# MIRAGE for environmental policies

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Section 1

The MIRAGE model

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## The MIRAGE model I

**MIRAGE** is a multi-country, multi-sector GE model, similar to other global CGE models.

- Developped at CEPII since 2001 Bchir et al. (2002); Decreux and Valin (2007)
- Used extensively to assess trade policies
- Energy-oriented version, MIRAGE-e (Fontagné et al., 2013)
- Land-use change version, MIRAGE-Biof (Laborde and Valin, 2012, IFPRI)

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The MIRAGE model II

**Agents**

- Representative household + Government (utility maximization), owns 5 production factors
    - Skilled and Unskilled labor
    - Land
    - Natural resources
    - Capital

- Firms: one per country/sector (profit maximization), perfect competition

**Data:** GTAP (9.1 in MIRAGE-e and 6/7 in MIRAGE-Biof [140 regions, 57 sectors]) and EconMap baseline (MIRAGE-e)

**Specific features:**

- specific representation of energy in the production function
- MIRAGE-Biof: specific representation of land use (intensification, land substitution, land extension. in 18 AEZ in each region)
- tentative quantity accounting

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# The MIRAGE model IV

Figure: MIRAGE-e, production function
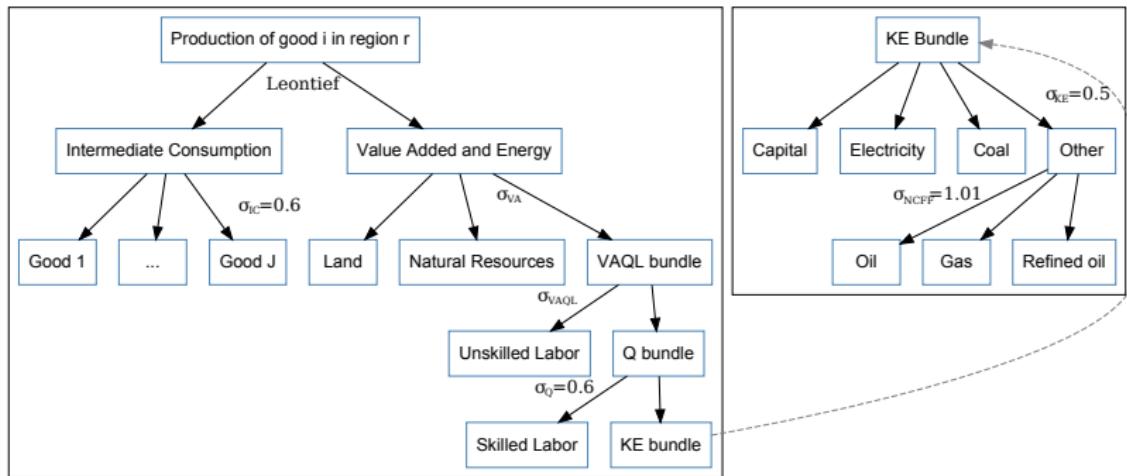
# The MIRAGE model V

Figure: MIRAGE-Biof, production function (partial)

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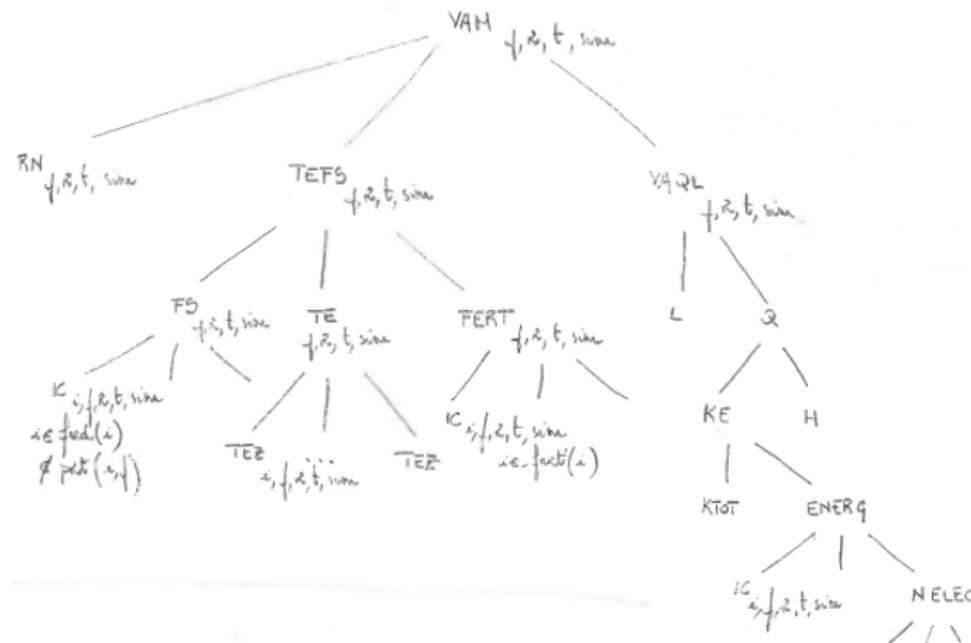
# The MIRAGE model VI

Figure: MIRAGE-Biof, endogeneous yield

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# The MIRAGE model VII
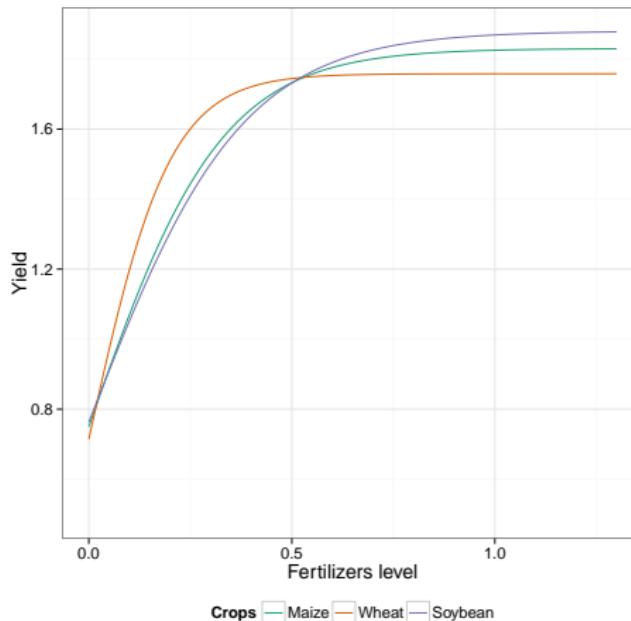
Figure: MIRAGE-Biof, land use representation

CEPII                              The MIRAGE model VIII
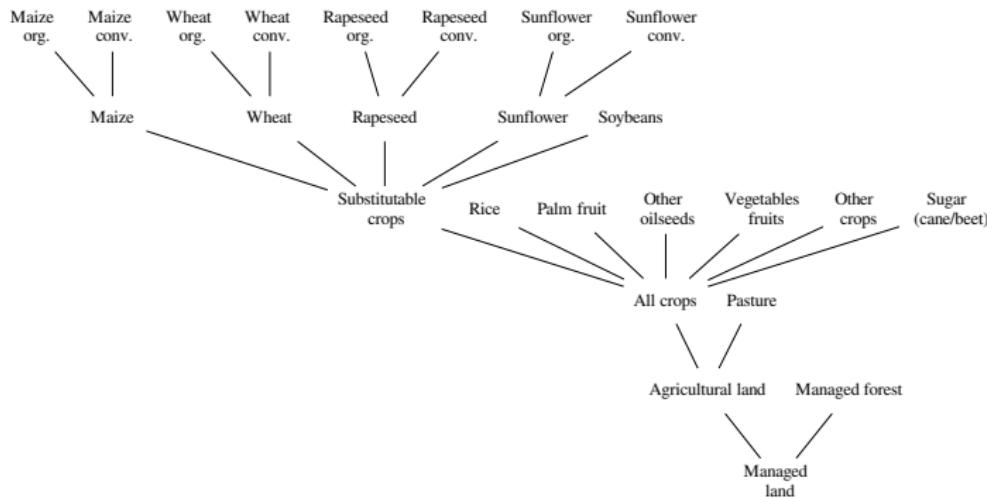
Figure: MIRAGE, demand function

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# Baseline building - MIRAGE-e
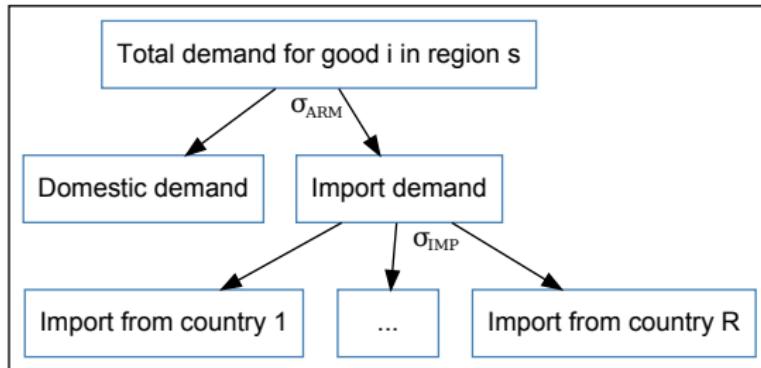
MaGE model (Fouré et al., 2013) $\Rightarrow$ long term projections

### MaGE approach

1. Build a coherent database (factors and productivity)
   - Data mainly from World Development Indicators
   - Theoretical value for energy productivity $B$
   - "TFP" $A$ as a Solow residual

2. Identify and estimate behavioral relations (mainly from the litterature)
   - Savings rate determinants, link to investment
   - Male and female participation to the labor force
   - Technological catch-up and determinants

3. Use these relationships in projection (recursive dynamics)

## Wrap up

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# The SSP scenarios I
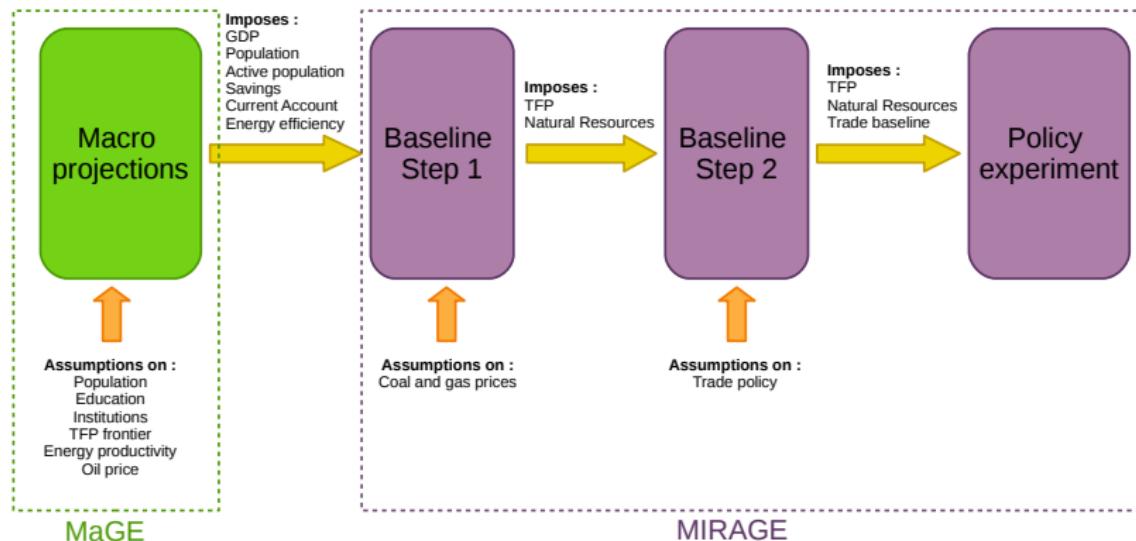
Actual quantification taken from the literature:

- Population and education: work by IIASA (Samir and Lutz, 2017)
- Fossil constraints: Price scenarios (representing relative rarity) from the World Energy Outlook (IEA).

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# The SSP scenarios II

Table: MaGE-MIRAGE implementation of the SSP scenarios

| Topic | SSP1 Sustainability | SSP2 Middle of the road | SSP3 Fragmentation | SSP4 Inequality | SSP5 Conventional | Model concerned |
|---|---|---|---|---|---|---|
| Population | | | Provided by IIASA | | | MaGE |
| Education | | | Provided by IIASA | | | MaGE |
| Institutions | Convergenc of fixed effects | – | -30% TFP | OECD:+50% TFP ; Other: -30% | +50% TFP ; conver- gence of fixed effects | MaGE |
| TFP frontier | +50% growth | – | -50% growth | +50% growth | +50% growth | MaGE |
| Energy productivity | +50% | – | -25% | – | -25% | MaGE |
| Fossil resource prices | – | – | – | High | Low | MaGE & MIRAGE (Step 1) |
| Agricultural productivity | – | – | -0.2% growth | OECD: +0.2% growth | +0.2% growth | MIRAGE (Step 2) |
| Services productivity | +1 p.p. growth (wrt. manuf.) | – | – | – | – | MIRAGE (Step 1) |
| Fossil productivity | -1 p.p. growth (wrt. manuf.) | – | – | – | +1 p.p. growth (wrt. manuf.) | MIRAGE (Step 1) |
| Tariffs | – | -50% (agr.) | Return to post-Tokyo round | – | -100% | MIRAGE (Step 2) |
| Transaction costs | – | – | +20% | – | -20% | MIRAGE (Step 2) |

# Section 2

# Outputs

## CEPII        MIRAGE outputs I

Figure: World $CO_2$ emissions under all scenarios

CEPⅡ        MIRAGE outputs II
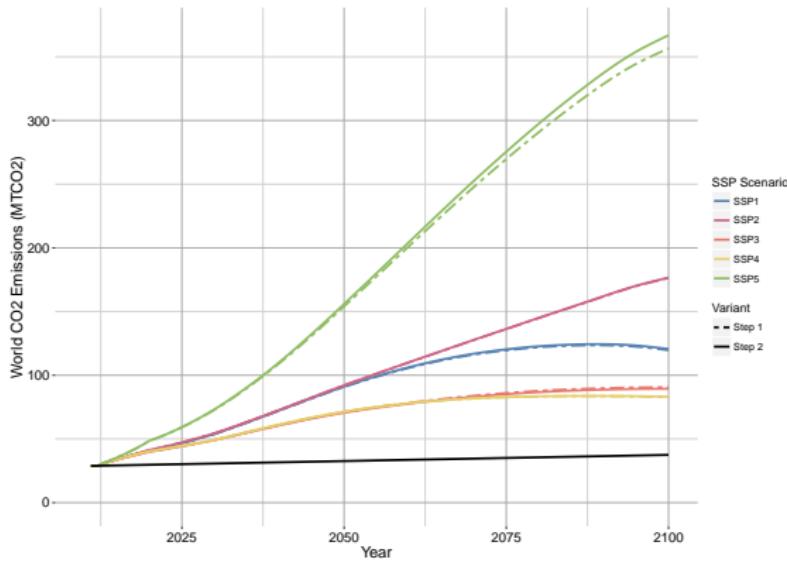
Figure: World GDP growth rate (volume) under all scenarios
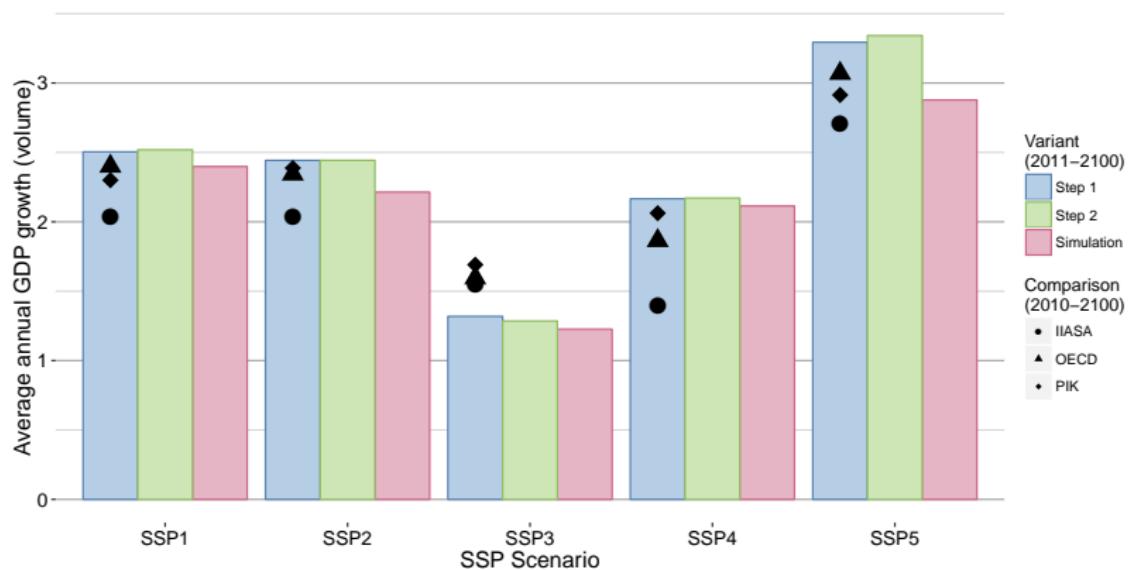


Simulation: uniform tax on $CO_2$ emissions, to reduce emissions by 30%

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# MIRAGE outputs III

Figure: Trade flows (volume), 2100, SSP3, Step 2
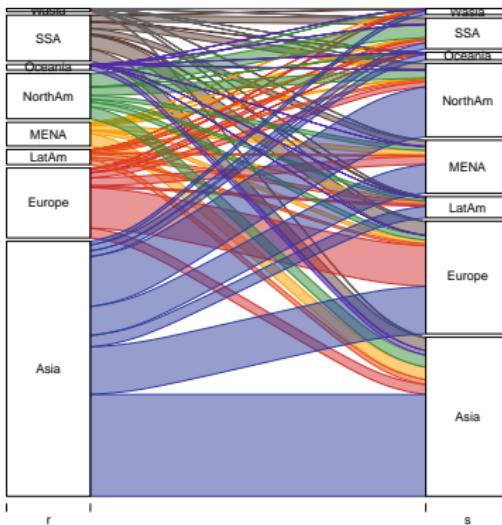
Figure: Trade flows (volume), 2100, SSP5, Step 2

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# MIRAGE outputs IV
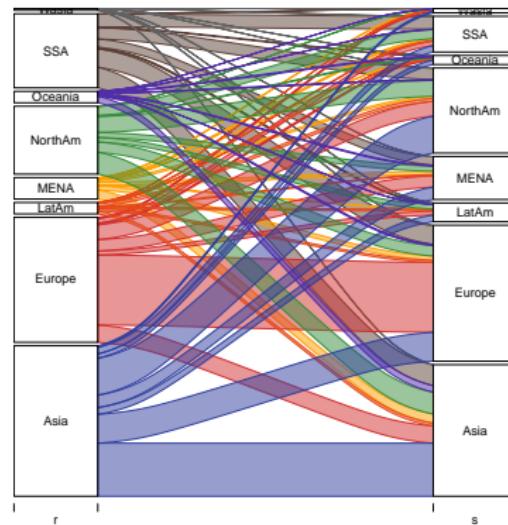
Table: Markets' balances in 2020 (1 000 t)

| | EU27 | Brazil | USA | IndoMa | RoW | World | Prices |
|---|---|---|---|---|---|---|---|
| **Maize** | | | | | | | |
| Supply | -3 453 | 630 | 606 | 57 | 991 | -1 169 | +2.3% |
| Final demand | -86 | -4 | -2 | -32 | -533 | -657 | |
| Livestock demand | 114 | -172 | -40 | 22 | 527 | 451 | |
| Other demand | -233 | -38 | -384 | -2 | -305 | -963 | |
| **Rapeseed** | | | | | | | |
| Supply | -874 | 0 | -1 | 0 | -8 | -882 | +1.6% |
| Final demand | -0 | -0 | -1 | -0 | -0 | -1 | |
| Livestock demand | 20 | 0 | 1 | 0 | 26 | 47 | |
| Other demand | -622 | -0 | -1 | -0 | -305 | -927 | |
| **Sunflower** | | | | | | | |
| Supply | -294 | 1 | -0 | 0 | -81 | -375 | +1.4% |
| Final demand | -0 | -0 | -0 | -0 | -0 | -0 | |
| Livestock demand | 36 | 0 | 3 | 0 | 42 | 81 | |
| Other demand | -191 | 1 | -4 | 0 | -261 | -455 | |
| **Wheat** | | | | | | | |
| Supply | -9 671 | 81 | 176 | 0 | 2 341 | -7 073 | +3.3% |
| Final demand | -157 | -3 | -3 | -0 | -297 | -460 | |
| Livestock demand | -1 859 | -5 | -229 | -92 | -3 345 | -5 530 | |
| Other demand | -746 | -98 | -16 | -3 | -221 | -1 084 | |

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# MIRAGE outputs V

Table: Land use changes

| Region and land type | 2008 $10^6$ ha REF | 2020 Area increase $10^3$ ha ORG | 2020 Carbon emissions MtoeCO$_2$ ORG |
|---|---|---|---|
| EU27 | | | |
|     Cropland | 93 | 20 | |
|     Pasture | 69 | 6 | |
|     SavnGrassInd | 20 | -2 | 2 |
|     Other | 52 | -2 | |
|     Managed forest | 148 | -22 | 5 |
|     Primary forest | 7 | | |
| World | | | |
|     Cropland | 1 258 | 602 | |
|     Pasture | 1 244 | -323 | |
|     SavnGrassInd | 3 415 | -59 | 50 |
|     Other | 2 844 | -54 | 4 |
|     Managed forest | 822 | -156 | 38 |
|     Primary forest | 3 101 | -10 | 2 |
|     Total | | | 95 |

# Section 3

# Scenario modelisation

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MIRAGE-e

- land productivity decrease (calibrated on the results of other models ?)
- decrease in fertilizer demand (fertilizers not isolated in GTAP sectors. . . )
- limitations: land representation $\rightarrow$ price impacts, shock calibration

MIRAGE-Biof

- -50% in fertilizers use (endogenous tax?)
- limitations: implementation of SSP2, database (update and availability)

# CEPİı̇                                               References I

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