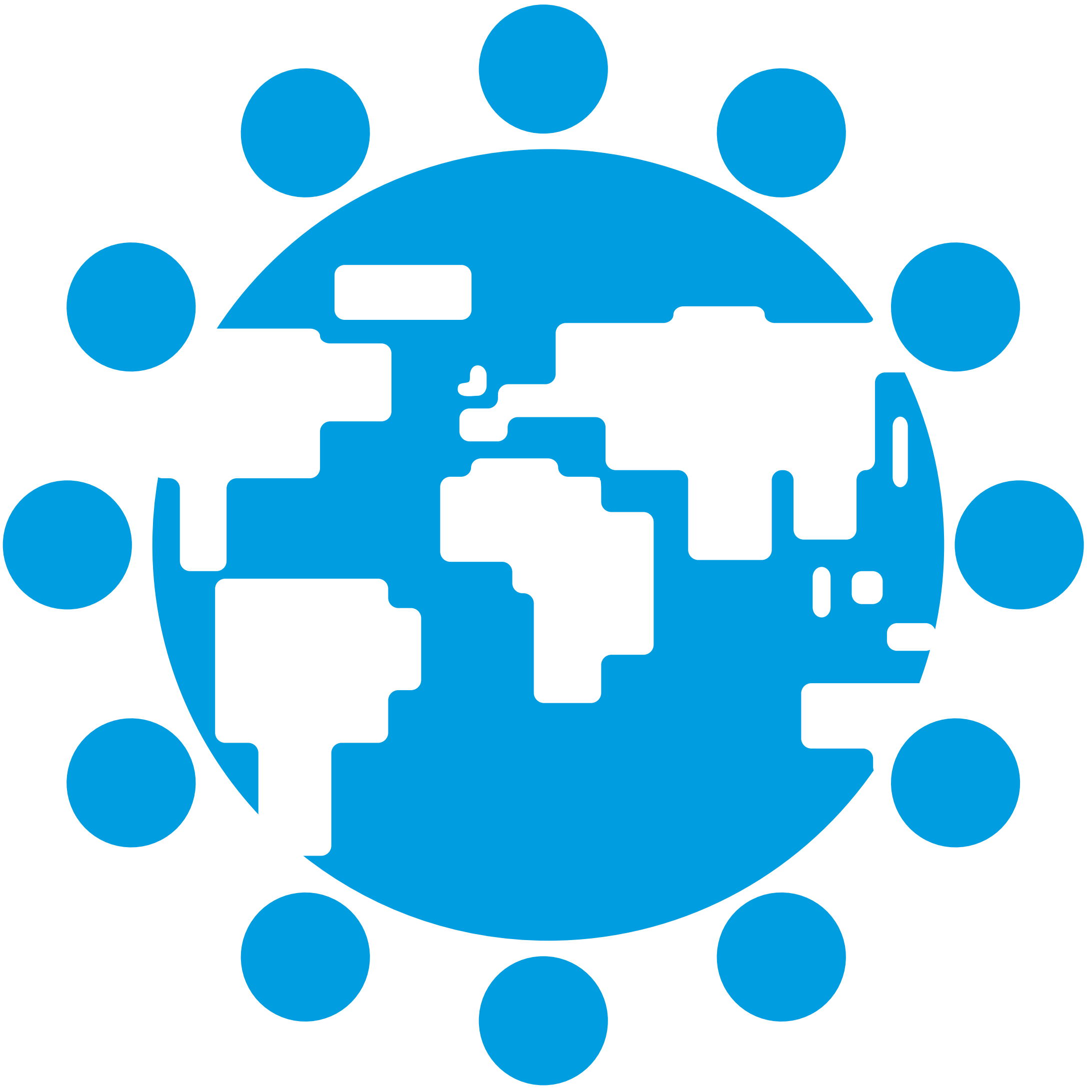

The Macroeconomic Effects of the Transition to a Low-Carbon Economy

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THE °CLIMATE GROUP

Breaking the Climate Deadlock
Briefing Paper

About the 'Breaking the Climate Deadlock' Initiative

'Breaking the Climate Deadlock' is an initiative of former UK Prime Minister Tony Blair and independent not-for-profit organisation, The Climate Group. Its objective is to build decisive political support for a post-2012 international climate change agreement in the lead up to the 2009 UN Climate Change Conference in Copenhagen. Its particular focus is on the political and business leaders from the world's largest economies, particularly the G8 and the major developing countries. The initiative builds on Mr Blair's international leadership and advocacy of climate change action while in office, and The Climate Group's expertise in building climate action programmes amongst business and political communities.

This briefing paper and its companions were commissioned by the Office of Tony Blair and The Climate Group to support the first Breaking the Climate Deadlock Report – 'A Global Deal for Our Low Carbon Future' – launched in Tokyo on June 27th 2008. Written by renowned international experts and widely reviewed, the papers' purpose is to inform the ongoing initiative itself and provide detailed but accessible overviews of the main issues and themes underpinning negotiations towards a comprehensive post-2012 international climate change agreement. They are an important and accessible resource for political and business leaders, climate change professionals, and anyone wanting to understand more fully, the key issues shaping the international climate change debate today.

The views expressed and information provided in this paper are the sole responsibility of the author. The Climate Group, the Office of Tony Blair and the staff of Breaking the Climate Deadlock Initiative accept no responsibility for any errors of fact or the opinions contained herein.

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Executive Summary

- Coordinated international action on climate change has the potential to raise global incomes; provide additional rural employment, especially in areas with limited alternative opportunities in developing countries; and improve human well-being through reduced air pollution
- However, the year-to-year effects of policies are likely to be so small as to be lost in the overall fluctuations in the growth of GDP, because well-designed policies will operate slowly and gradually (unlike the sudden oil-price effects of 2007-2008), aiming to replace fossil-fuel equipment with low-carbon alternatives at the end of its working life.
- Well-designed international policies could achieve the G8 50 percent reduction target by 2050, or earlier as implied by the EU's 2˚C target, with net benefit to global and national economies.
- Coordination reduces the investment costs, inducing technological change via agreements to establish global carbon prices, share new low-carbon technologies, apply standards of carbon efficiency, and open up markets to encourage economies of scale and specialisation.
- Globalisation of information and markets works in favour of rapidly reducing the costs of low-carbon processes and products through accelerated adoption, provided the market signals and incentives are favourable.
- The critical market signals and incentives come through carbon prices, created by carbon taxation and emission trading schemes ("cap and trade"). Carbon prices have to be "loud, long and legal" to be effective in influencing investment decisions.
- Low-carbon investments represent long-term benefits through reduced fuel costs and improved performance (beginning with the "no regrets" mitigation potentials identified by the IPCC) but short-term costs to those who pay for them. They also bring about a change in the structure of the economy, with reductions in value added in carbon-intensive activities and increases among the engineering and construction sectors that produce the new equipment and infrastructure.

Recommendations

- Develop the Bali Action Plan to formulate global targets.
- Propose mandatory limits for Annex 1 parties, a "Marshall Plan" for funding low-carbon policies and measures in developing countries, and a cap-and-trade scheme for international transport.
- Fulfil the Bali action plan by developing proposals for Reducing Emissions from Deforestation and Degradation (REDD) and Multilateral Climate Change Fund (MCCF), as well as the architecture of national Clean Development Mechanism (CDM) programmes.
- Agree a global target of greenhouse gas (GHG) emission reductions below 2000 levels for 2020, 2030 and 2050.
- Agree mandatory national caps for Annex 1 parties that appear likely to meet the global target, provided there is adequate funding of CDM, REDD, MCCF and other instruments.
- Agree the funding of a "Marshall Plan" by industrialised countries to promote low-GHG policies and measures in non-Annex 1 countries, including cap-and-trade for GHG emissions, carbon taxes, feed-in tariffs, and Carbon Capture and Sequestration (CCS) with coal.

Macroeconomic effects of the transition to a low-carbon economy

This paper reframes the debate on the macroeconomic effects of greenhouse gas (GHG) mitigation in terms of net benefits to the economy rather than net costs, drawing on the same modelling and other literature as the Intergovernmental Panel on Climate Change's Fourth Assessment Report (IPCC AR4)[1]. The traditional "costs" framing was more appropriate for a zero-sum approach to unilateral policy concerned with national competitiveness, especially when there was more doubt about the link between GHG emissions and climate change, as in the 1990s.

Today, with general acceptance of the scientific findings supporting the link, the issue is how to realise the potential for global macroeconomic benefits from international policy cooperation, in which all parties can benefit. A new approach is therefore more relevant, focused on the investment opportunities represented by the need to transform the world's energy system, and the potential of policies to accelerate sustainable development towards a decarbonised global economy.

The transition to a low-carbon global economy is a system-wide change. Nearly all sectors of the economy will be affected. Although the gradual and planned transition will have a minor impact on global economic growth, there will be much larger effects on a few sectors, e.g. renewable electricity generation or coal supply, and on those countries and regions with renewable resources or heavily dependent on oil and coal for exports and energy.

Good policy design and frameworks will be essential in achieving the greatest benefits from international coordination. For one thing, businesses planning future investments welcome clear signals and incentives for the transition. Further, a framework establishing a global carbon price – a price that is low at first but expected to rise sharply – will encourage innovation and rapid acceleration of investment in low-carbon technologies. There is potential for internationally coordinated policies to allow developing countries to "leapfrog" heavy polluting, industrialising technologies and instead to develop low-cost, information-intensive, less centralised economies based on zero-carbon electricity from renewables and solar heat. This is the challenge of the "carbon productivity revolution", but it requires education and training as well as access to information, funds and markets at global scale.

This paper assesses the impacts of climate policies for the global, national and sectoral economies at the macro, system-wide level, drawing on the Stern Review[2], the IPCC's AR4 and later literature. The emphasis is on the benefits of international co-ordination in a world of dynamic technological change, rather than on the costs of unilateral action with static technologies and known, certain outcomes.
The paper covers the following:

- Impacts of climate policies on GDP growth
- Effects of induced technological change
- Why high and rising carbon prices are essential
- Effects on employment and wages
- Other macroeconomic aspects of the transition
- Effects on international trade and competitiveness
- Recommendations on the road to a Copenhagen agreement

Box 1

Calculating the economic costs of greenhouse gas mitigation

The economic costs of greenhouse gas (GHG) mitigation are not observable from market prices, since they involve assessment of a complex energy-environment-economy (E3) system as it responds to price signals, regulations, and changes in environmental outputs that have no market valuations. The macroeconomic costs estimated for transition to a low-carbon economy are always hypothetical because they involve a comparison of two different states of the E3 system over future years: the "with mitigation" scenario is usually compared with a reference scenario (often taken as "business as usual", although this risks untold future extreme climate events).

In the analysis of macroeconomic costs and benefits it is important to distinguish those involving well being, as opposed to "utility" or those measured by Gross Domestic Product (GDP). *Well being* comes from friends, family, work and comparison with others after a minimum income is reached. *Utility* in the specific version used by traditional economists is aggregated self-interest. Its application can be deeply flawed, producing misleading if not meaningless conclusions for climate policy[3]. Results from this traditional approach assume mitigation costs (see Annex). *GDP* is the usual standard summary measure of macroeconomic effects as it covers all marketed output and is comparable across different countries' accounts. The costs and benefits are the differences in GDP in constant prices between two scenario outcomes, and for convenience most of the discussion in this paper, unless explicitly stated otherwise is about the GDP effects, with the caveat that GDP can be a poor indication of well being, ignoring critical climate and equity effects. The changes in GDP can be expressed (1) in absolute terms, (2) as percentage of the reference case GDP or (3) as differences in growth rates:

1. The absolute amounts are misleading if quoted out of context, and they depend on the price base chosen
2. The changes as a percentage of GDP in the reference case show the scale of the costs, avoid the discount rate problem (since the costs and the level of GDP are contemporaneous) and allow easier comparison across years and countries.
3. Differences in growth rates are appropriate for comparing long-term mitigation costs, for example over the years to 2100. As a rule of thumb, a change in GDP is insignificant if it implies a difference from base of less than 1 percent over a 10-year forecast period[4].

It is not appropriate to use the level of carbon tax or estimated permit price for CO_2 emissions as a summary measure of mitigation costs. The carbon tax rate is one of many policy instruments; it is always positive, whereas the costs can be positive or negative; and it is a partial measure, covering fossil-fuel use alone, whereas macroeconomic costs cover the whole economy.

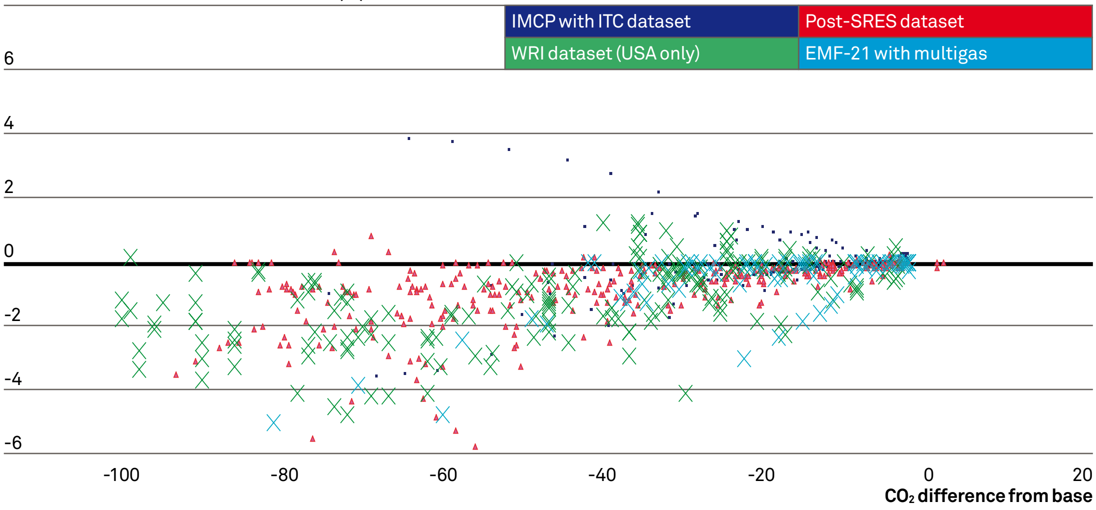
Impacts on GDP growth

The year to year effects of policies are likely to be so small as to be lost in the overall fluctuations in the growth of GDP

A key and repeated finding from modelling of policies for climate change mitigation is that the macroeconomic benefits and costs should be seen as having a minor impact on global economic growth, on average less than around +0.08 to – 0.12 percent of GDP growth for the G8 50 percent reduction target, based on modelling reported by the IPCC[5]. These differences in growth rates are negligible compared to the expected average of some 2 to 3 percent pa over the century.

Exhibit 1

Global & US GDP – difference from base (%)



Scatter plot of model cost projections

Source
Author's data from modelling comparison exercises with original data collected by Edenhofer et al., 2006 (IMCP); Morita et al., 2000 (post-SRES); Repetto and Austin, 1997 (WRI); Weyant et al., 2006 (EMF21).

Note
(1) Each point refers to one year's observation from a particular model for changes from reference case for CO_2 and the associated change in GDP from four sources for years over the period 2000-2050.

Exhibit 1 shows the Scatter Plot of abatements of CO_2 (as differences from reference cases from four major model comparison exercises) and the associated change in the level of GDP from a base case over a variety of projection periods to 2050 and for a variety of approaches. The plot shows all the outliers with a cut-off of -6 percent, but when an analysis is made of the data, and outliers removed, the results are consistent with the GDP growth results reported by the IPCC.[6]

The findings of net macroeconomic costs from "top-down" models usually arise by assumption

It is also clear from Exhibit 1 that most of the studies report reductions in GDP arising from mitigation policies (see Annex 1). The most important reason for this finding is that the traditional, equilibrium studies assume that policies, whether global, national or regional, will reduce marketed activity as measured in the models by GDP. The models assume that the economy is perfectly efficient and working at full employment, so that any policy such as a carbon tax will shift the economy from this favourable position[7]. A better approach is more neutral, based on observations and allowing for market failures and inefficiencies, and allowing GDP to change up or down, depending on circumstances.

The favourable outcome for GDP also depends on the treatment of induced technological change (ITC) in the models or the assumed use of revenues from taxes and auctions. The revenue recycling issue is especially interesting, since there appears to be a substantial opportunity for benefits from co-ordinated action. The outcome of the recycling depends fairly critically on whether the revenues are used to reduce inflationary impacts of the policies, to reduce labour taxes or to incentivise low-GHG technologies[8]. There is a clue to the possible scale of such reductions from the studies of the costs of ratifying the Kyoto Protocol for the USA. These postulated a 30 percent reduction in CO_2 emissions below business as usual over a 3 to 4 year period. With US emissions more or less static, this in turn implies a reduction of some 7 percent a year. One of the highest cost estimates for this reduction was made by the US Energy Information Administration[9], at 4.2 percent of GDP by 2010. However, this estimate excluded international policies and the recycling of revenues to reduce social security costs, and made no allowance for the gains in air pollution. With these extra policies and allowances, the estimated cost of such rapid decarbonisation drops to 0.7 percent of GDP.

Well-designed international policies, using revenues from auctions to accelerate technological and behavioural change, could achieve the G8 50 percent emissions reduction target with net benefit to national and global economies

A more targeted approach after 2009, recycling some of the revenues, e.g. from auctioning emission allowances, to encourage technological and behavioural change in times of under-employment in construction, could easily make the costs of such rapid decarbonisation negligible or turn any potential loss of GDP into a gain. Ex post studies of environmental tax reforms in Europe over the period 1990-2005 show results that are consistent with these modelling results, using several lines of evidence[10].

The effects of future policies are explored using economic models[11]. A 2008 modelling study suggests that a carbon price rising to \$100/tCO_2e by 2030 could achieve the G8 target by 2050, provided that the prices are embedded in a portfolio of policies and measures[12]. A cap-and-trade scheme with auctioned permits would set the carbon price for the energy sector, while environmental tax reform would influence the carbon price for the rest of the economy. Regulation and targeted use of some of the revenues from auctions would provide incentives for technological and behavioural changes in the use of fossil fuels in buildings, transport and industry. Mandatory standards for power station and vehicle emissions would lead to sufficient take-up of new technologies for market forces to accelerate their diffusion and adoption. The outcome is a small increase in GDP above base of 1 percent by 2050, although this is dependent on the "no-regrets" options[13] identified by the IPCC being taken up by business, government and households.

Costs mainly come as investment in low-carbon alternatives and reductions in coal output

Although the macroeconomic benefits seem likely to offset any costs, there are significant costs for the energy system, mainly in the form of substantial and large-scale investments in infrastructure (e.g., global direct-current power transmission), retro-fitting buildings, power generation, vehicle engines and design, industrial heat, agricultural and forestry projects. If these investments take place at the expense of fossil-fuel investment, the net costs may be negligible, but if they are at the expense of consumption then growth may be lower, again depending on whether there are spare resources in the system. In terms of sectoral effects, the costs are concentrated largely in the coal sector, especially if the policies require rapid decarbonisation (e.g., 7 percent a year or faster) before Carbon Capture and Sequestration (CCS) is available at scale. (If oil prices stay over \$100/barrel in real terms over the long term, it seems unlikely that much extra investment will be needed in transportation.) The electricity sector will invest substantially, but will pass on most of the costs to their customers, depending on the policy regime and the degree of competition in the power markets. Economic theory suggests that all the costs will eventually be paid by final private consumers, but they or their descendants will also receive the benefits.

Coordinated international action will also improve human well-being through reduced air pollution

These benefit and cost estimates do not include the further net benefits from reduced pollution through lower use of fossil fuels, especially in urban areas suffering human health damages and rural areas where crop productivity is damaged by episodes of low-level ozone pollution. These benefits are especially significant in urban areas down-wind of coal-burning sources of particulates, SO_2 and other pollutants. Low-level ozone from transport pollution has been shown to damage crop productivity. The benefits are generally underestimated because of difficulties in measurement and coverage, and they can amount to a percent or more of GDP in scale, depending on geography and climate.

Macroeconomic effects largely positive for developing and transitional economies

The macroeconomic effects of deep mitigation seem likely to be substantially positive for GDP and well being for most developing countries and economies in transition, such as Russia. These economies can benefit from additional investment and rural employment from decentralised mitigation policies aimed at improving the comfort of buildings, introducing new energy crops on degraded land, or combining adaptation, mitigation and development in extending forest cover and improving agricultural practices.

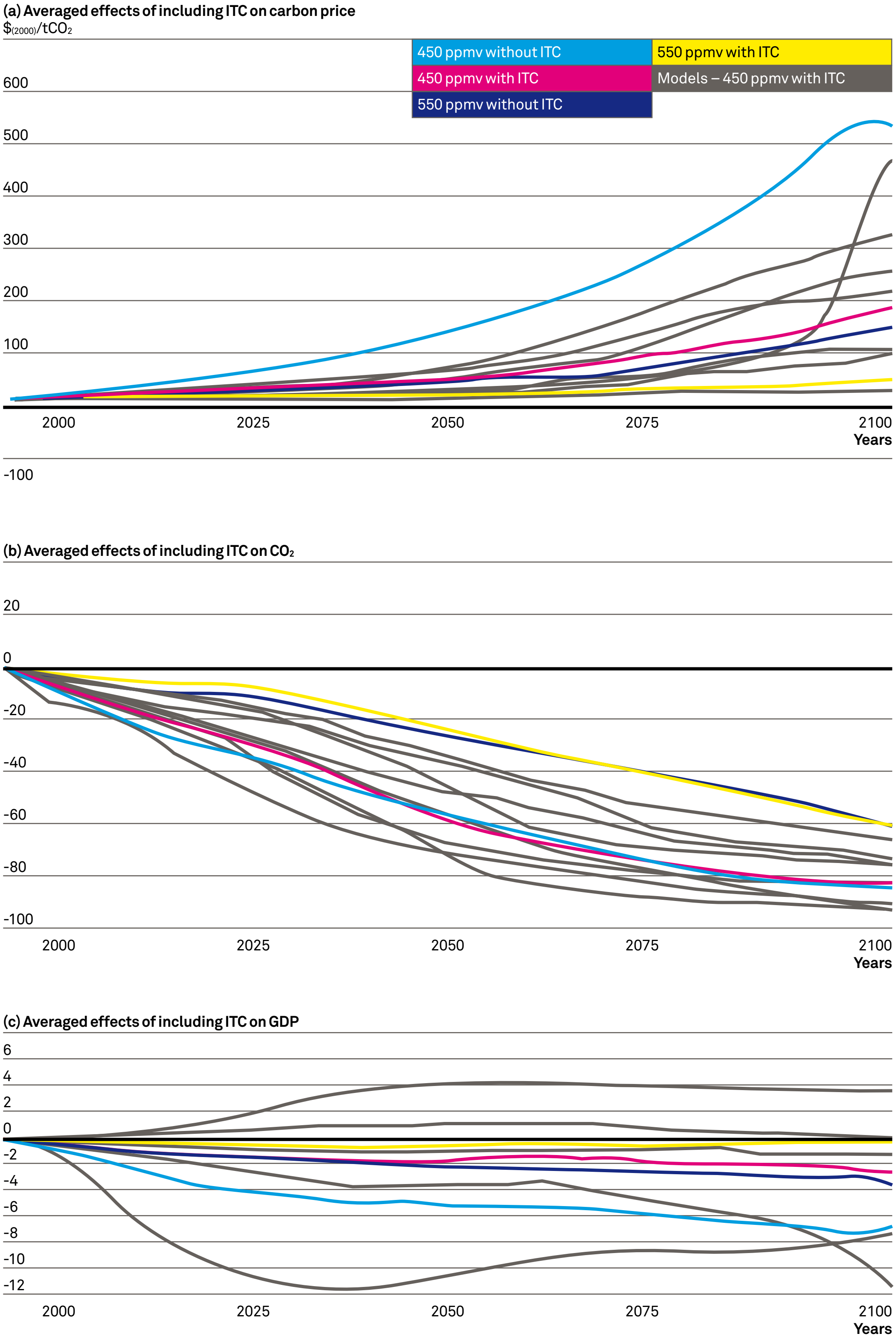
Effects of induced technological change

The literature after the IPCC's Third Assessment Report explored in much more depth the role of technological change in economic modelling and how policies might induce and accelerate such change. The models suggest that international coordination could lead to faster technological change and more benefits. In particular, the Innovation Modelling Comparison Project (IMCP)[14] co-ordinated modelling teams in a study of the achievement of 450 ppm CO_2-only stabilisation, which (under special assumptions about the abatement of the non-CO_2 GHGs) can be converted to 550 ppm CO_2-e. The key feature of the study is that it compared scenarios with and without induced technological change (ITC).

Exhibit 2

Effects of allowing for induced technological change on model estimates of carbon prices, CO_2 emissions and GDP

Source
IPCC AR4 WG3, Figure 11.9, adapted from (Edenhofer et al., 2006)



Notes
(1) The panels show the averaged effects of including ITC on (a) carbon prices, (b) CO_2 emissions and (c) GDP: 9 global models 2000-2100 for the 550 and 450 ppm CO_2 –only stabilisation scenarios.
(2) The 450-CO_2-only scenarios are approximately convertible to 550 ppm CO_2-e.
(3) The gray background lines show the range from the individual models for 450 ppm with ITC. See source for details of models.

Exhibit 2 shows the effects of introducing ITC into the models for the 550 and 450 ppm CO_2 –only stabilisation scenarios for 2000-2100. The panels show the simple averages of results from 9 global models for 2000-2100 for the carbon prices (tax rates and emission permit prices in $\$_{(2000)}/tCO_2$), changes in CO_2 (percentage difference from reference case) and changes in global GDP (percentage differences from reference case). The results are shown with and without endogenous (in the reference case) and induced technological change (i.e., induced by the carbon price).

The reductions in carbon prices and increases in GDP are substantial for many studies in both stabilisation cases when ITC is introduced. The effects on CO_2 reductions show that including ITC in the models leads to earlier reductions in emissions, but little difference in the overall reduction, which is given as a target. While learning-by-doing can lower the economic cost of emission reduction, there are other factors that are even more important in producing the reduction in costs shown in the figure. In many of the model results, the assumptions about crowding out of conventional R&D by low-carbon R&D and the availability of mitigation options (models have different sets of options) are more important factors than learning-by-doing[15].

Policy coordination reduces the investment costs through induced technological change

The results in Exhibit 2 show the ranges and the uncertainties for effects of ITC from climate policies[16]. The average differences should not be considered as entirely due to the effects of ITC because there are other assumptions that affect the costs, for example the use of tax or permit revenues, as is evident in a meta-analysis of the macroeconomic costs of mitigation undertaken for the UK Treasury's Stern Review. The meta-analysis[17] combines the IMCP results on costs with earlier data on post-SRES[18] scenarios[19] so that the effects of other assumptions can be identified. The GDP net costs for 550 ppm CO_2e stabilisation by 2030, as estimated by the IMCP models, are reduced from 2.1 percent without ITC but allowing for emission trading and backstop technologies, to 0.8 percent GDP by 2030 with ITC. If benefits from recycling of revenues are included and a valuation of the reductions in air pollution are included, GDP is above the reference case, i.e. the costs are turned into benefits. Even more important, the research shows that the ITC effects become more pronounced in reducing costs for later years and as the stabilisation targets become more stringent, partly due to the associated additional increases in the required carbon prices.

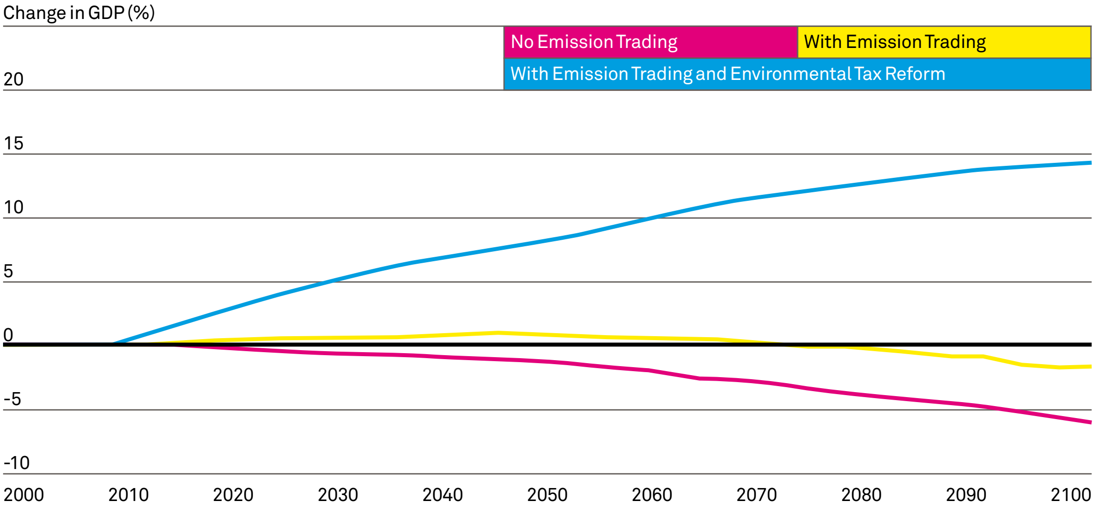
These calculations have also been done for 450 ppm CO_2e. Exhibit 3 shows the average effects of including different policy regimes in the models by 2030 for pathways to 450 ppm CO_2e. Clearly, emissions trading is crucial in turning unilateral costs into multilateral benefits, but the additional use of auction and tax revenues in multilateral environmental tax reforms creates opportunities for substantial increases in GDP, a very uncertain result based on a small number of studies. The key message here is that assumptions and approaches in the modelling have critical effects on the results and that policy choice and design can yield substantial benefits.

Exhibit 3

Effect of emission trading and environmental tax reform on GDP for 450 CO_2-e

Source
Barker and Jenkins (2007)

450 CO_2-e Estimate: Econometric model with ITC and non-climate benefits
Change in GDP (%)



Technology policies and mandatory CO_2 caps reinforce each other in correcting market failures

The US Administration under President Bush has generally led arguments favouring technological agreements rather than mandatory cap-and-trade schemes such as the EU Emission Trading Scheme (ETS). The argument is partly that cap-and-trade will not produce the fundamental new technologies required for a zero- or low-carbon economy. The problem with this argument is that some technological developments (such as CCS) require a carbon price to become economic and their investment prospects depend heavily on the price continuing over their useful life. The most effective policies thus appear to be those that combine the carbon price signal from an ETS with direct incentives to fund low-GHG innovation and research and development, for instance by auctioning emission permits and using a proportion of the revenues to provide additional technological incentives. Such a portfolio addresses the two market failures of global warming and insufficient technological innovation[20].

Why high and rising carbon prices are essential

The main reason why technologies, especially those embedded in no-regrets energy efficiency policies, are unlikely to produce effective climate-change mitigation is the so-called 'rebound effect'[21]. This arises where improvements in energy efficiency reduce the cost of production and consumption, which then prompts higher use of particular services (for example heat or mobility) that energy helps to provide, so that the energy saving from the innovation is offset by increased energy consumption. Although rebound effects will vary widely in size, any technological breakthrough without a carbon price to deter extra carbon use, risks higher energy demand overall – leading to only a weak reduction, if any, in emissions, especially at a global level. This indicates that a carbon-price signal is needed to provide a pervasive and long-term signal for investment decisions so that low GHG options are chosen consistently. Importantly, research and development decisions would also be influenced by the expected future carbon price.

Carbon prices have to be "loud, long and legal" to be effective in influencing investment decisions

In simple terms, the low-cost trajectories towards stabilization explored in the literature involve a firm expectation that carbon prices will rise to high levels, encouraging the design, deployment and installation of low GHG investments in energy supply and energy demand for power, comfort, light and transportation, depending on lifetime. That carbon prices will be low in the near term reduces the likelihood of premature obsolescence, while the expectation that they will be high later encourages research, development and investment in long-lived low-emissions capital and reduces the risk of investment lock-in. The outcome should be a rapid adaptation of the energy system without excessive costs. If the policy is successful, eventually no sector will ostensibly pay for carbon because emissions will cease, the structure of the economy will adjust and the overall costs will be more than recovered in the form of faster growth, more comfort, and lower pollution. However, the price signal must be credible and should be managed to provide time for adjustment in different sectors, depending on the lifetime of the carbon-burning assets, the ability to respond to price signals and the availability of alternatives to GHG-intensive activities.

The critical market signals and incentives come through carbon prices, created by carbon taxation and emission trading schemes ("cap and trade")

Carbon prices are generated by policy through two main market-based instruments: carbon taxes and emission-permit schemes. A carbon tax is a highly specific and targeted way of tackling global warming through the adaptation of established fiscal systems: the administrative and compliance costs are low compared with those of many other taxes; tax revenues will tend to grow with incomes; and expected responses to higher prices are such that revenues will continue to rise even while there is substantial erosion of the tax base as emissions decline. However, carbon taxes are disliked, particularly by energy-intensive industries.

In contrast, the externality can be managed by creating a "cap-and-trade" market in legally enforceable rights to emit GHG, such as the EU ETS, and then restricting those rights and auctioning all or part of them. These allowances can be given to the emitters as an incentive to participate, as occurred for Phases One and Two of the EU ETS, a crucial advantage over taxes in terms of reducing industry opposition. However, there are several objections to such schemes: they acknowledge rights that may not have existed previously; no compensation is normally provided for those who will suffer damage from future pollution; the schemes are open to abuse by collusion; transaction costs can be high, especially for small-scale and non-business sectors; and perhaps most important of all, an efficient market will lead to nearly all the extra costs of the allowances being passed on to the final consumer, with substantial extra profits going to the sectors that receive the free allowances[22]. The auctioning of the allowances, rather than free allocation, provides revenues for offsetting inflation, encouraging change and compensating vulnerable groups. So far the schemes have been confined to large, fixed, business uses of carbon, predominantly power generation.

A carbon price of $\$100/tCO_2e$ by 2020 for OECD countries appears to be an appropriate signal for the long-term 450 ppm CO_2e stabilisation target

What level of long-term carbon prices is needed to decarbonise the global economy? This question cannot be answered with any certainty because the underlying literature is insufficient in quantity and quality. In any case we should refer to a range of prices to achieve a quantitative target, which itself is chosen by taking into account the risks and uncertainties of not achieving the target. And, crucially, we should keep in mind that business as usual is the most dangerous and risky of the options available in the literature.

The global carbon prices required to reach the 450 ppm CO_2e target are not in the literature, but we can extrapolate from what is available – at least at ranges that may achieve the target. One study estimates a range of $\$24 – 173/tCO_2e$ year 2000 prices by 2030, depending on the treatment of technological change in the models, with the lower value assuming a technological speculative break-though in the form of a low-cost, low-carbon source of energy in unlimited supply (a "back-stop" technology)[23]. As a rule of thumb, given all the uncertainties and a precautionary approach, a carbon price rising from EU ETS level of about $\$30/tCO_2e$ in May 2008 to $\$100/tCO_2e$ by 2020 for OECD countries seems to be an appropriate starting point, with an expectation that the price would continue to rise and extend to the global economy by 2030 and after. A carbon price of this magnitude could emerge from emission trading schemes for the energy sector with a stringent GHG reduction target by 2020 of at least 30 percent below 1990 levels by 2020. Such a carbon price applies mainly to CO_2 emissions from electricity generation (it converts approximately to an extra $45/barrel on the price of crude oil). The carbon price would be paid on CO_2 emissions from burning coal and gas (the electricity sector does not use much oil for generation), essentially leading to a gradual rise in electricity prices. In the US, for example, electricity prices would rise by 70 percent in all, spread over 10 years, assuming that fossil-fuel use stayed at 2005 levels. If the sector decarbonised, the increase in prices would be much less.

It should be noted that there is a crucial difference between the carbon price increase contemplated here and the experience with increased oil prices in 2007-2008. The increase in carbon prices would be spread over several years and the revenues from auctioning the emission allowances would accrue to the countries regulating the emissions, not to the oil producers, and so they can be used to compensate those who lose employment and to provide incentives for low-carbon alternative sources of energy. If the energy sector responds rapidly and switches to renewables, nuclear and other low-carbon sources, then the CO_2 allowance costs will fall rapidly and the electricity price rise would be correspondingly lower.

Effects on employment and wages

Employment opportunities are substantially increased by widespread adoption of energy efficiency measures for retrofitting buildings, and adaptation-mitigation schemes that support energy crops on degraded land

Net employment can be increased by linking climate policies to other policies that improve economic performance, in particular policies that shift supply from centralised fossil-fuel-intensive sources (e.g. large-scale coal-fired power stations) to dispersed small-scale sources (e.g. small-scale renewable in local communities). The main job losses are in areas of labour-intensive coal mining, which is often inefficient and dangerous, but nevertheless is a crucial source of income for some groups. Well-targeted and voluntary redundancy schemes and alternative employment opportunities in environmental restoration and low-GHG renewables, including agricultural and forestry projects, can offset the losses in coal.

The tentative pilot experiments in environmental tax reform in Europe suggest the potential scale of the employment benefits, although in relatively affluent societies. In the case of Germany, the analysis suggested that a 2 – 2.5 percent reduction in CO_2 emissions below the reference case for a limited environmental tax reform increased employment in 1999-2003 by 0.1 to 0.6 percent, or as much as 250,000 additional jobs[24]. In a study of prospective climate policies for California, small increases are reported in employment for a package of measures focused on tightening regulations affecting emissions[25].

No employment effects are reported at a global level. It is clear that these will depend on the precise portfolio of policies and that they are likely to be small overall but with losses concentrated in the coal sector and the gains spread across many sectors, but most visibly in new low-GHG options: retro-fitting buildings, renewable energy and agricultural and forestry projects.

Other macroeconomic aspects of the transition

The scale and character of the benefits and costs of mitigation depend critically on the policy regime adopted. The high carbon prices required for a strong market response can raise substantial revenues, which can be used to offset the inflationary effects of higher carbon prices, remove and reduce barriers to action, support innovation, and help vulnerable social groups to adjust to the increased costs. The budgetary benefit of revenues from auctions is boosted by more buoyant public revenues from general taxation and lower public spending, as revenue recycling contributes to faster economic expansion. This is especially true if investment and employment are increased at a faster rate than would otherwise be the case.

These investments represent long-term benefits to the engineering and construction sectors that produce the new equipment and infrastructure, but short-term costs to those who pay for them

The critical feature of a successful transition to a low-carbon economy is the unleashing of a wave of pent-up investment in the infrastructure, buildings and equipment required to replace the outdated and obsolete alternatives based on fossil-fuel technologies. A secure and high carbon price will essentially deter the electricity sector from using more coal instead of gas and "lock in" part of the change in behaviour in the transport sector being forced by the extreme increases in oil prices evident since 1999, especially 2007-2008.

The short-term costs for many investments are recovered in the longer term though reduced fuel costs and improved performance

As the International Energy Agency estimates[26], the funding requirements of a low-carbon economy are surprisingly modest in the longer term because the transition means that much less investment in required for new coal and unconventional oil and, importantly, the associated infrastructure. In the shorter term the wave of new investment in renewables will be supported and broadened by a carbon price, especially if this is combined with regulation on standards and direct incentives to promote innovation and low-carbon technologies.

Although consumers will pay more as carbon prices rise, supporting policies will reduce overall demand for energy and shift the mix towards low-carbon electricity, solar heat and fuels. The intention is that as the economy eventually decarbonises, the carbon costs will be eliminated, and the capital stock will be more efficient in delivering energy services.

Effects on international trade and competitiveness

The main argument raised by business against the implementation of unilateral climate policies by one country is that it would lead to loss of international competitiveness and, worse, that it would be ineffective because the relocation of high emitting industries to countries without emissions constraints would increase overall emissions (carbon leakage). Detailed studies, however, conclude that these concerns are exaggerated[27]. Although carbon pricing tends to reduce the price competitiveness of carbon-intensive sectors, this may be offset by exchange rate adjustments or improvements in non-price competitiveness, while the extent of competitiveness impacts will vary with the international exposure of the sector in question (higher-value sectors will tend to have higher international exposure than lower-value industries). However, there is a risk that actual policies in many countries, despite international agreements, will include special exemptions for polluting sectors after lobbying by vested interests, which weaken the effectiveness or efficiency of actions. Rather than provide exemptions for sectors threatened by mitigation policies, a better approach is to provide explicit time-limited subsidies to support adjustment to low-carbon outcomes.

Recommendations on the road to a Copenhagen agreement

Policy coordination works through agreement to establish global carbon prices, share new low-carbon technologies, apply standards of carbon efficiency, and open up markets to encourage economies of scale and specialisation

There are various strands in a policy portfolio to move to a low-carbon world economy that will benefit the both the economy and the environment.

The keystone of any portfolio is a carbon price that is internationally recognised, in a convincing institutional framework, and that will provide benefits to all parties. A proposal to develop a global cap-and-trade scheme (GETS) for GHG emissions from international transport could provide this signal and incentive, with the target of zero net emissions (as proposed by the aviation industry) by 2050[28].

International transport is one of the most intractable sectors as a result of its international character and the apparent difficulties and ineffectiveness of international bodies in managing its emissions under international law. It can effectively be managed only by international policy. Although the sector's CO_2 emissions are a small share of the global total (around 7 percent) they have been growing rapidly and threaten to undermine the effects of future national controls. Moreover, those who will pay for aviation are generally among the most affluent of the global society, while those who pay for shipping are spread very widely across consumers of traded products.

The GETS proposal includes the auctioning of allowances, with revenues used for clean and safe development in one form or another. This recognises that it is in everyone's interest that climate change does not threaten globalisation and that the richer, industrialised nations are responsible for most of the accumulated fossil carbon in the atmosphere that is the cause of the problem. A high and rising carbon price determined by market forces will give the signal and incentive for strong technological change over the long term for aviation and shipping; limit the growth in emissions and eventually reduce emissions to a sustainable level; and provide a source of revenue for investment in low-carbon technologies in developing countries.

The framework to set the carbon price can be designed to achieve the international mandatory targets for global GHG emissions as a development of the Bali Action Plan, complemented by a "Marshall Plan" funded by industrialised countries for developing countries' low-GHG policies and measures, including the Bali REDD and programme CDMs (national cap-and-trade for GHG emissions, carbon taxes, feed-in tariffs, CCS with coal). A World Carbon Authority would be needed to manage a cap-and-trade for international transport in order to create a global carbon price that can achieve the target.

Other complementary policies that will reduce costs and accelerate change include: agreement of technological standards; use of revenues to reduce barriers and provide incentives for innovation; and regulation.

* * *

Political economy has been portrayed by Thomas Carlyle as the dismal science, but on the contrary, a new understanding of the economy suggests that that a transition to a low-carbon, even zero-carbon, economy is feasible; and that if we choose a good mix of policies, such action will benefit economic performance and improve human well-being. Just as Thomas Malthus was wrong (so far!) in his predictions of population growth leading to economic collapse, so rapid decarbonisation need not ruin our economies, and for much the same reason: technological change. GHG-reducing technologies with carbon trading and carbon taxes can accelerate decarbonisation, reduce the risks of dangerous climate change, and contribute to economic development and human well being. The economic feasibility and benefit of a net-zero carbon economy have not been investigated, at least by 2050 or earlier as implied for a long-term "safe" climate. The technologies required for most sectors are available and extrapolation of available studies suggests that the economy could benefit, but the main technical and institutional options have not all been explored and the scale of the transition, especially for the energy sector, is immense. The immediate challenge however is one of devising, then agreeing, international policies and actions that can guarantee results and benefits for the more modest 50 percent target, recognising that this is not strong enough for a safe climate but much better than no target at all.

Annex

Modelling Studies with GDP above Baseline

(Considered in the IPCC's Fourth Assessment Report)

The IPCC Fourth Assessment Report (AR4), published in 2007, Summary for Policy-Makers (SPM) for Working Group 3 on Mitigation states: "Some models give positive GDP gains (or negative GDP losses), because they assume that baselines are economically not optimal and that climate change mitigation policies steer economies towards reducing imperfections."[29]

This statement is based on a substantial number of studies. According to the database prepared for the 2007 report, there are at least 14 models considered in Chapter 11 of the Report that have shown GDP above base for GHG mitigation at the global and national levels over different periods and under some combination of assumptions. Exhibit 4 gives details and references. Many of the studies are for more near-term mitigation to 2010 or 2020, but several of the studies show long-term GDP above base for deep (60 percent or more) mitigation by 2100, including results from the models AMIGA, E3MG, FEEM-RICE-FAST, ENTICE-BR (high elasticities), and MARIA.

Exhibit 4

Modelling Studies reporting GDP above baseline

Study	Model	Area	Years	Reference
EMF21:	AMIGA	world	2010-2100	(Weyant et al., 2006)
IMCP:	AIM-DYNAMIC	world	2005-2030	(Edenhofer et al., 2006)
	E3MG	world	2015-2100	
	ENTICE-BR	world	2005	
	ENTICE-BR (high elasticities)	world	2005-2100	
	FEEM-RICE-FAST	world	2005-2100	
Post SRES	MARIA	world	2090-2100	(Morita et al., 2000)
WRI/EMF12	G-CUBED	USA	1990-2010	(Gaskins and Weyant , 1993) and (Repetto and Austin, 1997)
	FOSSIL2	USA	1990-2020	
	LINK	USA	1990-2010	
	DGEM	USA	1990-2050	
	BKV optimal	USA	1990-2020	
IPCC TAR	various	EU	various	(TAR, WG3, Figure 8.5, p. 516)
AR4, WGIII, Ch 11	similar to DGEM	China		(Garbaccio et al, 1999)

Note
The table shows models and studies that have reported mitigation scenarios with GDP above baseline for GHG reductions below baseline. These are outcomes from a variety of assumptions associated with recycling of revenues, induced technological change and high substitution elasticities. Some of the differences are negligible or very small.

In addition, it is important to note that many models assume that the global economy is operating at full efficiency, with full utilization of resources (e.g. no unemployment), with a social planner having full information and perfect foresight. In such models, any policies that reduce GHG emissions will also reduce welfare and GDP by assumption. There is no basis from empirical studies for such a result.

Endnotes

[1] The primary economic benefits are the avoided damages of climate change, but these are by convention set aside in assessing the macroeconomic impacts of mitigation. See: Barker, T., Bashmakov, I., Alharthi, A., Amann, M., Cifuentes, L., Drexhage, J., Duan, M., Edenhofer, O., Flannery, B., Grubb, M., Hoogwijk, M., Ibitoye, F. I., Jepma, C. J., Pizer, W.A., Yamaji, K., 'Mitigation from a cross-sectoral perspective', Chapter 11 in Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., Meyer, L.A. (eds), 2007, Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

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[4] Barker, T., Ekins, P., 2004, 'The costs of Kyoto for the US economy', The Energy Journal, Vol. 25 No. 3, 2004, pp.53-71.

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[6] Note that the World Resources Institute (WRI) study covers US mitigation only. The higher variance in the IMCP results comes from the increasing returns and other non-linear properties of models of induced technological change, as discussed below. The higher variance in the WRI study comes from the wider range of modelling approaches and assumptions covered.

[7] The carbon tax is correcting a market failure (use of the atmosphere as free waste disposal) but the welfare effects of avoiding dangerous climate change extend way into the future, and should not be expressed simply in money terms because of the risks to human life and health (Barker, 2008a). By convention, the benefits of correcting this market failure are set aside in the mitigation studies because of the uncertainties and the problem of monetising intrinsic values, a convention that is followed here.

[8] For a review of the costs for the US economy, see Barker and Ekins, 2004.

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[12] Barker, T., Foxon, T. and Scricieu. S., 2008, 'Achieving the G8 50% target: modelling induced and accelerated technological change using the macro-econometric model E3MG' Climate Policy Special Issue on the Low Carbon Society, 2008

[13] The IPCC (AR4, WG3, p. 818) defines these as those "whose benefits (such as reduced energy costs and reduced emissions of local/regional pollution) equal or exceed their costs to society, excluding the benefits of avoided climate change."

[14] Edenhofer, O., Lessman, K., Kemfert, C., Grubb, M. and Köhler, J., 2006, Induced technological change: Exploring its implications for the economics of atmospheric stabilisation. Synthesis Report from the Innovation Modeling Comparison Project. Energy Journal (Special Issue: Endogenous Technological Change and the Economics of Atmospheric Stabilisation), pp. 1-51.

[15] Edenhofer et al. (2006 - pp.101-104) conclude that small results for effects of ITC depend on: baseline assumptions about the role of technology that generate relatively low emission scenarios; the assumption of efficient use of resources so that there are fewer opportunities for policy to improve performance; the assumption of perfect foresight in modelling the investment decision; and the assumption of an exogenous backstop technology, which does not respond to a carbon price.

[16] One major research challenge is to test the influence of these aspects of ITC on current technologies by econometric and back casting methods, fitting the models to historical data

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[27] *Barker, T., Junankar, S., Pollitt, P. and Summerton, P., 2007, 'Carbon leakage from unilateral environmental tax reforms in Europe, 1995-2005', Energy Policy 35, 6281–6292, Convery, F., Ellerman, D. and de Perthuis, C., 2008, The European carbon market in action: lessons from the first trading period. Interim report. http://web.mit.edu/globalchange/www/ECM_InterimRpt_March08.pdf*

[28] *see details in Barker, T., 2008. Proposal for a Global Emissions Trading Scheme (GETS) for international bunkers (aviation and shipping). Tyndall Briefing Note 26.*

[29] *IPCC, 2007, "Summary for Policymakers", In Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., Meyer, L.A. (eds), 2007, Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, p.11, Line 30-32.*

Acknowledgements

Thanks to Michael Hanemann, University of California, Berkley, and Richard Lewney, Cambridge Econometrics, for reviewing the paper and Svetlana Tashchilova for including the EMF21 data in the scatter plot of CO_2 and GDP changes.

The views, opinions and recommendations in this paper are those of the author and do not, and are not intended to represent those of any organisation to which he belongs. They do not represent the views or position of Tony Blair, the Breaking the Climate Deadlock project or The Climate Group.

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The Centre's objectives are 'to foresee strategies, policies and processes to mitigate human-induced climate change which are effective, efficient and equitable, including understanding and modelling transitions to low-carbon energy-environment-economy systems.' The Centre aims to be at the forefront of research in the area of climate-change mitigation through technological change induced by use of economic instruments, such as the EU's emission trading scheme, applying a multi-disciplinary approach and informing national and international policy-making. The research is organised around energy-environment-economy (E3) econometric and simulation modelling at UK, European and global levels.

http://www.landecon.cam.ac.uk/research/eeprg/4cmr/index.htm