Introduction to the E3-India macroeconomic model

Presenter: Hector Pollitt, Cambridge Econometrics

Introduction

This paper introduces the E3-India macroeconomic model. The model is designed to assess the impacts of energy policy in India at the state level. The model is designed according to the following principles:

- There is considerable scope for increased deployment of renewables in India;
- Much of the energy policy in India is determined at the state level; and
- Energy markets in India are not 'perfect' and do not necessarily operate as described in economic textbooks.

In its initial phase, E3-India has been designed to assess the economic impacts of increasing the deployment of renewables in India. As part of its test phase, the model will provide estimates of the renewables policies on GDP and employment.

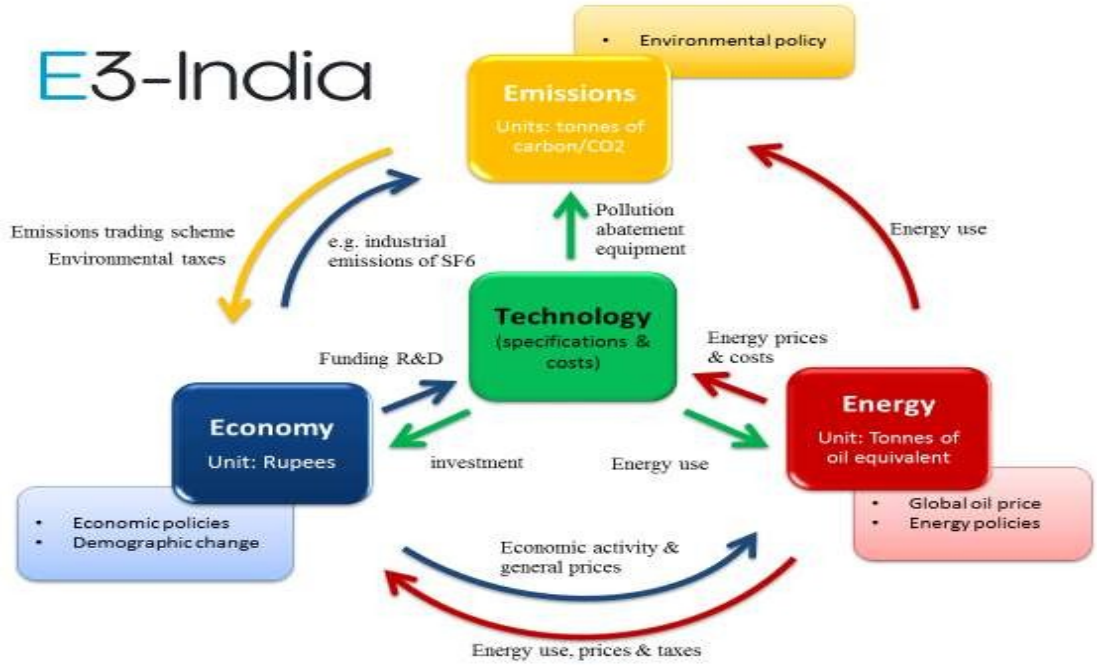
However, E3-India is a relatively flexible tool that can be used to assess a wide range of policies, either at the national or state level. While the integrated economy-energy linkages make the model an ideal tool for assessing various energy policies (e.g., efficiency programmes, energy or carbon taxation; see Figure 1 and below), the general structure of the model means it could be used to assess other more general economic policies.

Model dimensions

E3-India provides a representation of the Indian economy that is as detailed as possible, given the available data. The model has the following dimensions:

- 32 Indian states and territories
- 20 economic sectors
- 5 income quintiles (still under development)
- 8 users of 5 different energy carriers
- 24 power sector technologies
- 10 types of atmospheric emissions
- Annual projections out to 2035

Figure 1: Basic model structure



The model can be run for a single state or for India as a whole. The states are linked together through trade linkages, and the sectors are linked through input-output relationships. Energy-economy relationships are modelled by combining physical and economic data.

Outputs from the model include a full set of national accounts indicators, covering macro-level indicators such as GDP and inflation, but also sectoral output, trade, and prices. The sectoral dimension of the model is particularly important for assessing the effects of energy policy, as the ways in which sectors use (or provide) energy vary considerably.

Economic pedigree

E3-India is a macroeconometric simulation model, meaning it is based on a series of econometric equations, linked together by the national accounting framework. It is similar in design to the internationally recognised E3ME model (see www.e3me.com; Cambridge Econometrics, 2014) which has been used for official policy analysis in Europe (e.g., Pollitt et al, 2014). The theoretical background to the model is the post-Keynesian school of macroeconomics. Where there is a micro level representation in the model, this is based on post-Schumpeterian theory.

This approach sets E3-India apart from the more common CGE approach to economic modelling. Although econometric equations require a detailed database to be constructed,

there are substantial advantages to using this report. For example, E3-India does not assume full employment or perfectly competitive markets; instead, it estimates behaviour based on available historical data. The model allows for spare capacity in the economy, meaning that green growth scenarios are possible, for example, if policies are put in place to utilise idle resources. In summary, it is a simulation model based on real-world relationships, rather than an optimisation-based tool (see discussion in European Commission, 2016).

Energy linkages

The energy system is fully integrated to the economy within the modelling framework. Five of the economic sectors in the model (coal, oil extraction, gas extraction, electricity distribution, and gas distribution) are defined specifically to support these linkages. The other sectors consume energy as part of their production processes; econometric equations for demand are included in the model.

The power generation sector is modelled using a 'bottom-up' approach. The FTT (Future Technology Transitions) tool, which is based on evolutionary theory, is used for this purpose (Mercure, 2012). FTT defines 24 energy technologies, which are adopted on the basis of existing market structure and relative technology costs. The model is one of diffusion, which takes into account rates of learning and declining costs of development over time. However, it also recognises limitations in the energy system, for example, maximum shares of intermittent generation, or limitations on available sites for certain renewable technologies.

Data and estimation

The model data are derived from official and publicly available sources wherever possible. For most model variables, the data are sourced from state-level statistical offices. Limitations in the data are recognised and gaps are filled out using specialised software algorithms. Time series are collected (annually from 1995) so that econometric estimation may be carried out.

The estimation approach used is a two-stage least squares error correction model. The exact specification is derived from Hendry, Pagan, and Sargan. (1984) and Engle and Granger (1987). It provides both a long-term 'steady-state' outcome as well as looks at the transition period to get to the long-term outcomes.

Future availability

E3-India is being developed through a collaborative process—the technical development has taken place in Cambridge, but the design includes substantial input from partners in India.

The partners that assist will have the chance to use the model once its development is complete in mid-2017. The model will also be made available for researchers to use in India under license.

References

- Cambridge Econometrics. (2014). E3ME Manual, Version 6.0. See www.e3me.com
- European Commission DG ENER. (2016). *Policy-induced energy technological innovation and finance for low-carbon economic growth*. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/ENER%20Macro-Energy_Innovation_D2%20Final%20(Ares%20registered).pdf
- Engle, R.F., and Granger, C.W.J. (1987). Cointegration and error correction: representation, estimation and testing. *Econometrica, 55*, 251-76.
- Hendry, D.F., Pagan, A., and Sargan, J.D. (1984). Dynamic specification. In Griliches, Z., & Intriligator, M.D. (Eds.), *Handbook of Econometrics*, Vol II., Publisher: Amsterdam, North Holland.
- Mercure, J.F. (2012). FTT: Power: A global model of the power sector with induced technological change and natural resource depletion. *Energy Policy, 48*, 799-811.
- Pollitt, H., Alexandri, E., Chewpreecha, U., and Klaassen, G. (2014). Macroeconomic analysis of the employment impacts of future EU climate policies. *Climate Policy, 15*(5), 604-625.