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E3ME:
An Energy–Environment–Economy Model for Europe

An Overview

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Contents

Page

E3ME at a Glance iv

1 Introduction 1

2 A Brief Description of the E3ME Model 1

2.1 Advantages of the E3ME Model 1
2.2 E3ME as an E3 Model 2

3 Policy Analysis and Outputs of E3ME 3

3.1 Policy Analysis within E3ME 3
3.2 Outputs from E3ME 4

4 Appendix A: E3ME - based Projects 5

5 Appendix B: E3ME in Practice 7

5.1 Scenario Analysis: the Emissions Trading Scheme in Sweden 7

E3ME at a Glance

The Energy-Environment-Economy Model for Europe (E3ME)[1] has been built by a European team under the EU JOULE/THERMIE programme. It is intended to meet an expressed need of researchers, energy companies and policy makers for a framework for assessing energy-environment-economy issues and policies.

The key features of the E3ME model are summarized as follows. The E3ME model is:

- elaborated at a *European* rather than at a national level, with the national economies being treated as regions of Europe;
- deals with energy, the environment, population and the economy in one consistent and integrated modelling framework;
- designed specifically to address issues of central importance for economic, energy and environmental policy at the European level;
- capable of providing short and medium-term economic and industrial forecasts for use by business in planning and by government for policy analysis and evaluation;
- capable of analysing long-term structural change in energy demand and supply and in the economy.

The operational version of the E3ME model is able to generate annual comprehensive forecasts up to the year 2020 for the EU15 countries (plus Norway and Switzerland), covering the main macro indicators at a 41-industry level (including 16 service industries) and 28 consumers' expenditure categories.

Furthermore, the E3ME model offers:

- a fully integrated macro top-down and industrial bottom-up simulation analysis of the economy, allowing industrial factors to influence the macro picture and incorporating the effects of technological change;
- a scenario analysis, across a range of greenhouse gas mitigation policies including carbon taxes and permit trading;
- a sensitivity analysis, where it is possible to test robustness of baseline projections over the short and medium term by varying key assumptions exogenous to the model.

E3ME has been used in several EU-funded projects and also for country-specific analysis.

[1] A more detailed and technical description of the model is available upon request.

1 Introduction

This paper provides a short description for a general audience of the Energy-Environment-Economy Model for Europe (E3ME), developed by Cambridge Econometrics (CE). A more detailed and technical overview of the model is available upon request.

After a brief description of the model and its components, E3ME's main purposes and outputs are presented. A description of the EU projects involving E3ME is provided in Appendix A and an example of application of the E3ME model is given in Appendix B.

2 A Brief Description of the E3ME Model

The E3ME model has been built by an international European team under a succession of contracts in the JOULE/THERMIE and Fourth Framework programmes.

2.1 Advantages of the E3ME Model

E3ME uniquely combines the features of an annual short- and medium-term sectoral model estimated by formal econometric methods (over historical time-series) with the detail and some of the methods of the Computable General Equilibrium (CGE) models that provide analysis of the movement of the long-term outcomes for key E3 indicators in response to policy changes.

It can be used for dynamic policy simulation and for forecasting and projecting over the medium and long terms. As such, it has proved to be a valuable tool for E3 policy analysis in Europe.

Compared to other existing models targeted at achieving the same goals, the advantages of the E3ME model lie in three areas:

Model disaggregation The detailed nature of the model allows the representation of fairly complex scenarios, especially those that are differentiated according to sector and by country. Similarly, the impact of any policy measure can be represented in a detailed way.

Econometric pedigree The econometric grounding of the model makes it better able to represent and forecast performance in the short to medium run. It therefore provides information that is closer to the time horizon of many policy makers and businesses than pure CGE models.

E3 linkages An interaction (two-way feedback) between the economy, energy demand/supply and environmental emissions is an undoubted advantage over other models, which may either ignore the interaction completely or only assume a simple one-way causation.

E3ME is an estimated model, based on reputable international data sources such as Eurostat, IMF and OECD.

2.2 E3ME as an E3 Model

E3ME is a detailed model of 41 product/industrial sectors, compatible with Eurostat official accounting classifications, and with the disaggregation of energy and environment industries.

It also has a linked set of 17 fuel-using sectors, including the energy-intensive sectors. E3ME covers all the EU 15 plus Norway and Switzerland.

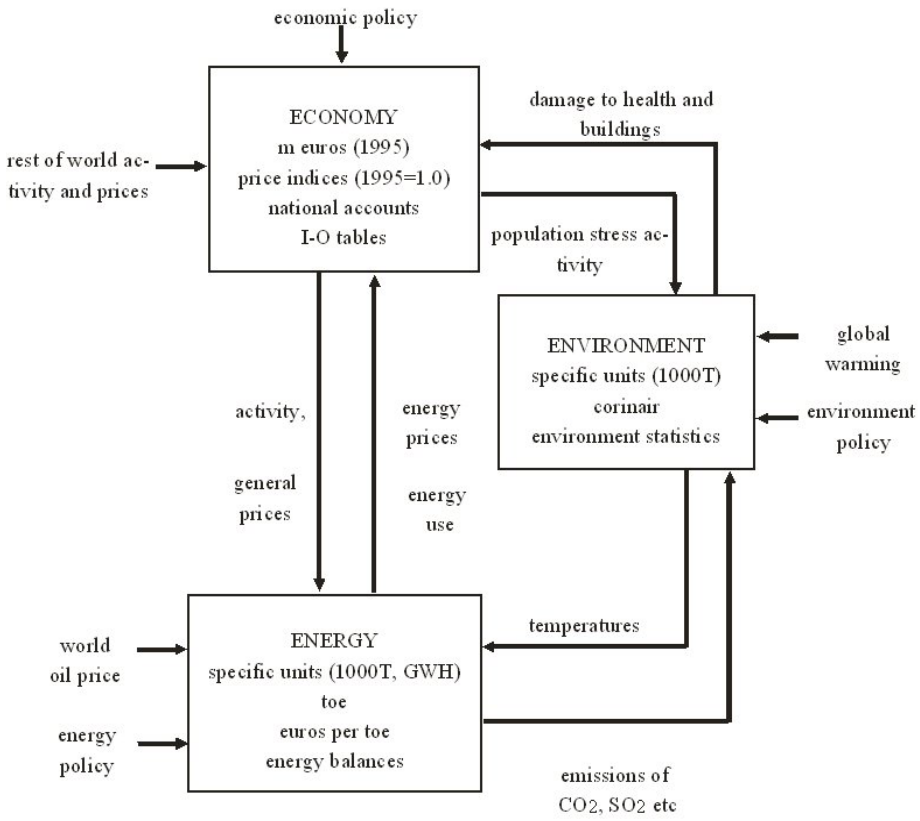
The E3ME model comprises:

- the accounting balances for commodities from input-output tables, for energy carriers from energy balances and for institutional incomes and expenditures from the national accounts
- environmental emissions flows
- 22 sets of time-series econometric equations: aggregate energy demands; fuel substitution equations for coal, heavy oil, gas and electricity; intra-EU and extra-EU commodity exports and imports; total consumers' expenditure; disaggregated consumers' expenditure; industrial fixed investment; industrial employment; industrial hours worked; labour participation; industrial prices; export and import prices; industrial wage rates; residual incomes; investment in dwellings; and normal output equations.
- Energy supplies and population stocks and flows are treated as exogenous.

The E3 interactions

Figure 2.1 shows how the three components (modules) of the model - energy, environment and economy - fit together. Each component is shown in its own box with its own units of account and sources of data. Each data set has been constructed by statistical offices to conform with accounting conventions. Exogenous factors coming from outside the modelling framework are shown on the outside edge of the chart as inputs into each component. The linkages between the components of the model are shown explicitly by the arrows that indicate which values are transmitted between components.

FIGURE 2.1 E3ME AS AN E3 MODEL



3 Policy Analysis and Outputs of E3ME

3.1 Policy Analysis within E3ME

Short and long-term effects of E3 policies

The E3ME model is intended to meet an expressed need of researchers, energy companies and policy makers for a framework for assessing energy-environment-economy issues and policies, especially those concerning R&D and environmental taxation and regulation. The model is also capable of addressing the short-term and medium-term economic effects as well as, more broadly, the long-term effects of such policies.

The E3ME model is:

- elaborated at a *European* rather than at a national level, with the national economies being treated as regions of Europe;
- deals with energy, the environment, population and the economy in one consistent and integrated modelling framework;
- designed specifically to address issues of central importance for economic, energy and environmental policy at the European level;

- capable of providing short and medium-term economic and industrial forecasts for use by business in planning and by government for policy analysis and evaluation;
- capable of analysing long-term structural change in energy demand and supply and in the economy.

3.2 Outputs from E3ME

The E3ME model is able to generate the following outputs:

- annual comprehensive forecasts up to the year 2020 for 19 European regions including the EU15, plus Norway and Switzerland;
- annual comprehensive disaggregated forecasts to the year 2020 for industry output, investment, prices, exports, imports, employment and intermediate demand at a 41-industry level including 16 service industries and for consumers expenditure in 28 categories.

Furthermore, the E3ME model offers:

- a fully integrated macro top-down and industrial bottom-up simulation analysis of the economy, allowing industrial factors to influence the macro picture;
- an in-depth and systematic treatment of changes in the input-output structure of the economy over the forecast period to incorporate the effects of technological change, relative price movements and changes in the composition of each industry's output;
- a dynamic multiplier analysis, capturing the responses of the main economic indicators, industrial outputs and prices to changes in the key macroeconomic assumptions, eg changes in world oil prices, income taxes, government spending, and exchange rates;
- a scenario analysis, enabling businesses to evaluate their long and short-term investment decisions and policy makers to assess a range of macroeconomic-structural policies (eg the effects of the EU single market or the impact of e-commerce) and greenhouse gas mitigation policies, including carbon taxes and permit trading;
- a sensitivity analysis, where it is possible to test robustness of baseline projections over the short and medium term by varying key assumptions exogenous to the model.

Applications of E3ME

E3ME has been used in several applications, ranging from macro-sectoral long-term forecasts to impact analysis of the introduction of new policies for the environment or employment. In Appendix B, an example of the application of the E3ME model is reported: an impact analysis of the introduction of the Emissions Trading Scheme in Sweden for the Statistics Office in 2004. Other applications of the E3ME model can be found at the website of the model, under the section 'Publications – Working Papers from the most recent applications of E3ME' (http://www.camecon.com/e3me/index.htm).

4 Appendix A: E3ME - based Projects

This section contains most recent projects involving the E3ME model. Most of them are EC-funded projects but there are also projects commissioned by other entities, such as the impact analysis of the introduction of the Emissions Trading Scheme in Sweden for the Swedish Statistical Office (see Appendix B).

COMETR[2] (Competitiveness Effects of Environmental Tax reforms) is a Specific Targeted Research Project (STREP) supported by financing from the EU's Sixth Framework Programme for Research (FP6). COMETR is coordinated by the Department of Policy Analysis at the National Environmental Research Institute in Denmark and has six partners. COMETR runs from December 2004 through to November 2006. The project will advance the debate on competitiveness effects by undertaking the first comprehensive sectoral analysis of Europe's environmental tax reforms from an ex-post perspective. It will use modelling frameworks as well as case studies concerning the existing tax reforms which have been introduced in the EU and Candidate Countries. Webpage: http://www2.dmu.dk/cometr/index.htm.

TranSust (The Transition to Sustainable Economic Structures). TranSust provides a communication platform for researchers interested in modelling the transition to sustainable economic structures. Based on experience with existing models, the following issues are addressed: 1) sharing of information about existing models in a peer review; 2) assessing the comparative advantages of various model designs; 3) identifying research tasks for modelling sustainable economic structures. Webpage: www.transust.org.

SEAMATE[3] (Socio-Economic Analysis and Macro-modelling of Adapting to information Technologies in Europe). The objective of SEAMATE was to analyse the overall economic impact of Information Society Technology (IST) within the context of the European Union (EU) and national policies. This objective was accomplished through a structured programme of work, conducted over a period of two years (2002-2003). Webpage: http://www.seamate.net/index.shtml

TIPMAC[4] (Transport Infrastructure and Policy: a macroeconomic analysis for the EU). This project analysed the role of transport in macroeconomic development and employment. It combined transport and macroeconomic modelling to quantify the indirect macroeconomic impacts of transport infrastructure investment (TEN-T) and transport pricing policies (eg marginal social cost pricing) in the EU. The project started on May 2001 and ended on December 2003. See: http://europa.eu.int/comm/dgs/energy_transport/rtd/5/index_en.htm.

Sectoral Economic Analysis and Forecasts up to the Year 2005[5]. In 2000, Cambridge Econometrics was commissioned by the European Commission DG EcFin to forecast the main key macroeconomic indicators for EU economy at sectoral and country levels. The report tried to find out in which sectors output

[2] European Commission contract no.: 501993.

[3] European Commission contract no. IST-2000-31104.

[4] European Commission contract no GRD1/2000/25347-SI2.316061.

[5] European Commission contract no: B2000/A7050/001.

and employment growth were most likely to come in the medium-term and which sectors were expected to decline; how sectoral specialisations were likely to change across Europe and in the Member States; the main drivers acting on the different sectors across Europe leading these trends to emerge. Also the project aimed to analyse the likely sectoral effects of events likely to happen in the near future, such as EMU, EU Enlargement, the development of E-commerce, and post-Kyoto environmental strategies for greenhouse gas abatement.

Analysis of the Introduction of Emission Allowance Trading Schemes in Sweden. A report for the Environmental Statistics Division of Statistics Sweden. The report analysed the impact of the introduction of the Emissions Trading Scheme on the competitiveness of Swedish economy and on the environment. See Appendix B for a more detailed description of this project.

Completion and Extension of E3ME - JOULE III[6] (Non Nuclear Non-Nuclear Energy - R&D Component, Fourth Framework Programme 1995-1997). The project addressed a task in the Workprogramme Non-Nuclear Energy - JOULE-THERMIE (1994-1998), the completion of the E3 models developed within JOULE II. The model also included the new member states of the EU, plus Norway and Switzerland, and introduced new modelling of the supply side. The purpose of the model was to provide a framework for evaluating different policies, particularly those aimed at achieving sustainable energy use over the long term. A main task of the model is the evaluation of policies reducing anthropogenic emissions of greenhouse gases (GG) in Europe by 10 to 20% over the period until 2020[7]. See:
http://dbs.cordis.lu/fep-cgi/srchidadb?ACTION=D&SESSION=34602005-3-15&DOC=3&TBL=EN_PROJ&RCN=EP_DUR:24&CALLER=PROJ_JOULE

[6] European Commission contract no: JOS3-CT95-0011.

[7] The atmospheric emissions are: carbon dioxide (CO2), sulphur dioxide (SO2), nitrogen oxides (NOX), carbon monoxide (CO), methane (CH4), black smoke (PM10), volatile organic compounds (VOC), nuclear emissions to air, lead emissions to air, chlorofluorocarbons (CFCs) and the other four gases: nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF6). These four gases together with CO2 and CH4 constitute the six greenhouse gases (GHGs) monitored under the Kyoto protocol.

5 Appendix B: E3ME in Practice

5.1 Scenario Analysis: the Emissions Trading Scheme in Sweden

The objectives of the study

In this project commissioned by the Swedish Statistics Office in 2003-2004[8], the E3ME model was developed and used to produce an analysis of emissions permits trading in Sweden incorporating the latest information available. The analysis implemented the characteristics of the European-wide emissions permit trading scheme as outlined in the European Commission document: COM(2002) 680 final. It also incorporated the latest information from the Swedish government on the implementation of the Swedish emissions permit trading scheme in 2005-2007.

The study used the latest Swedish national and environmental accounts data provided by Statistics Sweden. The data were used to update the E3ME databanks and the estimated elasticities of the model. This process involved re-estimating 11,343 time-series econometric equations that reflect the long and short-term behaviour of the Western European economies. The forecast period was 2005-2012.

Key findings of the study

The main finding of the study was that, with allowance prices of euro 15/tCO2, the reduction in greenhouses gases (GHG) emissions in Sweden is ½%, leaving the remaining reduction to be found from (1) importing GHG emission allowances, (2) other policies in the energy-intensive sectors, such as incentives for renewable electricity generation, and (3) policies directed at other sectors of the economy.

This conclusion was not greatly changed by higher allowance prices (euro 30/tCO2) or even by introducing a carbon tax at euro 15/tCO2 for all other non-energy intensive sectors at a corresponding rate to the allowance price.

Ancillary benefits[9] in the EU15 were estimated to be 0.42% of GDP and were expected from reductions in SO2, NOX and PM10 (based on ExternE cost estimates) in the period. Ancillary benefits were very small for Sweden; only 0.01% GDP average in the period.

[8] The full report is available at http://www.camecon.com/e3me/pdf%20files/Final_Report.pdf.

[9] These benefits comprises ancillary or secondary effects of climate-change mitigation policies on problems other than GHG emissions, such as reductions in local and regional air pollution, associated with the reduction of fossil fuels, and indirect effects on issues such as transportation, agriculture, land use practices, employment, and energy security. Sometimes these benefits are referred to as "ancillary impacts", to reflect the fact that, in some cases, the benefits may be negative. From the perspective of policies to abate local air pollution, GHG mitigation may be an ancillary benefit.