

- Several institutions use “MIRAGE” in the MIRAGE consortium and some of them developed their own variants of the model.
 - CEPII, IFPRI, EU Commission, INRA, ITC Geneva, UNECA
 - Coordinated by the CEPII, and open for free to new members
- MIRAGE-e is a proposal by CEPII to keep MIRAGE core assumptions while follow GTAP updates closely, dealing with energy issues, and using a refined baseline. It is meant to be :
 - provided to all consortium members
 - dedicated to be opensource
- This presentation corresponds to MIRAGE-e version 1.1 beta (1.1 to be released soon).
- More information available at <http://wiki.mirage-model.eu>.



Model structure

- **GTAP database** – version 9.2, 2011 base year
- Tariffs and NTMs
 - **MAcMap HS-6** – Tariffs aggregated to GTAP and model level by the reference group method
http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=12
 - **AVE of NTMs** in goods – Ad-valorem equivalents (AVEs) of non-tariff measures by Kee, Nicita and Olarreaga (2009)
<http://go.worldbank.org/FG1KHXSP30>
 - **AVES-Services** – AVEs for NTMs in services by Fontagné et al. (2016)
http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=33
 - **Value of Time** – AVEs by Minor (2013), after Hummels and Schaur (2013)
<https://impactecon.com/resources/data/>

■ Baseline data

- **EconMap** – Baseline projections for GDP, factors, productivity, etc., version 2.4

http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=11

■ Other

- **USDA Commodity and Food Elasticities** – Used to calibrate LES-CES demand

<https://www.ers.usda.gov/data-products/commodity-and-food-elasticities/>

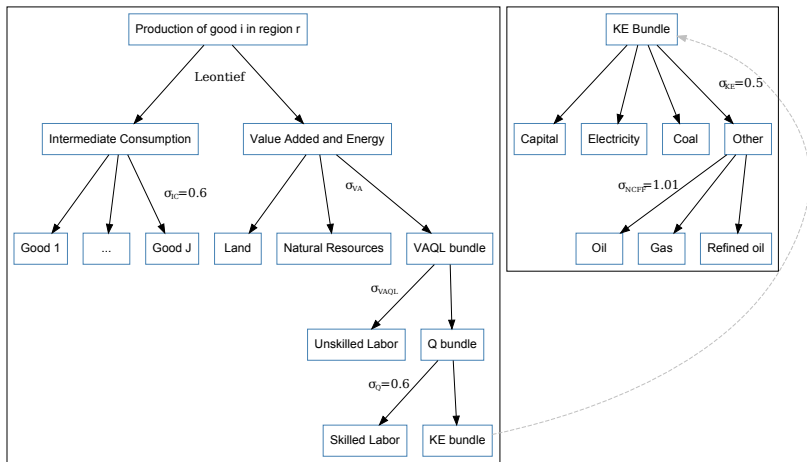
■ New commodities

- None.

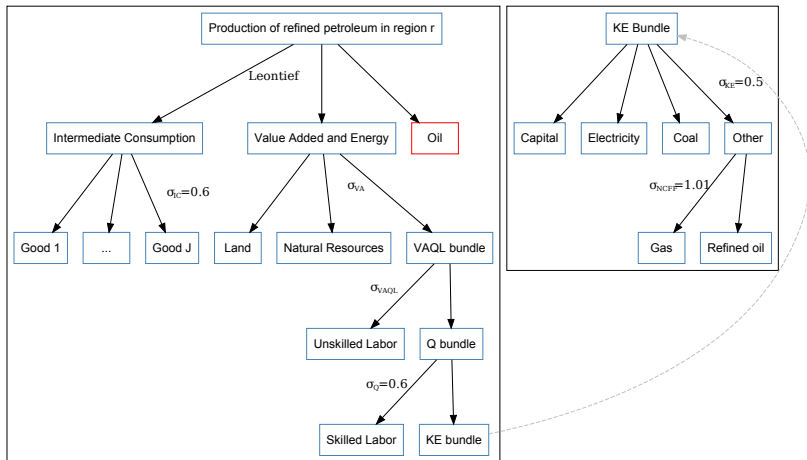
- Leontief between value-added and intermediate consumption
- Two cases: Energy in value-added (EVA) or Energy as intermediate consumption; depending on the chosen aggregation of energy sectors .
 - EVA case only: three archetypes – refined petroleum, other fossil fuels, other
 - Otherwise: One standard archetype (“Non-EVA”, standard in former versions of MIRAGE)
- Capital vintage
 - Putty-clay: Old capital is immobile, new capital perfectly mobile
- Market structure:
 - Perfect competition with constant return to scale
 - or Imperfect competition *à la* Krugman with increasing returns to scale

- EVA case only: Energy
 - Energy substitutes with capital
 - Deeply nested energy bundle
- EVA case only: Consistency in physical volume (Mtoe, MtCO₂)
 - Production in volume is \propto physical quantity
 - Two endogenous coefficients guarantee that, in physical quantities,
 - Production = Local demand + Foreign demand
 - Households consumption + Intermediate consumption = Demand for local good + Demand for foreign good

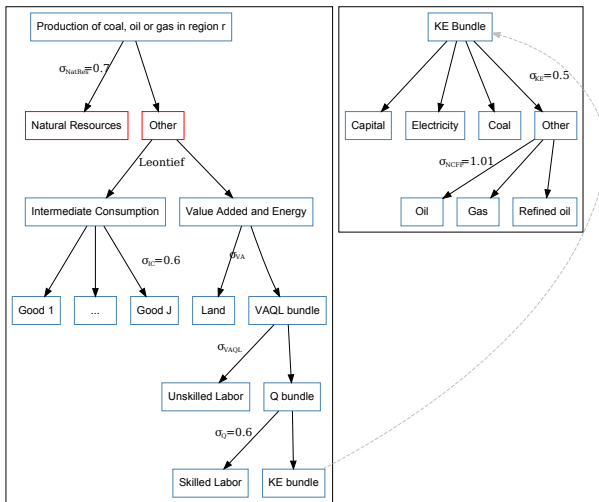
Standard (EVA) nesting:



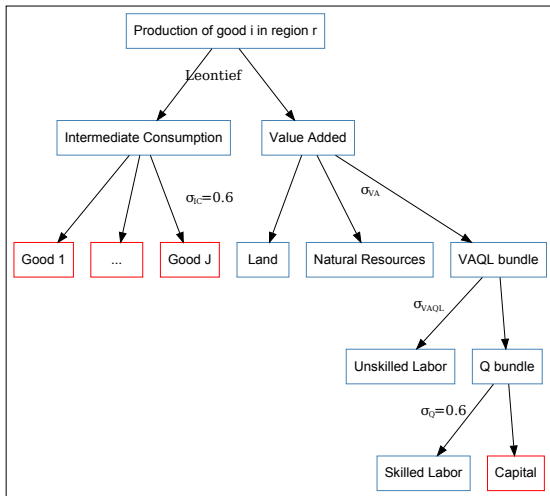
Refined petroleum production (EVA) nesting:



Primary fossil fuel production (EVA) nesting:



Non-EVA nesting:

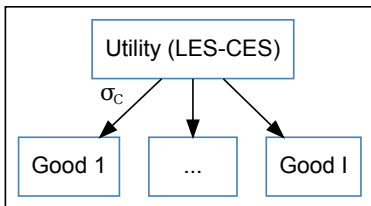


Symbol	Elasticity	Value
σ_{IC}	Intermediate consumptions	0.6
σ_{VA}	Land – Natural Resources – VAQL	1.01 // 0.1
σ_{VAQL}	Unskilled Labor – Q	ESUBVA
σ_Q	Skilled Labor – KE	0.6
σ_{KE}	Capital – Electricity – Coal – Other	0.5
σ_{NCFF}	Oil – Gas – Refined oil	1.01

- Homogenous output (products are not differentiated by destination)

- Representative agent gathering households and government
 - Collects tax revenue directly.
 - Equivalent to a non-distorsive lump-sum transfert.

- Exogenous share of disposable income is saved
- Single level LES-CES specification (both households and government)
 - Elasticity and minimal consumption calibrated to match USDA price and income elasticities

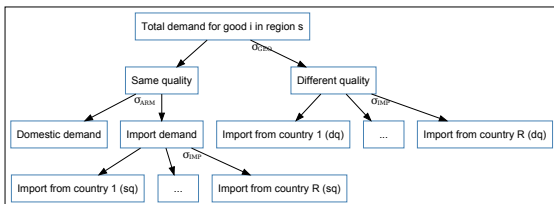


- Labor:
 - Perfect mobility between sectors, labor immobile between regions
 - Agricultural vs. non-agricultural segmentation to be updated
- Capital:
 - Installed capital immobile (depreciation à 6%)
 - New capital perfectly mobile between sectors
 - Level of new capital by region determined by domestic savings + current account balance
 - Allocation between sectors based on return to capital ($\alpha = 40$ is the elasticity of investment to return to capital)

$$INV_{i,r,s} = B_r a_{i,r,s} Capital_{i,s} e^{\alpha W_{i,s}^{Capital} / P_{s,t}^{INVTOT} - \delta_r}$$

- Land:
 - Total (agricultural) land is an isoelastic function of the real return to land
 - Regions can be “land-constrained” (elasticity 0.25) or not (elasticity 1), following the LINKAGE model specification
 - Imperfect mobility between sectors (CET, elasticity 0.5)
- Natural resources:
 - Immobile.
 - Constant for sectors other than primary fossil energy
 - Calibrated in the baseline (see below) for primary fossil energy

- Standard: Nationally nested Armington
 - D vs. M, M allocated across source regions
- Optional: Quality differentiation by region
 - Goods from the same quality-group are more substitutable



- Elasticities
 - $\sigma_{IMP} = \text{ESUBM}$ from the GTAP database
 - Consistency between elasticities is obtained by the “ $\sqrt{2}$ ” rule:
$$\sigma_{low} - 1 = \sqrt{2} (\sigma_{high} - 1)$$

- NTMs can either be:
 - Iceberg trade cost
 - Export-tax equivalent (rent-generating)
 - Import-tax equivalent (rent-generating)
 - Any split between the 3 alternatives
 - By default: 1/3, 1/3, 1/3
- Purchasing of international transportation services
 - International transport demand is ad-volumen, aggregated at world level
 - Split by mode (depending on aggregation) and region using two Cobb-Douglas specifications

- Each sector can be considered as:
 - Perfect competition: one representative firm by sector-region
 - Imperfect competition: Krugman (1980) specification [updated in 1.1, to be released soon]
 - Firms produce imperfectly substitutable varieties
 - with increasing returns to scale (elasticity following the “ $\sqrt{2}$ ” rule)
 - Firms consider themselves atomic: the markup is constant.
 - Hence, the actual number of firms do not matter.

- Capital account
 - Capital account is exogenous (in dynamics, exogenous percentage of world GDP, see below)

- Default closure
 - Exogenous savings rate (varies over time)
 - Exogenous current account imbalances
- Implications
 - Savings-led investment
 - Endogenous real exchange rate determined by current account imbalance
- Numeraire
 - Implicit numeraire, ensures no world inflation (World GDP in volume equals world GDP in value)



Baseline features

- Macro: the **EconMap** database (1980-2100)
 - One reference scenario plus 5 SSP scenarios, country-level (x167)
 - The database provides to MIRAGE-e, for the period 2011-2100:
 - GDP
 - Population (sourced from U.N. Population Division, or IIASA ; migrations are also configurable)
 - Active population by skill level
 - Savings rate, investment rate and current account
 - Energy productivity
- Sector-specific information:
 - **Coal, oil and gas price** trajectories (IEA World Energy Outlook 2016 for 2011-2040 ; continued trend 2041-2100)
 - **Agricultural productivity** (inhouse DEA analysis): trajectories for 9 world regions and two sector groups (Crops and Livestock)

- EconMap is built at CEPII along with MIRAGE-e, preserving consistency (common data sources, capital depletion, skill levels)
- It is the output of the Macroeconomics of the Global Economy (**MaGE**) model, with the following assumptions (in a nutshell):
 - CES aggregated production function with capital, labor and energy
 - Population from U.N. Population Division
 - Convergence of education level to best-performing countries
 - Participation rate of women depend on education
 - Savings follow a life-cycle relation to population age groups
 - Investment related to savings through a Feldstein-Horioka relation
 - TFP conditionnal convergence on education
 - Energy productivity conditional convergence on GDP per capita
- Both MaGE model and EconMap database available opensource on <http://www.cepii.fr>

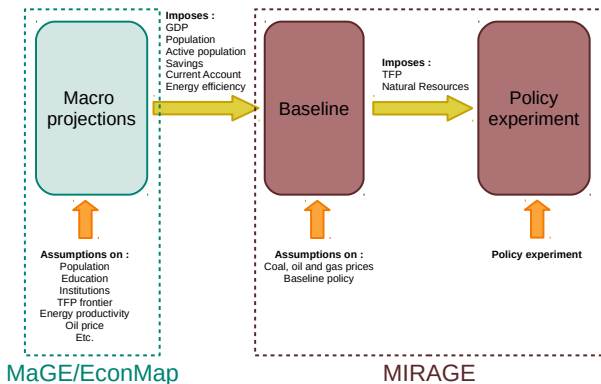
- Labor
 - Skilled and unskilled labor growth rates projected by EconMap (tertiary education vs. less than tertiary)
- Capital
 - Depletion at $\delta = 0.06$ and investment depending on savings and current account, projected by EconMap.
- Land
 - No specific dynamic assumptions (follow supply curve)
- Natural resources
 - Forestry, Fishery, Other Minerals: no specific assumptions
 - Coal, Oil, Gas: Natural resources calibrated to match average world price projected by the WEO. Natural resource depletion is homogenous across the world.
- Inter-regional
 - Current account trajectories projected by EconMap embody net international capital flows

- Natural resources 'loosely' coupled with World Energy Outlook 2016
 - Coal, crude oil and gas world prices are taken from WEO
 - Natural resources adjust endogeneously in the baseline to match price targets
 - Basic check that baseline GDP growth is not too far from WEO assumptions
- First investigations on coupling MaGE/EconMap with an energy-oriented model (POLES) to insure full consistency (technically feasible, but more work necessary)

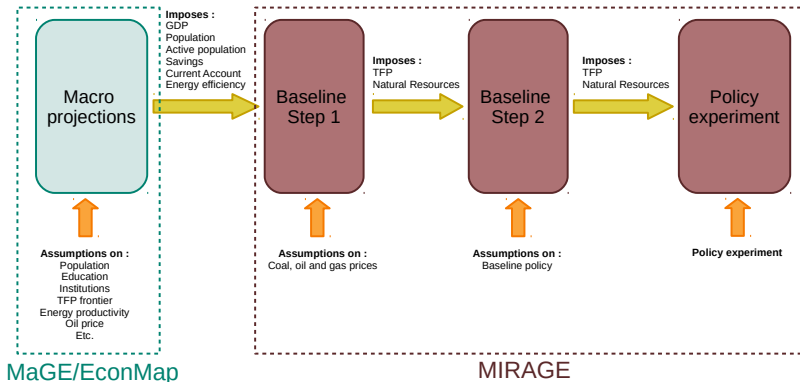
- Baseline policy assumptions are **specific to each paper or study**. They often include:
 - Already signed FTAs between relevant countries (tariff, and/or NTMs)
 - Completion of the Single European Market (tariff, and sometimes NTM reductions)
- (Standard) 1-step baseline (TFP calibrated to match GDP level at the same time as baseline policy changes)
 - e.g. completion of the Single European Market, FTAs
- (Optional) 2-step baseline: required when baseline policy options impact significantly GDP level
 - e.g. Paris Agreement NDCs, or in the SSP scenarios: large variation in tariffs (SSP 2,3,5), transaction costs (SSP 3,5) or agricultural productivity (SSP 3,4,5)

- 2-step baseline methodology:
 - 1 Baseline step 1: TFP and Natural Resources calibrated to match EconMap GDPs and WEO energy prices (no other policy assumption)
 - 2 Baseline step 2: GDP is free, implementation of the “big” policy assumptions
 - 3 Policy experiment: Compared to baseline step 2.

(Standard) 1-step baseline



(Optional) 2-step baseline



- Target GDP growth using a **sector-specific TFP shifter** subject to two constraints:
 - Agricultural productivity follows exogenous trajectories
 - A constant TFP growth wedge (2 p.p.) maintained between Industry and Services

- Autonomous energy efficiency improvement
 - Region-specific coefficient, targets EconMap energy productivity improvements
 - No improvement in fossil energy production sectors
- Iceberg trade cost
 - None by default
 - (Optional) 25% reduction per 30 years – calibrated to match past trade-to-income elasticities in the past
- TFP in the transportation sector
 - None by default
 - (Optional) 2% annual (i.e. same as industry) – calibrated to match past trade-to-income elasticities in the past
- Agricultural yields, feed efficiency, emission rates
 - None.

- None (excepted the convergence to a CES with the increase in income per capita)

- No specific assumption.

- No specific assumption (excepted endogenous adjustments to fossil energy prices).

- Treated as other sectors (extension under development).

- None.

- Use of Fisher price index and volume index at initial prices for all aggregated indices
- Real income
 - Equivalent variation
 - Decomposition between allocation efficiency, capital accumulation, land supply, terms of trade, trade cost, variety and other gains (to be updated)