Cambridge Centre for Climate Change Mitigation Research
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Proposed research project in response to an invitation from
the Three Guineas Trust

Modelling policies for accelerated decarbonisation of the global economy

Key messages from the latest climate science
One of the conclusions of the IPCC 2007 Report is that "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." (IPCC, 2007a, p.5). The Report warns of the increasing and long-term risks of serious climate-related damages to water resources, ecosystems, food, coasts and human health (IPCC, 2007b, pp. 13-15). These risks are sufficient to alarm climate scientists (e.g. Hansen, 2007) and to suggest that avoiding dangerous climate change will require that greenhouse gas emissions must be almost eliminated from human activity and technologies encouraged and developed to go further and actually remove some of the extra CO_2 from the atmosphere.

The research question
The implication is that the world's energy-economy system requires accelerated decarbonisation, through wholesale switching to low-carbon technologies and lifestyles. The crucial question is how fast can this be done, while maintaining and even accelerating economic development, and ensuring that the most vulnerable countries, and groups in society, are protected?

The macroeconomic costs of mitigation from the Stern Review and IPCC
In contrast with the stark warnings on the environmental risks and economic costs of business-as-usual from the Stern Review (2007), both the Review and the IPCC show that the *maximum* costs of mitigation are negligible for the most stringent stabilization range considered. For the range 445 to 535ppm (for greenhouse gas concentrations in carbon dioxide equivalent) the reduction in global GDP growth is 0.12 per cent a year to 2050, without including the environmental co-benefits of mitigation, such as reductions in urban air pollution. Nearly all the studies showed much more modest reductions in GDP. The IPCC Report makes it clear that, if well-designed, mitigation policies could *even lead to higher GDP growth and development* compared with the outcome of business-as-usual policies (IPCC, 2007c p.16). The Stern Review (2007, p. 271) quotes a range of GDP changes, from costs of 3.4% to benefits of 3.9%, compared with business-as-usual, depending on modelling approaches, policies and assumptions.

Why Governments have failed to act
Unfortunately, very few governments have acted since the dangers became clear in the 1990s, partly as a result of the fossil fuel lobby's fierce campaign against the USA's joining the Kyoto Protocol. For related reasons, the research into the economic costs and benefits of rapid abatement is sparse and not reliable enough for policy advice. In other words, governments do

not have a sound basis for taking decisions to introduce the policies for accelerated abatement necessary to achieve their stabilisation targets, making the most of the potential associated benefits, and without the risk of damages to the economy. An additional excuse for the failure to take strong action has come from equilibrium economists who have promoted inaction, arguing (1) that the value of the lives of our descendants should be discounted, massively reducing the estimated benefits of action and (2) that the overall costs of action rise sharply for the most stringent targets. The latter argument is based on inadequate theory (see the critiques by DeCanio, 2003, and Barker, 2008), and virtually no evidence, e.g. countries have for example typically mobilized for war and other kinds of emergencies without any loss of GDP. In fact, the equilibrium models that have been used to report costs of stabilisation are nearly all incapable to assessing the costs and benefits of accelerated transitions to deep mitigation. One critical limitation of such economic components of large-scale integrated assessment models (most of those reviewed in the IPCC 2007 Report) is that they are based on one year's data, which means that there is no observational basis within the models for representing dynamic behaviour. All the dynamics have to be assumed.

The proposed research

This proposal is to develop E3MG, an Energy-Environment-Economy (E3) Model at the Global level, so that it can fulfil its design specifications. Data on energy and the economy are available on a reasonably consistent basis for the years 1972-2005 from international sources. The idea is to simulate the year-by-year stochastic dynamics of greenhouse gas emissions, including effects of changes in oil prices and in existing policies, such as those affecting fossil-fuel taxes, over the period 1972-2005, so that the effects of new policies can be simulated for the period 2010-2100.

This model has been developed by the team in Cambridge (Barker *et al*., 2006) to respond to the gaps in knowledge evident in the IPCC's Third Assessment Report, 2001, in which Barker was one of the Coordinating Lead Authors and a member of the Core Writing Team of the Synthesis Report. The results of the modelling work were reported by the IPCC in 2007. E3MG already goes one step further than nearly all other global economic models in that some 30 years of data are used to estimate the dynamics and economic behaviour, but it is incomplete and it does not include strong interactions from and between global macro variables such as total GDP growth, exchange rates, interest rates and oil prices, all of which are treated initially as given by assumption. It is therefore unsuited, without further development, to assess the immediate problem of accelerated decarbonisation. We have worked with the model GVAR (Dees et al., 2007), which does explicitly cover the global financial system and its interactions with real GDP, but GVAR does not include any industrial structure, nor any policy instruments for GHG mitigation.

The difficulties in the modelling

The E3MG model, and the Tyndall Centre's Community Integrated Assessment System, CIAS, in which it is embedded, has not so far been estimated or solved as a dynamic system over the historical database 1970-2005. The emphasis instead has been in showing that such a model *could* be built and *could* yield coherent and defensible results, acceptable to peer-reviewed publications. There are good reasons for such difficulties.

1) It is a challenging intellectual task, basically because the global economy is a complex system in which there are major inter-dependencies between countries and variables, as well as over time. The most advanced macro-economic model to tackle the problem, GVAR, treats all the economic variables, including oil prices as endogenous in the system, so that the solution is driven by the starting point and the internal dynamics of

the model, but with a very limited role for policy instruments, and with no coverage of carbon taxes, emission trading schemes, R&D or even government expenditure.

2) The dynamics become more relevant and interesting for climate policy when technological diffusion is treated as responding to climate policies in the models, and this has been a relatively recent development in integrated modelling. Previously, as reported in the IPCC 2001 Report, technological change was treated as exogenous in the results reported, and any diffusion was assumed to be incorporated in the baseline.
3) The potential for international climate policy to yield substantial benefits in terms of higher global GDP via the adoption of specific portfolios of instruments (international emission trading with auctioning and use of revenues for technological incentives and/or environmental tax reform) has only recently been modelled in stabilisation scenarios (Barker *et al*., 2006). Moreover it has taken until the IPCC in 2007 (Summary for Policy Makers, Box SPM4, p. 28) to recognize that the benefits from induced technological change may be even larger at more stringent levels of mitigation.

The opportunity for funding

For these same reasons, as well as the manifest inadequacies of the economic models being used for climate policy, there is now the opportunity for a major breakthrough in the economic modelling of climate policies. The proposal is to develop our integrated global model, by fitting key parameters to the spatial and temporal data for the years 1972-2005. If we are successful, this will represent a breakthrough in the understanding of how economic behaviour leads to greenhouse gas emissions and how these can be stopped or stored with general benefit to well-being and sustainable development. Such a project could transform the policy debate by producing a convincing analysis of the costs and benefits of accelerated and immediate action by governments, especially those that have already instituted and studied new policies, such as emission trading and environmental tax reform. It will challenge governments to act over the next few years, for which the economic outlook is dismal, and the investment resources required for transforming the world's energy system are likely to become available at lower cost and with greater benefit than at other times.

What we are promising to deliver

This system will provide a detailed pathway for global policy action to 2030 (with later effects to 2100) by the 13 largest national emitters of greenhouse gases: Annex 1 countries (USA, Japan, Germany, UK, France, Italy, Canada, Australia, and Russia) and non-Annex 1 countries (China, India, Mexico, and Brazil). Policies will include: emission trading, environmental fiscal reform, transfer of funds to developing countries via the Clean Development mechanism expanded to cover unilateral programmes, regulation for energy efficiencies and the use of clean technologies, incentives for reducing barriers to no-regrets options and technological agreements. The policy actions and effects will be distinguished by the main sectors of power generation, 'other industry', transport, and dwellings and commercial buildings, as distinguished in the IPCC 2007 Report. The stochastic simulation will provide the range of uncertainties in the analysis. The aim will be to show the costs and robustness of the policies in the context of uncertainties about economic development and oil prices. From our earlier research it seems likely that we shall be able to show that decarbonising the global economy is possible at the same time as improving the well-being of the most vulnerable countries and groups.

The scale of funding

The Cambridge mitigation centre, 4CMR, was founded in 2006, and was immediately and spectacularly successful in raising research funds. It soon reached full capacity in its present offices of 9 staff including associated PhD students. The current funding stream comes from the UK Research Councils, via the Tyndall Centre and the UK Energy Research Centre, and the European Commission, via the ADAM project. However, this funding has been, and is, completely inadequate for the tasks involved in the global modelling, which have also required considerable contributions, mostly benefits in kind, from Cambridge Econometrics, a consultancy that originated in the University of Cambridge and is now owned by an educational trust.

We are requesting funding for the stochastic modelling project sufficient to support 4 full-time posts, plus funding for Cambridge Econometrics to update and maintain the current model and Dr Barker's input as director of the research.
The posts would be:

1) expert energy data analyst to process the data on energy and energy prices
2) applied econometrician to work on the data, estimation, and economic simulation
3) computer/software expert to manage the model solution and graphics
4) climate scientist/modeller to manage the interface between the economic model and the integrated assessment system.

The costs of this expansion of 4CMR's activities would be of the order of £85K per average full-time post, i.e. £510K, plus a subcontract with Cambridge Econometrics to provide the updated estimation and solution of the model for forecasting and analysis or perhaps £125K a year (to be negotiated), and plus the cost of buying-out Dr Barker, as Director, from his current commitments over the project.

Terry Barker, February 25, 2008

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