Tyndall°Centre for Climate Change Research

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Adaptation and Mitigation Strategies:
Supporting European Climate Policy

Energy-environment-economy (E3) modelling of climate policies after AR4:
methodological problems in the equilibrium approach

Terry Barker
4CMR, Land Economy, University of Cambridge

"How can climate policy models shape real decisions? Policy costs and policy signals"
IDDRI and CIRED, Paris, March 25, 2009

Outline

1. Economic Theory: traditional vs “new economic”
2. Characterising the economic models used for climate policy
   - The EMF19 and IMCP (induced technological change) models
   - EMF and EMF21 (multigas) model comparison exercises
3. Advances in Understanding
   1. Induced technological change
   2. Multigas abatement
   3. Recycling of carbon tax/permit revenues
   4. Assessment of co-benefits
   5. The Stern Review and more emphasis on risk

Climate change policy and economics: traditional models rely on unrealistic and stylised assumptions that impose effects that may be misleading (e.g. net costs instead of benefits)

Critical differences	Traditional economics	New economics
ethics and society	Utilitarian: optimising rational self-interested individuals	Observed: satisficing altruistic punishers in evolving social groups
time and equilibrium	Full employment forever: higher GDP growth ruled out by assumption; no double dividend for policy	Path-dependency: many unused resources and new business plans in response to threats
uncertainty	Normal: distributions derived from the past; use of "certainty equivalence"	Non-linear: catastrophic surprises are inherent in complex systems
technology	Exogenous: CGE and growth models have no feedbacks via technology	Induced: by climate policies

EMF-19: Effects of stabilisation on GDP, energy and CO_2: the shift to more or less energy intensity is likely to be an incidental effects of ad hoc choice of production functions and parameters, not one based on evidence

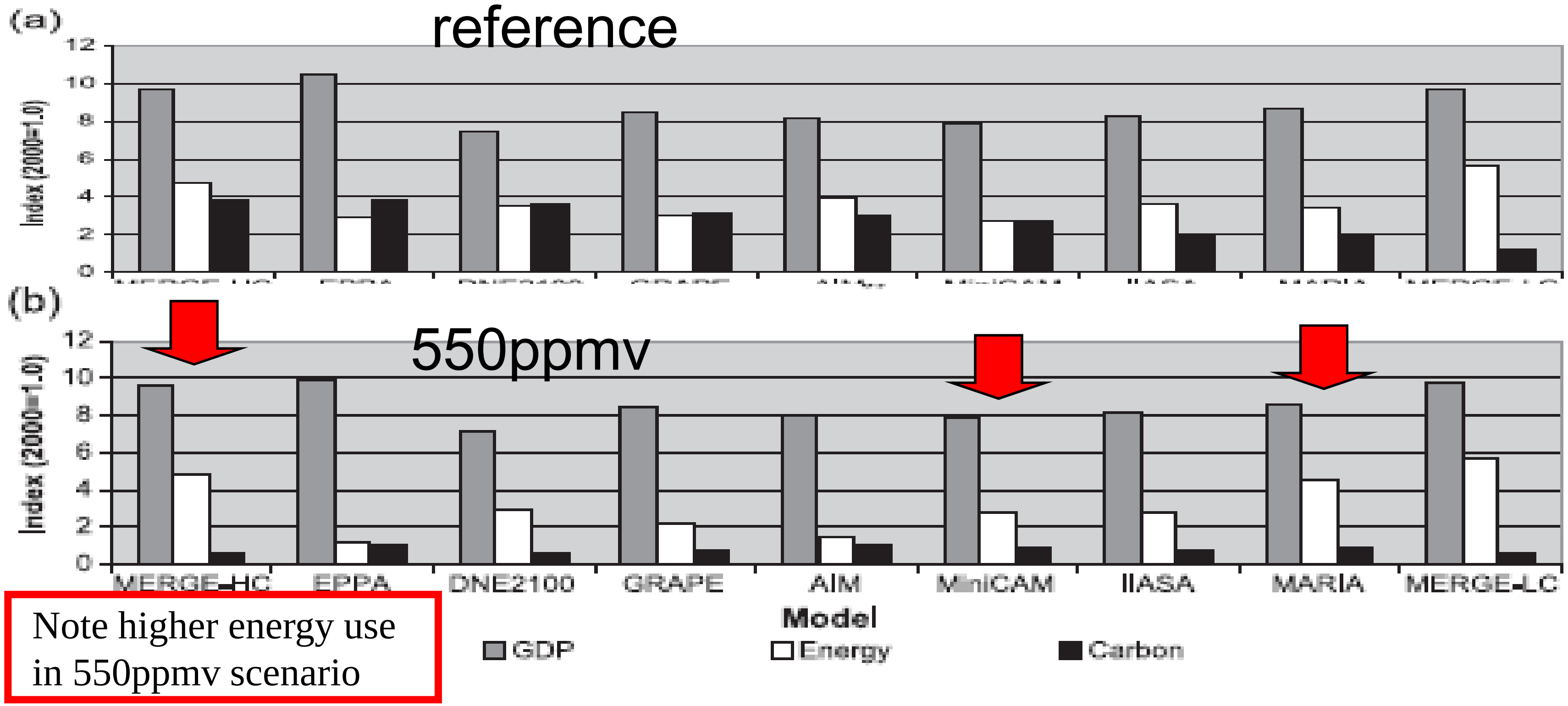


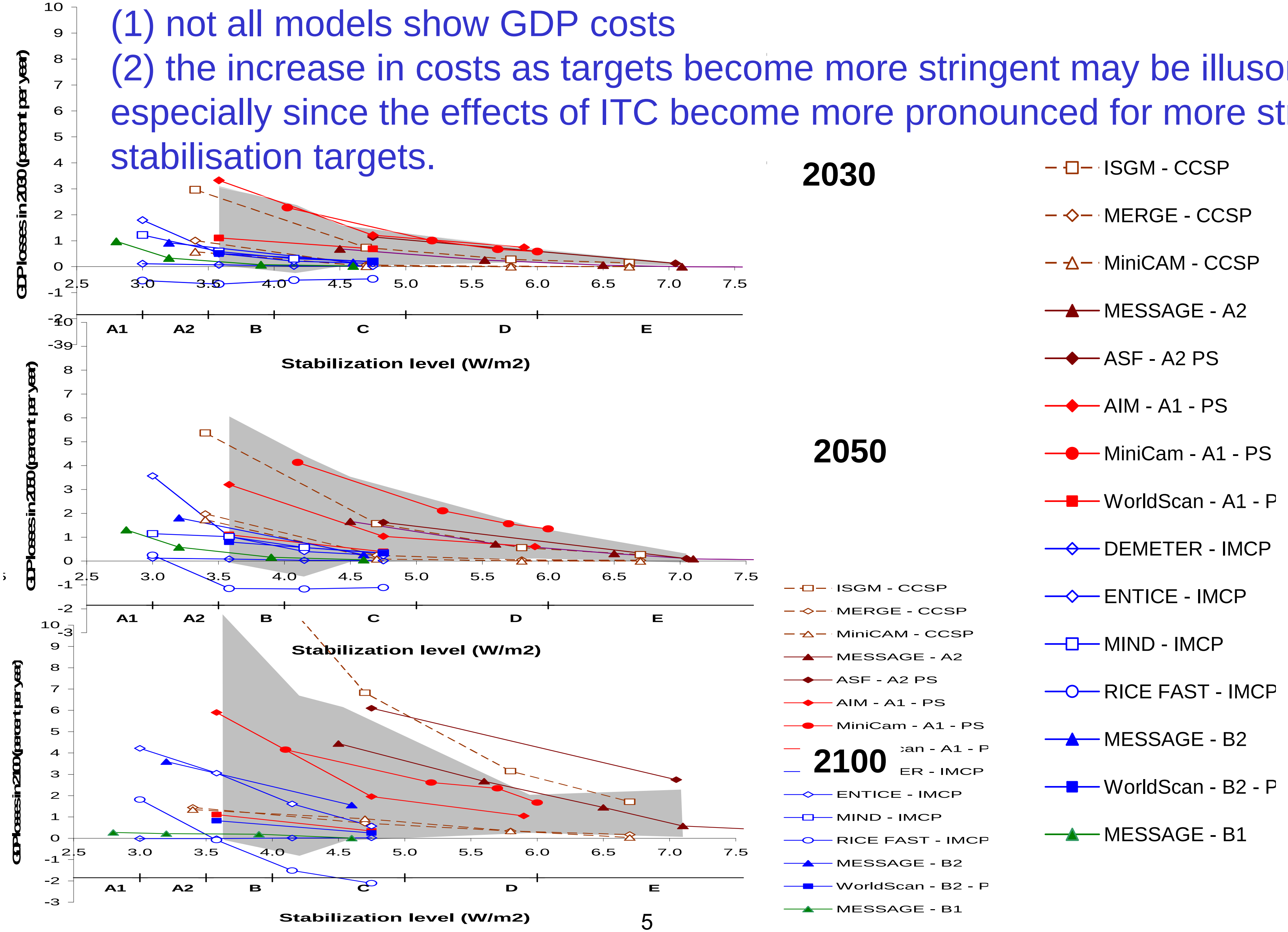
Fig. 2. (a) World carbon emissions drivers for the reference scenario between 2000 and 2100. (b) World carbon emissions drivers for the 550 ppmv scenario between 2000 and 2100.

Source: Weyant, J.P. (2004) “Introduction and summary” EMF-19 Special Issue of *Energy Economics*, pp. 501-515.

IPCC AR4 WG3 chapter 3 GDP losses:

(1) not all models show GDP costs

(2) the increase in costs as targets become more stringent may be illusory, especially since the effects of ITC become more pronounced for more strin[g] stabilisation targets.



E3 Models in the EMF21 study

AIM Asian-Pacific Integrated Model	J. Fujino, R. Nair, M. Kainuma, T. Masui (National Institute for Environment Studies, Japan) and Y. Matsuoka (Kyoto Univ., Japan)
AIM/EU-India AIM - End-Use Component Applied to India	P.R. Shukla (Indian Institute of Management), A. Garg (UNEP/RISO), M. Kapshe (Maulana Azad Inst.of Tech.), and R. Nair (NIES, Japan)
AMIGA All Modular Industry Growth Assessment	D. Hansen (Argonne National Laboratory, U.S.), J. Laitner (U.S. EPA)
COMBAT COMprehensive aBATement	H.A. Aaheim, J.S. Fuglestvedt, and O. Godal (CICERO, Norway)
EDGE European Dynamic Equilibrium Model	J. Jensen (TECA TRAINING ApS)
EPPA Emissions Projection and Policy Analysis Model	J. Reilly, M. Sarofim, S. Paltsev, and R. Prinn (Massachusetts Institute of Technology, U.S.)
FUND Climate Framework for Uncertainty, Negotiation, and Distribution	Richard Tol (Economic and Social Research Institute, Ireland and Hamburg, Vrije & Carnegie Mellon Universities)
GEMINI-E3/GEMWTrap General Equilibrium Model of International Interaction for Economy-Energy- Environment	A. Bernard (Min. of Equipment, Transport, and Housing, France), M. Vielle (CEA-LERNA, France), and L. Viguier (HEC Geneva and Swiss Federal Institute of Technology)
GRAPE Global Relationship Assessment to Protect the Environment	A. Kurosawa (Institute of Applied Energy, Japan)
GTEM Global Trade and Environment Model	G. Jakeman and B. Fisher (Australian Bureau of Agricultural and Resource Economics)
IMAGE Integrated Model to Assess The Global Environment	D.P. van Vuuren, B. Eickhout, P.L. Lucas and M.G.J. den Elzen (National Institute for Public Health and the Environment, The Netherlands)
IPAC Integrated Projection Assessments for China	K. Jiang, X. Hu, & S. Zhu (Energy Research Institute, China)
MERGE Model for Evaluating Regional and Global Effects of GHG Reductions Policies	A. Manne (Stanford University, U.S.) and R. Richels (Electric Power Research Institute, U.S.)
MESSAGE Model for Energy Supply Strategy Alternatives and Their General Environmental Impact	S. Rao and K. Riahi (International Institute for Applied Systems Analysis, Austria)
MiniCAM Mini-Climate Assessment Model	S. Smith (PNNL/Univ. Maryland, U.S.) and T.M.L. Wigley (National Center for Atmospheric Research, U.S.)
PACE Policy Analysis With Computable Equilibrium	C. Böhringer, (University of Heidelberg), A. Löschel (Centre for European Economic Research – ZEW, and T. Rutherford (University of Colorado)
POLES-GECS Prospective Outlook on Long-Term Energy Systems-Global Emissions Control Strategies	P. Criqui (Institute of Energy Policy and Economics, France), Peter Russ (EC- Institute for Prospective Technological Studies, Spain), and Daniel Deybe (EC Environment DG)
SGM Second Generation Model	A. Fawcett (U.S. EPA) and R. Sands (PNNL/Univ. Maryland, U.S.)
WIAGEM World Integrated Applied General Equilibrium Model	C. Kemfert (German Inst. of Economic Research & Humboldt University), T. P. Truong (Univ. of New South Wales, Australia) and T. Bruckner (Institute for Energy Engineering, Tech Univ, Germany)

Source: Weyant, J.P., F. C. de la Chesnaye and G. J. Blanford. 2006: Overview of EMF-21: Multigas Mitigation and Climate Policy. *The Energy Journal*, **27** (Multi-Greenhouse Gas Mitigation and Climate Policy, Special Issue #3), pp. 1-32.

Characteristics of the EMF21 models: most models are equilibrium-based (codes blue and green). Problems: (1) assumes knowledge we do not have (2)ill equipped to model global depression effects on climate policy

Model	Model type (a)	Representation of NCGG emission reduction options (b)	NCGG contribution method (c)	Solution concept (d)	Time horizon (e)	Group in this paper (f)	**Colour code**
AMIGA	MSGE	RFPF	GWPs	RD	2100	1	
GTEM	MSGE	RFPF	GWPs	RD	2030	1	
GEMINI-E3	MSGE	RFPF	GWPs	RD	2050	1	
EU-PACE	MSGE	RFPF	GWPs	RD		1	
EDGE	MSGE	RFPF	GWPs	RD	2030	1	
EPPA	MSGE	RFPF	GWPs	RD	2100	1	
IPAC	MSGE	RFPF	GWPs	RD	2100	1	
SGM	MSGE	RFPF	GWPs	RD	2050	1	
WIAGEM	MSGE	RFPF	GWPs	RD	2100	1	
Combat	AGE	RFM	RF	INTOP	2100	2	
FUND	AGE	RFM	RF	INTOP	2100	2	
MERGE	AGE	RFM	RF	INTOP	2100	2	
GRAPE	AGE	SM	RF	INTOP	2100	2	
IMAGE	ISM[a]	SM	GWPs	RD	2100	3	
MESSAGE	ISM	SM-2	GWPs	RD	2100	3	
AIM	ISM	SM-2	GWPs	RD	2100	3	
MiniCAM	ISM	SM-2	GWPs	RD	2100	3	
POLES/AgriPol	ISM	SM	GWPs	RD	2030	3	

NCGG—non-CO_2 GHG gases.
(a) MSGE—Multi-Sector General Equilibrium; AGE—Aggregate Gen Equilibrium; ISM—Integrated Structural Model.
(b) RFPF—Reduced Form Adjustment to Production Functions; RFM—Red Form MACs; SM—Structural Models; SM-2 indicates models that have included individual reduction measures.
(c) RF—Radiative Forcing; GWPs—Global Warming Potentials.
(d) RD—Recursive Dynamic; INTOP—Inter-temporal Optimization.
(e) Groups only refer to the colour coding used in the figures.
[a] The term Integrated Structural Model (ISM) is used here to indicate the group of models that include relatively detailed structural models of the sectors that emit non-CO_2 greenhouse gases. Most of the models in this group can also be classified as Integrated Assessment Models.

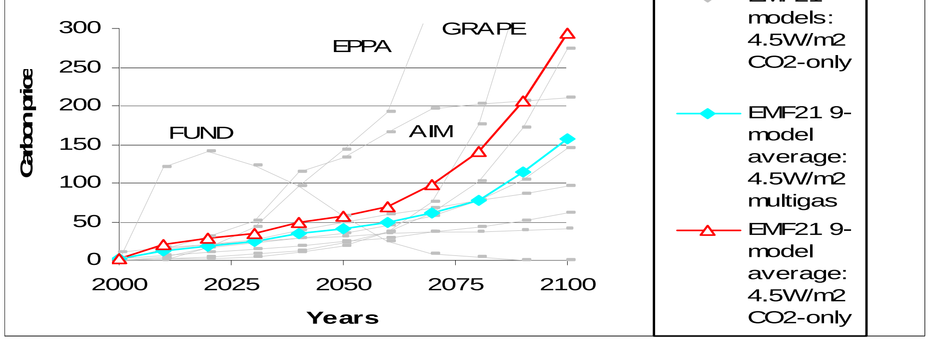
Source: Van Vuuren, D.P., J. Weyant, and F. de la Chesnaye, 2006a. Multi-gas scenarios to stabilize radiative forcing. *Energy Economics*, 28, pp. 102-120.

Average effects on carbon prices, CO2 and GDP of stabilization targets:

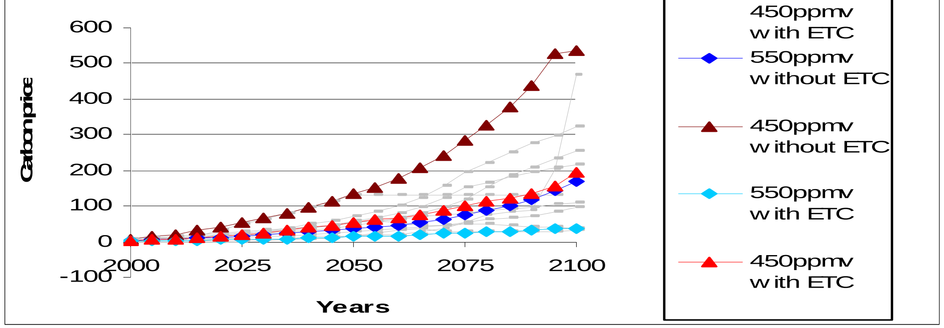
EMF21 — Reduction in costs: multigas abatement

IMCP — induced technological change

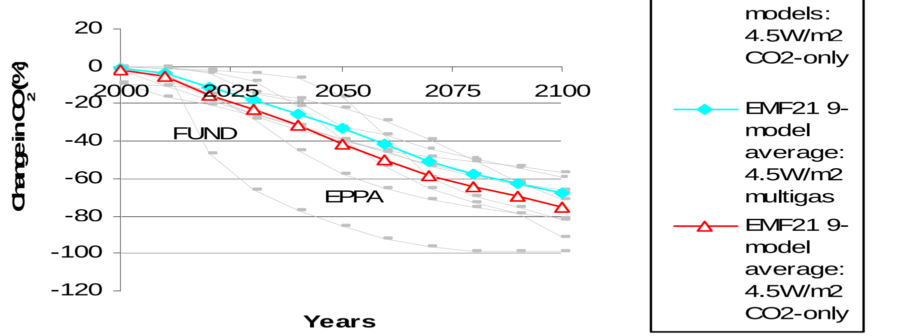
(a) Averaged effects of multigas abatement on carbon price $(2000)/$tCO_2$-eq



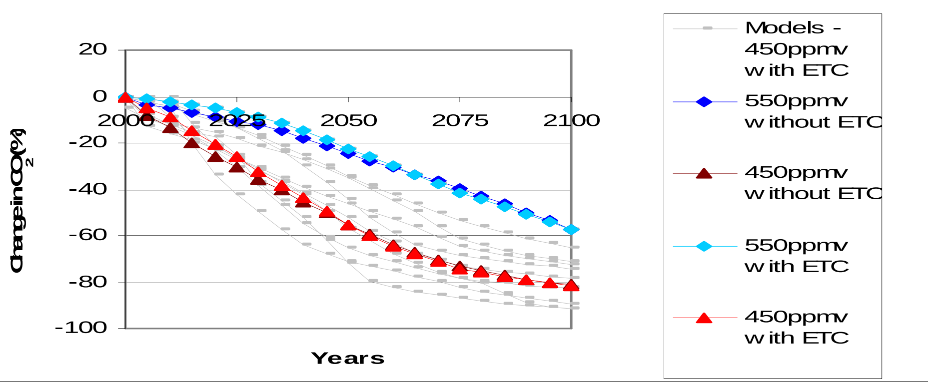
(a) Averaged effects of including ETC on carbon price $(2000)/$tCO_2$



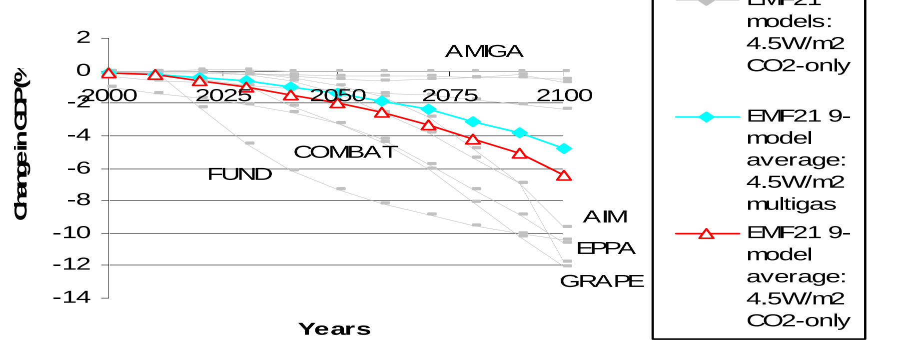
(b) Averaged effects of multigas abatement on CO_2



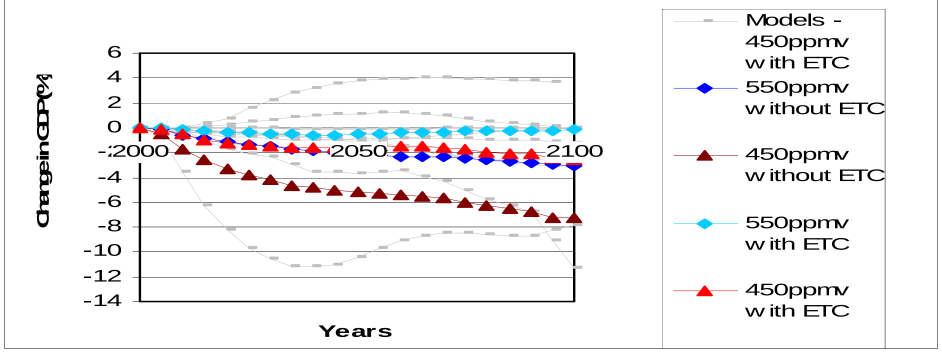
(b) Averaged effects of including ETC on CO_2



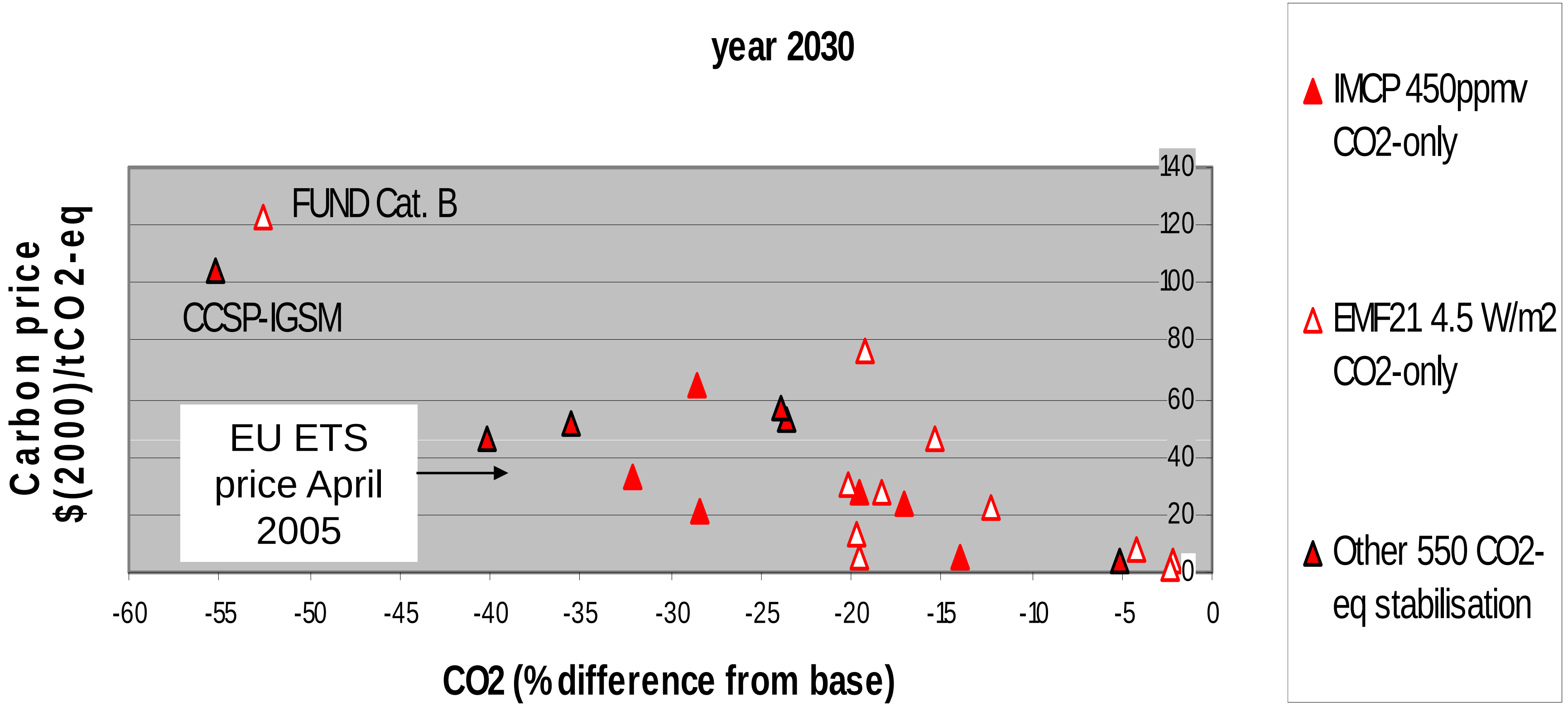
(c) Averaged effects of multigas abatement on GDP



(c) Averaged effects of including ETC on GDP

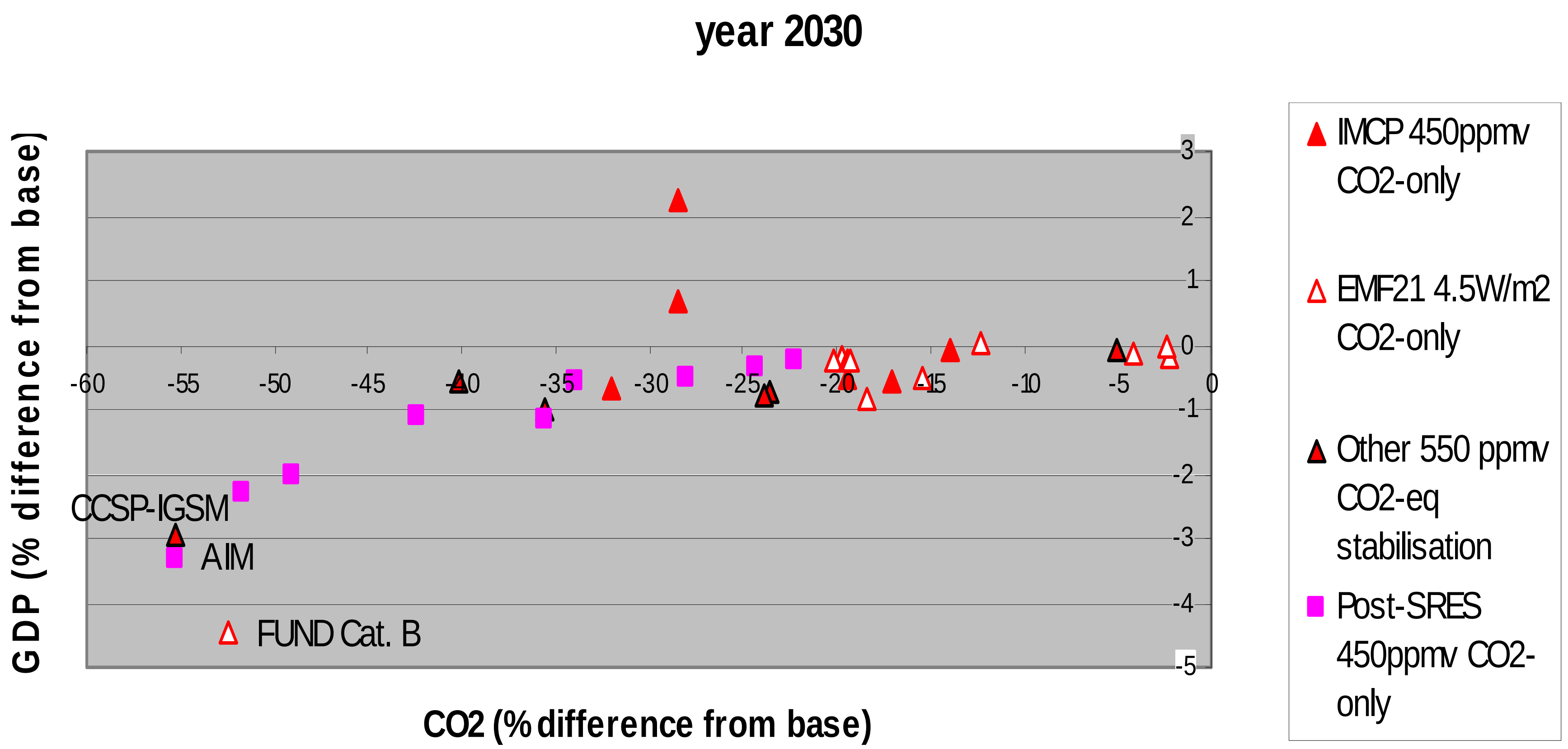


Carbon prices and CO_2 effects for 550ppm CO_2-eq stabilisation from modelling studies: outliers can lead to mis-representative results



Note that to achieve the stabilisation target, non-CO_2 GHGs are also assumed to be reduced by the CO_2-equivalent prices for all scenarios shown.

GDP and CO_2 effects for 550ppm CO_2-eq stabilisation from modelling studies: outliers can provide interesting alternative views



Note that to achieve the stabilisation target, non-CO_2 GHGs are also assumed to be reduced by the CO_2-equivalent prices for all scenarios shown.

Advances in Understanding

- Induced technological change
- Multigas abatement
- Recycling of carbon tax/permit revenues
- Assessment of co-benefits

- The Stern Review

“The economics of climate change is shaped by the science.” Stern, 2007, p.1

- The science and the politics (“dangerous”) both emphasise that the problem is one of risk and uncertainty – the economics is increasingly following the science
- The Stern Review changed the terms of the economics debate by not using traditional cost-benefit analysis for climate change assessment, but developing an uncertainty analysis
- It gives a separate assessment of costs of climate change (5 to 20% global GDP) and costs of mitigation (-1 to +3.5% GDP)
- Message: the costs of doing nothing far outweigh costs of mitigation - therefore act urgently
- Compare this with the message from cost-benefit analysis:
  - Nordhaus “optimal” temperature increase above pre-industrial is at least about 3.7ºC, requiring a very low carbon tax (c \$20/tCO_2 or less by 2050 (2002, p.197)
  - but such “optimal” temperature rises ignore the unquantifiable risks of catastrophe