

MITICA Enhancement

1 Introduction

To enhance MITICA, we are developing four interconnected modules:

1. Macroeconomic Structure Estimation Module
2. Energy Module
3. Land Use, Land-Use Change, and Forestry (LULUCF) Module
4. Integration Module

2 Macroeconomic Structure Estimation Module

The objective of this module is to project Gross Domestic Product (GDP), its sectoral components (primary, secondary, and tertiary sectors), and population dynamics.

2.1 Option 1: Endogenous Estimation

Macroeconomic Model

We define total GDP (Y) as the sum of its demand-side components:

$$Y = C + I + G + (X - M) \quad (1)$$

where:

- C = Consumption (household spending).
- I = Investment (private and public capital formation).
- G = Government spending (public expenditures).
- $X - M$ = Net exports (exports - imports).

User-Defined Inputs for the Projection Period

For the projected period, users can define key macroeconomic variables to drive the model's estimations. If users do not provide these values, they will be estimated based on historical data. The main projection variables include:

- **Interest Rate (r):** Affects investment via capital costs.
- **Population Growth Rate (g_P):** Influences labor supply and consumption.
- **Government Spending (G):** Direct impact on total GDP.
- **Tax Rate (T):** Affects disposable income and consumption.
- **Expected Growth Rate (g):** Drives investment expectations.
- **Net Exports ($X - M$):** Determines trade balance effects on GDP.

2.2 Option 2: User-Defined Inputs with Plausibility Validation

To ensure economic coherence, the following plausibility checks will be applied:

- **GDP Growth Consistency:** Verify that projected GDP growth is in line with historical productivity trends:

$$g_Y = \frac{Y_{t+1} - Y_t}{Y_t} \approx A + \theta I + \psi G \quad (2)$$

- **Investment-Productivity Relationship:** Ensure that investment projections align with plausible productivity increases:

$$g_A = \frac{A_{t+1} - A_t}{A_t} \leq \phi I \quad (3)$$

- **Labor Market Plausibility:** Check if projected GDP growth aligns with employment and population growth:

$$g_Y - g_L \approx g_P + g_A \quad (4)$$

If inconsistencies are detected, feedback will be provided to users to adjust their inputs accordingly.

3 Energy Module

The objective of this module is to project total and sectoral electricity demand and production by technology type.

Approach:

- The Balmorel model (<https://github.com/balmorelcommunity/Balmorel>) will be used for energy system modeling.
- The macroeconomic module will provide total energy demand (linked to the demand component of the model) for the three economic sectors.
- The model will forecast electricity production and consumption based on installed capacity, technological transitions, and energy policies.

4 LULUCF Module

The LULUCF module aims to model carbon dynamics related to land use, land-use change, and forestry activities.

Approach:

- The module integrates the **Generic Carbon Budget Model (GCBM)**, an open-source, spatially explicit framework developed by Natural Resources Canada.
- Spatial data on land cover, land-use changes, forest inventories, and management practices will be used.
- Users can input scenarios related to land management, afforestation, deforestation, and other relevant activities.

5 Integration Module

The integration module represents the current version of MITICA. It consolidates outputs from the Macroeconomic, Energy, and LULUCF modules to project greenhouse gas (GHG) emissions across IPCC categories and evaluate Policies and Measures (PAMs).

Approach:

- **Data Aggregation:** Compiles projections from all modules to form a comprehensive emissions profile.
- **Policy Simulation:** Allows users to simulate the impact of various PAMs on emissions trajectories.
- **Feedback Mechanism:** Provides insights into how changes in one module (e.g., increased renewable energy capacity in the Energy Module) affect overall emissions and economic indicators.