnaut Review estimated that the 2020 GNP cost of the unconditional offer was 1.4 percent, little different from the cost of the 15 percent target (1.5 percent) or the 20 percent one (2.0 percent). The greater ambition of the conditional offers is almost fully offset by the greater potential for international trade in permits afforded by an international agreement (Garnaut 2008: Table 12.3).[11]

This reaction from participating countries (to do less) will prevent incomplete participation leading to an escalation of domestic mitigation costs. It will of course do nothing to help achieve the environmental objectives of mitigation.

TRANSITIONAL AND DISTRIBUTIONAL COSTS

Policymakers are not only, or even primarily, concerned with the aggregate, long-run costs reported at the start of this chapter. They are also concerned with the costs that will fall in the near term and on particular regions or industries or on groups of households or workers. In the long run, resources will adjust, and there will be both losses in and gains to employment. But political concerns are likely to focus more on existing jobs, and threats to them, particularly when they are in concentrated geographical areas.

Though some mitigation cost models incorporate adjustment costs and so allow for rises of unemployment, in general these models are not a strong basis on which to base short-term forecasts. Figure 2.6 illustrates this point with the two models used in the Garnaut Review (2008). It shows projected emissions (relative to their 2012 level) from the introduction of a carbon price into Australia in 2013. Though by 2030, the two models show a similar level for domestic emissions, the two models show very different emissions paths prior to 2020. They also both show implausibly large single-year falls in the year in which the carbon price is introduced: in GTEM, emissions fall by 14 percent in a single year, and in MMRF by 9 percent. An emissions decline of this magnitude in a single year is unlikely, and one would place more faith in the convergent 2020 results than in the divergent 2013 ones. The introduction of adjustment



Note: A carbon price consistent with a 550 ppm stabilization path is introduced in 2013.

Source: Modeling undertaken for the Garnaut Review (2008).

Figure 2.6 Emissions in Australia 2010–30 following the introduction of a carbon price in 2013, according to two different models used by the Garnaut Review

costs would yield more plausible and smaller short-run changes, but given our limited experience with carbon pricing, it is difficult to know just how costly the adjustment will be.

Similarly, some modelling work incorporates distributional costs, but regional estimates, which are often the focus of policy concern, are particularly fraught with uncertainty.

While it is difficult to model the short-term, transitional and regional impacts of mitigation, policymakers do have tools available to manage these impacts, namely through programs of structural adjustment, similar to those often used in response to programs of tariff reform.

Another form of transitional costs that might be incurred is the rise in prices due to mitigation-induced demand surges, for example, for renewable technologies. Helm notes that

> the prices of wind turbines have risen sharply as the dash-for-wind has been embedded in renewables policy; and now there is evidence in the sharply rising prices of new nuclear development technologies as manufacturing production lags demand. These price effects are of a significant order of magnitude. . . . (Helm 2008:225)

The presence of these rents does not increase economic costs (since they are in the nature of a resource transfer), but they will increase the costs to households (for example, resulting in higher electricity prices) and thus make the transition politically more difficult.

A MITIGATION STIMULUS?

The previous sections have examined whether the standard estimates of mitigation costs might be systematically biased downward. Are there any reasons why they might be systematically biased upward?

There is some evidence that past predictions of environmental compliance have been overly pessimistic. Hodges (1997) examines twelve cases of new pollution regulations, and finds that in eleven of them early cost estimates were more than double later estimates (and for the twelfth, was 30 percent above). Will climate change be another example where we have underestimated the human capacity for innovation? We do not know. But it is important to note that the current range of models already reflects a range of views on technological development. Climate change mitigation will demand a restructuring of the economy, and it is unclear whether one can extrapolate from the experience of dealing with other, far less costly environmental problems.

Some point to broader, spillover impacts from mitigation spending. In the short term, such spending could help boost demand during a slowdown, an argument that became popular in the response to the global financial crisis. In the words of Gordon Brown, Prime Minister of Great Britain (2009): “the drive to a low carbon economy is not something to be delayed because of the global recession; instead it can be a powerful driver of global recovery.” In the long run, however, mitigation spending is an unlikely counter-cyclical fiscal policy tool.

The longer-term argument that mitigation will drive the next round of innovation and growth has also become increasingly popular. Nicholas Stern (2009) makes this case.

> The changes in technology required to get to a low carbon world are likely to usher in a burst of innovation, creativity and investment. . . . The new technologies and investment opportunities of low carbon growth will be the main drivers

> of sustainable growth in the coming few decades. These investments will play the role of the railways, electricity, the motor car and information technology in earlier periods of economic history. (Stern 2007:47, 206)

The 2009 *World Economic and Social Survey* argues that the large-scale investments needed to respond to climate change could trigger "virtuous growth circles" in developing countries (United Nations 2009:xv).

Whether mitigation will not only drive but also accelerate global growth at the global level will depend on whether it will stimulate additional innovation and investment, or rather shift existing innovation and investment from other areas (see Weyant 2000; Jochem and Madlener 2003). This seems uncertain, and difficult to measure. It is more straightforward that individual countries could benefit from early mitigation by obtaining a first-mover advantage in particular mitigation technologies. This is essentially an infant industry argument, best illustrated by Denmark's success in the wind-turbine industry, not only domestically but subsequently overseas (Brandt and Svendsen 2006). Denmark has about 3,000 megawatts (MW) of installed windpower capacity, but Danish firms have installed about 20,000 MW globally, about 40 percent of the world total. Denmark started promoting wind power in the mid-1970s. One review of the Danish experience concludes that: "The careful balance and timing of R&D and procurement support [including investment subsidies and feed-in tariffs] have both been important to promote both innovation and diffusion of wind energy" (Klaassen et al. 2005:231).

Brazil's experience with sugar-based biofuels provides another example. Almost 20 percent of Brazil's automotive fuel now comes from ethanol, and the industry runs without subsidy, generating significant employment and greenhouse gas savings (provided that the additional demand for sugar cane does not lead to deforestation, which is an open question).

As discussed earlier, the potential for reaping first-mover advantages is an argument in favour of domestic mitigation in the context of incomplete global participation. And this mixing of objectives of industrial policy and climate change policy would lead one to consider policies (such as renewable energy mandates) that one would otherwise regard as inferior to a carbon price. But one's judgement on whether these potential first-mover advantages are worth pursuing will depend on broader views of the importance and appropriateness of countries pursuing activist industrial policies, and the likelihood of governments being able to "pick winners." If one is an optimist in these matters, one will see gaining a first-mover advantage as an upside to incurring mitigation costs; if one is a pessimist, one will see only an additional downside risk to embarking on mitigation, namely that of failed industrial policies.

CONCLUSION

The second section of this chapter argues that if the standard mitigation cost estimates are reliable, then given the risks of unmitigated or even moderately mitigated climate change, there is a strong case for stringent mitigation. The standard cost estimates are typically in the range of 1–5 percent of global output by 2050. Are they reliable? Various criticisms of them can be made. Five are considered in this chapter. The first two emerge as well founded and the other three less so. Working in reverse order through the chapter, I summarize each in turn below.

First, it is possible that the global and national costs of mitigation might be not under- but over-estimated. At the national level there can be first-mover advantages, and at the global level dynamic gains from the investment and innovation that mitigation will no doubt bring. However, these gains appear too uncertain to be given much weight, and the activist industrial policies needed to pursue a first-mover advantage could just as likely add to mitigation costs as reduce them.

Second, the short-term, transitional costs of mitigation are difficult to predict, and the costs of mitigation will be unevenly distributed across society. This makes the case for structural adjustment programs to accompany mitigation, and no doubt increases the political costs of mitigation. However, it does not suggest that aggregate mitigation costs are underestimated, nor does it undermine the case for mitigation.

Third, though incomplete participation is often presented as putting significant upward pressure on mitigation costs, the reality is more complex. Many developed countries will suffer an increase in mitigation costs if opportunities for international trade in permits are limited or made more expensive as a result of incomplete participation. Incomplete participation also reduces the global environmental benefits of domestic mitigation through leakage. But whether or not it increases domestic mitigation costs depends on the feedback from global mitigation to the domestic economy, for example, through demand for exports. The shielding given to emissions-intensive trade-exposed sectors can also be a source of additional costs. Most importantly, in practice, countries have shown that they will reduce levels of mitigation ambition in situations of incomplete participation, and thereby limit domestic costs, albeit at the expense of the environment.

This leaves two problems with the standard mitigation cost estimates, which I conclude are real causes for thinking that the standard estimates are under-estimates.

First, perhaps the biggest risk to mitigation costs comes from poor policies. Recent experience with biofuels and renewable energy suggests that policymakers may choose mitigation options that are far from least cost. Even granting that first-mover advantages might flow from the concerted and systematic pursuit of particular mitigation policies, and that the political and economic challenges of mitigation require a multifaceted policy response, it is hard not to be alarmed by the scope for costly policy error.

Second, decisions to mitigate will be made not at the global but at the national level. Mitigation costs will vary significantly from country to country. This chapter presents evidence to suggest much higher domestic mitigation costs in developing countries (and the former Soviet Union) on account of their higher emissions intensities, even after output is adjusted for differences in purchasing power. Significant international transfers may be needed to poor, high-mitigation-cost countries. Such compensatory transfers will increase costs for developed countries, and reduce them for developing countries. If the mitigation efforts of developing countries are more cost-sensitive, as seems plausible, this will induce greater total global mitigation.

Combined, these conclusions provide strong backing for mitigation policies that are both equitable (with support for developing countries, which have lower incomes as well as higher costs, and are arguably more mitigation-cost-sensitive) and efficient (to minimize policy costs).

These conclusions also imply that national mitigation costs could lie well above the 1–5 percent of GDP range typically cited. Nevertheless, Dieter Helm's fears with which I began this essay—that the cost of mitigation poses a threat to our standard of living—are misplaced. Even if the actual costs of mitigation were double those in Table 2.1, Figure 2.1 shows that they would still be manageable in the context of a growing economy, at least for most countries. And incurring even heavy costs would be worth it for the avoidance of catastrophic climate change.

We should be worried about the costs of mitigation, not because high costs might make mitigation not worth undertaking, but because high costs, like incomplete participation, will discourage mitigation effort. The costs of mitigation are, one suspects, self-limiting: the higher the average costs, the less mitigation will be undertaken.

Mitigation is a journey into the unknown. This brief survey has revealed that there are large uncertainties, and little historical experience on which to draw. Mitigation might turn out to be cheaper than we think, but there are also serious risks that run the other way. Strenuous efforts to put in place efficient and equitable national mitigation policies will likely have a high environmental return.

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NOTES

1. Global cost estimates also typically assume away uncertainty. Jotzo and Pezzey (2007) show that in a stochastic world the use of emissions intensity targets rather than absolute emissions targets can substantially reduce the uncertainty about costs and reduce the net expected costs of global abatement by 15 percent or more relative to the use of absolute emission targets. See McKibbin et al. (2008) on the impact of uncertainty at the national mitigation cost level.
2. That is, 3.9 degrees Celsius above preindustrial levels (Stern 2007:180).
3. Melting of the Arctic summer sea ice and the Greenland ice sheet (with tipping points identified by a survey of experts for both estimated to be below 2° C above the 1990 level); dieback of the Amazon (3–4° C); melting of the west Antarctic ice sheet, disruption of the Atlantic thermohaline circulation, disruption of the Sahara/Sahel and West African monsoon, and dieback of boreal forest (3–5° C); and disruption of the El Niño–Southern Oscillation (3–6° C).
4. Figure 20.3 of IPCC (2007b) reproduces Figure 19.4 from Chapter 19 of IPCC (2001) and adds Stern's estimates, which are within the range of the 2001 estimates.
5. The IPCC Fourth Assessment Report does not go into this issue except to note that with "high prices in the range of 100–150 US\$/tCO_2 (in 2000 U.S. dollars) more CO_2 reductions are expected in China and India than in developed countries when the same level of carbon price is applied" (IPCC 2007a:217).
6. In the model used, there is no significant correlation between a country's marginal mitigation costs (as measured by the extent of the deviation of emissions from business as usual) and its total mitigation costs.
7. "Neither public R&D nor prime reliance on carbon pricing/cap-and-trade will achieve the far-reaching, long-term innovations required to address climate change" (Grubb 2004:120).
8. One estimate of the carbon dioxide price of solar photovoltaics in Germany is 900 euros (http://en.wikipedia.org/wiki/Erneuerbare-Energien-Gesetz#Costs_and_advantages).
9. Certainly, leakage has been the most controversial mitigation policy issue in Australia. In the words of the opposition leader: "That issue of carbon leakage is the problem at the absolute core of this challenge of reducing global carbon dioxide emissions" (Turnbull 2009).
10. The modelling undertaken for the Garnaut Review (2008) was of a mitigation strategy that begins in 2012. Australia's emissions entitlement is reduced in a linear fashion consistent with a 60 percent reduction target by 2050 over 2000 levels. Permits are available (or offsets), but at a premium price due to the absence of comprehensive global mitigation. The MMRF model is used. For more details, see Box 12.2 of the Garnaut Review.

11. Though using a different instrument, McKibbin puts forward a similar argument. Australia should not wait for other countries to act, he argues. Instead a "low short-term permit price can be imposed until other countries are also taking effective action" (McKibbin 2007:11).

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3. Tradable carbon allowances: the experience of the European Union and lessons learned

Jos Sijm

INTRODUCTION

In January 2005 the European Union introduced an Emissions Trading Scheme (the EU ETS) in order to reduce greenhouse gas emissions in a cost effective way. Since then, the EU ETS has become the cornerstone of E.U. climate policy, which has attracted much attention and stimulated debate both inside and outside the European Union. The main purpose of the present chapter is to evaluate the performance of the EU ETS during the first three to five years of its existence and to draw some lessons from its experience. These lessons may be useful in particular for other regions or countries interested in setting up and developing their own emissions trading scheme.[1]

The following section outlines some main features of the EU ETS up to 2012. Subsequent sections discuss different aspects of the performance of the EU ETS since early 2005, including the performance of the allocation system, the question of whether the scheme has already led to some carbon abatement, the development of the market for trading E.U. emission allowances, and the impact of the EU ETS on economic growth, industrial competitiveness, and carbon leakage. The next-to-last section discusses some important changes in the fundamentals of the EU ETS, which have been adopted and will be implemented after 2012. The final section provides a summary of some achievements and lessons learned during the first five years of the EU ETS.

MAIN FEATURES OF THE E.U. EMISSIONS TRADING SCHEME UP TO 2012

As part of the Kyoto protocol, the member states of the European Union agreed to reduce their annual greenhouse gas (GHG) emissions over the