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The IMACLIM modeling platform
Principles, methodologies and applications

Emmanuel COMBET, Julien LEFEVRE, Jules SCHERS, Henri WAISMAN

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IMACLIM modeling team

CIRED

The methodologies behind the IMACLIM modeling platform

The threefold hybridization behind the IMACLIM platform

1. Articulating accounting systems: money flows / physical quantities

2. Articulating technical and economic expertises: Bottom-up / Top-down

3. Articulating growth at different time scales: natural growth / real growth

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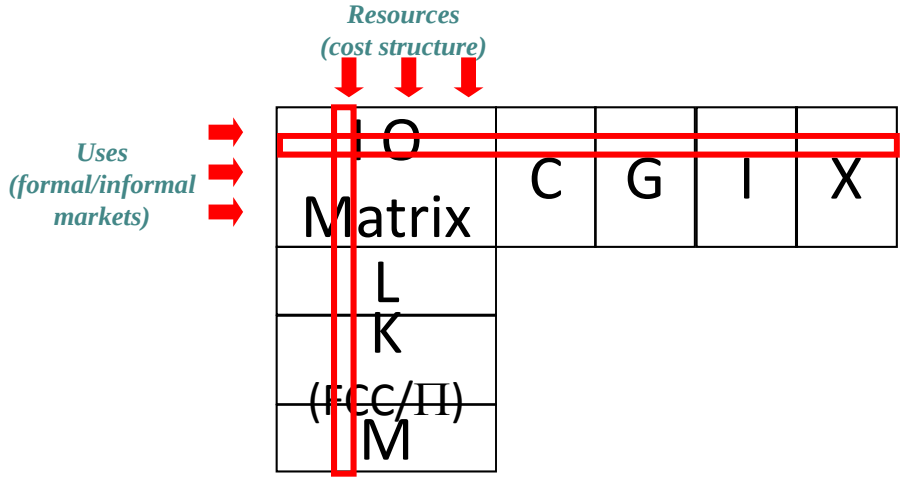
Towards dual accounting systems

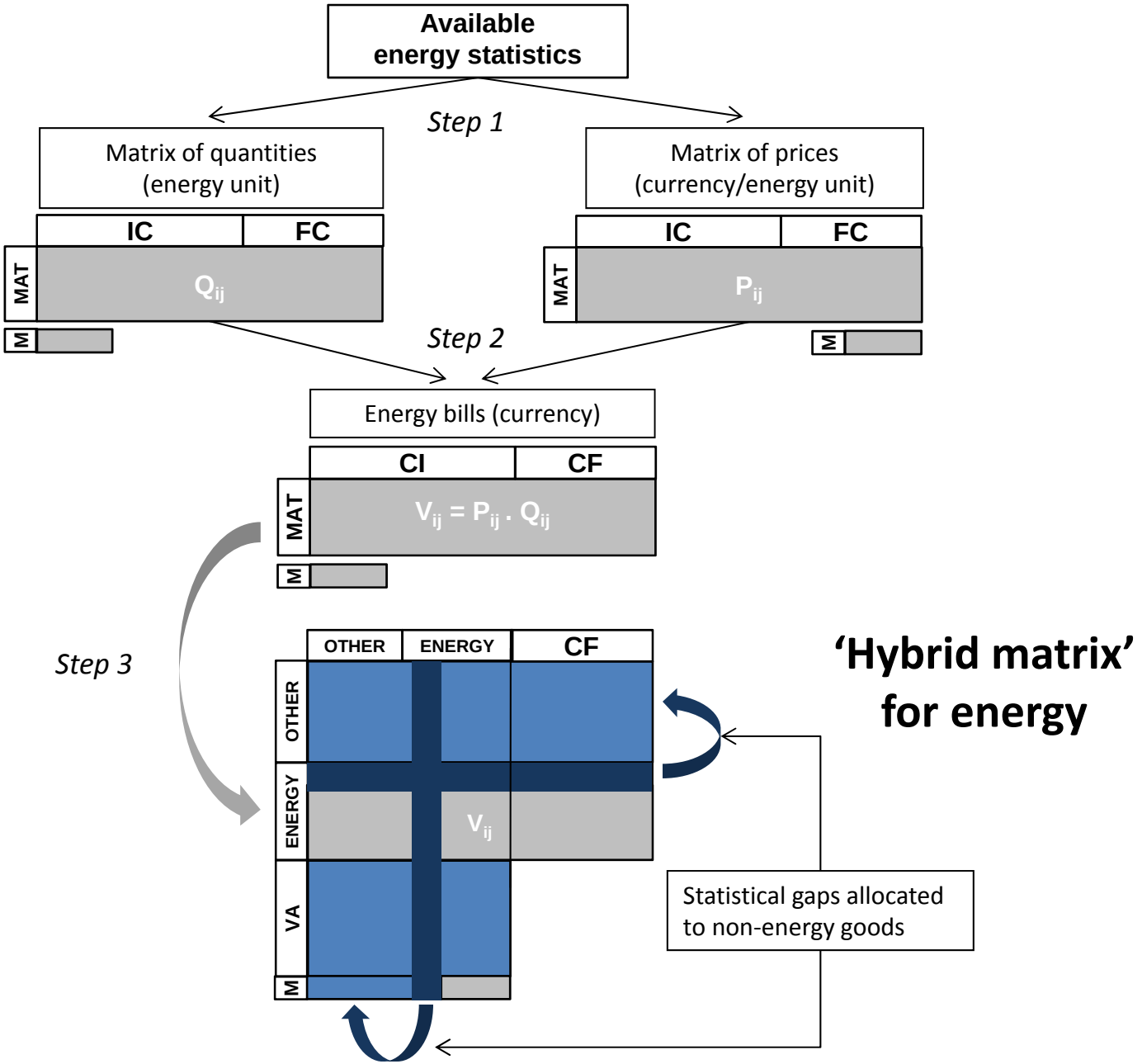
Recurrent debates about the representation of techniques: Re-establish the conditions of control at the interface between technical systems and the global economy

- Back to Arrow-Debreu axiomatic: Dual description of economic flows, General equilibrium in the large sense
- Simultaneous equilibrium of economic and material flows linked by the price system
- Economic projections rely on plausible technical background / technical systems are coherent with the economic environment

In practice: building accounting tables both in monetary values and physical quantities by combining macroeconomic tables and balances of physical flows



Our methodology of Hybridization



Rationale 1 : Using all available information to enrich the picture of the initial economy

Importance of methodologies to combine datasets from different sources (no consistent datasets on quantities/values in official statistics)

Example : Energy-cost shares

- crucial impact on macroeconomic analysis: Energy/GDP ratio, energy bills and CO_2 emissions of households and firms

- but important statistical gaps between national accounts and results obtained by combining statistics on physical quantities and prices (gaps in nomenclature)

Statistical gaps in the economic value of energy flows

French national accounts (Input-Output table, 116 products)		Energy statistics, AIE	Statistical gaps
Energy products/sectors	Values (2004 millions €)	Energy bills (2004 millions €)	
Coal, lignite and peat	1 965	1 558	**26%**
Crude oil and hydrocarbons	26 875	17 234	**56%**
Refined petroleum products	92 974	67 454	**38%**
Gaseous fuels, heat and air conditioning	20 229	15 230	**33%**
Mineral chemistry	*(11 596)*	*(-)*	*(109%)*
Fossil energies, commercial circuit *inc. mineral chemistry*	142 043 *(153 639)*	101 476	**40%** ***(51%)***
Weight in total value of production *inc. mineral chemistry*	4,8% *(5,2%)*	3,4%	**1,4 pts** ***(1,8 pts)***

Statistical gaps in the allocation of carbon emissions

	Energy statistics (calculated)	NAMEA accounts* (published)	Statistical gaps
Total emissions (Mega tons of carbon)	109 107	111 904	**-2,5%**
From production	67 846 (41 261)	76 095 (35 809)	**-10,8% (+15,2%)**
From households Housing / Individual vehicles	16 / 25	17 / 19	**-6,0% / 34,8%**

*** NAMEA : National Accounting Matrix Including Environmental Accounts**

Source : Pasquier (2010). Allocation based on national accounts (macro data on expenditures)

Rationale 2 : Overcoming the limits of standard models

- **Stylized representation of technical dimensions**
  - A-temporal description of technical possibilities: future technical change deduced from the past (econometrics on monetary and macro statistics)
  - Representation valid only in the short-term (‘small deviations’)
  - Impossibility to use sectoral forecasts of technical change possibilities
  - No control on the technical plausibility of ‘important mutations’

- **Stylized economic behaviours**
  - Minimizing immediate costs
  - Maximizing current profit
  - Two polar options for the dynamics:
    - Simulation under myopic expectations
    - Intertemporal optimization under perfect foresight

- **No ‘second-best’ mechanisms** : oligopolies, labour rigidities, technical inertias…

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2. Articulating technical and economic expertises: Bottom-up / Top-down
   - The projected economy is supported by a realistic technical background: explicit description of infrastructures, equipments and technologies.
   - Projected technical systems corresponds to realistic economic flows and relative price sets: description of investment costs and microeconomic decisions

The IMACLIM platform in practice
Two complementary versions

- The static version IMACLIM-S describes socio-economic interactions *at a given time horizon (e.g., 2050)*

  - Heterogeneous socio-economic groups and High sectoral resolution
  - Reduced forms of bottom-up approaches (mimic adjustment possibilities)

- The dynamic recursive version IMACLIM-R describes the trajectories of socio-economic interactions *over a given time period (e.g., 2010-2050)*

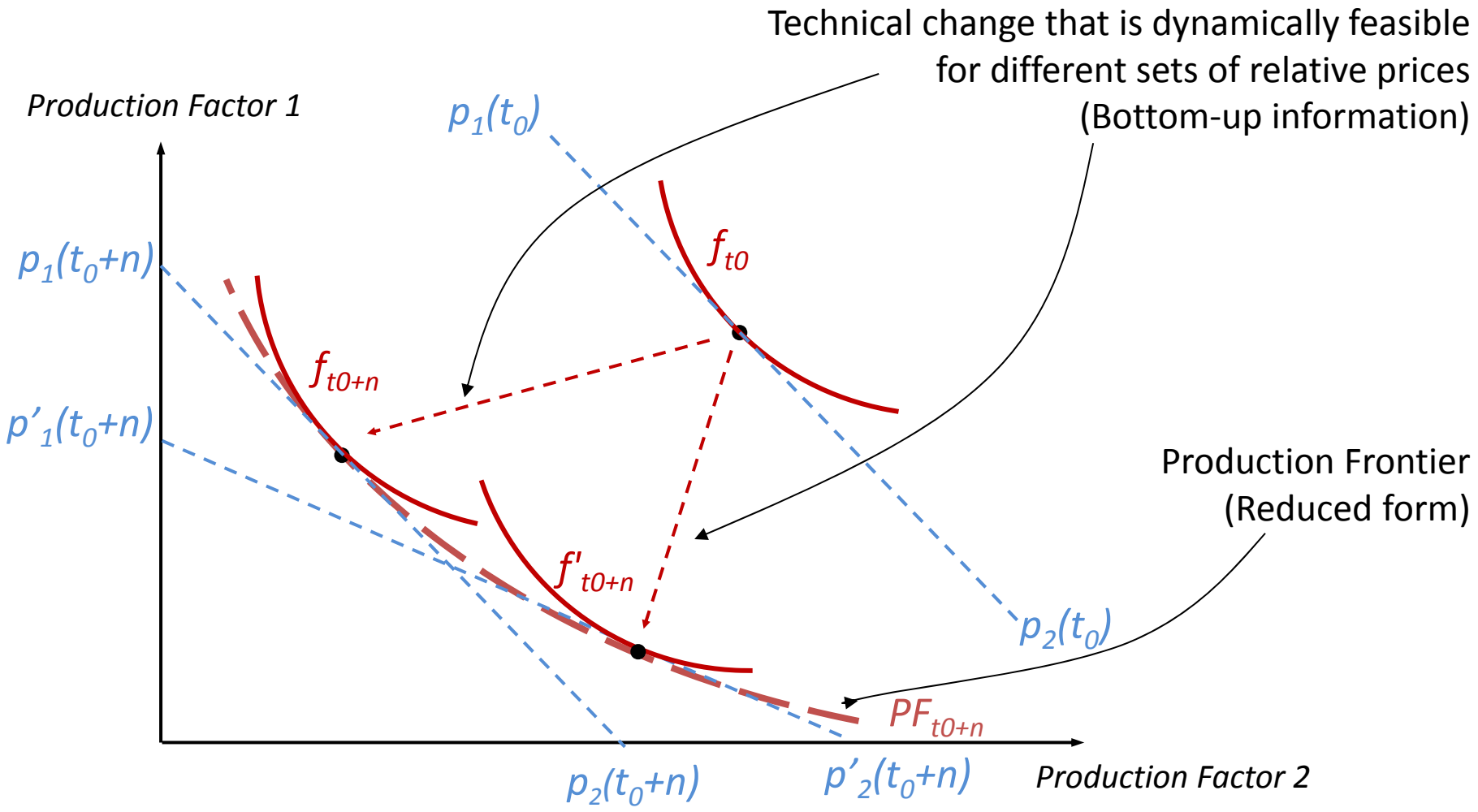
  - Representative agents and Aggregated description of production
  - Explicit dynamic modules describing the reaction of technical systems, resource availability, preferences and location decisions to socio-economic signals

Rationale for using the IMACLIM-S version

- A tool for sensitivity analyses by comparison of various “conceptions” about
  - constraints and potentials (parametric uncertainty on techniques, resources…)
  - modalities of policy implementation associated to various combination of objectives
  - the structure of interactions in the socio-economic system (nature of labor markets, importance of market imperfections, size of the informal sectors)
- Exploring the indirect mechanisms triggered by general equilibrium interactions by abstracting from controversies on dynamic effects
  - Social and Institutional: poverty, inequalities and redistribution mechanisms
  - Investments: financing sources, macroeconomic imbalances

Representation of techniques in IMACLIM-S: reduced forms of bottom-up modules

From detailed bottom-up modules to production possibility frontier as a reduced form



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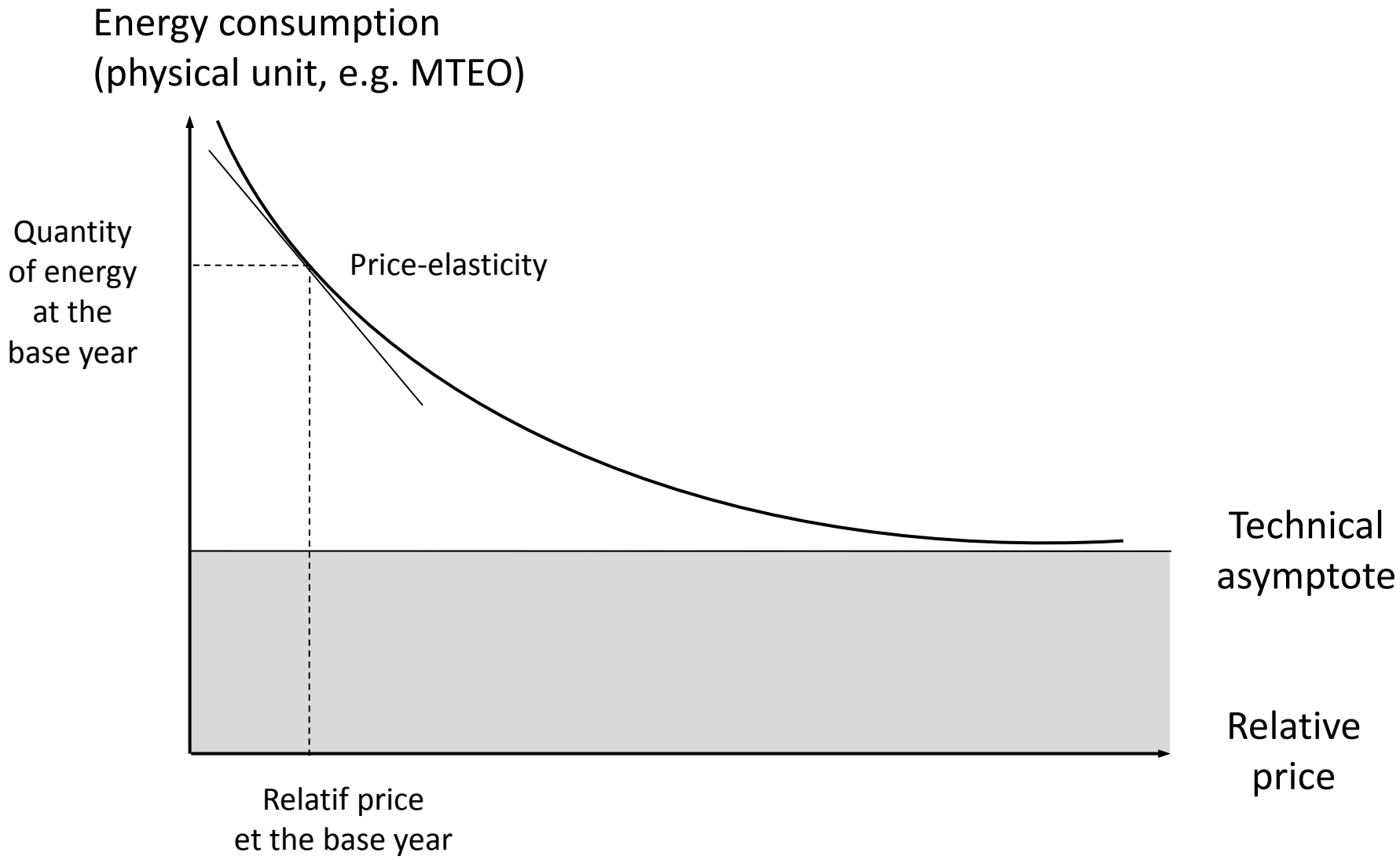


Rationale for using the IMACLIM-R version

- A tool for exploring the dynamic effects and investigate the interplay between short-term and long-term mechanisms
  - Short-term inertias and constraints imposed by installed infrastructures
  - Long-term path dependency of trajectories due to cumulative investments decided under imperfect foresight (risk of 'lock-in' effects)
- Representing the material content of socio-economic trajectories as a result of the interplay between
  - Techniques: incorporation of information from technology-explicit models on production technologies and end-use equipments
  - Resources: constraints on the extraction of fossil resources
  - Locations: representation of land uses at different territorial scales as from the location of transport and housing infrastructure

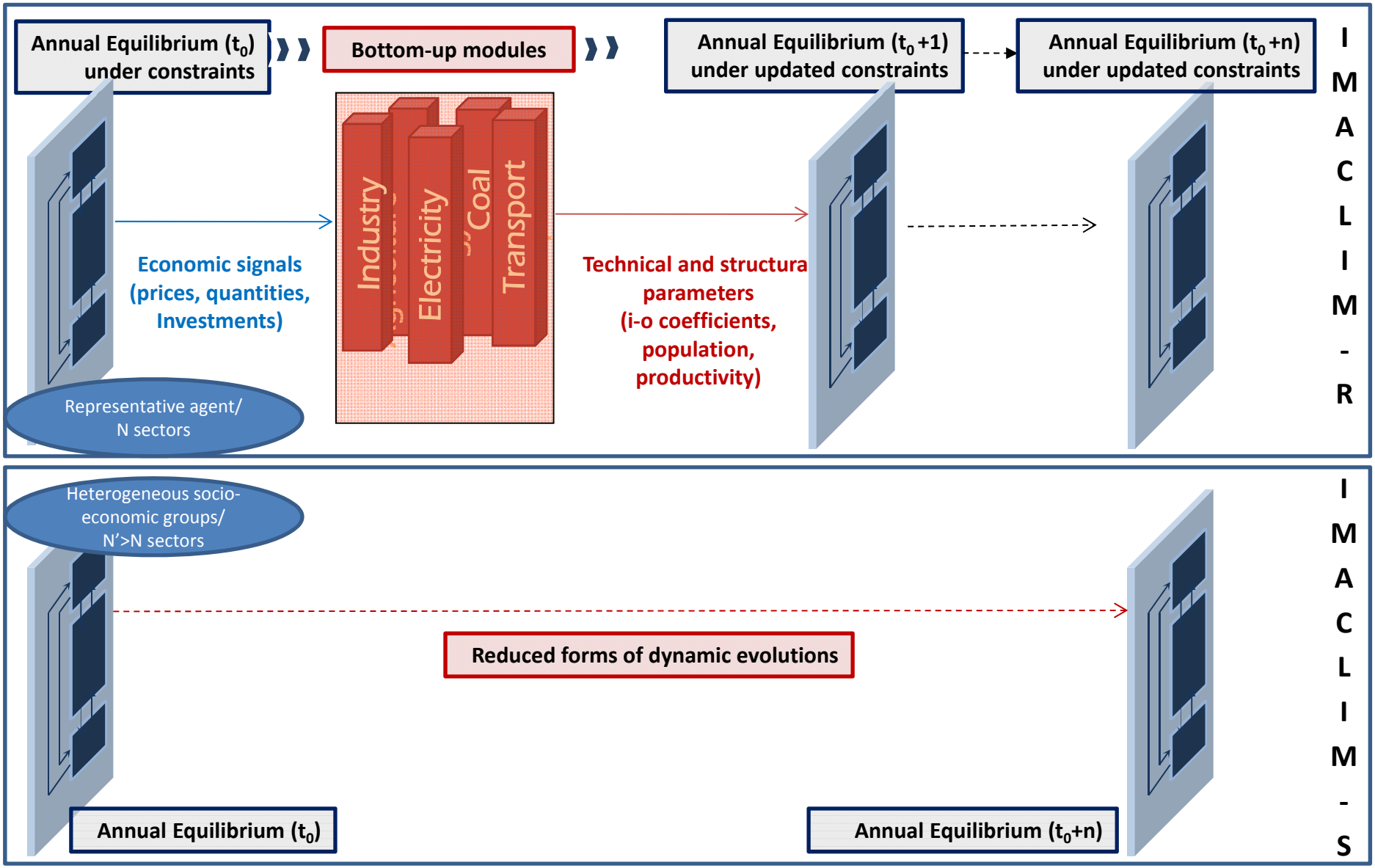
Representation of techniques in IMACLIM-R: detailed bottom-up modules

- Primary energy (oil, coal, gas)
  - Geological, technical and geopolitical constraints

- Energy transformation
  - Electricity : 15 explicit technologies, load curve
  - Liquid fuels : tradeoffs btw. refined oil, biofuels and Coal-To-Liquid

- Final energy demand
  - Residential : stock of m^2 building shell, standards of living
  - Industry : energy efficiency, fuel switch
  - Transport:
    - 5 explicit types of private vehicles
    - constrained mobility in function of urban forms
    - transport infrastructure investments across four modes
    - freight transport intensity of production

A schematic view of the two versions



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3. Articulating growth at different time scales: natural growth / real growth
   - The long-term natural rate of growth is given by demographic and productivity trends
   - Transitory disequilibria happen due to market imperfections and past suboptimal allocation decisions under imperfect foresight

Simulating « non-optimal » economic growth

- An exogenous growth engine defining long-term trends
  - Demography (total and active population)
  - Labor productivity (catch-up)
  - Saving rates (consistent with demographic trends)

- A model of “second best” socio-economic interactions under uncertainty capturing short-term constraints on economic development
  - Imperfect foresight: adaptive anticipations
  - Inertia of capital stocks: past choices constrain future potentials
  - Market imperfections: over- or under-utilization of production factors
  - Physical constraint: availability of natural resources

- A flexibility to represent different beliefs/views about those constraints

The IMACLIM modeling platform
Applications

A variety of questions, A common approach in 5 steps

a) Delineate precisely the policy question(s) under investigation
(project of reform, objectives, domain of dialogue)

b) Identify the partners to collaborate with
(« experts », « policymakers », « stakeholders »)

c) Elaborate the structure of the model
(available data, theoretical issues, controversies)

d) Build a picture of the economy at the initial date
(hybrid matrix at a base year, statistical synthesis, diagnostic)

e) Represent dynamic interactions
(modelling economic, social, technical adjustments)

A number of completed or on-going projects

❑ Global scale with IMACLIM world models

- ➢ Long-term scenarios : development styles, technical change and macroeconomic trajectories
- ➢ Resource depletion and energy markets (Peak Oil)
- ➢ Climate policy analysis : time profiles of costs, sensitivity to technical assumptions, impact of different policy architecture
- ➢ Urban systems and macroeconomic trajectories
- ➢ Energy, land use and food markets (Nexus land-use)

❑ Local scale with IMACLIM national/regional models

- ➢ Carbon taxation (France) …
  - … and distributive justice
  - … pensions and public finance
  - … labour market and competitiveness
- ➢ Structural change, low carbon and inclusive transition (Brazil)
- ➢ Employment, distribution and green growth strategies (South Africa)
- ➢ Energy transition and low-carbon economy (France)
  - Sectoral policies
  - Co-benefits/cost in the short term?
  - Nuclear power: Impact of different pace of phasing out
- ➢ Energy transition and land use in an insular economy (La Réunion)