

# The ENVISAGE Model in a Nutshell

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# Research with ENVISAGE

- Emission mitigation scenarios, focused on regional impacts (LAC)—World Bank
- Economic impacts of climate change, with R. Roson—World Bank
- Future food security under various scenarios—AgMIP
- Carbon dependent economies and climate change—World Bank
  - ① SSP2+carbon policies: unilateral, unilateral+BTA, coordinated
  - ② Endogenous R & D, acceleration of new technologies
  - ③ Different coping mechanisms: subsidize energy, subsidize carbon intensive goods, diversification

# History

- 1980's: Stanford (Shoven/Borges), ULB (Waelbroeck/Burniaux)  
Rural/Urban-North South Model—birth of OECD WALRAS
- 1990's: OECD WALRAS morphed into OECD GREEN, LINKAGE  
developed at OECD and World Bank—Important novelty, emergence  
of GTAP data and model
- 2000's: LINKAGE morphed into ENVISAGE (World  
Bank/FAO/Purdue)

Original models in FORTRAN/C++, LINKAGE first in GAMS

# ENVISAGE in a nutshell I

- Global, recursive dynamic computable general equilibrium model
- Calibrated to GTAP database
- Multi-regional—121 countries and 20 composite regions
- Multi-sectoral—57 GTAP sectors of which:
  - 14 agricultural activities & 8 processed foods
  - 3 primary energy (coal, oil and gas)
  - 3 other energy (refined oil, electricity and gas distribution)
  - New power database with 11 power activities and including distribution and transmission
- Nested CES production structure with 3 archetypes:
  - Crops (intensification vs. extensification)
  - Livestock (range- vs. ranch-fed)
  - Standard (Labor/capital substitution)

● Vintage capital: Old vs. New, different substitutability across inputs

## ENVISAGE in a nutshell II

- Net factor income accrues to households
- Nested household demand—transition matrix approach
- Top level has 5 alternative consumer demand systems:
  - AIDADS, which includes Cobb-Douglas and LES
  - Extended Linear Expenditure System (ELES)
  - Constant differences in Elasticities (CDE)
- Second level consumer demand uses nested CES
- Nested CES (Armington) demand for goods by region of origin
  - National or agent preferences for top level choice
  - National or agent preferences for second level choice
- Nested CET allocation of domestic production by region of destination
- Trade associated with 4 prices:
  - Producer price of exports
  - Border (or FOB) price of exports

## ENVISAGE in a nutshell III

Five types of factors of production:

- 5 labor types—exogenous supply and full or partial wage flexibility, possibility of segmented labor markets
- Capital—exogenous with partial mobility for installed capital
- Land (satellite account with up to 18 AEZs)—CET supply allocation with aggregate price sensitive supply curve and possibility of upper bound
- Natural resource (in some sectors only)—upward sloping supply curves (introducing resource depletion module)
- Water being introduced as a new factor—irrigated vs. rain-fed in agriculture, aggregate demand elsewhere, nested CET allocation with aggregate price sensitive supply curve and possibility of upper bound

## ENVISAGE in a nutshell IV

### Standard closure

- Savings-led investment—no separate investment function. In baseline, may calibrate private savings to target investment.
- Fixed government expenditures (relative to GDP) and fixed deficit. Lump sum tax on households adjusts to given deficit target. For example, carbon tax leads to a reduction in direct household taxation.
- Fixed capital account—real exchange rate adjusts to targeted capital account. For example, a reduction in import tariffs leads to an increase in imports, which need to be financed by additional exports, i.e. typically requiring a real exchange rate depreciation.



## ENVISAGE in a nutshell V

- Incorporates so-called Kyoto greenhouse gases ( $\text{CO}_2$ , methane, nitrous oxides and fluoridated gases):
  - Carbon emissions are currently only linked to fuel combustion (no process emissions and no land-use change emissions)
  - Other gases can be linked to inputs, factors (e.g. herd size in livestock) and/or output (e.g. process emissions in waste management)
- Incorporates 10 other air emissions: BC, CO,  $\text{NH}_3$ , NMVB, NMVF,  $\text{NO}_x$ , OC, PM10, PM2.5 and  $\text{SO}_2$
- Multiple carbon regimes:
  - Carbon tax
  - Carbon caps with multiple regional regimes (including global) and with and without trading
  - Allows for flexible exemptions (for example by activity, households, etc.)

## ENVISAGE in a nutshell VI

- GHG emissions feed into a simple climate module, which generates a change in global mean temperature:
  - Integrated à la MERGE
  - Linked to MAGICC (TBD)
- Temperature signal feeds into climate change impact module:
  - Sea level rise
  - Agricultural productivity (crop yields)
  - Heat-related labor productivity
  - Human health
  - Tourism
  - Household energy demand

## ENVISAGE in a nutshell VII

### Model dynamics

- Labor supply grows exogenously, often equated with growth of working age population (15-64)
- Capital stock grows with standard stock-flow accounting—savings is the prominent driver
- Depletion modules for non-renewable natural resources (coal, oil and gas)
- Technology shifts: labor augmenting, possibly partially driven by R&D, autonomous shifts in energy and transport efficiency, cost curves
- Preference shifts: imports, food and energy
- Labor force, population and GDP calibrated to Shared

## Research agenda—model improvements

- Demand functions—dynamic consistency, nutrition analysis, scenario-based preferences
- Resource depletion for coal, oil and gas (testing)
- Families of cost structures for future energy technologies—informed by energy models?
- Non-price changes in preferences, e.g. renewables, electric vehicles—informed by energy models?
- Endogenous R & D (testing)
- International capital flows

## Research agenda—policy

- Future food security (AgMIP)—under various scenarios including climate
- Linking PE with CGE models in agriculture and energy
- Quantifying and interpreting the SSPs with ENVISAGE

Thank you!