IRENCGE-DF Model - Assessing Environmental and Regional Effects: description of the model

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IRENCGE-DF: OVERVIEW

The Italian Regional and Environmental Computable General Equilibrium Model of the Department of Finance (IRENCGE-DF) is a (recursive) dynamic single country computable general equilibrium (CGE) model that is developed by MEF with the support of the World Bank.

The model can be calibrated to different Social Accounting Matrices (SAM) that follow a standard set of conventions in representing the economic structure, which we will describe further in the next session.

The model is implemented in the GAMS software. In short, GAMS solves the model by solving a determined system of equations with respect to endogenous variables. Each equation describes agents' behavior with respect to some objective function.

Key changes are the focus on energy, emissions and climate change thanks to both a multi-input/multi-output structure and a detailed energy specification that allows for capital/labor/energy substitution in production; a detailed demographics by age; revised tax equations; in demand system; air pollution impacts on labor productivity; endogenous capital supply to capital stock improved price indices k ratio.

IRENCGE-DF: OVERVIEW

- **Modules:** 2 modules, one for the national version and the other for the regional ones.
- **Agents:** 1 Government, 1 Firm, 1 Rest of the World, 10 Households.
- **Dimensions:**
  - **Environmental module:** 76 sectors, 67 commodities (5 energy commodities), 5 consumer commodities (food, manifactures, services, energy, transports), 13 emission types (9 air pollutants and 4 GHGs), 3 factors of production (land, capital, labor), 2 capital vintages (old and new), 3 labor skill levels (unskilled, skilled and high-skilled).
  - **Regional module:** 20 Regions, 5 sectors, 5 commodities, 13 emission types (9 air pollutants and 4 GHGs), 2 factors of production (capital, labor), 2 capital vintages (old and new),
- **Main blocks:** production block (with nested CES function to derive optimal demand of input/intermediate goods), income block (transfers, taxes, labor and capital incomes), demand block (with CDE demand system for households), trade block (with CET function for export supply allocation and CES function for import demand).
- **Other blocks:** apart from these main blocks, we have different sets of equations describing the model. We can group them in other five blocks: demographic equations, macroeconomic identities, capital market dynamics, emissions and climate change impact channels.

PRODUCTION BLOCK

In this block we have the equations describing the production of gross output in each activity sector.

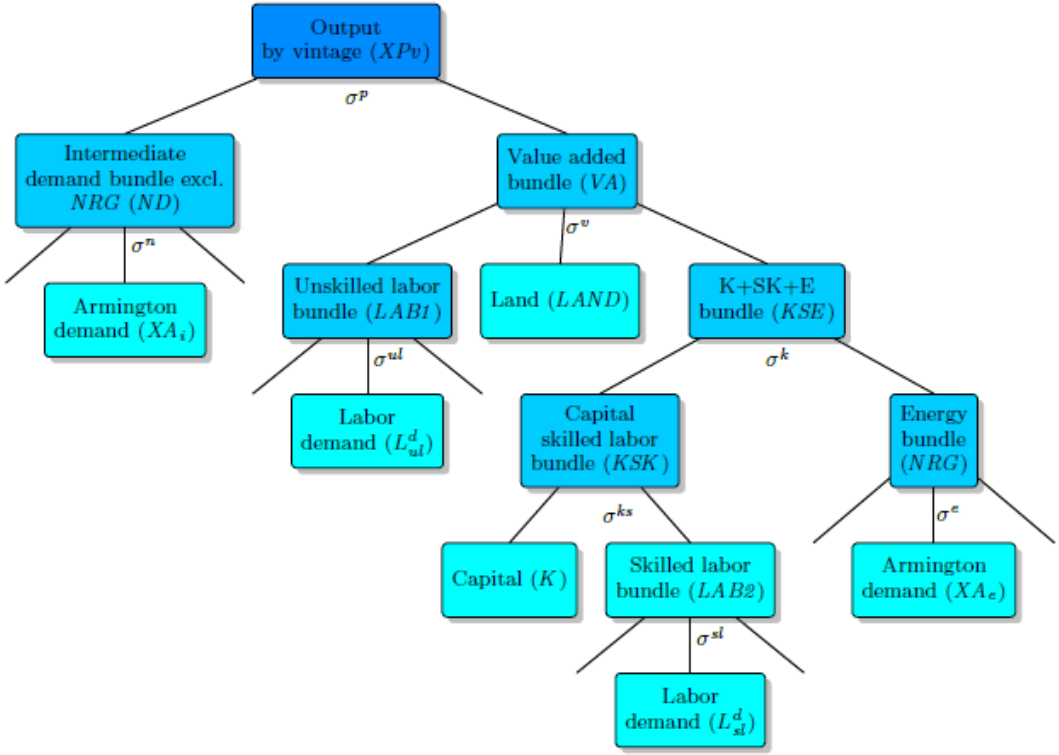
The model uses a nested CES function, i.e. we can obtain a **flexible production structure** by changing elasticities between different input or intermediate goods – which in the end determine different supplementary or complementary conditions – or by twisting their technological and share parameters – which might give cost neutral different input ratios.

The model is **multi-input** because a given activity might use different inputs or intermediate goods. For example, electricity production can be done by multiple activities: thermal, hydro, solar and other renewable forms of electricity production.

The model is **multi-output** because a single activity might produce more than one output. For example, sugar production can produce sugar, ethanol, rum and even power.

The following scheme illustrates how the nested CES production function works:

PRODUCTION BLOCK



INCOME BLOCK

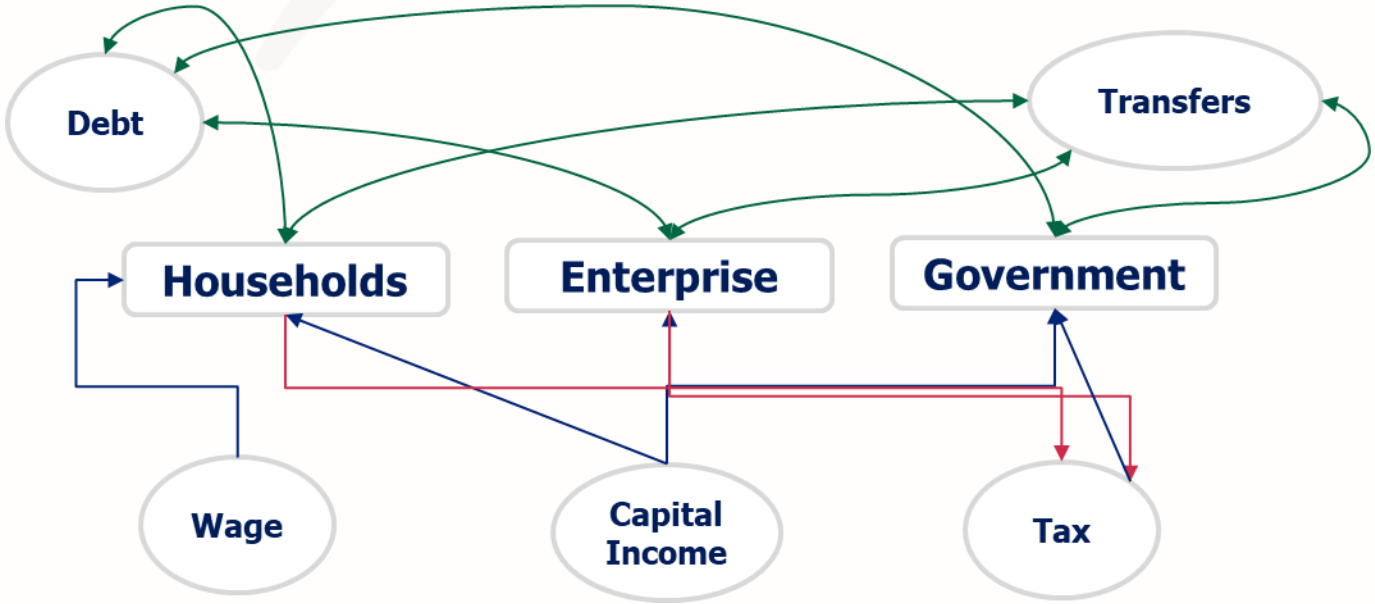
We have multiple households, the government and a representative firm as our final demand agents. In this block we determine their income, which consequently determines their expenditure and saving/investment decisions.

Households are the only ones with labor incomes, differentiated according to their skill level. Moreover, they also receive transfers from and pay taxes to the government. Lastly, they have a share of capital income as they also are the firm's owner, and they finance the government through debt.

Enterprise has a share on capital income, pays taxes and remunerates factor of productions (namely land, capital and labor). It could also receive transfers and finance the government through debt. Together with government and households, enterprise savings determine the national investments.

Government has the residual share of capital income, makes transfers, pays its debt to households, firms and the rest of the world (with distinct foreign and domestic interest rates) and has a stream of revenues thanks to taxation, which is highly detailed with different tax streams in order to simulate different fiscal policies.

INCOME BLOCK



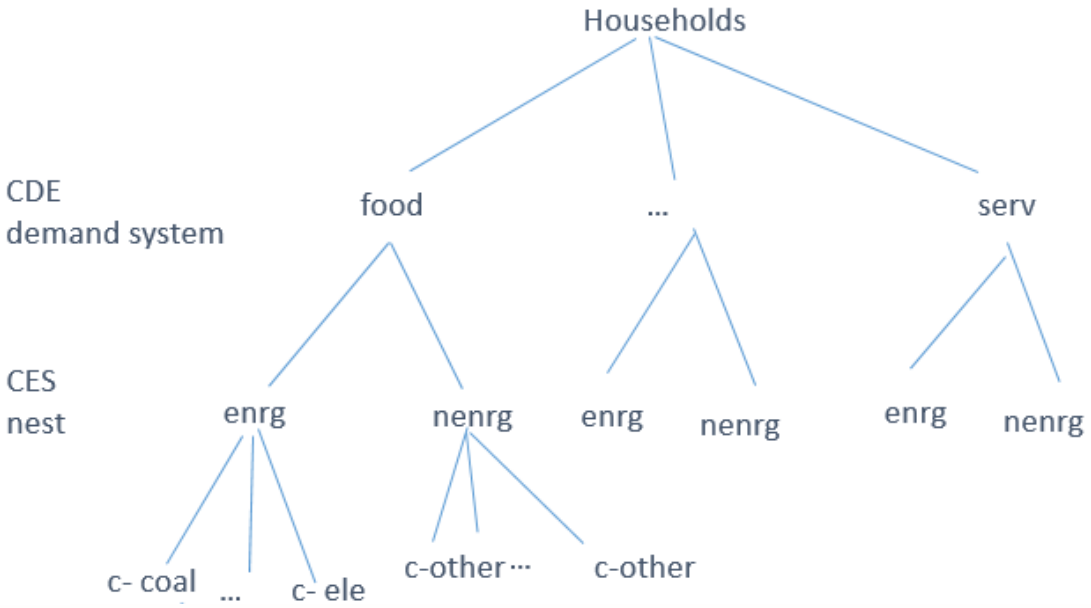
DEMAND BLOCK

Households: they demand consumer commodities (food, manifactures, services, energy, transports – derived with a CDE utility function), which are further broken down as energy and non-energy bundles through a CES function, which lastly determines the Armington demand for all produced commodities (67 in the national module of the model, 5 in the regional ones). Since we are modeling a small open economy, these demands can be satisfied both with domestically produced and imported goods *(see Trade block).* In the regional module, households consume commodities from other regions as well.

Other agents: they have an aggregate expenditure on goods and services which is broken down into the demand for energy and non-energy bundles, which is further broken down into the demand for all produced commodities. The logic is the same as before, but they just have one aggregate demand on top of the nest.

Margins: for each produced commodity there is also a demand for transport margins, which are the sum of 3 different nodes: from factory gate to domestic market, from factory gate to the domestic border for export and from the border to the domestic market for import.

DEMAND BLOCK



TRADE BLOCK

Up so far, we have determined completely the so-called Armington demand for goods across all agents, which include activities, private or consumer demand, other final demand and margin delivery.

In the Trade block, we split this into the demand for domestically produced and imported goods, based on their relative price, by using a national CES function to make the breakdown (→ **Import demand**)

Moreover, in this block we determine through a CET allocation function which part of the domestic production will be allocated in the domestic market and which part will be exported (→ **Export supply**)

Assumptions are:
1. Armington demand for goods is homogenous across agents and so can be aggregated in volume terms.
2. All agents have the same preference function for domestic and imported goods.

OTHER BLOCKS

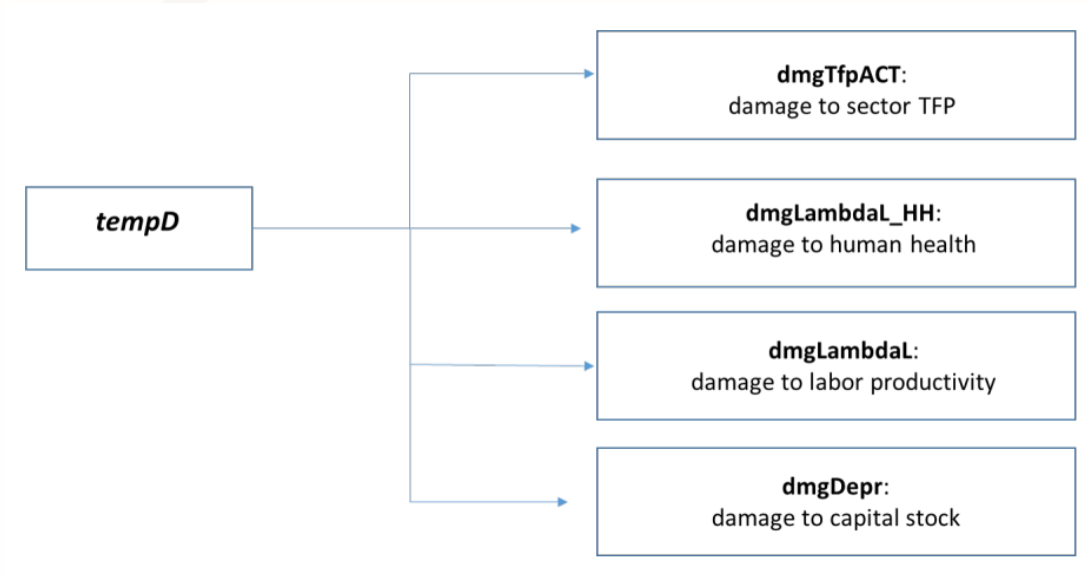
Demographic block determines the population by age, cohorts and multiple households. Only the population in the working age cohort is considered in the labor supply.

Macroeconomic identities are standard: aggregate stock building, aggregate import/export (both in nominal and real terms), aggregate price, GDP (both at market price and factor cost), ecc.

Capital Market dynamics: the model allows for two types of capital vintages (*old* and *new*), to introduce differences between rate of return of capital generated by recent investments and elasticity of substitution in the production function.

Emission block determines the level of emissions associated with consumption for each good (both intermediate and final), use of factors of production and total output for each activity.

OTHER BLOCKS



Climate change impact channels

MODEL CLOSURE

IRENCGE-DF allows for choosing the closure rules flexibly:

Default closure rules are:

- Saving – Investment: By default saving rates fixed, investment adjusts
- Government: Government expenditure and investment are fixed as a share of GDP; government savings adjust
- Rest of the world: Foreign savings are fixed as a share of GDP; real exchange rate adjusts

Default closures can be changed easily.

FUTURE RESEARCH

- Segmented labor markets
- Pricing industrial process and product use emissions and emissions from factor use (e.g. Livestock)
- Flexible production nesting that would allow changing the production nest based on policy question