The Fiscal Implications of Climate Change

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Executive Summary

This paper reviews the fiscal implications of climate change, and the potential role of the Fund in addressing them. It stresses that:

- The potential fiscal implications are immediate as well as lasting, and liable to affect—in differing forms and degree—all Fund members.

- Climate change is a global externality problem, calling for some degree of international fiscal cooperation…

- …and has features—an intertemporal mismatch between the (early) costs of action to address climate change and (later) benefits, pervasive uncertainties and irreversibilities (including risk of catastrophe), and sharp asymmetries in the effects on different countries—that raise difficult technical and ethical issues, and hinder policy coordination.

- In addition to itself impacting the public finances, climate change calls for deploying fiscal instruments to *mitigate* its extent and *adapt* to its remaining effects.

On fiscal aspects of mitigation, the paper concludes that:

- A range of fiscal instruments—taxes, cap-and-trade, or hybrids—can be used to face those emitting greenhouse gases, notably CO_2, with a price reflecting the damage they cause others, with both the level and (especially) the future path of such "carbon prices" critical. The paper addresses key issues in instrument design, such as the possibility of a "double dividend" from carbon pricing, administrative considerations, and effects on fossil fuel extraction.

- Views on appropriate carbon prices vary widely, but often imply fairly modest initial values. The potential revenue is sizable, but does not transform the public finance outlook.

- Cross-country flows under international cap-and-trade are sensitive to the rule for allocating emission rights. Under common stabilization objectives, they could in some cases be sizable relative to GDP.

- Many current fiscal measures affect emissions. Effective policy-making, and international coordination, would be facilitated by greater simplicity, transparency, and coherence in domestic energy taxation.

- Current international cooperation in mitigation policies is limited and flawed, but shows potential—though the difficulties inherent in carbon credit schemes remain problematic, and measures to reduce deforestation elusive.

- Supportive tax and spending policies are needed to enable technical progress addressed to climate problems—but require careful design and close monitoring.

On fiscal aspects of adaptation:

- Much adaptation will occur through normal market reactions, but additional public spending may be needed to provide and strengthen various public goods, and to facilitate private sector adjustment.

- There has been little assessment of the extent and timing of likely public spending needs, especially in developing countries. Rudimentary estimates suggest additional total costs in poorer countries in the tens of billions of dollars annually.

For the fiscal work of the Fund:

- Key policy recommendations from the paper—such as the need in many countries to raise and broaden energy taxes, and the importance of identifying and preparing for fiscal risks—reinforce current Fund advice in these areas.

- Many of the design and practical issues lie within the established expertise of the Fund, and so could be the object of Fund advice.

- Preparedness for the fiscal challenges from climate change, and progress towards mitigation objectives, could be raised in bilateral surveillance work in those limited cases in which they are potentially so substantial as to affect external stability.

- The Fund's universal membership, global perspective, and expertise make it well-positioned—drawing on the environmental and sectoral expertise of other institutions—to inform the discussion of fiscal implications of climate change that are of multilateral interest, likely to intensify as negotiations towards a successor to the Kyoto protocol gather pace.

- The potential implications for the fiscal work of the Fund appear quite modest, and can be accommodated within the prospective budget envelope.

CHAPTER

1 Introduction

Climate change (CC) and measures to respond to it, have potentially significant macroeconomic effects. The Intergovernmental Panel on Climate Change (IPCC, 2007) projects that—under current policies ("business as usual," BAU)—the global mean temperature will increase over the next century by 2.8°C, with a 3 percent chance of rising 6°C or more[1] (the latter being roughly the same as the increase since the last ice age). (A brief review of the science of CC, and a glossary of terms, are in Appendix I. The physical consequences include changed precipitation patterns, sea level rise (amplified by storm surges), more intense and perhaps frequent extreme weather events, increased prevalence of vector-borne diseases—and perhaps catastrophic events, such as reversal of the Gulf Stream or melting of the Greenland ice sheet. The potential economic consequences include productivity changes in agriculture and other climate-sensitive sectors, damage to coastal areas, stresses on health and water systems, changes in trading patterns and international investment flows, financial market disruption (and innovation), increased vulnerability to sudden adverse shocks, and altered migration patterns—all with potential implications for external stability.

Views differ on the likely extent of these effects, but few doubt that they warrant serious and current attention—or that the worst-affected countries will be those least equipped to deal with them. Assessments of the macroeconomic impact of CC are reviewed in Jones and others (2007), and in the Spring 2008 *World Economic Outlook (WEO).* For a 3°C rise, benchmark estimates for the loss of global GDP range from zero to 3 percent (reflecting differing degrees of coverage of market- and nonmarket effects, the presumed ease of adapting to changing climates, and the treatment of catastrophic risk).

[1] Relative to average temperatures between 1980–1999.

Behind these aggregate losses, it is generally agreed that hotter and lower-lying countries—often already the most vulnerable—are most at risk, with some more temperate countries even benefiting from moderate temperature rise. Most of the likely aggregate damage is expected in the latter part of the century. But events such as Hurricane Katrina, the 2002 drought in Ethiopia and floods in Europe—though not simply attributable to CC—illustrate the possible severity of near-term challenges. Moreover, since core actions to deal with CC must be anticipatory, policy responses need to be considered far in advance of the damage to be averted. The current impact of biofuel subsidies is a stark illustration of the potential for strong current impacts from climate policies (Mercer-Blackman, 2007).

The fiscal implications of climate change could be among its most powerful and immediate, affecting—in differing ways—all Fund members. Climate developments will directly affect fiscal positions, through their impact on tax bases and spending programs: Germany, for instance, postponed tax cuts to deal with the 2002 flood damage. But potentially even more important, and urgent, is the case for purposive use of fiscal instruments in *mitigating* the extent of CC and *adapting* so as to limit the damage that remains. The science of CC means that mitigation will take decades to reduce future climate risks; and adaptation needs already arise in many countries experiencing worsening weather risks or significant sea-level rise. The nature and extent of the fiscal challenges—and opportunities—will vary considerably across countries. But the commonality of the global climate and potential magnitude of effects make them ones that, in some form, all Fund members face.

This paper reviews the fiscal implications of climate change, and the possible role of the Fund in addressing them.[2] It builds on Jones and others (2007), and complements an analysis of the macroeconomic implications of alternative mitigation strategies in the Spring 2008 *WEO*. Section II sets out the key features of the economics of CC. Sections III and IV consider fiscal aspects of mitigation and adaptation. Implications for the fiscal work of the Fund are discussed in Section V.

[2] A longer piece on "The Public Economics of Climate Change," in preparation, elaborates on technical aspects of this paper.

CHAPTER

2 Climate Change and Public Finance

The Economics of Climate Change

Climate change is an externality problem raising issues of international coordination…

Emitters of greenhouse gases (GHGs) fail to recognize the aggregate damage they cause, so emit more than is collectively desirable. Countering this requires slowing and then (starting in 2020–40) cutting global emissions (by 60–80 percent). But each country would prefer others to shoulder the costs of doing so—a classic "free-rider" problem.

...that are amplified by asymmetries in physical impact and past emissions.

Emissions have the same effects wherever they arise, but those effects differ greatly across countries (being most adverse in lower-income countries). So does responsibility for current concentration levels: high-income economies generated about 80 percent of past fossil fuel-based emissions, and hence account for much of the prospective damage. But limiting that damage requires that others also cut emissions: within a decade, most emissions will come from outside the OECD. Asymmetric interests and views on historical responsibility further complicate identifying generally acceptable policy responses.

Dealing with climate change is made difficult by its slow-moving, stock nature….

Global temperature depends not on the current flow of emissions but on the cumulative stock, with emissions taking decades to have their full effect and decay. Thus little can be done to avoid temperature rise in the next decades, and there is a strong intertemporal mismatch between the (early) costs and (late) benefits of reducing emissions. This raises issues of inter-generational distribution which make views on the appropriate discount rate, largely reflecting differing ethical judgments, critical in assessing alternative policy responses (Jones and others, 2007).

…by considerable uncertainty, and real possibility of catastrophe…

The relationships between emissions, policy interventions, market responses, and economic damage remain very unsure. Extremely costly events (such as a reversal of the Gulf Stream or collapse of the West Antarctic Ice Sheet) are possible, but the probabilities—while likely low—are unknown.

…by interactions with other market failures…

Innovation in mitigation and adaptation, for example, may convey externalities and so raise questions of policy support. The design of mitigation instruments may be affected by their impact on revenue and the wider tax system. And addressing deforestation (about 20 percent of GHG emissions) may be hindered by weak property rights and governance.

…and by the exhaustibility of fossil fuels.

Suppliers must decide not simply whether, but also when, to extract oil, gas, or coal, or to cut trees—which can have powerful implications for the impact of mitigation measures.

Impact Effects and Policy Responses

Climate change will have direct impacts on the public finances that tend to amplify the wider challenges it poses. Global warming brings both slow-moving, sector-specific productivity changes and the risk of more intense shocks. Countries heavily dependent on tourism or on selling fishing rights, for example, or experiencing reduced agricultural productivity, may face significant revenue reductions. Public spending may be stretched by increased incidence of vector-borne diseases, or by new population movements. The importance (and sign) of these fiscal impacts will vary across countries, but they are likely to be most adverse precisely where wider vulnerabilities to CC are greatest.

Tax and spending instruments have a key role to play in responding to climate change—with fiscal considerations tending to favor measures that increase rather than use public funds. The direct fiscal impacts will necessitate some response, but taxes and spending each also have purposive roles in both mitigating and adapting to CC. Carbon taxes can reduce emissions, for instance, and so can reorienting public spending between road and metro/rail links. But the central fiscal instruments for mitigation are sources of public funds—with exceptions, such as technology support—whereas most instruments of adaptation are uses. Given the distortionary costs of raising public revenue, fiscal considerations create a marginal preference for revenue-raising over revenue-using measures.

Pervasive uncertainties and irreversibilities pose particular challenges for fiscal aspects of both mitigation and adaptation:

- Events with strongly adverse impacts, even if unlikely, can dominate assessments of alternative policies. Moreover, the uncertainty as to the likelihood of such events may make it appropriate to attach particularly high weight to them, implying correspondingly aggressive policy responses (Weitzman, 2007).

- Irreversible effects are pervasive in addressing CC, but have ambiguous implications for the urgency of action. The risk of irreversible environmental damage—increased atmospheric concentrations, extinction of species, and catastrophic events—points to a "precautionary principle:" act now to avoid bad future outcomes. But the prospect of better information on the likely extent and nature of damage, and of improved technologies, argues for the opposite: delay action to avoid incurring costs (including through mitigation) that may prove unnecessary. Balancing these two considerations is complex, and—beyond some consensus that the risk of catastrophe argues for caution—assessments of the practical implications differ.[3]

[3] O'Neill and others (2006), Pindyck (2007).

CHAPTER

3 Fiscal Instruments for Mitigation

Fiscal instruments are not the only way to reduce GHG emissions, but can be particularly well-targeted. Performance standards for cars, for example, limit fuel used per mile traveled but do not charge drivers for the emissions from the marginal mile traveled. Preferences and traditions in the relative use of regulatory and fiscal instruments vary, but the best-targeted policy is to charge an appropriate price for GHG emissions.

Principles of Carbon Pricing[4]

"Pigovian" pricing

The classic prescription for externality problems—facing polluters with a price for their emissions equal to the marginal social damage they cause—implies charging a price for emitting CO_2 equal to the present value of the social damage it causes. Faced with such a "carbon price"—an addition to the price paid for the underlying resource itself (such as coal)—they will not emit beyond the point at which the marginal cost of reducing ('abating' or 'mitigating') their emissions is less than that price. In this way, the marginal social cost of abatement is equated to its marginal social benefit (from reduced damage).

[4]Similar principles apply to other GHGs, but the discussion here follows much of the debate in focusing on mitigating CO_2 emissions—the largest (and most rapidly increasing) share of GHG emissions. Burning fossil fuels also generates other pollutants (such as nitrous oxides and particulates) that can cause significant local and regional harm. While carbon pricing can have significant co-benefits in reducing such emissions, they are best dealt with by differential charges related to each pollutant.

Efficiency requires—absent other market failures—that this carbon price be the same for all emissions, however and wherever they arise. The social damage from CO_2 emissions being the same wherever in the world they arise, efficiency requires that marginal abatement costs also be the same. This requires identical carbon prices: otherwise the same emissions reduction could be achieved more cheaply by raising the carbon price on fuels, or in regions, where it is low, and decreasing it where it is high.

Not only its current level, but—especially—the future path of the carbon price, and its credibility, are critical. The stock nature of the externality means that the damage from current emissions depends on future emissions; and since those depend on future carbon prices, so too does the appropriate carbon price today. Energy investments are commonly made for the long term—possibly decades—and with substantial sunk costs, so that efficient decision-making requires confidence on the future course of carbon prices. So too do incentives to innovate. And current emissions are the counterpart of current extraction decisions by owners of fossil fuels, which depend on future as well as current prices.

Pigovian policy requires a steady increase in the real carbon price. Intuitively, the carbon price is optimally lower today than in the future if the marginal damage from emitting today is less than the average (present value) of marginal damages from future emissions. That is likely to be the case, given the long lags in the climate process, for several decades. Calculating a Pigovian price path is complex, one key determinant being the discount rate: a low discount rate implies a high current level for the Pigovian price (because it implies a higher present value of future damages) but a slower rate of increase (because it also means that the present value of future damages increases less rapidly as they draw nearer).

Supply-side responses, including through the exhaustibility of fossil fuels, may affect the impact and incidence of carbon pricing. A carbon tax rising at the market interest rate, for example, would not affect the choice between extracting today or in the future, since the present value of tax paid would be the same. And (excluding such considerations as resource discovery), the incidence of such a tax would be entirely on the resource-owner: the long-run supply of the resource being inelastic, they bear the full burden.

High fossil fuel prices do not substitute for carbon pricing, but increase resistance to it. The social damage caused by emissions is not directly dependent on the price paid for the underlying resource, and so neither is the Pigovian charge. There may be an indirect link, to the extent that higher resource prices reduce emissions, and hence the marginal damage they cause—and it may even be that resource price movements have a greater impact on emissions than would carbon pricing. But the purpose of the carbon price remains: to send a signal additional to that associated with the underlying resource scarcity.

Market imperfections

Using the proceeds from carbon pricing

Government receipts from carbon pricing—whether as tax revenue or from auctioning emission rights—can ease pressures on the public finances. These receipts enable a reduction in other distorting taxes (or an increase in public spending, or reduction of debt) that provides a distinct source of social gain. Revenue from carbon pricing may, for instance, help governments cope with revenue pressures from international tax competition or trade reform. It might be tempting to suppose that carbon pricing can thus yield a "double dividend"[5] in the sense of not only mitigating CC but also improving the overall efficiency of the tax system—in which case it would be optimal to set the carbon price *above* the Pigovian level. But this is much less clear-cut. For in addition to the beneficial "revenue recycling" effect just described, there is a "tax interaction" effect: carbon pricing will affect the distortions caused by the pre-existing tax system. By raising the consumer price of energy-intensive goods, for instance, it would have effects similar to a reduction in the after-tax wage, and thus reinforce the distortionary impact of labor taxes—implying an the optimal carbon price *below* the Pigovian level.[6] Indeed if the initial tax system is well-designed (climate concerns aside) then the two effects must cancel out: tautologically, it is impossible to raise the same revenue in a way that (climate concerns aside) is better. In practice, however, initial tax systems may be less than perfect, and the political impetus behind carbon pricing may enable beneficial reforms that were previously unpalatable.

The best use of additional revenue from carbon pricing, including to offset any adverse equity impact (discussed below), will vary with countries' circumstances. In many developing countries, revenue from better carbon pricing would naturally be used to strengthen revenue mobilization. Several developed countries, on the other hand, have used additional revenue from increased energy taxes to reduce social contributions, such "green tax swaps" being intended to

[5]Usage of this term differs: see Goulder (1995).

[6]Bovenberg and de Mooij (1994).

reduce unemployment: Germany, for example, shifted around 3 percent of total tax revenue in this way in 1996–99. The likely effectiveness of such measures depends on the extent to which the burden of carbon prices can be shifted to factors other than labor. The (scant) empirical evidence does not suggest strong employment gains.[7]

Exhaustibility—supply-side distortions

Some argue that fossil fuels are extracted excessively rapidly, which may call for a carbon price increasing at less than the market interest rate. Resource-owners may use "too high" an interest rate (so preferring to extract the resource now and invest the proceeds, rather than leave it in the ground), either because they over-discount the future or because they feel insecure in their property rights (Sinn, 2007). This could be countered by having the carbon price rise at less than the interest rate, giving an incentive to shift emissions further into the future. But insecurity of property rights might also lead to too little extraction, by discouraging any accompanying sunk investments it requires: there is evidence that it reduces oil production, but increases deforestation (Bohn and Deacon, 2000). Nevertheless, aiming for too rapid an increase in the carbon price risks *increasing* current emissions.

Instrument Choice—Taxes, Cap-and-Trade, Hybrids

Carbon pricing can be implemented through carbon taxation, cap-and-trade, or hybrids of the two (and with many variants). A carbon tax is simply one levied at the same specific rate on all emissions, whatever their source. Since carbon emissions are proportional to fossil fuel use, this could be charged not directly on emissions but on fossil fuels—petrols, gas, coal— themselves. Under cap-and-trade, some fixed total of emission rights is issued, and firms trade to hold the permits they need. The price paid for the permit is then, in effect, a carbon price. "Hybrids" let the carbon price vary (like cap-and-trade) but also allow some flexibility in aggregate emissions (like a tax): this might involve, for instance, cap-and-trade with a maximum price (at which unlimited permits would be issued). More generally, since no tax or emissions limit would remain unchanged forever, any scheme will in practice be some form of hybrid. Variants include a cap-and-trade scheme in which countries are allocated emission rights corresponding to BAU and a central authority, financed by direct country

[7]See, for instance, Carraro, Galeotti, and Gallo (1996).

contributions, controls emissions by purchasing and retiring them (Bradford, 2002).

Tax and cap-and-trade schemes can be[8] **equivalent—in terms of aggregate emissions and government revenue—if emission rights are auctioned and the structure of abatement costs is known.** Any outcome under some carbon tax can then also be achieved by cap-and-trade: auctioning permits in an amount equal to the level of emissions under the carbon tax will result in an equilibrium permit price equal to that initial carbon tax; so each firm will emit the same amount and the government will collect the same revenue. But if permits are allocated free of charge, as often in practice, the government foregoes revenue that it would collect under carbon taxation.

Equivalence fails when abatement costs are uncertain, with carbon taxation then likely preferable to pure cap-and-trade. While hybrids can improve on both, no instrument assures credibility. Carbon taxes provide certainty on carbon prices, cap-and-trade provides certainty on aggregate emissions. Appendix II explains that the science of CC makes the former more valuable, and elaborates on other aspects of instrument choice.

The cross-country allocation of revenue from carbon pricing may be quite different under a common carbon tax and under global cap-and-trade. Revenue from a carbon tax is commonly presumed to remain in the country that levies the tax, which is taken to be that in which final use occurs. (There is, however, no inherent reason why carbon tax proceeds should be allocated on such a "destination" basis. The close link between extraction and emissions means, for example, that the tax could be levied on an "origin" basis, in the country of extraction; and some have proposed using carbon tax proceeds to finance development and other global public goods). Under international cap-and-trade, in contrast, countries where abatement is relatively cheap would sell emission rights to those where it is costly. The extent of the consequent transfers—and hence incentives to join the scheme—depends on how emission rights are allocated. Calculations below explore this further.

[8] "Can be" rather than "are" because equivalence also requires, for instance, effective competition in both product and permit markets.

Rates, Revenue and International Flows

What should the carbon price be?

Estimates vary widely, but the starting value of the carbon price path is in many studies often only moderately daunting: in the order of US$15–US$60 per ton of carbon(/tC)—equivalent to around US$2–US$8 per barrel of oil, or 5–20 cents per gallon of gasoline. The technical complexities and judgments required to calculate carbon price paths are reflected in widely-varying estimates. One meta-study of estimates of the marginal social damage from carbon emissions[9] finds a modal value of around US$20 per ton of carbon (tC), and a median—the distribution being strongly right-skewed—of US$48/tC. (Tol, 2007). The Stern Review (2007) estimate, towards the upper end of the distribution, is US$312/tC; Nordhaus (2007), on the other hand, suggests a starting carbon price of around US$17/tC. (For comparison, the current EU-ETS forward price (for delivery in late 2008) is around € 83/tC). Since the BAU projections from which they derive implicitly reflect current policies, the corrective carbon prices these estimates imply should be seen as additional to existing measures.

More important than the initial level of the carbon price is its future path—with estimates suggesting substantial real increases. Of the several models that could be used to examine more concretely the potential fiscal aspects of mitigation, this paper focuses on two widely used "integrated assessment models": the "IGSM" and "MiniCAM."[10] The analysis in the forthcoming *WEO*—to which reference will also be made—uses instead the G-cubed model of McKibbin and Wilcoxen (998), which is similar to the IGSM but includes explicit modeling of international capital flows. (Appendix III summarizes key features of these models, which are discussed at more length in an Appendix to the forthcoming *WEO*). Results are reported for three stabilization objectives (Figure 1): the most ambitious (450 pm) is widely regarded as effectively unattainable and the highest (650 ppm) as very risky, so the discussion focuses on stabilization at 550 ppm. In the IGSM, the carbon price (shown in the lines) rises from about US$75/tC to US$380/tC (nearly US$50 per barrel of oil) by 2060. It is far lower throughout under MiniCAM (note the different scales), as baseline emissions are far less, reaching US$135/tC by 2060.

[9]Since carbon pricing would reduce emissions and hence marginal social damage, estimated damage under BAU overstates the corresponding Pigovian charge. Stern (2007), for example, has strong mitigation reducing marginal damage to US$105/tC.

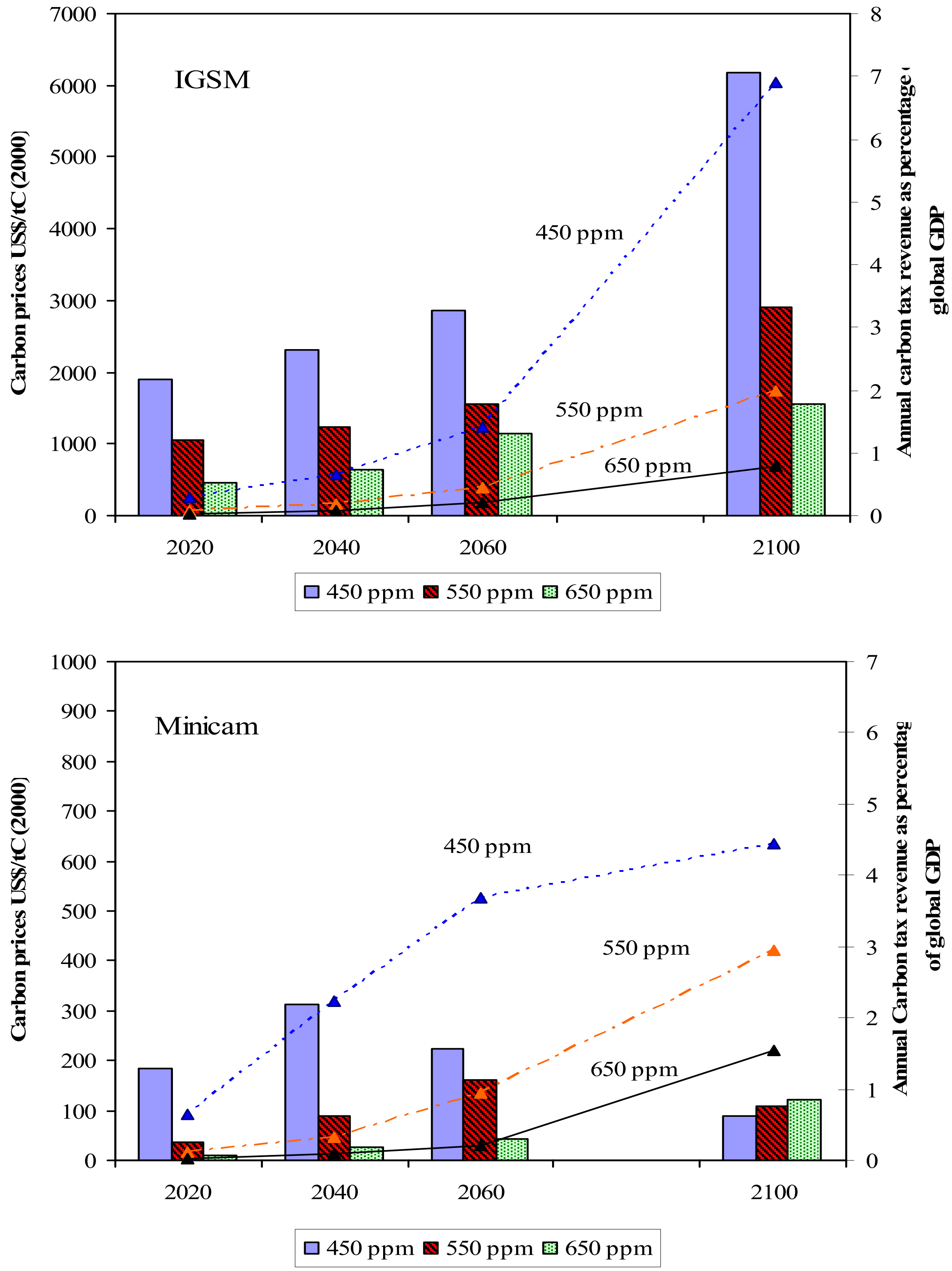
[10]See, respectively, Paltsev and others (2005) and Brenkert and others (2003).

How much revenue is at stake?

The potential revenue from appropriate carbon pricing is around 1–2 percent of global GDP until mid-century—significant but not transformational. Revenue increases throughout the century (except under the more aggressive MiniCAM scenarios, which achieve stabilization much earlier), with the increasing carbon price more than offsetting any fall in emissions. Table 1 reports implied revenue by region in the MiniCAM simulations (such a breakdown not being available for IGSM). The figures are in some cases sizable—a 2 point increase in the tax ratios in Africa, FSU/East Europe and India by 2060 stands out—and would be something like twice as large with carbon prices at IGSM levels. Country-specific studies provide a sharper sense of possible revenue effects. For the United States, a tax of US$55/tC (slightly less than the IGSM starting value) would raise around US$80 billion a year: equivalent to 30 percent of the corporate income tax, or enough to rebate the first US$560 of payroll taxes to all workers.[11] These are substantial effects, and at a time of increasing international tax competition are rare examples of potential for increased rather than reduced tax revenue. But they are not transformational: thoughts of using revenue from carbon pricing to eliminate the corporate income tax, for example, seem misplaced.

[11]Green, Hayward and Hassett (2007), Metcalf (2007).

Figure 1. Carbon Prices and Global Revenue



Source: IMF staff calculations using MiniCAM and IGSM output.
1/ Lines represent carbon price (left scale), bars represent revenue in percent of GDP (right scale).

Table 1. Revenue from Carbon Pricing by Region
(in percent of GDP)

	450 alternative			550 alternative			650 alternative		
	2020	2060	2100	2020	2060	2100	2020	2060	2100
Africa	2.5	2.9	1.3	0.5	2.2	1.4	0.2	0.6	1.5
China	2.5	1.7	0.6	0.6	1.3	0.7	0.2	0.4	0.8
FSU/East Europe	3.9	1.9	0.2	0.9	2.0	0.6	0.2	0.5	1.0
India	2.6	1.2	0.1	0.6	1.7	0.7	0.2	0.5	1.1
Japan	0.5	0.8	0.4	0.1	0.5	0.4	0.0	0.1	0.2
Latin America	1.2	2.6	1.3	0.2	1.1	1.2	0.1	0.3	1.0
United States	0.9	1.1	0.5	0.2	0.7	0.5	0.1	0.2	0.4
West Europe	0.7	1.0	0.2	0.1	0.8	0.4	0.0	0.2	0.5
Rest of the world	1.7	1.4	0.8	0.5	1.1	0.9	0.2	0.3	1.0

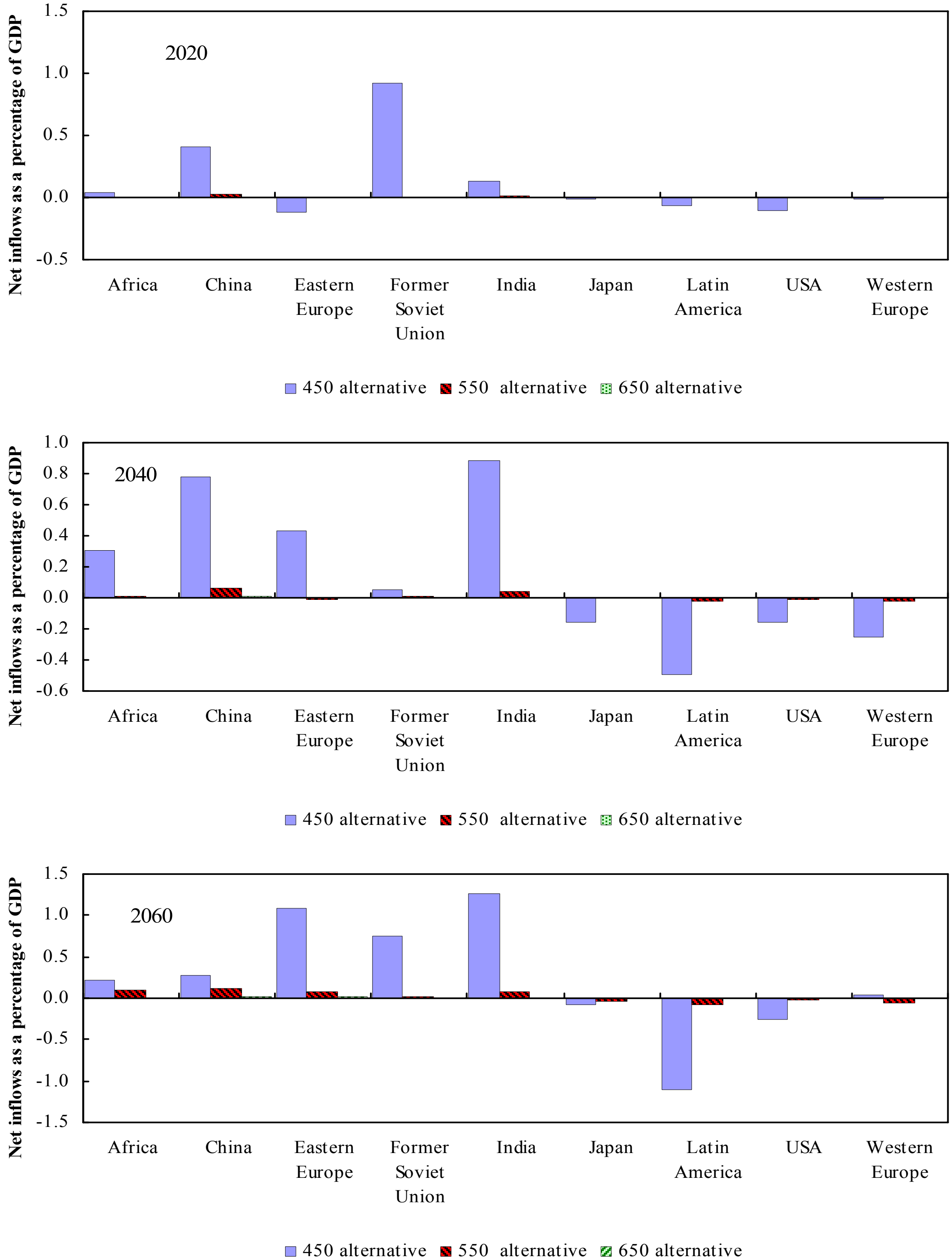
Source: IMF staff calculations using MiniCAM output.

Cross-country flows under international cap-and-trade

International flows from cap-and-trade, sensitive to the allocation method, could in some cases be sizable. Figures 2 and 3 show financial inflows by region (from MiniCAM) under two illustrative rules for the allocation of rights: proportional to BAU emissions, and to population. In each case—recurrent features in analyses of this issue—Africa and India sell permits, and the OECD buys. But whereas flows are much less than one percent of GDP with allocation relative to BAU (again, except under the 450 ppm alternative), with equal per capita allocation Africa and India have inflows of around 1 percent of GDP in 2020, rising steadily thereafter in Africa. The results also show that the allocation rules have notably different effects for particular regions: having relatively high emissions but a relatively small population, the Former Soviet Union (FSU), for example, sells permits in one case but buys in the other.

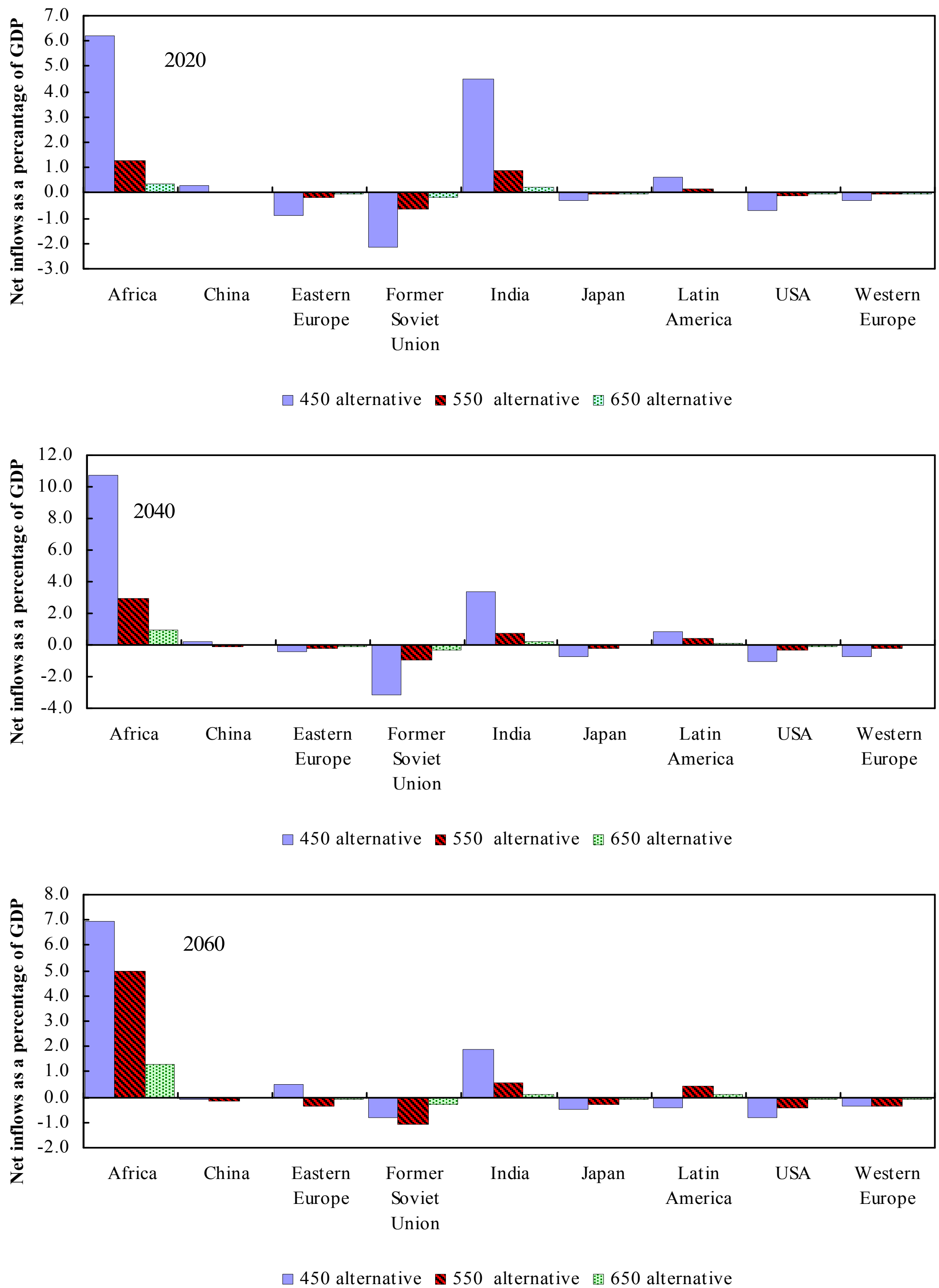
Results are in important respects model-specific. Table 2 reports results using G-cubed, taken from the Spring *WEO*. Though the exercises underlying the two sets of results are not fully comparable—there are differences, for instance, in BAU projections and regional/country coverage—they are in many

Figure 2. Financial Inflows from Global Cap-and-Trade, Allocation by Baseline, 2020–60



Source: IMF staff calculations using MiniCAM output.

Figure 3. Financial Inflows from Global Cap-and-Trade, Allocation by Population, 2020–60



Source: IMF staff calculations using MiniCAM output.

respects qualitatively similar, and consistent with others. But there are also differences. Most notably, China emerges as a modest buyer or seller in Figures 2 and 3 but a large seller in Table 2.[12] This calls for great caution in interpreting the results, and stresses the importance of understanding better the relative ease of mitigation across countries and other drivers of international permit trade.

Domestic Equity and Compensation

Carbon pricing will affect the level and distribution of households' real incomes, directly through their own use of fossil fuels and indirectly through the prices of other commodities. The strength and nature of these effects depends on how far the burden is borne by final consumers (through increased prices) rather than suppliers (including owners of fossil fuels), the usual assumption being that, at least in the short run, there is full pass-through. They will depend too on patterns of consumption and production: the effect through gasoline prices is more likely to be regressive where car ownership is high, and that through kerosene more regressive where its use for household lighting and heating more common.

In both developed and developing countries, increased fossil fuel prices are likely to have a regressive impact. But, especially in the former, instruments to offset this are commonly available, at a cost less than the additional revenue raised:

- The impact on U.S. households, for example, of a carbon price around US$50/tC is noticeably regressive, reflecting quite large increases in the prices of electricity and gas (around 12 percent) and gasoline (around 8 percent). But this can be largely offset by reconfiguring the earned income tax credit and social security payments (Metcalf, 2007). Other benefits targeted to vulnerable groups, such as the winter supplement to pensioners in the United Kingdom, may also play a role. Compensating measures need to be carefully designed, however: reduced indirect tax rates on energy-intensive products, for instance—such as the lower VAT rate on electricity in the United Kingdom—compromise climate objectives and are poorly targeted on vulnerable groups.

[12]The wider literature also reaches divergent conclusions. Böhringer and Welsch (2004) and the German Advisory Council on Global Change (2003), for instance, have China respectively selling and buying permits.

Table 2. International Transfers under Cap-and-Trade, Using G-Cubed[1, 2]
(In percent of GDP)

Region	2020	2030	2040
	Annual emission rights proportional to initial emissions[3]		
United States	0.02	0.11	0.22
Japan	0.00	-0.01	-0.04
Europe	0.00	-0.01	-0.03
China	0.32	2.16	5.95
Less developed countries	-0.11	-0.59	-1.44
Eastern Europe and Russia	-0.01	-0.05	-0.12
OPEC	0.08	0.29	0.53
	Annual emission rights proportional to population share		
United States	-0.02	-0.32	-0.32
Japan	-0.12	-0.24	-0.35
Europe	-0.12	-0.24	-0.34
China	0.33	1.96	5.46
Less developed countries	0.71	1.08	0.77
Eastern Europe and Russia	0.29	-0.62	-0.87
OPEC	0.51	1.15	1.66

Source: IMF staff estimates, reported in Spring 2008 *World Economic Outlook*.

[1] Emissions reduced by 40 percent from 2002 levels.

[2] A positive value denotes receipt of transfers.

[3] This allocation rule differs from that underlying Figures 2 and 3 (which is by emissions throughout the BAU path).

- In many developing countries, the first step towards effective carbon pricing is eliminating remaining fuel subsidies, both explicit and implicit. Often substantial—17 percent of GDP in Azerbaijan, for instance, and 10 percent in Yemen—these are an expensive way of supporting the poor: fuel and fuel-intensive goods account for a larger share of the spending of the poor, but the rich spend absolutely more on them.[13] Even where tax-benefit systems are relatively weak, there are may be better-targeted ways of protecting the poor. Ghana, for instance, accompanied fuel price increases with such measures as the elimination of school fees for primary and secondary education. Political resistance to raising fuel prices can be considerable. And there can be unintended effects to guard against: increasing kerosene prices, for instance, may induce substitution towards burning wood, with adverse implications for both health and deforestation. But the fiscal imperatives are strong, and available instruments often have significant power.

Earmarking revenue from carbon pricing is generally undesirable—except that it may help overcome political resistance. Since the purpose of environmental taxes is to change behavior rather than raise revenue, pressures arise to compensate the losers and to ensure the proceeds are not spent wastefully—both of which can create calls for earmarking.[14] Tight earmarking, however, can overly-constrain the public finances. The economic rationale, for example, for allocating part of the proceeds from the Clean Development Mechanism (CDM) to an Adaptation Fund is unclear: there is no link between the appropriate revenue from mitigation and the appropriate spending on adaptation. Nevertheless, the acceptability of carbon pricing may be increased by linking spending measures to the revenue it would raise.

Fiscal Aspects of International Coordination

A fully coordinated approach would involve a uniform carbon price in all countries, with cross-country transfers addressing any fairness concerns—but a range of national fiscal concerns impede such a cooperative outcome. Importers of fossil fuels have a collective incentive to use carbon taxes or tariffs to extract rent from exporters; and exporters have a corresponding incentive to manipulate supply. The net outcome could be carbon taxes that, from a global perspective, are too high rather than too low (Strand, 2007). Energy security concerns could point in the same direction, but may relate more to the diversity of supply than

[13]See for instance the review of experience in Coady and others (2006).

[14]See OECD (2006) and Brett and Keen (2000).

the level of demand. Given the likely damage projected under BAU, however, it seems clear that noncooperation currently results in too little mitigation, not too much. A dominant concern in fuel pricing—at the heart of the free-rider problem—is each country's fear that unilateral action would disadvantage producers of energy-intensive products (such as aluminum, paper, steel, and international transport) in world markets.

Incomplete participation in mitigation efforts could cause significant inefficiencies. While emissions are concentrated among relatively few countries—25 accounting for about 80 percent—wider agreement is likely to be needed for efficient and effective mitigation. Mitigation costs differ markedly across countries, pointing to substantial gains from trade. "Leakage" (shifting of emissions to nonparticipants) is also a concern. Carbon pricing by some subset of countries that reduces the world price of fossil fuels, for instance, will tend to increase demand, and hence emissions, from others. The potential extent of leakage remains unclear, but since marginal mitigation costs vary greatly across countries and increase steeply, there is a strong efficiency case for "broad-but-shallow" agreements over "narrow-but-deep."

Measures to encourage cooperation include adopting minimum (rather than harmonized) carbon tax rates and—with a less clear-cut balance of costs and benefits—selective border tax adjustments:

- A standard prescription for responding to downward pressures on low rates from international tax competition—adopted in the EU, for example, for excises—is to adopt not common but minimum rates. This provides some protection for countries wishing to set relatively high rates, potentially inducing them to increase their rates by enough to benefit even countries obliged to raise their tax.[15]

- Border tax adjustment (BTA)—remitting the carbon price content of exports and imposing corresponding charges on imports—has the merit of preserving mitigation in respect of domestic consumption without impacting international competitiveness. Moreover, it is one of the few credible devices by which countries implementing carbon pricing can encourage participation by others: participants gain, presumably, from the BTA; and nonparticipants would then benefit by imposing a carbon price themselves, since by doing so they would capture revenue otherwise accruing to others. Against this, however, BTA risks hiding tariffs or export subsidies, and may be WTO-inconsistent. It also raises many

[15]Kanbur, Keen, and van Wijnbergen (1995).

practical issues, including the need to assess carbon prices implicit in taxes paid abroad (perhaps in a chain of production activities across several countries).

International considerations may also affect administrative aspects of instrument choice. Since the proper carbon price is a specific (not ad valorem) charge, a carbon tax common to several countries needs to be specified in terms of some basket of currencies; the market price under cap-and-trade, on the other hand, would map automatically into national currencies. More fundamentally, instruments may differ in their ability to reassure each participating country that others are honoring their obligations. Under a tax scheme, countries would need confidence that others are not offering subsidies or tax breaks that offset the impact of the carbon tax itself. Under a trading scheme, they would need assurance that the governance of permit schemes (including the use made of any quota rents) is sound. If tax rules are transparent and readily comparable across countries—which may require simplification (or extensive analysis) of energy tax structures, as discussed below—carbon taxes might on this account be preferable.

Restrictive tariff and trade polices may impede effective responses to CC. Liberalization of trade in items that help address CC, including biofuels, while having some revenue cost, can help foster efficient mitigation and adaptation (World Bank, 2008).

Current Measures of Carbon Pricing

Systematic carbon pricing is rare, but in most countries a wide range of fiscal instruments affect emissions. No country has a carbon tax in the strict sense, uniform across uses and sectors. The closest examples are perhaps found in Denmark, Norway and Sweden, and the Climate Change Levy in the United Kingdom, though in each case there are significant exemptions. Cap-and-trade schemes also remain rare, the most extensive being the Emissions Trading Scheme of the EU (EU-ETS), though this covers only about 45 percent of GHG emissions. But a wide variety of taxes, generally designed with other considerations in mind, affect emissions. The most obvious are the excises—or subsidies—on petroleum products (differing from systematic carbon taxation in that they are not calibrated to the varying carbon contents of the various fossil fuels). But there are typically many others. Emissions from transportation, for example, may be affected by the tax treatment of company cars. And regulatory provisions have effects in some respects akin to carbon charging. In fossil fuel producing countries, fiscal arrangements also impact extraction and hence emissions.

Effective carbon pricing requires greater coherence in energy tax policies, less extensive exemptions and, perhaps, an "unbundling" of fuel excises in higher income countries. There is scope in many countries for taking inventory of significant measures in place, so as to assess their coherence, transparency, and effectiveness. Complexity often comes from pursuing several purposes with a single instrument. Fuel excises in developed countries, for example, are used not only to raise revenue, but also to correct for congestion and other externalities associated with road use. As technological developments allow more effective congestion pricing, fuel excises could be restructured—and perhaps lowered—so as to focus more sharply on the mitigation objective that they are best suited to serve.

The diversity of fiscal and other instruments of energy policy complicates cross-country comparisons, impeding effective coordination. A common policy, such as a minimum carbon tax, would need to recognize measures already in place. But the variety and complexity of these—including differing reliance on regulation—make them hard to compare. Closer international coordination would increase each country's interest in measures adopted by others, so that coordination would be facilitated by greater coherence, simplicity and transparency of fiscal policies towards energy. It may also be facilitated by coordinated data gathering—along the lines of the database on environmentally-related taxes and charges maintained by the OECD and the European Environment Agency[16]—and analytical work to assess implied effective rates of taxation on carbon emissions.

The first step to proper carbon pricing in many countries is to increase fossil fuel taxes and equalize them across types. Raising fuel prices is called for, even absent climate concerns, not only in many developing but also in some higher income countries: Parry and Small (2005) conclude, for example, that—given the multiple objectives being served—fuel excises were "too low" in the United States in 2000. Many tax systems are unduly favorable to diesel, while fuel used in international aviation and shipping is largely uncharged (Keen and Strand, 2007).

Realizing the full fiscal benefits of cap-and-trade requires that rights be sold, not allocated free. The EU-ETS, for instance, has been marked by extensive "grandfathering" of emission rights (allocating them without charge, in relation to past emissions). Most recent U.S. cap-and-trade proposals also envisage extensive grandfathering. This not only risks undermining incentives to

[16] Available at http://www2.oecd.org/ecoinst/queries/index.htm.

mitigate—firms will be less inclined to abate if they feel this will reduce their future free allocation—but foregoes a sizable benefit to the public finances: in the order of €40 billion annually, for the EU-ETS, and US$130–US$370 billion (in 2015) for recent U.S. proposals. Grandfathering may be reasonable for investments sunk when substantive emissions charges were unforeseeable. But the force of such considerations is now considerably less, and indeed the European Commission now proposes full auctioning of EU-ETS permits for power companies from the start of 2013, and for all others by 2020.[17] Where grandfathering is politically unavoidable, however, the value of grandfathered rights should at least be recorded as a tax expenditure, opening the issue to public debate.

International cooperation in fiscal aspects of mitigation has been limited and flawed, but shown potential. The EU-ETS, for example, has been marred by incomplete coverage, extensive grandfathering and inappropriate entry/exit rules. But it has shown the technical feasibility of international cap-and-trade schemes, at least among closely-related countries. Similarly, the CDM has suffered from administrative and, still more fundamentally, conceptual

Box 1. Carbon Credits and the Clean Development Mechanism

Carbon credits enable those subject to emissions restrictions to meet them in part by purchasing emissions reductions from those not so restricted. This is the nature of the CDM, under which support of emissions-reducing projects in lower income countries is creditable against Kyoto commitments. The CDM (with about US$8 billion of cumulative trades in primary markets) has been the primary means of encouraging mitigation in developing countries. Behind criticisms of the CDM as overly-bureaucratic, now being addressed in part by strengthening programmatic as well as project-based support, lie two fundamental difficulties with credit schemes (which would also apply, for example, to schemes providing payment for avoided deforestation): identifying the baseline relative to which emissions reductions are measured, and ensuring that such reductions are not undone by increases elsewhere.

difficulties (Box 1). But it has started to build a framework, short of fully global carbon pricing schemes, for encouraging developing countries' participation in achieving globally efficient mitigation.

Little progress has been made, however, in mitigation through reduced deforestation (accounting for about 20 percent of emissions, and often reckoned a particularly cheap form of abatement). This reflects both the

[17] Commission of the European Communities (2008).

conceptual challenges posed by carbon credit schemes and problems in forestry governance. Some progress may be looked for from the World Bank's recently-launched Forest Carbon Partnership Facility, which provides for both capacity building and piloting of incentive schemes.

Innovation—What Role for Fiscal Incentives?

Proper carbon pricing is a critical anchor for efficient innovation. Technical progress—for instance, in developing carbon sequestration technologies—will be pivotal in dealing with CC. Such innovation needs to be guided by carbon prices (present and prospective) that reflect the social gains from developing less carbon-intensive technologies. While it may be politically tempting to set a low carbon price and instead provide strong public support of innovation, this risks wasting resources by substituting, at the margin, relatively expensive R&D for relatively inexpensive mitigation.

Fiscal instruments have a potential role in overcoming market failures in climate-related R&D. Technical progress in dealing with CC will be subject to the same broad market failures and challenges—reflecting the inability of innovators to appropriate of the full social benefits, and the desire to ensure rapid, wide diffusion of new technologies—that affect all innovation. While general R&D support measures should apply to climate-related innovation as to any other, there may be a case for further fiscal measures reflecting, for instance, the costliness of catastrophic outcomes (putting some premium on geoengineering solutions), energy security concerns, and such sector-specific issues as the inability of private insurers to cope with particular risks from nuclear power.

Targeted public research spending may be preferable to additional tax incentives. Many countries already offer generous R&D incentives (this being one feature of intensified international tax competition). There is evidence that these do increase spending on R&D and patenting,[18] but they can be difficult to shape so as to target innovation conveying social rather than private benefit. And tax reductions may do little for innovative start-ups, since they are relatively unlikely to have any taxable income. Although not without risk of waste, public spending to support private innovation can potentially be better targeted where social returns are likely to most exceed private.

[18]Hall and van Reenen (2000), Jaumotte and Pain (2005).

The cost-effectiveness of the fiscal instruments being used to encourage the development of renewable energies remains unclear—and should be monitored. Such measures include, for example, capital grants and low interest loans for renewable energy capacity and development of energy technologies, feed-in tariffs, and tax credits. It is not clear that such support has proved cost-effective (especially at a time when private finance appears quite abundant): OECD (2004) finds the cost of displacing emissions by these means to be considerably higher than most estimates of the marginal damage those emissions cause. This will be too pessimistic a view once learning-by-doing is taken into account, but stresses the importance of monitoring such spending—including through tax expenditure analysis—to inform policy formation in an increasingly important area.

CHAPTER

4 Fiscal Aspects of Adaptation

Much adaptation will occur as spontaneous private sector adjustment, with limited fiscal impact. Slow-moving temperature changes can be expected to generate relatively smooth market responses: ski resorts, for example, will be run down in areas experiencing less snowfall and built up in those experiencing more. More intense weather events may affect location decisions and trigger financial innovations, including continued rapid growth in weather derivatives and catastrophe bonds. Such market responses will have fiscal effects, but, with exceptions, seem unlikely to pose problems more challenging than those from the changing circumstances to which economies are routinely subject.

Fiscal Implications of Adaptation—Key Elements

Efficient private sector adaptation requires an appropriate carbon price path, with a role for fiscal instruments in financing elements of adaptation and facilitating market adjustments. If carbon pricing is too weak, for example, more potential harm will arise—and hence more resources will be devoted to adaptation—than is desirable. Even with effective carbon pricing, however, market failures may create a case for fiscal intervention.

Public goods and adaptation

Adaptation will require increased public expenditure, both on climate-related public goods and to protect programs driven by other concerns. Information acquisition and dissemination—on changing precipitation patterns, for example—is one such public good, whose provision requires public intervention (though delivery and some aspects of finance may be left to the private sector). Traditional big ticket items of public expenditure potentially affected include transport networks, water and health systems, and sea defenses. Additional spending will also be needed to protect wider investments. Full "climate-proofing," however, is generally not optimal: the investments themselves may need reconsideration, and some residual climate risk accepted.

Most adaptation-related public spending is likely to be national in nature, but some regional or global cooperation may be required—to improve management of water systems, for example, or improve regional weather forecasting.

Institutional and financial weaknesses in many most vulnerable countries create scope for donor support in meeting adaptation costs. Some see this as a natural way for countries responsible for most past emissions to bear an enhanced share of the clean-up costs.[19] Indeed signatories to the UNFCCC are committed to helping "developing countries that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects." Funds have been created to this end, but remain modest: delivered financing is around US$26 million (UNDP, 2007), though committed amounts are larger.

Uncertainties and irreversibilities require balancing precautionary spending on adaptation against the risk of undertaking costly expenditures that may prove unnecessary. The considerations discussed in Section II.B point to gradualism and flexibility in incurring sunk costs to deal with adaptation. This is essentially a matter of project design: for example, in identifying efficient adaptation options for coastal zones (IPCC, 2007). To the extent that public investments are more likely to involve heavy sunk costs, the option value of waiting may be significant.

Reducing barriers to private sector adaptation

Market failures may impede private adaptation. Private agents may be imperfectly informed (systematic CC may be hard to infer where the natural climate is variable, for instance); credit market imperfections may hamper adaptation requiring substantial investments; insurance may be unavailable or unaffordable; the Samaritan's dilemma[20] may lead to inefficiently low adaptation; and the private sector may discount too heavily (so spending too little on projects more robust to climate developments).

[19] UNDP (2007), for example.

[20] This is the tendency for under-insurance by those who expect external help in the event of adversity: those supplying the help would wish to limit its extent by committing to relatively low support—but their benevolence means they cannot do so credibly.

Fiscal instruments, particularly tax measures, may not be the best response to such failures. If the expectation of ex post assistance leads to excessive location in flood-prone areas, for instance, one response is to tax the use of such land. But where administration is weak, zoning regulations, even if less efficient (in denying use even to those willing to pay a proper price) may be more practicable. Other fiscal measures may be tempting but poorly-targeted: tax breaks or subsidies for insurance, for example, reduce the public revenues but do not overcome the Samaritans' dilemma, since they do not address potential donors' inability to commit to limiting ex post support.

Dealing with fiscal risks

Intervention may be appropriate to facilitate private insurance. Insurance does not reduce the physical damage from CC (and through moral hazard effects could worsen it). But it can reduce the consequent welfare losses, including by reducing implicit fiscal risks**.** One response to the Samaritan's dilemma, for instance, is to make purchasing insurance mandatory. In many developing countries, however, market insurance may be unavailable or unaffordable at actuarially fair rates. There may then be scope for public intervention to provide or facilitate access to risk markets: in Malawi, for instance, the World Bank and donors provide drought insurance. Strengthening wider social insurance schemes also improves resilience to extreme weather events, as to other traumas.

Recent financial innovations point to new ways of coping with some climate-related fiscal risks.[21] The Caribbean Catastrophe Risk Insurance Facility (CCRIF), for example—bringing together CARICOM countries and launched with donor support in 2007—pays out in the event of parametric trigger points (such as hurricane wind speeds) being exceeded. It is estimated to offer premia about 40 percent below market rates, and provides rapid payment if disaster strikes. The scheme is limited in several respects: verification has proved more contentious than expected, for instance, and pooling among countries subject to correlated shocks limits the benefits from risk-spreading. But it indicates scope for addressing fiscal and other risks from CC through insurance mechanisms (and is an instance of effective regional collaboration in addressing adaptation challenges). Potentially even more promising, as tapping more deeply into global capital markets, is the sovereign issue of catastrophe bonds (for which principal is forgiven if disaster strikes). This is likely to become increasing attractive as the market continues to develop. Whether further innovations could

[21] The spring 2008 *WEO* provides a more general discussion of the role of financial markets in dealing with CC.

deal with longer-term climate risk, and the uncertainty surrounding some risks, remains an open question (Heal and Kristrom, 2002).

The enhanced fiscal self-insurance needed will be difficult to achieve in many low-income countries, but the fiscal risks should be assessed and recognized. Part of an appropriate response to the likelihood of increased uninsured losses from extreme weather events is increased precautionary public saving. This would convey fiscal benefits not only when disaster strikes but also, through improved ratings and reduced risk premia, when it does not. Given the many other fiscal challenges faced by low-income countries and the possible scale of damage, however, the self-insurance reasonably achievable may often be limited. An important first step—hardly yet begun—is to recognize the fiscal risks involved.

How Much?—Assessing the Fiscal Costs of Adaptation

Evidence on the likely aggregate costs of appropriate adaptation measures is scant, especially for lower income countries—and evidence on the likely fiscal costs even rarer. Many higher income countries have costed public projects to protect against adverse impacts of CC, but with few estimates of the aggregate fiscal cost. Little is known of fiscal costs in the poorest and most vulnerable countries. This gap reflects remaining scientific uncertainties, particularly acute in lower income regions—UNDP (2007) points out, for instance, the paucity of meteorological stations in Africa—and limited attention to climate issues, at least until recently, in forming national development programs, including PRSPs.

Elements of adaptation that have been studied for developing countries are often relatively inexpensive in absolute terms, but can be large relative to the countries affected. On sea level rise, for example, Nicholls and Tol (2006) find coastal protection costs (for a rise of around 0.2–0.3 meters over the century) to be less than one percent of GDP for the 15 most-affected countries by 2080. In some exposed small islands in the Pacific, however, the figure is notably larger: 5–13.5 percent of GDP in Micronesia, for instance, and 3.9–9.1 percent in Palau. These estimates likely understate total adaptation costs, however, in that they deal only with sustained sea rise at mid-point estimates, and hence exclude costs of coping with storm surge and other associated effects, or with more dramatic rise.

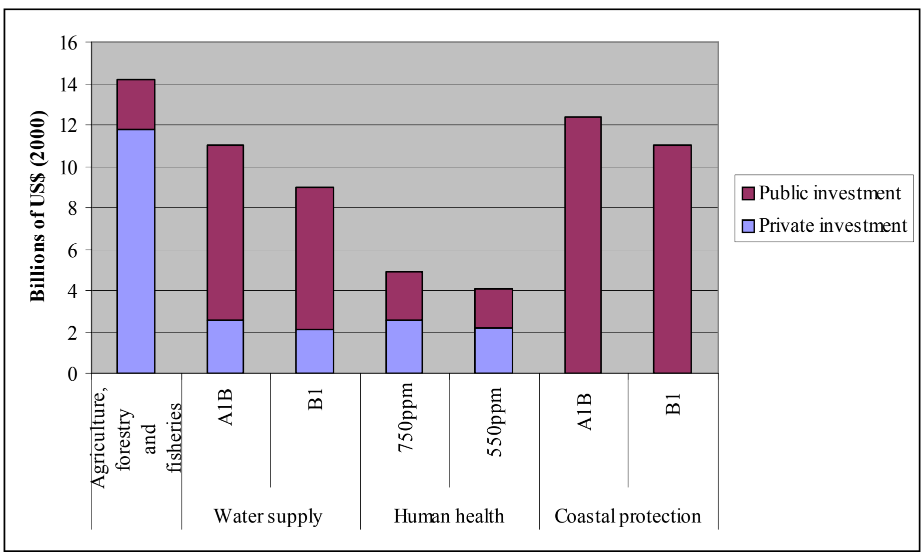
Emerging estimates of aggregate adaptation costs in developing countries—which are very rough, and do not distinguish public and private costs—run in several tens of billions of dollars per annum:

- The World Bank (2006) puts the cost of climate-proofing existing investments in developing countries at US$10–US$40 billion per annum. Even excluding outlying estimates within the study (which are as high as US$100 billion), this is a wide range: from around 10 to 40 percent of net ODA. Climate-proofing ODA and the most exposed concessionally-financed investments is estimated to cost US$4–US$8 billion annually.

- UNDP (2007), building on the earlier work of the World Bank, estimates an annual cost of climate-proofing development investment, by 2015, of around US$44 billion per annum, with an additional US$2 billion to strengthen disaster response—and a further annual US$40 billion in strengthening social safety nets.

- UNFCCC (2007) estimates suggest an annual investment cost for agriculture, health, water and coastal protection, of around US$40 billion per annum by 2030—perhaps half of which might fall on the public sector (Figure 4). It also reports a very wide range for additional infrastructure needs, of US$8–US$130 billion annually.

Figure 4. Additional Adaptation Investment, 2030



Source: UNFCCC (2007) and staff estimates of public/private split.

Notes: A1B and B1 are emissions scenarios from the UNFCC Special Report on Emission Scenarios (SRES), with a faster transition to less carbon-intensive technologies in the latter.

These estimates are extremely rudimentary, generally derived by applying to current activities a rough adjustment for climate-proofing. This overstates costs, in so far as full climate-proofing is unlikely to be optimal, but understates them to the extent that it does not capture the need for additional projects. They are also likely to be underestimates in that they focus on dealing with trends in temperature and water availability, and so neglect challenges from increased variability, for example in water supplies.

Assessing the fiscal challenges from adaptation in developing countries requires a far better understanding of their likely country-specific magnitude. It is currently hard to judge where and when these costs rise to levels of macroeconomic significance relative to the wide variety of other fiscal risks that countries face.

Such estimates are needed, not least to properly integrate spending on adaptation into wider development programs. A strong case can be made for increased assistance to developing countries to support adaptation efforts, with achievement of the Millennium Development Goals otherwise potentially jeopardized.[22] Even within an expanded resource envelope, however, adaptation needs to compete with other uses of scarce funds. There will be "win-win" opportunities for spending that promotes climate resilience whilst also being warranted on other development grounds (such as improved malaria control and prevention). But limited resources need to be allocated where the social return is highest. And while benefit-cost ratios seem high for many measures of public spending on adaptation, the same is true for many nonclimate-related items.

[22] The point is stressed by both Stern (2007) and UNDP (2007).

CHAPTER

5 Implications for the Fiscal Work of the Fund

Climate change raises fiscal risks and design issues that are potentially of macroeconomic significance, in some cases immediate, and within the Fund's established expertise. Given its impact on extreme weather events and the need for early action, especially to reduce future damage, the potential fiscal impact is a concern for the short- as well as the long-run. Indeed the fiscal challenges from CC are reminiscent of those from aging—where the Fund has long urged early action to address pressures arising decades into the future—but are marked by greater uncertainty and more dire extreme outcomes. The technical issues of tax design and implementation are ones in which the Fund has considerable experience (with cap-and-trade schemes, while not a topic of operational work in the past, raising closely similar issues).

The fiscal challenges from climate change reinforce many aspects of existing Fund fiscal advice. This is so, in particular, in relation to the potential wastefulness of inappropriately low fossil fuel prices, the need to recognize and prepare for shocks affecting the public finances, and the value of tax expenditure analysis in guiding policy decisions. Strong and clear advice on these issues will continue to be needed.

Other institutions have expertise in the scientific, environmental, and sector-specific issues that will be central to addressing climate change. The World Bank, United Nations Development Program, and United Nations Environment Program, for example, have considerable experience with the impact of, and micro-level responses to, changing climates. The International Energy Agency has expertise in energy markets. The Fund need not acquire such skills.

Fiscal aspects of climate change may arise in a range of Fund activities—and many outside observers appear to look to the Fund to bring its fiscal,

as well as wider macroeconomic and financial, expertise to bear. Drawing on the skills of others, and the experiences and concerns of its universal membership, fiscal aspects of CC may arise, on a modest scale, in a range of Fund activities:

- ***Technical assistance*** may be requested in designing and implementing fiscal instruments for mitigation, or in monitoring climate-related expenditures. Such requests might be either stand-alone or part of wider reviews of tax or expenditure management systems—encompassing, for example, questions as to how best to realize any potential double dividend from carbon pricing. Countries may also seek advice on assessing and managing the fiscal risks associated, for example, with more intense extreme weather events.

- ***Bilateral surveillance*** provides an opportunity to discuss the fiscal and other macroeconomic consequences of CC with members whose external stability may be affected. This has already occurred in a number of vulnerable countries (in the Caribbean and Pacific, for example), and can be expected to become more common as concerns continue to mount. Most Fund members are signatories to the UNFCCC, and so are committed to assess the likely economic impact of the climate risks they face—but few do so, especially in developing countries. Raising such issues in Article IV consultations where they are of potential macroeconomic significance, could usefully focus attention on identifying and addressing potentially significant fiscal challenges—and opportunities—from CC (Heller, 2007). FAD could support the Area Departments in such discussions, within its limited resources.

- ***Multilateral surveillance*** may provide an opportunity to discuss international cooperation in fiscal measures addressed to spillover effects from national emissions. Here as in other areas the most appropriate and constructive role for the Fund will depend on developments in the institutional structure for cooperation in climate policies, likely to be one aspect of the dialogue now underway towards a successor to the Kyoto protocol.

- Some further ***Policy Development and Research Work*** could inform public debate on the fiscal and macroeconomic consequences of alternative fiscal responses.

- ***Lending arrangements***. The Exogenous Shocks Facility already provides for support to countries hit by extreme weather events.

The potential implications for the fiscal work of the Fund thus appear quite modest. Much is being done elsewhere, and areas in the Fund's domain can be accommodated within the existing resource envelope.

APPENDIX

1 Glossary and Science

BAU	Business as Usual: The outcome under current policies (generally referring to a path of GHG emissions).
BTA	Border Tax Adjustment: Remitting tax on exports, charging tax on imports.
Carbon price	A price charged—whether in the form of a tax or a permit price—for emitting CO_2, payable in addition to the price of the resource itself.
CC	Climate Change.
CDM	Clean Development Mechanism: Provision under Kyoto Protocol for industrialized ('Annex B') countries to credit against their emissions targets financing of projects reducing emissions in non-Annex B countries.
CO2e	CO2 equivalent (see Box 2 below).
EU-ETS	European Union Emission Trading Scheme.
Geoengineering	Deliberate climate modification (e.g., using aerosols to reflect solar radiation).
GHG	Greenhouse Gas (see Box 2 below).
IAM	Integrated Assessment Model: Seeks to combine major socio-economic and physical processes and systems that characterize the human influence on, and interactions with, the global climate.
IPCC	Intergovernmental Panel on Climate Change: Established by the United Nations Environment Program and World Meteorological Association to synthesize research on climate

	change. Generally seen as providing closest available to scientific consensus.
Kyoto protocol	Protocol to UNFCCC committing industrialized ("Annex B") countries to (differentiated) GHG emissions reductions relative to 1990, for 2008–12.
ppm	Parts per million (see Box 2).
Sequestration	Terrestrial or oceanic storage of CO2 (e.g., in depleted oil and gas fields).
tC	Tonne (metric) of carbon.
UNFCCC	United Nations Framework Convention on Climate Change: Entered into force 1994, ratified by 192 countries; recognizes "Common but differentiated responsibilities" towards "Stabilizing GHG emissions at a level that would prevent dangerous anthropogenic interference with the climate system."

Box 2. The Science of Climate Change

Average global temperature increases with the atmospheric concentration of greenhouse gases (GHGs). There are three main GHGs (other than water vapor, which is little affected by human activity and decays rapidly):

- Carbon dioxide (CO_2) currently accounts for about 75 percent of GHG emissions; burning fossil fuels—petroleums, coal and natural gas—contributes 55 percent, and deforestation 20 percent.
- Methane, mainly from agricultural activity, contributes 15 percent
- Nitrous oxides, generated by industrial and agricultural activities (including nitrogen-based fertilizers) account for most of the remaining 10 percent.

Some man-made factors reduce global warming, most importantly aerosols (particles resulting from sulphur emissions and reflecting sunlight), though these decay relatively quickly and have more localized effects.

The concentration of GHGs in the atmosphere—conventionally measured in parts per million (ppm) of CO_2 equivalent (CO_2e)—has risen from about 280 ppm in 1750 to around 430 ppm now. It is currently rising by more than 2 ppm per annum, and under business as usual (BAU) could increase to around 750 ppm by 2100.

Temperature rises more than linearly with GHG concentration. By the best current estimate (IPCC, 2007), the global average temperature has increased by about 0.75 degrees Celsius (°C) since 1960 (with the cooling effect of aerosols roughly offsetting the warming effect of GHGs until about 1980). Under BAU, the average global temperature might rise by the end of the century by between 2.2 and 6.4 °C above pre-industrial levels (5–95 percent confidence; IPCC (2007)). Strong mitigation might limit this to 1–3 °C.

APPENDIX

2 Aspects of Instrument Choice

Uncertainty tends to favor the use of tax- rather quantity based instruments. There are two main reasons:

- ***Errors in assessing marginal abatement costs*** will arise under either tax or cap-and-trade schemes, but with different consequences (Weitzman, 1974).[23] If costs prove higher than expected, for example, cap-and-trade will lead to too much abatement (because it takes no account of that increased cost) whereas a carbon tax will lead to too little (because it does not allow for the increased marginal benefit of abatement when abatement is cut). In the CC context, such errors under cap-and-trade over any relatively short period are likely to be more costly than those under taxation: this is because marginal abatement costs rise rapidly as abatement increases, but emissions over any short interval make little difference to the accumulated stock, and hence to damage from CC. The consequent gain from the use of tax schemes may be sizable (Pizer, 2002).

- ***Volatility*** of the carbon price may be greater under cap-and-trade, and ***international spillovers*** stronger, since aggregate emissions cannot respond flexibly to aggregate demand shocks. This may discourage mitigation-related investments by increasing the option value of waiting. In an international setting, the same effect can cause negative macroeconomic spillovers as increased growth in one country has an amplified effect on the carbon price also faced by others (McKibbin and Wilcoxen, 2004).

[23] A standard diagrammatic exposition of the Weitzman argument is in Jones and others (2007).

Hybrids can in principle improve on either a simple tax or cap-and-trade. In practice, the choice is not between an unchanging tax scheme and a fully predetermined path for aggregate emissions: each would be updated in the light of emerging information, producing an outcome with elements of both. More generally, faced with uncertainty in abatement costs, the best policy in principle is neither a simple tax nor cap-and-trade, but a scheme allowing both the carbon price and total emissions to vary.[24] Such hybrids can take many forms, such as supplementing cap-and-trade with price caps and provision for "banking" (saving) and borrowing (against future emission rights) permits. Simulations suggest that the gains from such provisions can be substantial even relative to an optimal tax scheme (Pizer (2002)).

Credibility of future carbon prices is not easy to achieve under any instrument choice. One hybrid proposal, for instance, involves issuing very long term permits, to create a vested interest in the maintenance of tight emissions limits (McKibbin and Wilcoxen, 2002). Whether governments faced with an urgent need to limit emissions would be willing to pay market prices to retire long-term permits, however, is questionable. Carbon taxation may, through the revenue it raises, create a strong vested interest in the government itself, but it can also be prone to strong resistance. Some degree of international cooperation seems likely to be needed, in any event, to support the credibility of domestic policies.

Domestically, practical considerations tend to favor tax-based schemes. Implementing carbon taxes and cap-and-trade both require monitoring payments and emissions. And since what matters is the amount of fossil fuels ultimately burnt, not who does the burning, both can be implemented at any stage between "upstream" (extraction, refining or import) and "downstream" (the final burning). The general principle of restricting monitoring to as few points as possible suggests in each case an upstream focus—but with the difference that under cap-and-trade this may compromise the competitiveness of any auctioning process. Tax arrangements also fit well with the established expertise of tax administrations in relation to fuel and other excises, whereas cap-and-trade requires, in many countries, a new institutional apparatus. For the same reason,

[24] Dasgupta (1982), Roberts and Spence (1976).

compliance for firms may be less burdensome if existing tax schemes are strengthened rather than new trading mechanisms created.

APPENDIX

3 Key Model Features

An Appendix to the spring 2008 *WEO* provides a detailed comparison of G-cubed, IGSM, MiniCAM, and other models. Key features for present purposes are:

- IAMs combine a wide range of economic and physical processes characterizing the human influence on, and interactions with, the global climate (including both mitigation and adaptation). Their strength in the present context is a relatively detailed modeling of energy use and mitigation opportunities. They (especially MiniCAM) are less well-suited than G-cubed, which is an intertemporal general equilibrium model, to modeling investment, savings, and balance of payment effects.

- There are differences in underlying baseline assumptions. Loosely speaking, IGSM and G-cubed have substantially higher BAU emissions than MiniCAM.

- Other differences between the MiniCAM and G-cubed simulations here and in the *WEO* include the extent of country coverage and precise permit allocation rules considered under cap-and-trade.

The diversity and complexity of the structures of these models and their underlying assumptions can make it hard to isolate the precise source of differences in results, which can be significant—so quantitative results remain essentially illustrative.

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