Importance of Modelling in Environmental Policy

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The Questions

- What are the **direct** benefits and costs of controls on local pollutants or protection of nature?
- If we introduce these controls or protective measures, what are the **indirect** costs and benefits?
- Can we benefit from “green” tax reforms in both economic and environmental terms?
- With global pollutants:
  - How do we define and characterise optimal actions?
  - What actions are needed to adapt to the changes and how can these actions be evaluated?

This Evaluation

- What modelling tools are available for each of these questions?
- How useful have they turned out to be?
- How can we combine tools to the greatst advantage?
- What needs to be done to make them more effective?
- Do we need new tools, and if so in which areas?

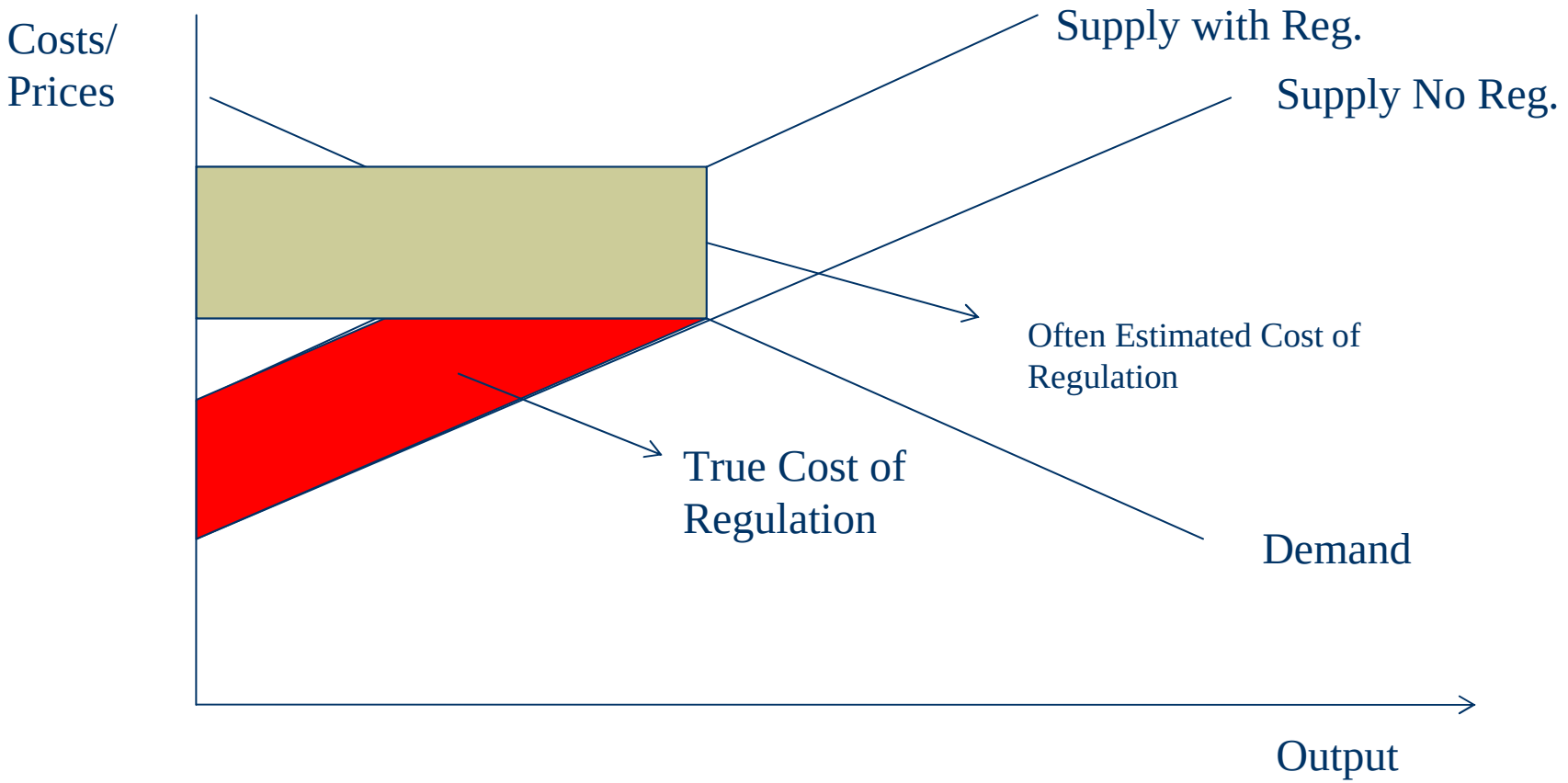
Direct Effects of Environmental Regulations

- On benefits side we have a number of approaches, such as the Impact Pathway Approach:

$$Emissions => Ambient\ Concentrations => Physical\ Impacts => Eonomic\ Values$$

- Other approaches include market demand and supply assessments, with regulations shifting supply curves and creating changes in environmental benefits.
- On the costs side we assess direct costs on established protocols but mostly simplifications are made.
- The whole method is a “partial equilibrium” approach and is one of the commonest in use.

Direct Effects of Environmental Regulations



Direct Effects of Regulation

- Limitations of a Partial Equilibrium Approach:
  - We ignore the impacts of the changes in one good or service on other goods and services (e.g. On demand for labour)
  - Often we cut corners – the estimated costs are much more simply taken as the additional expenses for the regulators.

Applications of Partial Equilibrium Approaches

- Economic evaluation of the draft directive on Non-hazardous Waste Incineration (1997)
- Study of public transport modes along the Edgware Road corridor (1997) (UK)
- Regulatory appraisal of the NO2 and PM10 air quality objectives. (1997)
- Regulatory appraisal of the SO2 air quality objectives. (1997).
- Cost and benefits of the Multi-pollutant, Multi-effect protocol. (1998)
- Economic evaluation of the costs and benefits of acidification and ground level ozone. (1998)
- Non-health benefits of the National Air Quality Strategy (1998)
- Cost-effectiveness analysis of health impacts. (1998)
- Comparative Risk Assessment of Electric Power Technologies. (1998)
- Economic evaluation of costs and benefits for the Emission Ceilings Directive. (1998)
- Comparison of the external costs of renewable energy technologies versus conventional sources. (1998)
- Cost-benefit analysis of proposals under the UNECE Multi-pollutant, Multi-effect protocol. (1999)

Applications of Partial Equilibrium Approaches

- Economic Evaluation of Air Quality Guidelines on CO and Benzene (1997-1999)
- Cost benefit analysis of NOx and VOC control under the UNECE Multi-pollutant, Multi-effect Protocol (1997-1998)
- Quantification and valuation of the health effects of fine particles. (1999)
- The environmental costs of lorries: a study to incorporate environmental costs in vehicle excise duty rates. (1999)
- Economic evaluation of diverting PVC from incineration to landfill and recycling (1999)
- Surface transport costs. A study of the comparative environmental costs of road and rail in the UK. (2000)
- A comparison of the external costs of very large lorries and rail freight in the UK.
- Guidance on Reducing the Environmental Impacts of Urban Energy-Use in Developing Countries. (2000)
- Economic evaluation of air quality limits for PAHs (2000)
- Economic Evaluation of the Diversion of PVC from Incineration (2000)
- Study of the Benefits of Compliance with the EU Environmental Acquis: Quantification of the benefits of air quality improvements. (2000)

Applications of Partial Equilibrium Approaches

- Economic evaluation of the Second NOx Protocol (1998-2000).
- Current, historical and future external costs of the UK power generation sector. (2000)
- Comparison of external effects from CPH plants with those from separate production of power and heat. (1999)
- Assessment of the production of energy from biomass. (2000)
- Economic evaluation of the large combustion plant directive. (1999)
- A Regulatory and Environmental Impact Assessment (REIA) on the Second Daughter Directive Concerning Air Quality Limits for CO and Benzene. (2000)
- Development of an integrated approach to environment and health
- Environmental impacts upon technology, employment and competitiveness to 2010: Environmental quality and health (2000)

Indirect Costs and Benefits

- Indirect Costs:
  - Reductions in employment (temporary or permanent)
  - Loss of export markets
- Indirect Benefits
  - Dynamic gains - reducing costs of clean production in the future
  - Gains in export market
  - Government revenue gains

Indirect Costs and Benefits: Methods Used

- Macroeconomic Models - National and International (Top Down)
- Surveys of Affected Industries (Bottom Up)
- CGE Models – National and International (Bottom Up)
- Engineering Based Partial Equilibrium Models (Bottom Up)

Examples of Macro Models

- Assessment of Impact of Regulations on Competitiveness. In general macroeconomic models based on econometric analysis find lower competitiveness effects or even negligible effects when revenues are recycled via reduction in other taxes. (OECD, 1997).
- OECD in 1997 looked at a number of studies relating to impacts of expenditure on pollution abatement and its impacts on competitiveness. It found that such measures do not significantly affect international patterns of trade. (Eg. US-Mexico trade).

Examples of Macro Models

Jaffe et al reviewed over 100 studies looking at the potential effects of environmental regulations on US competitiveness. Found little evidence to support hypothesis that regulations had an adverse effect on competitiveness. Reasons:

- Except for very highly polluting industries costs of compliance are small
- Other countries also introduce similar regulations
- Relocation for environmental reasons is rare.
- Multinationals often respect higher standards anyway

Examples of Trade Models

- Study using gravity model of trade from 1988 to 2005 for all OECD countries.
- Trade flows are a function of the relative size of 2 countries and distance between them, plus presence of carbon taxes and energy efficiency standards.
- Results show both carbon taxes and efficiency standards have an effect on competitiveness through their impacts on trade flows.
- Impacts are as shown over.

Examples of Trade Models

IMPACTS ON EXPORTS OF A CARBON TAX

CARBON TAX IMPOSED BY			
	EXPORTING	IMPORTING	BOTH
CARBON TAX	-	MARGINAL –VE	-
CARBON TAX + EE STANDARDS	-	MARGINAL –VE	-

Examples of Trade Models

IMPACTS ON EXPORTS OF ENERGY STANDARDS

CARBON TAX IMPOSED BY			
	EXPORTING	IMPORTING	BOTH
ENERGY STD GENERAL	HIGHLY SIG. AND -VE	HIGHLY SIG. AND -VE	HIGHLY SIG. AND -VE
ENERGY STANDARD SELECTED INDUSTRIES	HIGHLY SIG. AND -VE	HIGHLY SIG. AND -VE	HIGHLY SIG. AND -VE

Macro Trade Model

- Carbon tax in an importing country affects competitiveness of exporting country – maybe because of offsetting measures of the importing country?
- Otherwise a carbon tax does not have an impact on trade between countries (exemptions work?).
- But energy efficiency standards can reduce trade, by around 10%. Similarly when both EE and carbon taxes are introduced.
- Study is simple and measures are introduced as dummy variables.

Surveys of Affected Industries

- Can collect much more detaild information than you get from normal data sources.
- But answers may be biased.
- Used to see effects of switch from labour tax to carbon tax in selected engineering companies in UK.
- We can compare results with top down models – see next slides.

Analysis of Green Taxes

- Is there a double dividend – will an increase in green taxes and a reduction in labor taxes that is fiscally neutral increase employment and improve the environment?
- Much has been written on this and theoretical analysis is important in understanding the key modeling issues.

Key Parameters that Affect Results of DD Models

- Elasticities of substitution between energy, labour and capital.
  - Effect is greater when elasticity of substitution between energy and labour is high
  - And when elasticity of substitution between energy and capital is low
- The economy has unemployment in the first place.
  - Effect is greater when reduced labor taxes, which increase demand for labor are not offset by increased wage demands
  - The unemployment is not ‘structural’ and the labor market can respond to increased demand.

Analysis of Green Taxes

- Models: HERMES, EUROGEM, GEM-E3, E3ME, HONKATUKIA, LEAN-TCM.
- All except GEM-E3 and HONKATUKIA's models assume unemployment.
- All are CGE models except E3ME. Does is matter E3ME is not?
- Models vary w.r.t. elasticities of substitution in production, how real wages are determined.
- All assume capital immobility and some market power but do not address non-worker issue

Key Parameters that Affect Results

- The economy may not have unemployment but labor supply may be responsive to increased real wages. (How responsive is labor supply?)
- The employment effect will be greater when:
  - Capital is not very mobile internationally (if it is, carbon tax cannot be absorbed by capital and has to be borne by labor, reducing employment effect)
  - Non-working households are significant in number, so carbon tax can be passed on to them and less is borne by workers

Results from European Models: 1992 Tax Proposals

- 1992 tax proposal of carbon/energy tax @ $3->$10 over 7 years recycled via reduced social security payments.
- Results show employment increase of 0.1% to 2.2% in first year, going up to 0.4% to 3.2% in year 10.
- Highest impact is in one scenario of LEAN-TCM model where real wages go up very little when employment demand increases. E3ME also shows large employment effects. Smallest impact is with GEME3, which has full employment assumption.

Results from European Models: 2002 Energy Directive

- Looked at energy directive of 2002 with reductions in social security taxes.
- ‘Top Down’ analysis carried out using HERMES, GEM-E3 and E3ME models.
- ‘Bottom Up’ analysis carried out in the UK, surveying firms that faced the changes in energy prices.

Energy Directive Taxes

Fuel	Unit	Tax Rate €
Gasoil	KL	26.0
Heavy Fuel Oil (Low S)	TONNE	28.0
Heavy Fuel Oil (High S)	TONNE	34.0
Kerosene	KL	25.0
LPG	TONNE	34.0
Natural Gas	GJ	0.7
Solid Fuel	GJ	0.7
Electricity	MWH	3.0

Top Down Analysis of ED

- Employment results of tax harmonization in year 2005 for EU 15:
  - HERMES: +190,000 (0.13%)
  - GEM-E3: +155,000 (0.11%)
  - E3ME: +457,000 (0.33%)

Bottom Up Analysis

- Tax will result in investment at plant level to increase energy efficiency. This will have direct and indirect employment effects. Estimates based on detailed discussions with industry representatives in UK.

Bottom Up Analysis

- Without recycling about 2,000 jobs would be created in the UK
- With recycling via a reduced employment tax the number of jobs would be around 19,000.
- As % of employment in the UK this is small about 0.08%.
- Extending to EU15 we get about 119,000 jobs (0.08%) – smaller than the Top Down Model.

Other Models

- Honkatukia's model for Finland looked at carbon taxes of around $13/ton + 50 to 200 percent.
- Base case showed virtually no employment effect
- Increase in carbon tax from $13/ton up by 50% had very little effect on employment (0.05%).
- Reasons?
  - Model assumes full employment
  - Elasticities of substitution between labour and energy and between energy and capital are very similar

Some Conclusions

- Results of the analysis point to small possible employment effects of a carbon tax, when accompanied by recycling of revenues.
- For the energy directive, the likely effect is an increase of around 0.1-0.4%
- In new member states the effect may be at the upper end of this range. Why?

Some Conclusions

- In new member states the effect may be at the upper end of this range. Why?
  - There is some genuine unemployment and the full employment models are not appropriate (GEME3 and HONKATUKIA)
  - The elasticity of substitution between energy and labor is likely to be fairly high in the short run (hiring middle skilled level workers to improve energy efficiency)

Models for Global Pollutants

- Integrated Assessment Models
- Models for Estimating Costs of Adaptation
  - Partial Equilibrium Models
  - CGE Models
  - Other Approaches (Participatory Assessments)

Integrated Assessment Models

- Single sector models with labor, capital and different energy inputs. Original world was one entity but now we have multi country versions.
- Use of fossil energy generates GHGs, which reduce GDP. But using non-fossil energy is expensive
- Aim is to maximize welfare over very long horizon.

Integrated Assessment Models

- Models include DICE, RICE, WITCH, FUND, and a number of others.
- They provide answers to the question, how much should the world aim to reduce GHGs and over what time frame?
- Results are very sensitive to:
  - Discount rate
  - Damage function
  - Rate of fall in costs of renewables.

Integrated Assessment Models

- IAMs can also be used to allocate resources between mitigation (reducing GHGs) and adaptation (expenditure that lessen the impact of climate change through GHGs).
- The results depend on very aggregate models and while the indicate that adaptation has a high benefit cost ratio the results are not useful in planning adaptation expenditures at the local or even national level.

Other Models for Global Problems

- Bottom up models are widely used to estimate the least cost solutions for achieving a given reduction in GHGs. These work with detailed engineering data by sector and technology – MARKAL is a typical example
- These are combined with top down models that look at how instruments such as taxes or standards will achieve a given reduction. Top down models come up with higher costs. Example is EMF model – energy modeling forum

Other Models for Global Problems

- Nowadays hybrid models are also being developed. WITCH is a hybrid model that has detailed engineering data as well as a macroeconomic structure. Like all IAMs it is a CGE model as well but a very simplified one.
- Other models look at the energy market in great detail but assume macroeconomic projections based on consensus models. POLES is one such model. It is useful to understand how the energy markets will respond to climate targets and who will gain and lose.

Some Conclusions

- Models are very important and useful in deciding on environmental policies but we have to chose the right model to answer the right question.
- For decisions about local pollutants and local land use, partial equilibrium models can perform quite well. But even they are not simple, and if we take account of all changes the analysis can be quite complex.

Some Conclusions

- Macro models are useful in assessing some indirect effects, such as impacts on employment and competitiveness. They lack the ´discipline´ of CGE models but they are more adaptable. Trade models are often useful
- CGE models are useful when distinct sectors are involved – such as with ETR. But the results still can be sensitive to parameters we don´t have good estimates for.

Some Conclusions

- There is a role for direct surveys and data collection, especially when specific sectors will be affected. Methods for using choice experiments in this area are worth developing.
- For climate change and global problems, IAMs contribute to the debate at a very high and abstract level.

Some Conclusions

- For more practical decisions we need to combine bottom up and top down models. The bottom up models do not take account of economic linkages and are naïve about possible changes in practices. Top down models lack the technical detail needed to evaluate the options. Hybrid models are filling the gap but are still simple on the economic side.

Thank You