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E3 modelling of the 2°C target

- the literature on the macroeconomic benefits and costs of achieving the target

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Outline

- The costs of stringent climate-change mitigation
  - "stringent" means that required to meet the 2°C target
- The literature
  - IPCC AR3 and AR4: long-run costs before financial crisis
  - too few studies of 450pmv and below for reliable estimates
  - more recently IMCP, EMF21 and EMF22
- Observational versus policy meta-analysis
- Estimated costs
- Can policies deliver "green growth" i.e. a low-carbon economy with GDP growth?

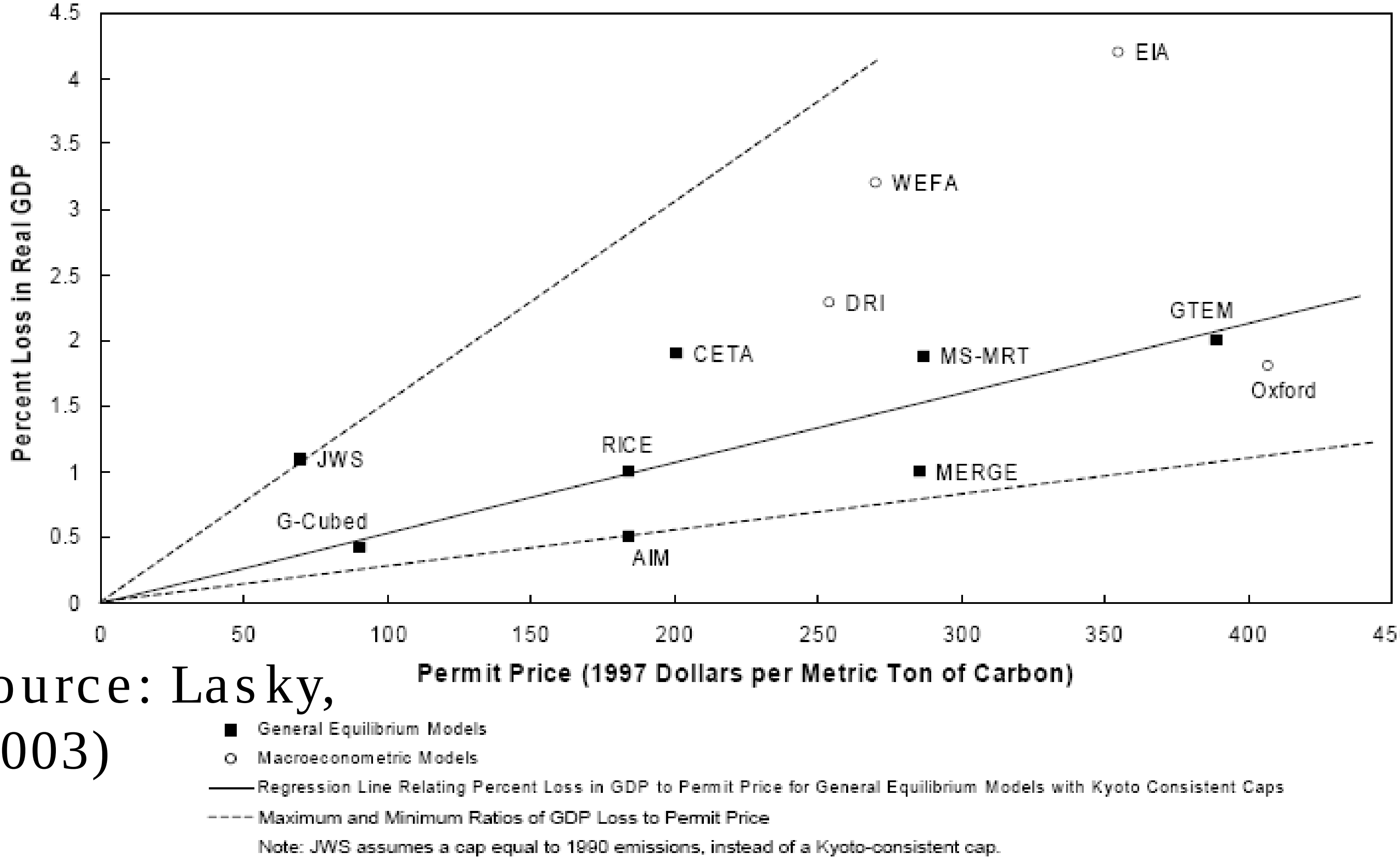
What are the mitigation costs?

- Costs not observable from market prices because
  - outcome of complex E3 interactions
  - involve changes in environment that have no market valuations
  - hypothetical: comparison of 2 states of the E3 system over future years

- Macroeconomic costs are usually measured in terms of future loss of GDP, comparing one hypothetical state of the world with another
- Costs include loss of fossil fuels output and employment, and short-term costs, e.g. from any premature retiring of fossil fuel burning power plant; tax/permit rates are “political” costs
- Such costs are offset by co-benefits from use of tax or emission permit revenues; however
  - taxes/auctioned permits may incur high “political” costs
  - free allocation of emission permits (as in phase I EU emissions trading scheme (ETS)) yields no revenues to recycle

Macroeconomic costs ≠ carbon prices

e.g. costs of Kyoto: model estimates of permit prices and % loss GDP (US 2010 no international permit trading)



Source: Lasky, (2003)

The GDP effects of GHG abatement can be positive, i.e. macroeconomic benefits

- Many models have reported macroeconomic benefits in terms of GDP being higher in abatement scenario than in reference case
- Why higher GDP?
  - higher investment in low-GHG products and processes gives higher GDP especially if unemployed resources
- The reasons for higher GDP growth
  - lower unemployment stimulates demand-side growth
  - shift to a more productive technological pathway
  - use of revenues from carbon tax or permit auction to increase spending on R&D or other
- … but GDP is not the same as well-being
  - E.g. well-being is improved by lower air pollution

Modelling Studies reporting GDP above baseline with GHG abatement

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		1990-2010	(Gaskins & Weyant , 1993) & (Repetto & Austin, 1997)
	FOSSIL2		1990-2020	
	LINK		1990-2010	
	DGEM		1990-2050	
	BKV optimal		1990-2020	
IPCC TAR	various	EU	various	(TAR, WG3, Fig.8.5, p. 516)
AR4,WG3,Ch11	similar to DGEM			(Garbaccio et al, 1999)

Assessing estimated costs of mitigation

- Estimates are affected by the types of models used:
  - bottom-up energy sector models with no impact on rest of economy (lowest cost estimates)
  - general equilibrium models provide century-long time horizons but assume rigid economic structures (e.g. EMF-16 & EMF-19 studies)
  - endogenous growth models also long-term, but stylised and aggregate
  - macro econometric E3 models track the economy-wide adjustment process to new policies e.g. EIA model (highest cost estimates)
- and what approach to costs is taken
  - In cost-benefit or cost-effectiveness study
  - modelling of cost-reducing government policies (e.g. many EC studies)
  - estimating costs to business of badly designed policies (e.g. many US studies)
- and what policy instruments are used
  - permits: international trade reduces costs
  - taxes: use of revenues reduces costs
  - but if no revenues (free allocation of permits) there are no recycling benefits

The mitigation literature

- IPCC Assessment Reports WG3 Mitigation
  - Second (1995) – value of life controversy
  - Third (2001) – costs of Kyoto
  - Fourth (2007) – induced technological change
  - Fifth (2014) - ???
- Modelling comparison studies
  - IMCP (2007), EMF21, EMF22
- Journal articles with meta-analysis

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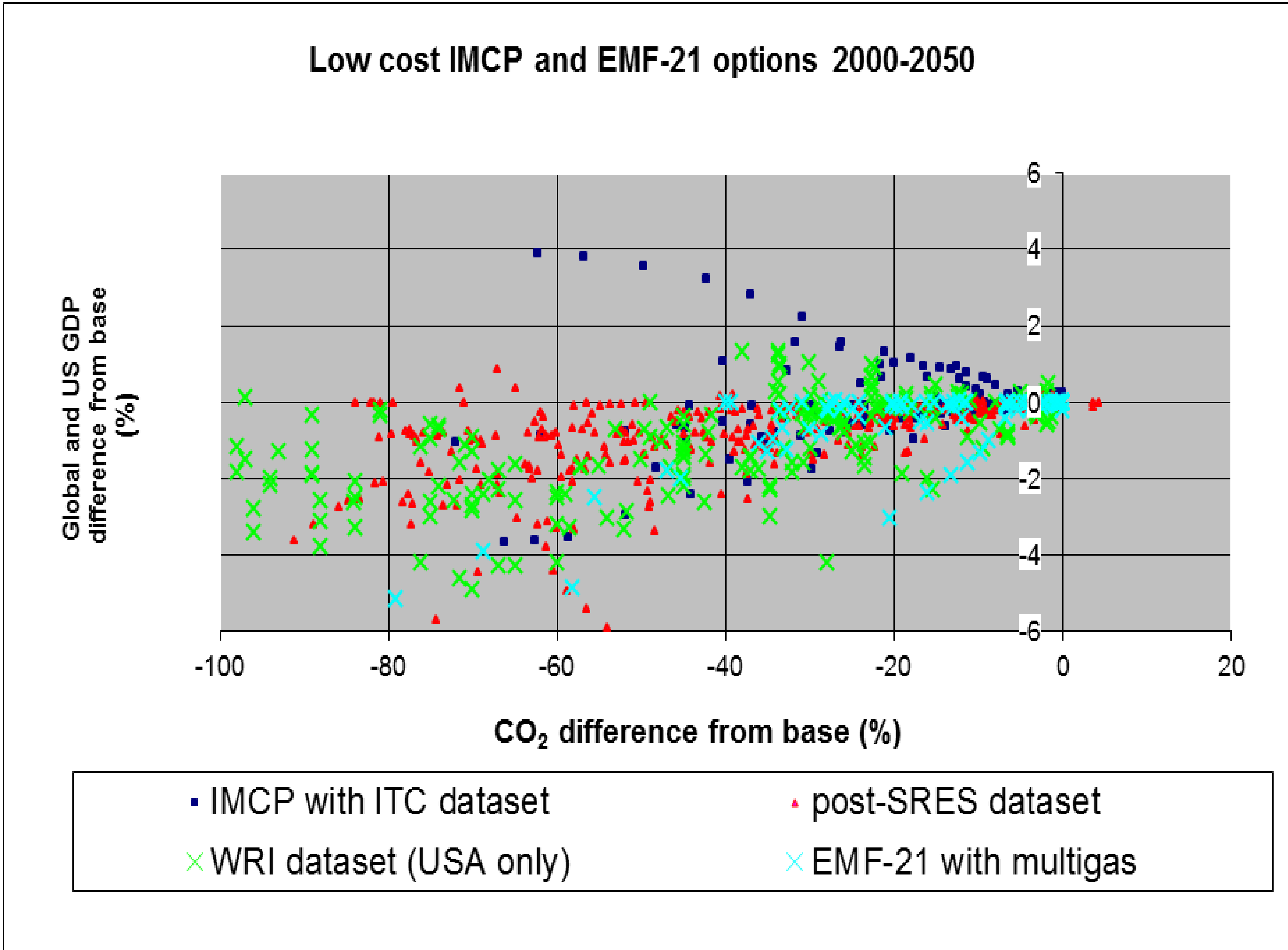
Developments in the literature

- General progress
  - Relaxation of assumptions (e.g. Edmonds et al., 2004; Babiker, 2005, EMF21 multigas)
  - Applied theory of technological change and growth (e.g. Rosendahl, 2004; Barker et al., 2006)
  - Understanding of models (e.g. FUND in Downing et al. 2005)
  - More studies of stringent mitigation (EMF22, E3MG)
- Slow improvement in data bases
  - E.g. GTAP, OECD's STAN, EDGAR, WIOD
- Trends
  - More integration with climate and impact models
  - More on technology (theory and practice) in top-down models


Low cost IMCP and EMF-21 options 2000-2050
Global and US GDP difference from base (%)
6
4
2
0
-2
-4
-6
-100
-80
-60
-40
-20
0
20
CO2 difference from base (%)
IMCP with ITC dataset
post-SRES dataset
WRI dataset (USA only)
EMF-21 with multigas

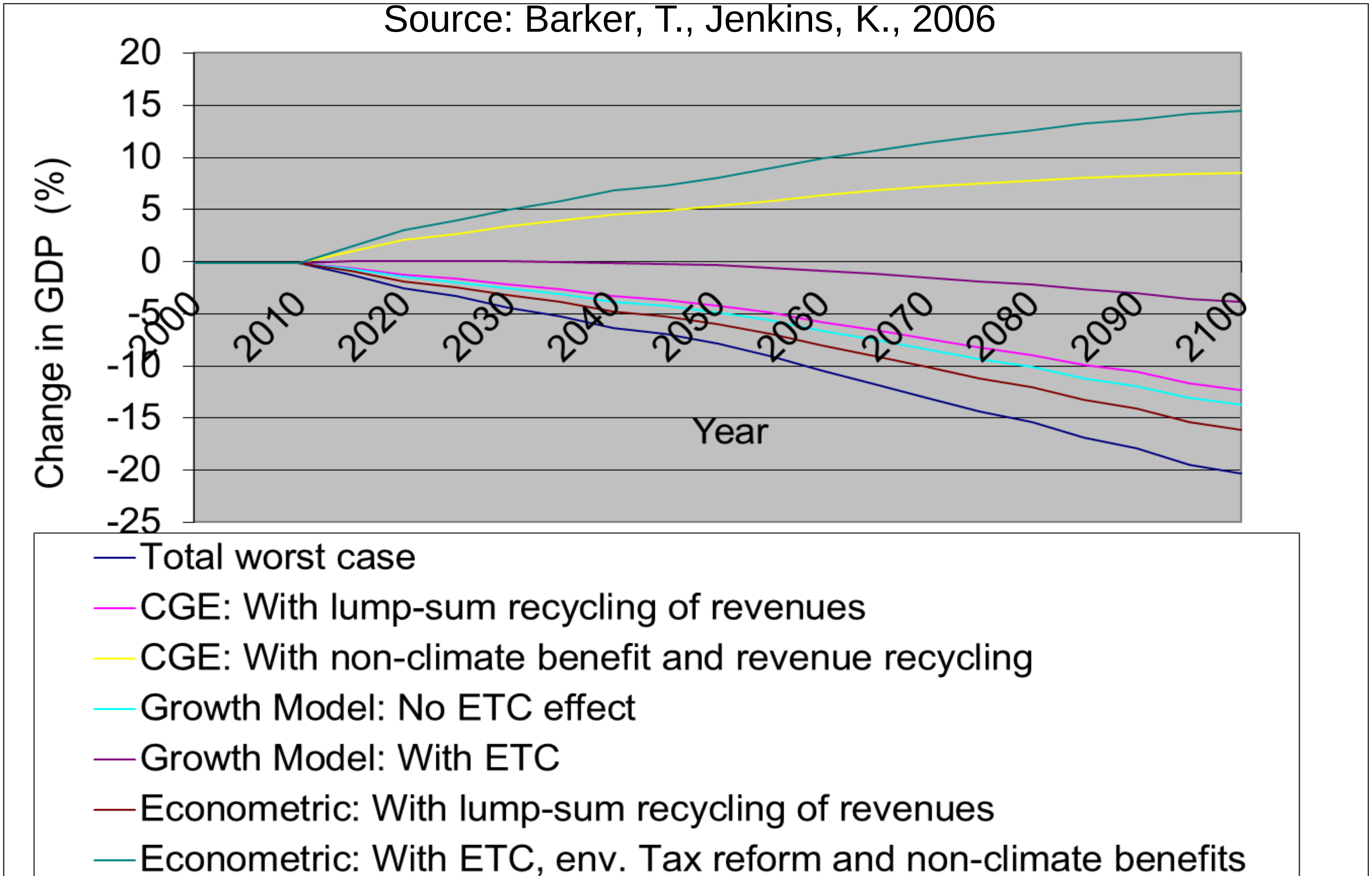
Policy meta-analysis: effects on GDP by 2030 of stabilisation policy

(difference from reference case in %)

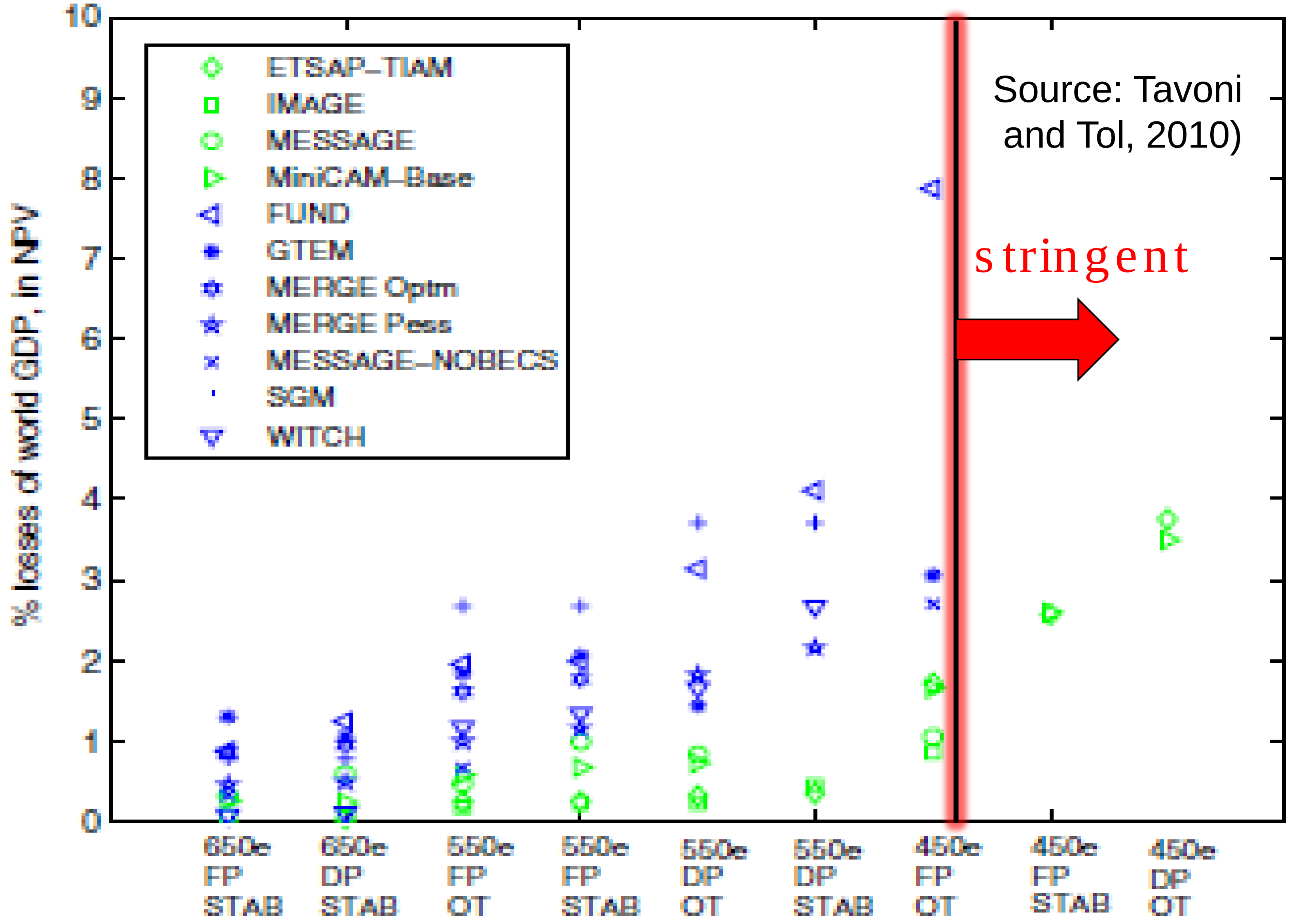
	550ppmv	effect	450ppmv	effect
Worst-case assumptions	-3.3		-4.4	
assumption: CGE model		0.8		1.0
:Kyoto mechanisms		0.9		1.1
:‘Backstop’ technology		0.5		0.6
:Climate benefit		0.5		0.6
:Non-climate benefit		1.0		1.3
:Induced technological change (ITC)		2.0		2.6
:Active revenue recycling		3.3		4.3
Total extra assumptions		9.0		11.5
Best-case assumptions	5.7		7.1	

Source: Barker, T., Jenkins, K., 2006

Meta-analysis of costs for 450 CO2-eq: Impact of Assumptions/ Alternatives



Policy costs (EMF22 data set) by model run



Tavoni and Tol's claims of "sample bias"

1) Some models did not solve for more stringent scenarios
2) Tavoni and Tol argue that these models are more likely to give high cost solutions, therefore there is a "sample bias" in the data available for costs of stringent mitigation
3) However, this is using inappropriate statistical language, since these are a few model-generated results, not a "sample" of a normal distribution
4) And the model failures are due to omission of mitigation options, e.g. BECCS or electric vehicles
5) A serious bias is the exclusive use of CGE modelling in EMF21 based on one year's data to project to 2100

Meta-analyses of the costs of climate-change mitigation

Terry Barker and Douglas Crawford Brown to appear in *Climatic Change*: “Are estimated costs of stringent mitigation biased? a commentary on "Counting only the hits? The risk of underestimating the costs of stringent climate policy" by Massimo Tavoni and Richard S. J. Tol”

- Tavoni & Tol’s claims of bias in estimates of costs are pseudoscientific: the implied methodological basis for their work is that used for observational meta-analysis in science-based studies using past data, whereas in policy meta-analysis the data-generation process is fundamentally different, being driven by modellers and their assumptions about the future.

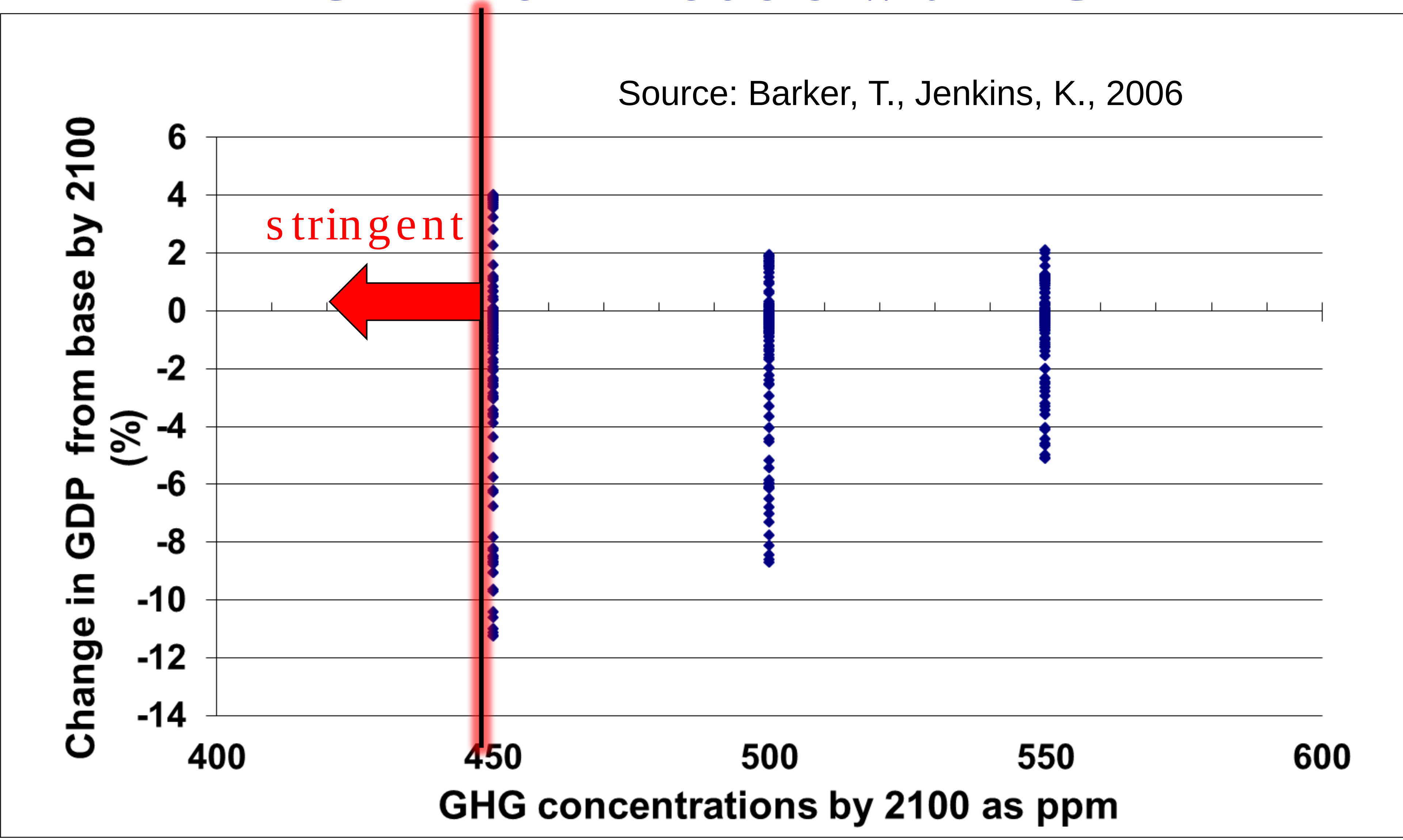
Observational Meta-analysis is

- Based on historical data with an expected statistical distribution
- With the same underlying distribution in different studies
- Samples can be seen as random from this underlying distribution

Policy Meta-analysis is

- Based on model-derived data of future outcomes
- Data generated by models and assumptions
- The data are not random but completely determined by the models

Effects of mitigation policy on world GDP from models with ITC



Why are long-run GDP costs so low?

1) The small shares of fossil-fuel energy in global GDP (3 to 5%)
2) The baseline scenarios assume 100 years of high CO_2 emissions
   – these imply substantial later funding of investment in coal and unconventional oil with alternative uses of funds
3) There is an easy substitution to low-GHG-emission products and processes in the long-run
   – Low-carbon technologies require more earlier investment and this generates more demand and therefore growth
4) Low-carbon technology has more ITC potential
   – Earlier in experience curves than fossil-fuel technologies

Conclusions on technological change in macroeconomic modelling of mitigation

- Inclusion of induced technological change
  - significantly reduces the costs , especially for stringent mitigation
- General technological change alone insufficient
  - one break-through solution unlikely
  - improvements in energy efficiency are offset in their effects on CO_2 emissions by the effects of higher growth on energy demand
- Emission trading schemes/carbon taxes/innovation subsidies are required to provide the price incentives to induce new technologies
- A wide range of technology and system changes may be induced by higher real costs of carbon
  - substantial mitigation options feasible at relatively low rates of permits/taxes
  - Permit/tax revenues recycled via innovation subsidies gives greatest GHG reductions for given carbon price

Conclusions on costs of mitigation

- Economic modelling suggests that costs are likely to be insignificant, provided
  - the policies are well-designed
  - there is time for adjustment
  - the policies are expected to continue indefinitely
- However, the short-term costs are more certain and more concentrated than the long-term benefits and there are economic groups facing short-term costs, who have a direct interest in resisting change
- Green growth is possible typically revenue-raising policies with revenues used to incentivize technological change
- But policies must include compensation to the losers to be acceptable

Thank you

Questions for the workshop

1. Is the green growth idea consistent with General Equilibrium (CGE) modelling?
2. Are future scenarios of technological change too conservative compared to the changes in history?
3. Is it possible for policy to substitute GHG abatement for economic growth?
4. Are the Integrated assessment models and the CGE models capable of assessing the effects of regulation on economic growth?
5. Does regulation to achieve GHG reductions raise or reduce growth?
6. Could radical cuts in GHG emissions have a lower GDP cost (or a higher GDP benefit) than less radical cuts? How and why?
7. Are the macroeconomic costs of GHG mitigation unknowable?
8. Is it reasonable, given the modelling literature, to assume that GHG abatement policies can lead to higher GDP and higher growth in GDP? And well being?
9. Is the conventional treatment of a reference case with no climate change effects on the macro economy justified?
10. Are CGEs adequate, given their assumptions, for assessing the macroeconomic effects of GHG mitigation? Especially in relation to their treatment of technological change.
11. Is the methodology adopted in studies of mitigation of “relaxing one assumption at a time” appropriate?
12. Will a new global financial crisis lead to deeper GHG emission reductions?