1 Overview of the OECD ENV-Linkages model

The OECD ENV-Linkages Computable General Equilibrium (CGE) model is an economic model that describes how economic activities are linked to each other across sectors, regions and economic agents (i.e. intermediate sectors of production, households, and government). It also links economic activity to environmental pressure, namely to emissions of greenhouse gases. Economic activities and corresponding emissions are projected over several decades.

ENV-Linkages model is a dynamic neo-classical general equilibrium model, featuring capital vintages. This global economic model primarily draws upon a database of national accounts and estimated world trade flows. Each regional activity is described by an economic input-output table (usually sourced from national statistical agencies and collected under the GTAP V8 data base (Narayanan et al 2012)).

The advantages of multi-sectoral, multi-regional dynamic CGE models such as ENV-Linkages include their global dimension, their overall consistency accounting for economy-wide interactions and the fact that they are based on rigorous micro-economic foundations. It thus facilitates exploration and quantification of policy responses to a wide range of government initiatives. These models are best suited to analyse the medium- and long-term implications of large policy shifts generating significant reallocations across sectors and countries/regions together with associated spill-over effects, including energy and environmental policies. More details about the model and some of its recent applications can be found on the following webpage: http://www.oecd.org/environment/modelling

2 Linking the OECD ENV-Linkages and WEM model

Despite large differences in the nature and functioning of the ENV-Linkages and World Energy Model (WEM) model, ENV-Linkages was calibrated to reproduce all energy-related patterns from the WEO-2013 Scenarios and to derive further implications stemming from the CGE framework. The scenarios studied include the Current Policies Scenario, the New Policies Scenario and the Efficiency World Scenario from WEO-2012.

The calibration phase consisted in directly factoring in various policy instruments implemented in the WEO such as patterns of fossil-fuel subsidies reform, CO₂ markets, other regulations such as fuel economy standards for the transport sector, and extra investment costs on energy-efficient appliances. Further calibration efforts were devoted to key trends on energy consumption by fuel, by sector and by country; on fossil-fuel supply by country; and on changes in electricity generation mix by country. These energy trends were apprehended indirectly by adjusting some of the model parameters such as the autonomous energy efficiency (AEE) rates of improvement and technical progress experienced by sectors of fossil-fuel extraction to reproduce the outcomes of the WEO scenarios accurately.

2.1 Calibration steps for the Current Policies Scenario

The calibration of the Current Policies Scenario is crucial for the derivation of the other two scenarios and is therefore explained in more detail.

First, ENV-Linkages takes WEM GDP assumptions as given, as well as energy supply patterns arising in the Current Policies Scenario. However, embedding this information with other baseline assumptions from OECD databases would not be suffice to warrant a consistent storyline for the Current Policies Scenario and to reproduce the full set of energy demands correctly. This is due to the specific ENV-Linkages model structure (i.e. a nested Constant Elasticity of Substitution or CES structure) and its functioning (full general equilibrium obtained by adjustments in relative prices). Therefore a set of exogenous parameters of ENV-Linkages (like AEE parameters) needs be adjusted at each time period, for each country to reproduce to the extent possible energy demands over the entire time horizon (2010-2035) from WEM. Since ENV-Linkages’ quantity and price variables are fully determined by equilibrium relationships across all markets of goods and services, it is
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virtually impossible to match WEM price assumptions, demand and supply at a time. In a first step, only physical flows of energy demand and supply are reproduced. In a second step, other parameters are adjusted to be consistent with the WEM time profiles of energy prices. At the end of this stage the ENV-Linkages and WEM share a consistent reference scenario, the Current Policies Scenario.

2.2 The implementation of the New Policies and the Efficient World Scenario for WEO-2012

All the parameters determined for the Current Policies Scenario are taken as given to simulate the New Policies Scenario. The core information for the New Policies Scenario consists in a set of energy policies integrated into the modelling for the WEO scenarios: these policies include a reform on fossil fuel subsidies, carbon prices, other regulation instruments (e.g. fuel economy standards) and additional investments relative to the Current Policies Scenario needed to reach targets in the New Policies or Efficient World Scenario. This information is provided for every subsector in WEM. Moreover, sectoral investments in ENV-Linkages are described as an increase in the capital stock of the sector. These increases in capital stocks in conjunction with AEE parameters are the key elements needed to reproduce energy demands in the New Policies Scenario or the Efficient World Scenario. This methodology, which consists in using extra investments as policy levers, ensures the compatibility between all endogenous mechanisms of the OECD model and the exact energy savings obtained in the WEO scenarios. For instance, rebound effects stemming from cheaper energy prices in the Efficient World Scenario are fully taken into account in all measured economic impacts.

Importantly, the composite investment good (or the implied physical capital goods) is built by using a given composition of expenses on goods that include essentially construction (investment in buildings), services (e.g. investment in R&D, software) and equipments (e.g. transportation vehicles and other manufacturing goods). When the Efficient World Scenario is implemented, two direct effects on the sectoral activity of services can be distinguished: first, extra investments, as derived from WEM, result in an additional capital stock in this sector together with a lower energy bill. Second, additional demand for services from sectors that have increased their own investments further stimulates activity levels in the services sector. Alternatively, only the first effect applies in the chemicals sector, for example, as the demand for chemical products remains fairly rigid and therefore their production level is poorly affected by increased investment expenses elsewhere in the economy.

2.3 Analysis of the competitiveness of energy-intensive industries for WEO-2013

The linkage between the two models was not only carried out to analyse the impact of efficiency on global economic growth but also to analyse energy trends’ impact for future competitiveness of energy-intensive industries. Global economic output is determined by household consumption, investments and net exports, with investments playing a particularly big role in non-OECD countries. Energy consumption, energy price levels and production of energy-intensive goods have been calibrated to approximately match levels from WEM.

Within the context of the competitiveness analysis for WEO-2013, detailed analysis was carried out for the following energy-intensive industries: chemicals, iron and steel, non-metallic minerals (which is dominated by cement), pulp and paper and non-ferrous metals (which is dominated by aluminium). Developments of export market shares for various regions were obtained on the assumption that allocation of trade responds to relative prices at the equilibrium. International trade is based on regional bilateral flow and uses Armington specifications. This implies that each region faces a reduction in demand for its exports if domestic prices increase, e.g. as a result of higher energy prices. Total import demand for each good is allocated across trading partners according to the relationship between their export prices.

3 References

Narayanan, G., Badri, Angel A. and McDougall, R., Eds. 2012. Global Trade, Assistance, and Production: The GTAP 8 Data Base, Center for Global Trade Analysis, Purdue University