# User Manual: Philia 1.0
## Modeling Sustainable Economies in EViews

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# 1) Instructions for running the program

## 1.1) Requirements

The statistical software EViews (version 11 or later) must be installed on your computer.

EViews is a specialized software designed for estimating, simulating, and analyzing economic models. EViews is known as a user-friendly interface and advanced tools for handling time series, cross-sectional, and panel data. Its programming interface is ideal for implementing SFC models that rely on dynamic interactions between stocks and flows across sectors. Using EViews allows researchers to perform simulations, check model stability, and conduct sensitivity analyses efficiently.

Installing EViews is straightforward. First, download the software from the official EViews website (https://www.eviews.com) and choose the version compatible with your operating system (Windows or macOS). Then, run the installer and follow the on-screen instructions to complete the setup. During installation, you will be asked to enter your license key (provided on purchase). Once installed, you can launch EViews and open and run Philia 1.0 or modify it by importing your data and coding your SFC model equations.

## 1.2) Download and Extract the Program

To use Philia 1.0, first download the Philia 1.0 zip file from the official GitHub repository at the following address: https://github.com/Philia-ecs/Philia1.0/blob/main/Philia1.0.zip. This archive contains all the necessary files and scripts required to run the model in EViews.

Once the file has been downloaded, extract all the contents of the archive to a folder on your computer. Make sure to keep all files in the same directory, as the model's scripts and data are linked together. After extraction, you can open the main EViews project file (00-philia.prg) and begin working with the Philia 1.0 model.

## 1.3) Launch the Program

To start using the Philia 1.0 model, **open the file named 00-philia.prg** by double-clicking on it in your file explorer. This action will automatically **launch EViews** (if it is installed on your computer) and execute the program contained in the file. The script initializes the model by loading all necessary data, parameters, and equations into EViews.
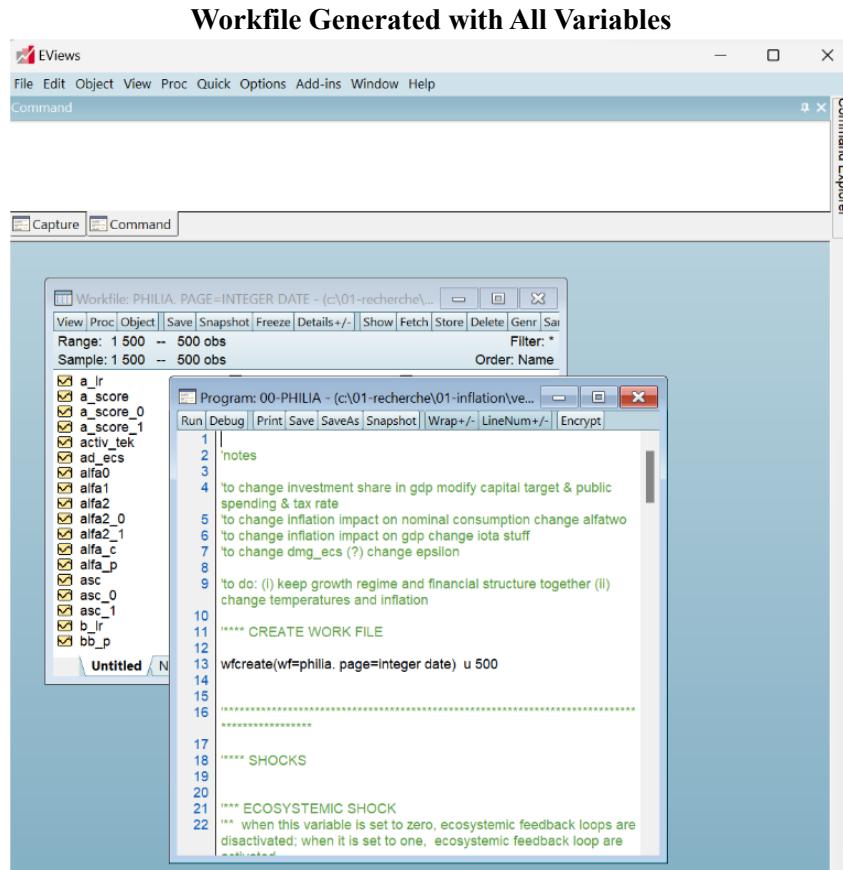
**Launching the File 00-philia.prg from Explorer**

As an alternative, you can also **start EViews first** and then open the program manually. To do this, open EViews, go to **File → Open → Programs...**, and navigate to the folder where the Philia 1.0 files are located. Select the file **00-philia.prg** and click **Open**.

This method provides the same result — it loads and runs the Philia 1.0 model — but it can be useful if you already have EViews open or want to verify the script before execution. Once the file is opened, you can run the program directly by clicking on the button "**Run**" from within EViews to initialize the model and generate the corresponding Workfile.

Once the program has finished running, EViews will generate a **workfile containing all the variables** used in the Philia 1.0 model. This workfile serves as the main environment where you can view data, examine model equations, and perform simulations or analyses.

**Workfile Generated with All Variables**



## 1.4) After Execution

When you run the 00-philia.prg program, it will **automatically generate a Workfile** in EViews. This Workfile serves as the core workspace for the Philia 1.0 model and contains all the variables and results produced by the program.
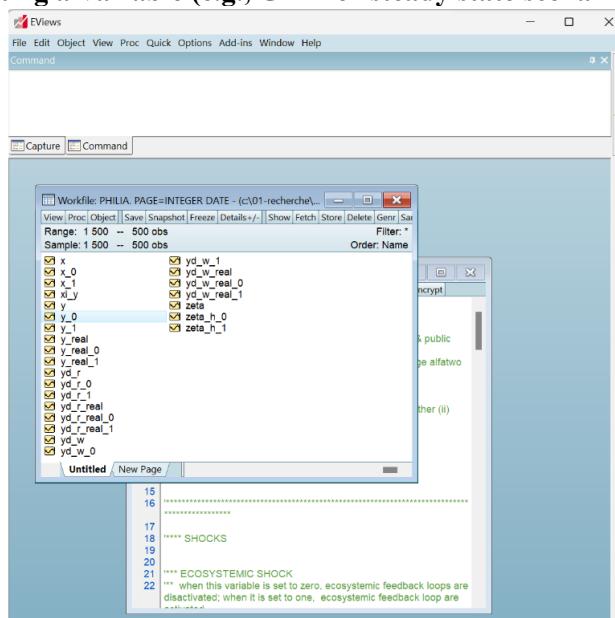
Within the Workfile, you will find variables created for each period and each simulation scenario. Specifically, variables ending with **_0** correspond to the **base scenario** (var_0), while variables ending with **_1** represent the **alternative scenario** (var_1), also referred to as **Scenario 1**. This structure allows you to easily compare results between different scenarios and analyze how changes in assumptions affect the model's outcomes.

## 1.5) Output Analysis
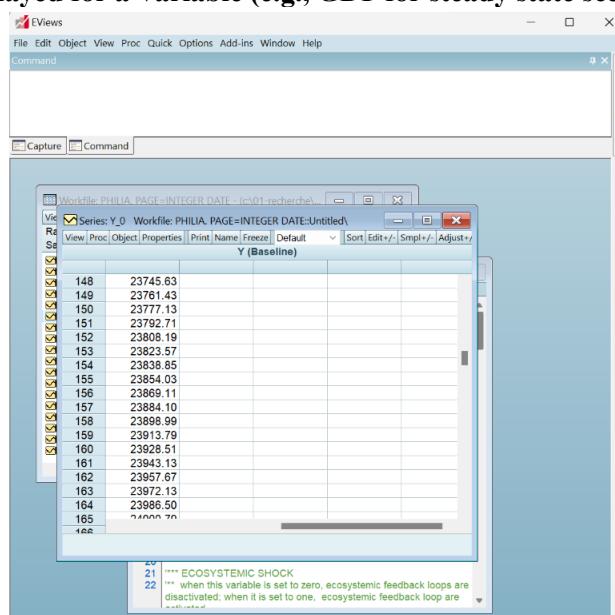
Philia 1.0 is an **Ecological Stock-Flow Consistent (SFC) model**, meaning it ensures that all flows and stocks in the economy, as well as interactions with the ecosystem, are linked through accounting identities and evolve consistently over time. When performing **data analysis**, it is important to focus on the period in which the model reaches a steady state — in this case, from **period 150 to period 210**. This time range represents the phase where the model's variables converge and meaningful economic interpretations can be made.

For example, **GDP** in the steady state scenario is stored in the variable **y_0**. To analyze it, you can select this variable directly in the EViews Workfile. Similar variables exist for other indicators and scenarios, allowing you to visualize and compare the dynamic behavior of the economy across different simulation settings.

**Selecting a Variable (e.g., GDP for steady state scenario: y_0)**
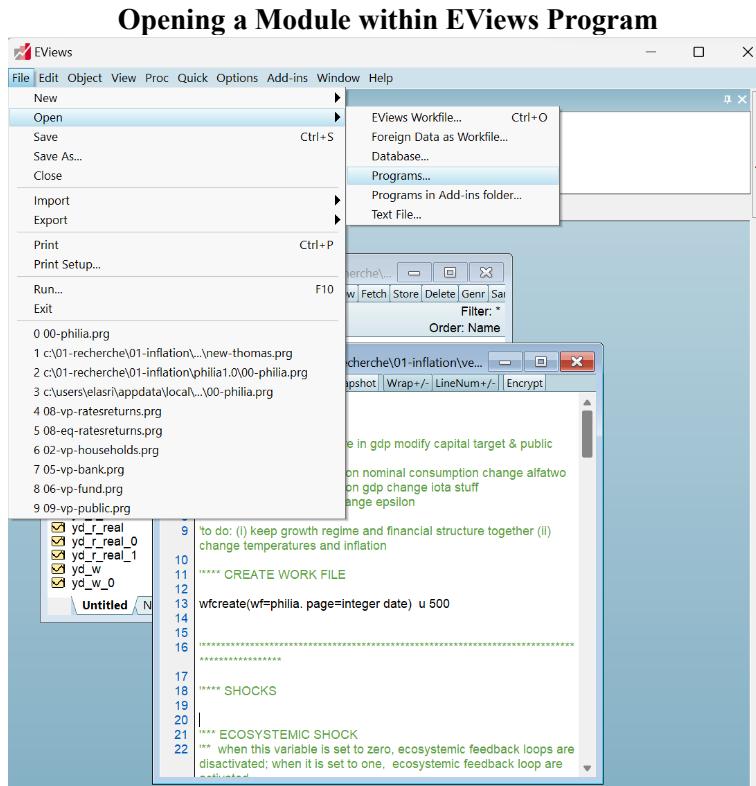


**Data displayed for a Variable (e.g., GDP for steady state scenario: y_0)**

## 1.6) Accessing Additional Modules

To access the **additional modules** used by the main 00-philia.prg program, open them directly within EViews. From the main EViews window, go to **File → Open → Programs...** and then browse to the folder where the Philia 1.0 files are stored. Select the module you wish to view or edit — these modules are individual program files that are called by the main script to perform specific parts of the model.

**Opening a Module within EViews Program**



Each module contains a different set of equations or routines related to particular components of the SFC model, such as aggregate indicators and performance metrics, households behavior and consumption decisions, central bank policy and monetary control, or environmental system and resource management (Table 1). Opening them individually allows you to explore, modify, or extend the model's structure as needed.

**Table 1: The Different Modules Representing the Economic System**

| Module | Title | Description |
|--------|-------|-------------|
| 01 | Macroeconomic model | Aggregate Indicators and Performance Metrics |
| 02 | Households | Household Behavior and Consumption Decisions |
| 03 | Social Businesses | Social Enterprise Sector and Production Activity |
| 04 | Listed Corporations | Corporate Sector and Investment Dynamics |
| 05 | Banks | Banking Sector and Credit Allocation |
| 06 | Investment Funds | Investment Funds and Portfolio Allocation |
| 07 | Central Bank | Central Bank Policy and Monetary Control |
| 08 | Rates and Returns | Interest Rates and Financial Returns |
| 09 | Public sector | Fiscal Policy and Government Spending |
| 10 | Ecosystem | Environmental System and Resource Management |
| 11 | Biomimicry | Biomimetic Monetary Flows and Sustainable Circulation |

# 2) The executable module "00-philia.prg"

The executable module "00-philia.prg" prepares and solves a complex SFC (Stock-Flow Consistent) macroeconomic model that integrates the economy, finance, and the ecosystem. It simulates the interactions between different sectors (households, firms, banks, government, environment, etc.) while respecting fundamental accounting constraints (stock = flow, assets = liabilities, etc.).

It can be used to study various economic policy, ecological transition, and crisis scenarios by activating or deactivating relevant mechanisms.

## 2.1) Variables and parameters

A workfile (named philia) is created to contain all the data and simulations, with 500 periods (custom time units, such as years or quarters):

```
wfcreate(wf=philia. page=integer date)  u 500
```

The following variables (Table 2) are defined to act as switches (values between 0 and 1) that enable or disable specific effects in the model. Changing these variables allows the creation of different scenarios (climatic, financial, technological, etc.).

**Table 2: Activation parameters for various shocks and mechanisms**

| Shock or mechanism | Role in the model | Default value |
|---|---|---|
| ecosystemic_shock | Activates **ecological feedback loops** (e.g., climate impact on the economy) | 0 (off) |
| shock_risk_k, shock_risk_c | Modifies **banks' perception of risk** regarding green credit | 1 (on) |
| shock_tek | Activates **endogenous green technological change** | 0 |
| shock_qe | Activates **central bank interventions** (quantitative easing) | 0 |
| phi_b, phi_g, phi_bg | Simulates **capital gains in secondary markets** for green/brown assets | 0 |

In the order indicated above (Table 1), the modules containing all the variables and parameters are loaded using the "include" command.

For the purpose of their own simulation, users can modify the variables and parameters directly in the corresponding file: 01-VP-macromodel, 02-VP-households, 03-VP-social, 04-VP-capitalist, 05-VP-bank, 06-VP-fund, 07-VP-centralbank, 08-VP-ratesreturns, 09-VP-public, 10-VP-ecosystem, 11-VP-biomimicry. The complete list of variables and parameters can be found in Section 6.

```
'****************************************************
'***** VARIABLES AND PARAMETERS (VP)


'Module 1: Variables and Parameters
include 01-VP-Macromodel

'Module 2: Variables and Parameters
include 02-VP-Households
```

'Module 3: Variables and Parameters
include 03-VP-Social

'Module 4: Variables and Parameters
include 04-VP-Capitalist

'Module 5: Variables and Parameters
include 05-VP-Bank

'Module 6: Variables and Parameters
include 06-VP-Fund

'Module 7: Variables and Parameters
include 07-VP-CentralBank

'Module 8: Variables and Parameters
include 08-VP-RatesReturns

'Module 9: Variables and Parameters
include 09-VP-Public

'Module 10: Variables and Parameters
include 10-VP-Ecosystem

'Module 11: Variables and Parameters
include 11-VP-Biomimicry

## 2.2) Model equations

Next, still following the same order for the different modules (Table 1), all the behavioral, accounting, and dynamic equations of the model are assembled.
Each include command adds a module containing a specific block of equations for one sector of the economy: 01-EQ-macromodel, 02-EQ-households, 03-EQ-social, 04-EQ-capitalist, 05-EQ-bank, 06-EQ-fund, 07-EQ-centralbank, 08-EQ-ratesreturns, 09-EQ-public, 10-EQ-ecosystem, 11-EQ-biomimicry.

'****************************************************
'***** EQUATIONS (EQ)

model philia

'Module 1: covers the basic equations of a macroeconomic model
include 01-EQ-MacroModel

'Module 2: concerns worker and rentier households within the economy
include 02-EQ-Households

'Module 3: invests the social enterprises as companies with virtuous investment behavior
include 03-EQ-Social

'Module 4: adresses listed corporation as a response to market logic

include 04-EQ-Capitaliste

'Module 5: deals with banks in the granting of credit and the purchase of debt
include 05-EQ-Bank

'Module 6: examines investment funds in their financing of the economy
include 06-EQ-Fund

'Module 7: discusses the role of central banks as regulators
include 07-EQ-CentralBank

'Module 8: determines different interest rates and rates of return
include 08-EQ-RatesReturns

'Module 9: studies the public sector, both government and state-owned enterprises
include 09-EQ-Public

'Module 10: presents the relationship between the ecosystem and the economy
include 10-EQ-Ecosystem

'Module 11: contains the intersectoral monetary 'trophic' flows
include 11-EQ-Biomimicry

philia.solve

---
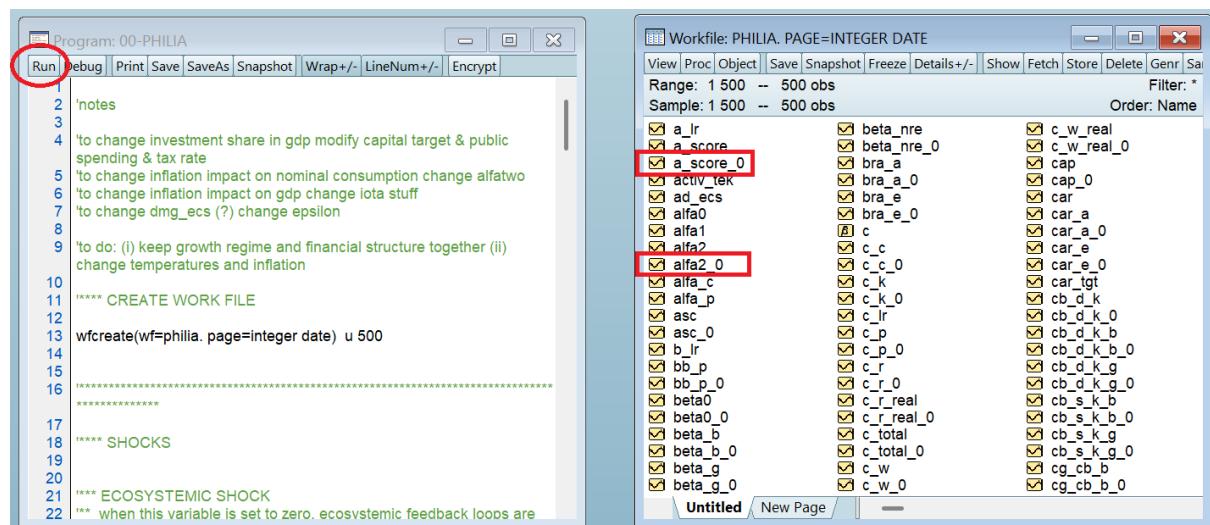
Using the command "philia.solve", all the equations are solved for each period.

philia.solve

---

## 2.3) Execution and results

After running the "00-philia" module by clicking the "Run" button and then OK (left window), the results of this first simulation will appear in a Workfile containing all generated variables and parameters (right window).
Since this is the first simulation, all variables and parameters will have the suffix "_0".

## 2.4) Model calibration and steady-state verification

A model is considered well-calibrated in Philia 1.0, and in stock flow consistent model, when it converges to a steady state — that is, a theoretical long-run equilibrium in which all key variables reach credible levels and grow at a constant rate. This condition, as defined by Godley and Lavoie (2012, p. 71), applies to both stocks and flows, in contrast to short-run equilibria where only flows may stabilize temporarily.

The module "12-Stationary" is designed to verify that the model effectively reaches a steady-state condition starting from period 150. In this context, a set of ratios is created to check that key variables grow at the same proportional rate over successive periods — a necessary condition for steady-state equilibrium.

```
'Steady-state verification
include 12-Stationary
```

To perform this check, Philia computes and plots several stationary ratios, each comparing the relative changes ($\Delta$) of major macroeconomic variables.

The first and main ratio, stationary_yk, compares the growth of GDP ($\Delta Y$) with the growth of the total stock of productive capital ($\Delta K$). A corresponding graph is generated (show fig0_ssflow_yk) to illustrate that, at the steady state, the ratio $\Delta Y/\Delta K = 0$ — meaning both variables increase at the same constant rate.

```
series stationary_yk = d(y_0/k_0)

smpl 150 210
graph fig0_ssflow_yk.line stationary_yk
fig0_ssflow_yk.axis(l) range(-0.1,0.1)
fig0_ssflow_yk.addtext(t) GDP to capital stock ratio
show fig0_ssflow_yk
```

Similarly, the module generates and plots additional ratios that compare the growth rates of consumption, investment, bank deposits, household wealth (total, workers, and rentiers), the wage bill, and disposable income.
Each of these variables is successfully compared with:
- The growth of GDP ($\Delta Y$),
- The growth of the total capital stock ($\Delta K$), and
- The growth of total household wealth ($\Delta V$).

These graphical checks confirm whether the model is properly calibrated — that is, whether all key stocks and flows expand in stable proportions once the transient phase has passed.

This method of steady-state verification follows the approach described by Godley and Lavoie (2012), who emphasize that a consistent stock-flow model should converge endogenously to a steady state where both stocks and flows grow at compatible rates.
Formally, for any two variables i and j, steady-state consistency requires that their growth rates be equal ($g_i = g_j$). This can be expressed as follows:

$$\frac{\Delta i}{\Delta j} = \frac{i_t}{j_t} - \frac{i_{t-1}}{j_{t-1}} = \frac{(1+g_i)i_{t-1}}{(1+g_j)j_{t-1}} - \frac{i_{t-1}}{j_{t-1}} = \frac{(g_i - g_j)i_{t-1}}{(1+g_j)j_{t-1}}$$

At the steady state, when $g_i = g_j$, we have:

$$\frac{\Delta i}{\Delta j} = 0$$

This implies that the main flow/flow, flow/stock, and stock/stock ratios remain constant.
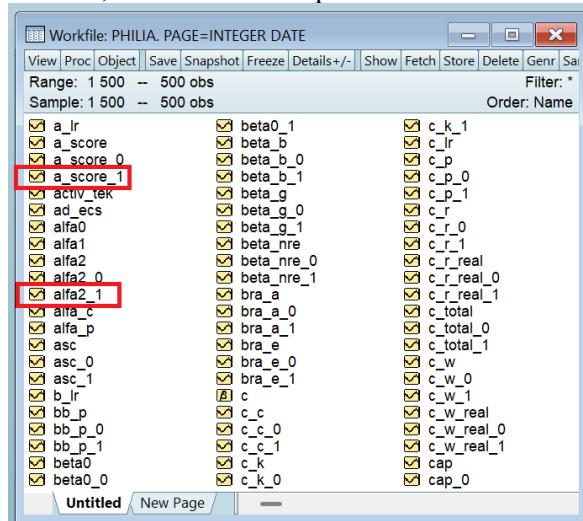
A consistent and properly calibrated model should reach this steady state endogenously—that is, without further adjustment—after an initial transient period. Philia 1.0 reaches its steady state after approximately 150 iterations, using EViews' Broyden algorithm.

## 2.5) Scenario analysis

A new simulation scenario is generated with the command "philia.scenario" for periods 150 to 210, indicated by "smpl 150 210". For these periods (150–210), the ecosystemic shock is activated (ecosystemic_shock = 1). It is possible to activate or deactivate other shocks or mechanisms, as well as to modify certain parameters. The complete list of variables and parameters can be found in Section 7. Then, the model simulation is executed again using "philia.solve" for all periods 1 to 500 ("smpl @all"), and all results (GDP, emissions, balance sheets, etc.) are displayed in a Workfile window.

```
philia.scenario "scenario 1"
smpl 150 210
ecosystemic_shock =1
smpl @all
philia.solve
```

Since this is the second simulation, all variables and parameters will now have the suffix "_1".

# 3) Stability and robustness analysis: Monte carlo Simulation

The module "13-MonteCarlo" is designed to analyze the model's response to changes of its parameters in a specific scenario. As with all stock-flow consistent models, the economy shall give fairly consistent results in the short and long term, regardless of the value of parameters, as pathways are constrained by the watertight accounting structure.

```
'Monte Carlo simulation
include 13-MonteCarlo
```

## 3.1) Defining the baseline scenario

This section sets up and solves a baseline scenario for the "philia" model.
- The ecosystemic_shock is activated (set to 1), meaning that environmental feedback effects are included.
- The model is solved for a sample period from time 150 to 210.
- This produces a baseline trajectory for variables such as:
    - Temp_atm → atmospheric temperature
    - y → GDP
    - k → capital stock
    - v → household wealth

```
'Scenario baseline
philia.scenario(n) "scenario 2"
ecosystemic_shock=1
smpl 150 210
philia.solve
```

## 3.2) Setting up Monte Carlo parameters

A Monte Carlo experiment is prepared with 500 iterations.
We choose a small intensity of deviation around the mean (IDM) (0.0005), controlling the variance of the shocks applied to key parameters. The value of IDM shall be set depending on computing power, which will change depending on the scenario under scrutiny and the parameters subject to Monte-Carlo analysis.

```
'Monte Carlo parameters
scalar IDM
IDM=0.0005
smpl @all
!reps = 500
```

## 3.3) Randomizing key behavioral parameters

For each iteration !i:
- The code generates slightly different values of the key behavioral parameters:
    - alpha1 → impacts household consumption via disposable income.
    - alpha2 → impacts consumption via accumulated wealth.
    - nu_c → affects investment by social businesses.
    - nu_k → affects investment by listed corporations.
- Each parameter is drawn from a normal distribution centered around its mean, with a variance equal to: IDM × mean.
- This Monte Carlo analysis therefore applies a sensitivity analysis to the core parameters determining the demand for investment and the demand for consumption goods

```
'Randomizing key behavioral parameters
for !i=1 to !reps

!mean_alfa1 = 0.85
!var_alfa1 = IDM*!mean_alfa1

!mean_alfa2 = 0.02
!var_alfa2 = IDM*!mean_alfa2

!mean_nu_c = 0.07
!var_nu_c = IDM*!mean_nu_c

!mean_nu_k = 0.09
!var_nu_k = IDM*!mean_nu_k

!n = 10

series alfa1!i = !mean_alfa1 + @sqrt(!var_alfa1)*nrnd
series alfa2!i = !mean_alfa2 + @sqrt(!var_alfa2)*nrnd
series nu_c!i = !mean_nu_c + @sqrt(!var_nu_c)*nrnd
series nu_k!i = !mean_nu_k + @sqrt(!var_nu_k)*nrnd

next
```

This means each simulation run draws on a different set of time-varying parameters.

## 3.4) Solving the model for each Monte Carlo iteration

The model is re-solved 500 times, each time using the randomly drawn parameter values (alfa1!i, alfa2!i, nu_c!i, nu_k!i).

```
'Solving the model for each Monte Carlo iteration
for !i=1 to !reps

philia.scenario(a=!i) "scenario 2"
alfa1=alfa1!i
alfa2=alfa2!i
nu_c=nu_c!i
nu_k=nu_k!i
```

```
smpl 150 210
smpl @all
philia.solve

next
```

This produces 500 possible trajectories for all endogenous variables (temperature, GDP, capital, wealth, etc.).

## 3.5) Computing relative changes (gaps)

For each iteration !i, the code calculates the percentage change relative to the baseline (_0):
- temp_gap → % deviation of atmospheric temperature
- y_gap → % deviation of GDP
- k_gap → % deviation of capital stock
- v_gap → % deviation of household wealth

```
'Computing relative changes (gaps)
for !i=1 to !reps

series temp_gap!i=((Temp_atm_!i-Temp_atm_0)/Temp_atm_0)
series y_gap!i=((y_!i-y_0)/y_0)
series k_gap!i=(k_!i-k_0)/(k_0)
series v_gap!i=((v_!i-v_0)/v_0)

next
```

These variables measure the sensitivity of the model outcomes to parameter uncertainty.

## 3.6) Building cumulative distribution plots (CDFs)

These commands create empirical cumulative distribution functions (CDFs) of the observed difference between the value of each variable hence obtained, and its baseline value (obtained under the steady state scenario).

```
'Building cumulative distribution plots (CDFs)
pagestack (wf=try) temp_gap? y_gap? k_gap? v_gap?

freeze(mc_temp) temp_gap.distplot cdf
freeze(mc_y) y_gap.distplot cdf
freeze(mc_k) k_gap.distplot cdf
freeze(mc_v) v_gap.distplot cdf

show mc_temp mc_y mc_k mc_v
```

The CDF shows, for instance, the probability that GDP deviates by less than a given percentage from its baseline value, under parameter uncertainty.

## 3.7) Interpretation of the graphs
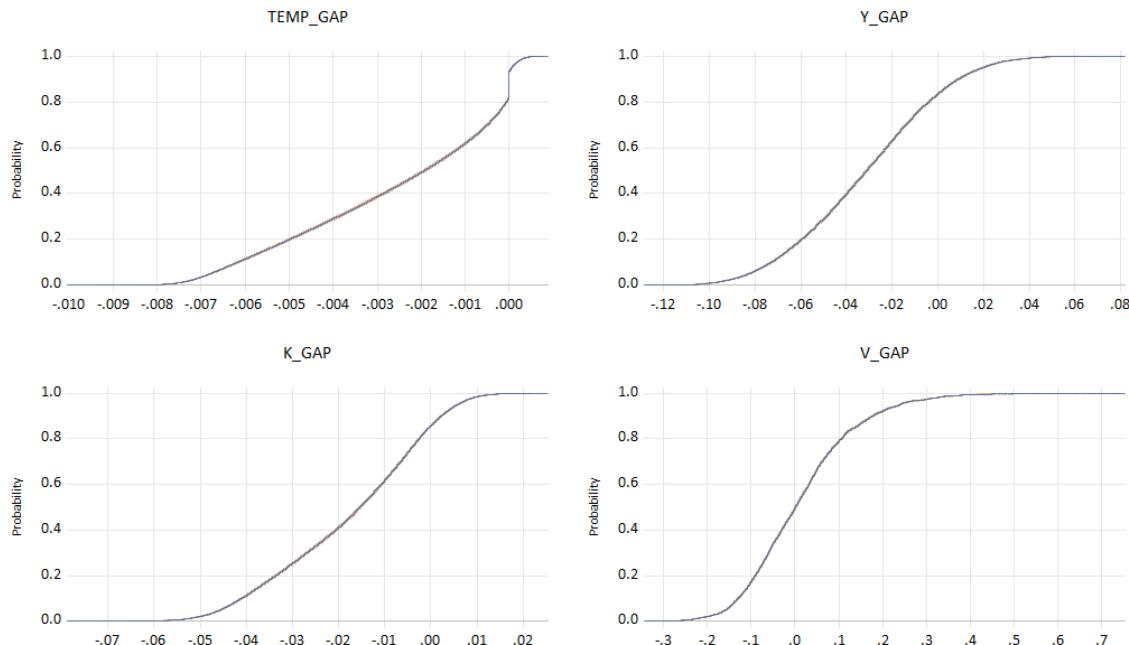
The four cumulative distribution plots represent the uncertainty distributions of the simulated deviations (or *gaps*) in key variables—atmospheric temperature, GDP, capital stock, and household wealth— relative to the baseline scenario (Figure 1). Together, they illustrate how small stochastic variations in behavioral parameters, particularly those affecting consumption and investment decisions, propagate through the ecological macroeconomic model.

The first panel shows the atmospheric temperature gap. The temperature gap's nearly linear CDF indicates an extremely stable environmental subsystem: in the presence of random fluctuations in economic behavior, atmospheric temperature remains almost unchanged relative to the baseline trajectory. This suggests that, within the model's time horizon and structure, environmental dynamics evolve in a smooth and predictable way. This provides a robustness check for the stability of ecosystemic interactions: structural changes are necessary to alter the temperature pathways.

The second panel shows the GDP gap. While most GDP outcomes cluster near the baseline, behavioral uncertainties—particularly in consumption propensities— do induce variations in aggregate output, in the short and long term. The third and fourth panel, depicting the gaps in the stocks of capital and financial wealth, displays wider distribution of trajectories.  In stock-flow consistent models, stocks keep the memory of the past flows. Accordingly, monetary wealth accumulation emerges as the most volatile and uncertain outcome in the system. This is a typical feature of a post-Keynesian model, where the economy is conceived as being in a permanent state of disequilibrium, with no restoring force ensuring full employment. However, interpretation of all logical sequences is possible since "*the skeleton and the dynamic equations provide a structure that restricts all possible results*" *(Lavoie, 2004, p. 75).*

In summary, the model demonstrates **robust global stability**: random, time-varying shocks to key behavioral parameters—such as those governing consumption and investment—do not lead to explosive or chaotic dynamics in the system's key macroeconomic or environmental variables.

**Figure 1: Uncertainty distributions of the simulated gaps in key variables**

# 4) Architecture of the different Modules

**Main macroeconomic indicators (Module 1)**
These include gross domestic product (GDP), investment, consumption, inflation, and capital stocks. These variables serve as reference points for evaluating the dynamics generated by the model.

The model integrates several **institutional sectors**, each represented by a dedicated module:
- **Households** (**Module 2**),
- **Companies**, subdivided into **social enterprises (Module 3)** and **listed firms (Module 4)**,
- The **financial sector**, encompassing **banks (Module 5)** and **investment funds (Module 6)**,
- **Public organizations**, including the **central bank (Module 7)** and **state-owned enterprises (Module 9)**.

For all institutional-sector modules, the circulating monetary flows between sectors are explicitly modeled to establish inflows and outflows of funds, enabling the computation of sectoral balances for each period.

**Households (Module 2)**

In **Module 2**, the balance of the household sector is defined as the difference between disposable income (inflows) and consumption (outflows).
Disposable income differs across working households and rentier households.
- For working households, it includes wages, dividends from social enterprises, and interest on deposit savings, net of income taxes.
- For rentier households, disposable income originates from dividends paid by investment funds and interests on deposit savings, both also subject to taxation.

**Companies (Modules 3 and 4)**
**Modules 3 and 4** distinguish between **social enterprises** and **listed firms**, both required to pay taxes on profits.
- **Social enterprises (Module 3)** derive revenue from household consumption, private investment, and public expenditure, from which they subtract wages, asset depreciation, and interest payments on bank loans (green and brown).
- **Listed firms (Module 4)** follow a similar structure but additionally pay interest on corporate bonds and commercial paper**s** (green and brown).

**Public Organizations (Modules 7 and 9)**
**Modules 7 and 9** describe the public sector.
- The **government budget balance (Module 9)** comprises tax revenues from households and companies, income from public central bank equity and profits, and expenditures including public spending (supporting companies) and interest on government bonds.
- **State-owned enterprises (Module 9)** generate income from household consumption and investment, offset by wage costs and depreciation.
- The **central bank (Module 7)** mostly provides liquidity to financial institutions and, in exchange, receives interest payments.

**Financial Sector (Modules 5 and 6)**

**Modules 5 and 6** formalize the mechanisms through which the financial sector—banks and investment funds—operate.
- **Banks (Module 5)** receive interest income from loans to social enterprises and listed firms, corporate bonds, commercial papers, and government securities, as well as from deposits held at the central bank. They, in turn, pay interest on household savings and on reserve loans from the central bank.

- **Investment funds (Module 6)** act as intermediaries for rentier households, receiving dividends from banks and listed firms, and interest from government bonds and bank deposits.

Real sector transaction flow variables are denoted by a capital letter. In the financial sector, a lower-case letter denotes a flow variable, and an upper-case letter denotes a stock variable. Regarding subscripts (Table 3), the first subscript reads $s$ or $d$ to indicate whether the corresponding variable is supply or demand-side. The second subscript identifies the sector to which the variable belongs: the household sector ($h$), worker households ($w$), rentier households ($r$), social firms ($c$), listed firms ($k$), banks ($bk$), investment funds ($if$), the central bank ($cbk$), and the public sector ($p$). The third subscript, when present, applies a green ($g$) or brown ($b$) taxonomy to the variable. A (-1) subscript indicates a lagged variable. A variable which is preceded by the sign $\Delta$ is first-differenced.

**Table 3: Subscripts used in Philia 1.0**

| Symbol | Code | Description | Symbol | Code | Description |
|--------|------|-------------|--------|------|-------------|
| $c$ | _c | social firms (coop firms) | $ecs$ | _ecs | ecosystem |
| $k$ | _k | listed corporations | $sa$ | _sa | savings account |
| $p$ | _p | public sector (government) | $l$ | _l | bank loans |
| $w$ | _w | working households | $cb$ | _cb | corporate bonds |
| $r$ | _r | rentier households | $cp$ | _cp | commercial papers |
| $h$ | _h | households | $gb$ | _gb | government bonds |
| $if$ | _if | investment funds | $df$ | _df | deposit facility |
| $bk$ | _bk | banks | $mr$ | _mr | mandatory reserve |
| $cbk$ | _cbk | central bank | $xs$ | _xs | excess |
| $d$ | _d | demand | $qe$ | _qe | quantitative easing |
| $s$ | _d | supply | $e$ | _e | equities |
| $g$ | _g | green | $LR$ | _lr | lender risk |
| $b$ | _b | brown | $wb$ | _wb | wage bill |
| $-1$ | (-1) | previous period value | $f$ | _f | firms |

**Table 3: Superscripts used in Philia 1.0**

| Symbol | Code | Description | Symbol | Code | Description |
|--------|------|-------------|--------|------|-------------|
| $a$ | _a | ex-ante | $T$ | _Tgt | target |
| $e$ | _exp | expected, ex-post | $max$ | _max | maximum |
| $\widehat{\phantom{x}}$ | _real | real value | | | |

**Module 8** defines expectations and values in financial markets, determining **interest rates** and **returns** on financial assets (Figure 3).

**Environmental Feedback (Module 10)**
Module 10 captures the **interactions between the economy and the environment** (Figure 4). The depletion rates of material and energy resources are computed as the ratio of resource extraction or energy use to lagged reserves. Economic damages due to climate change are modeled as a nonlinear function of temperature variations, reflecting persistent supply shocks from resource depletion and climate-induced losses.

**Monetary Trophic Flows (Module 11)**
Finally, **Module 11** describes the **monetary trophic flows**, illustrating how money circulates across different levels of the economic system—from producers to consumers, and among households, firms, financial institutions, and government, generating various levels of throughput, resilience and capacity for evolution.

**Stationarity (Module 12)**
**Module 12** verifies that the model converges toward a **steady-state equilibrium**, where all key stocks and flows grow at consistent rates. By computing and comparing stationary ratios—such as GDP to capital or wealth growth—it ensures that the system achieves long-run proportional stability and internal coherence after the transient phase.

**Monte Carlo Simulation (Module 13)**
**Module 13** tests the model's stability and robustness through **Monte Carlo simulations**, introducing small stochastic variations in behavioral parameters such as consumption and investment propensities. By analyzing the resulting distributions of GDP, capital, wealth, and temperature, it evaluates the model's sensitivity and resilience to uncertainty and random perturbations.

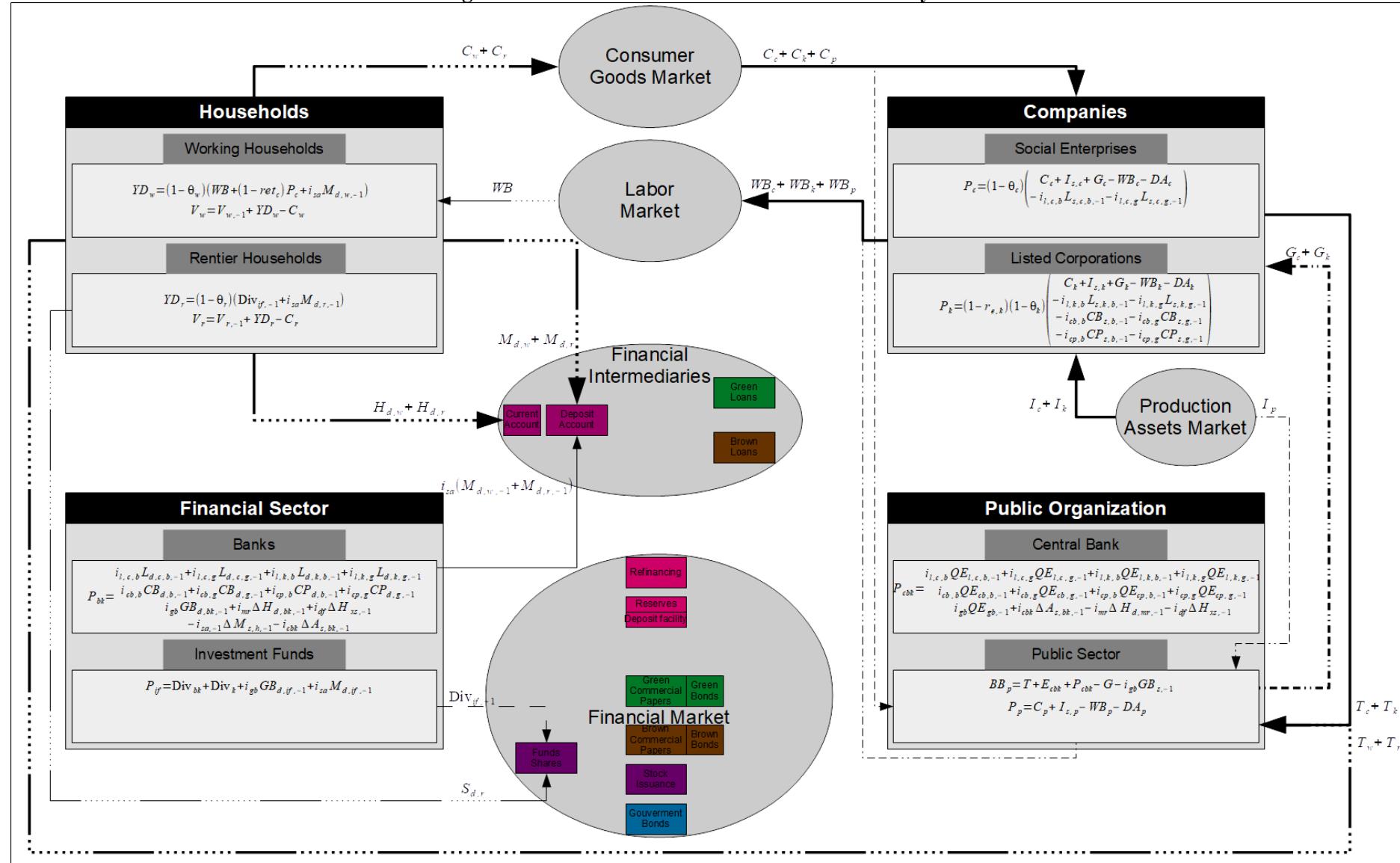**Figure 2: The circular flow model : The economic system**

**Figure 3: The circular flow model : The financing system**
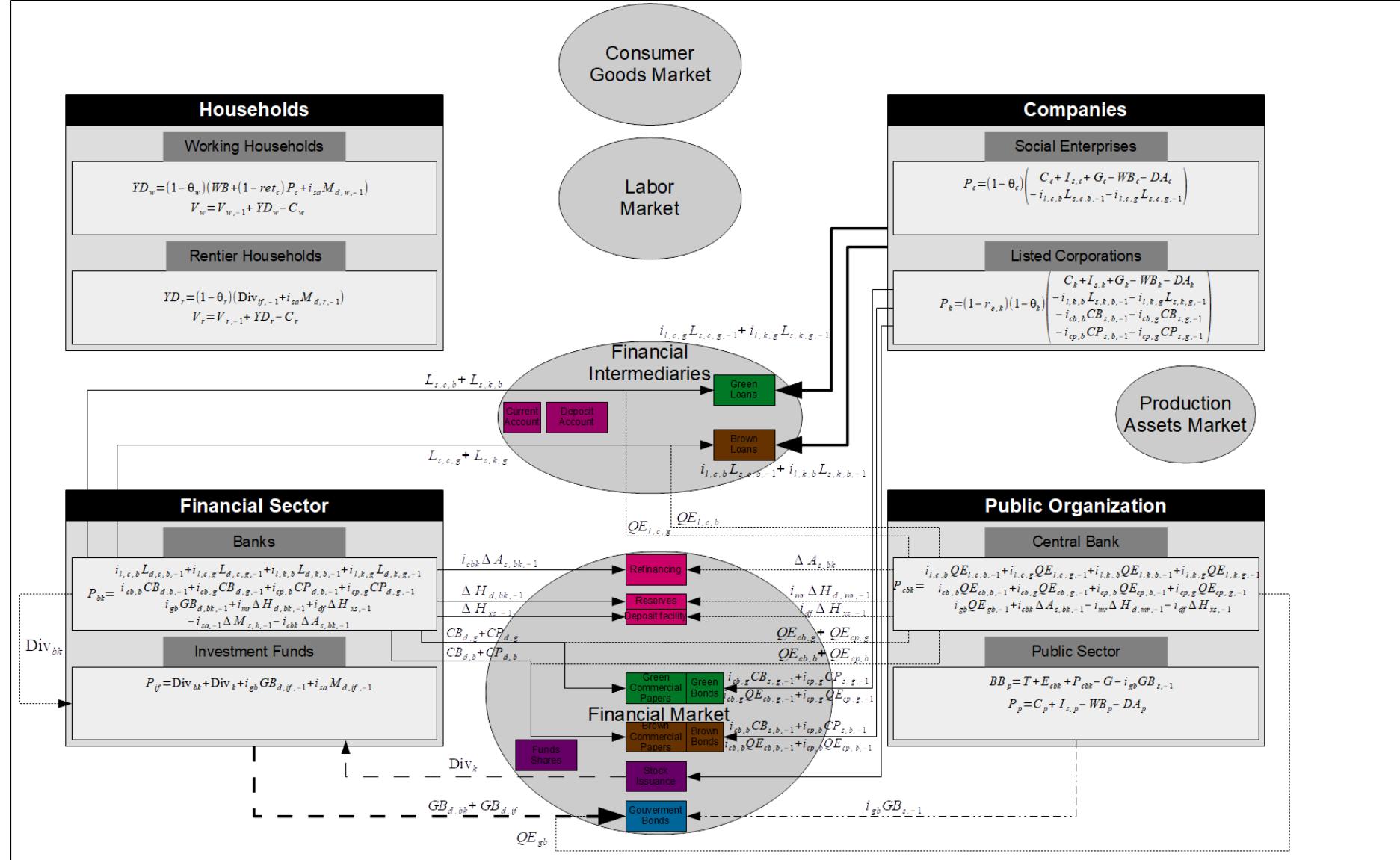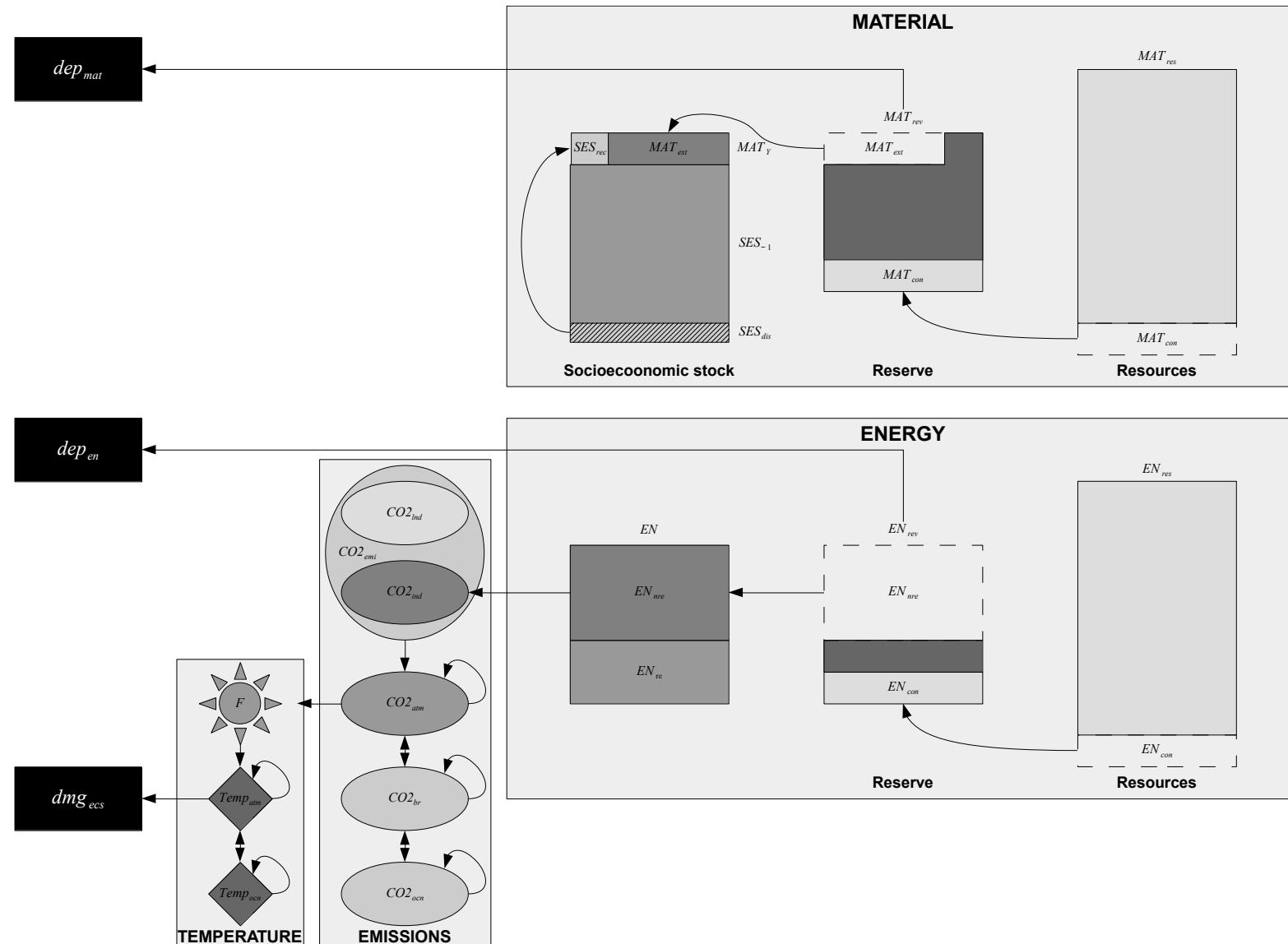
**Figure 4: The eco-systemic block**

## 4.1) Module 1: Macroeconomic model (01-macromodel)

To estimate the main macroeconomic indicators, module 1 is divided into 3 sections: Nominal GDP, Inflation and real GDP, and Productive capital assets.

$$Y = C + I + G$$
$$\pi = \pi_f + \varepsilon_\pi$$
$$K = K_k + K_c + K_p$$

The "Nominal GDP" section displays the following macroeconomic indicators: Gross Domestic Product (the sum of Consumption, Investment, and Public Expenditure), Investment (the sum of investments by listed corporations, social businesses, and public sector firms), and Consumption (the sum of consumption by workers and rentiers).

The "Inflation and real GDP" section focuses on the evolution of prices through inflation, which depends on the evolution of wages and environmental consequences (energy depletion, material depletion, and ecosystem damage).

The "Productive capital assets" section presents the productive capital assets of listed corporations, social businesses, and public sector firms (as well as their depreciation) and distinguishes between green and brown productive capital assets.

**Sections in module 01-macromodel**

'MACROECONOMIC MODEL

'Nominal GDP
'Inflation and real GDP
'Productive capital assets

## 4.2) Module 2: Households (02-households)

To determine the increase in the financial wealth of households (workers and rentiers), this module is divided into 3 sections: Consumption, Saving, and Income.

$$V_w = V_{w-1} + (YD_w - C_w)$$
$$YD_w = (1 - \theta_w)\left[WB + (1 - ret_c)P_c + i_{sa}M_{d,w-1}\right]$$
$$V_r = V_{r-1} + (YD_r - C_r)$$
$$YD_r = (1 - \theta_r)\left(Div_{if} + i_{sa}M_{d,r-1}\right)$$

The "CONSUMPTION" section for households depends on their annual income and previous wealth (impacted by environmental degradation). This consumption is distributed among social businesses, public companies, and listed firms.

The "SAVING" section of households serves to allocate household savings among savings accounts, share purchases through investment funds, and cash holdings.

The "INCOME" section determines the household disposable income of workers and rentiers.
The income of worker households comes from their wages, post-tax profits from social businesses, and interest from savings.
The income of rentier households comes from dividends received from institutional funds and interest from savings
An income tax rate is applied to household income.

And wages are paid by social businesses, public companies, and listed firms based on their respective share in the economy.

**Sections in module 02-households**

'HOUSEHOLDS

'## CONSUMPTION
'Nominal and real household consumption
'Consumption allocation

'## SAVING
'Households' portfolio choice

'## INCOME
'Nominal and real household disposable income
'Wage bill and allocation of wages

## 4.3) Module 3: Social Enterprises (03-social)

To determine the profit (PnL: Profit and Loss) generated by social businesses, this module is divided into 2 sections: Investment (Assets) and Financing (Liabilities).

$$P_c = (1 - \theta_c)\left[C_c + I_{s,c} + G_c - WB_c - DA_c - \left(i_{l,c,b}L_{s,c,b-1} + i_{l,c,g}L_{s,c,g-1}\right)\right]$$

The "INVESTMENT (ASSETS)" section includes:
Total investment demand: the total capital requirement for social businesses and depreciation.
Productive assets: determines the investment level required based on the target capital stock, while offsetting depreciation.
Green structure of investment demand: estimates the allocation of investment between green and brown.
Investment spending: shows the level of green and brown investment.

The "FINANCING (LIABILITIES)" section includes:
Financial structure: determines new borrowing in green and brown sectors.
Financial liabilities: gives the new amount of debt stock.

**Sections in module 03-social**

'SOCIAL ENTERPRISES

'## INVESTMENT (ASSETS)
'Total investment demand
'Productive assets
'Green structure of investment demand
'Investment spending

'## FINANCING (LIABILITIES)
'Financial structure
'Financial liabilities

## 4.4) Module 4: Listed Corporations (04-capitalist)

To determine the profit (PnL: Profit and Loss) generated by listed corporations, this module is divided into 2 sections: Investment (Assets) and Financing (Liabilities).

$$P_k = (1 - r_{e,k})(1 - \theta_k)\Big[ C_k + I_{s,k} + G_k - WB_k - DA_k$$
$$- \binom{i_{l,k,b}L_{s,k,b,-1} + i_{l,k,g}L_{s,k,g,-1} + i_{cb,b}CB_{s,b,-1} + i_{cb,g}CB_{s,g,-1}}{+i_{cp,b}CP_{s,b,-1} + i_{cp,g}CP_{s,g,-1}}\Big]$$

The "INVESTMENT (ASSETS)" section includes:
Total investment demand: total capital needs of listed corporations and depreciation. The investment level is determined based on the target capital stock, while offsetting depreciation.
Green structure of investment demand: estimates the allocation between green and brown investments.
Investment spending: indicates the level of green and brown investment.

The "FINANCING (LIABILITIES)" section includes:
Investment financing: determines new borrowing in green and brown sectors.
Financial liabilities: shows the balance between supply and demand for different types of borrowing (bank loans, corporate bonds, and commercial papers) and the new debt stock.

**Sections in module 04-capitalist**

'LISTED CORPORATIONS

'## INVESTMENT (ASSETS)
'Total investment demand
'Green structure of investment demand
'Investment spending

'## FINANCING (LIABILITIES)
'Investment financing
'Financial liabilities

## 4.5) Module 5: Banks (05-bank)

To determine the profit (PnL: Profit and Loss) generated by the banking sector, this module is divided into 3 sections: Investment (Assets), Financing (Liabilities), and Regulation.

$$P_{bk} = i_{l,c,b}L_{d,c,b,-1} + i_{l,c,g}L_{d,c,g,-1} + i_{l,k,b}L_{d,k,b,-1} + i_{l,k,g}L_{d,k,g,-1}$$
$$+i_{cb,b}CB_{d,b,-1} + i_{cb,g}CB_{d,g,-1} + i_{cp,b}CP_{d,b,-1} + i_{cp,g}CP_{d,g,-1}$$
$$+ i_{gb}GB_{d,bk,-1} + i_{mr}\Delta H_{d,m,-1} + i_{df}\Delta H_{xs,-1} - i_{sa}\Delta M_{s,h,-1} - i_{cbk}\Delta A_{s,bk-1}$$

The "INVESTMENT (ASSETS)" section includes:
Quantitative easing: balances the stock of debt demand (bank loans, corporate bonds, and commercial papers) with the supply.
Debt structure: distributes debt between loans, corporate bonds, and commercial papers.
Banking credit: incorporates lending risk to estimate the amount of loans to grant.
Inside money creation: corresponds to money created through loans granted to social businesses and listed corporations.

The "FINANCING (LIABILITIES)" section includes:
Cash and deposit liabilities: balances cash supply and demand from households and bank deposits of households and investment funds.

Refinancing operations: balances refinancing demand of the banking sector with central bank supply.
Banks' balance sheet: determines amounts of equity, total assets, and total liabilities in the banking sector (deposits, reserve loans, and reserve money).

The "REGULATION" section includes:
Capital adequacy ratio (CAR): ensures compliance with the equity-to-risk-weighted-assets ratio.
Liquidity ratio (LCR): ensures compliance with the class 1 assets-to-total deposits ratio.
Banks' balance sheet: shows the total amount of all types of debt (bank and bond).

**Sections in module 05-bank**

'BANKING SECTOR

'## INVESTMENT (ASSETS)
'Quantitative easing
'Debt structure
'Banking credit
'Inside money creation

'## FINANCING (LIABILITIES)
'Cash and deposit liabilities
'Refinancing operations
'Banks' balance sheet

'## REGULATION
'Capital adequacy ratio (CAR)
'Liquidity ratio (LCR)
'Banks' balance sheet

## 4.6) Module 6: Investment Funds (06-fund)

To determine the profit (PnL: Profit and Loss) generated by investment funds, this module is divided into 2 sections: Investment (Assets) and Financing (Liabilities).

$$P_{if} = Div_{bk} + Div_k + i_{gb}GB_{d,if,-1} + i_{sa}M_{d,if,-1}$$

The "INVESTMENT (ASSETS)" section determines investments in equity of listed corporations, government bonds, and bank deposits.

The "FINANCING (LIABILITIES)" section displays the amount of shares issued by investment funds to finance their investments.

**Sections in module 06-fund**

'INVESTMENT FUNDS

'## INVESTMENT (ASSETS)

'## FINANCING (LIABILITIES)

## 4.7) Module 7: Central Bank (07-centralbank)

To determine the profit (PnL: Profit and Loss) generated by the central bank, this module is divided into 2 sections: Investment (Assets) and Financing (Liabilities).

$$P_{cbk} = i_{l,c,b}QE_{l,c,b,-1} + i_{l,c,g}QE_{l,c,g,-1} + i_{l,k,b}QE_{l,k,b,-1} + i_{l,k,g}QE_{l,k,g,-1}$$
$$+ i_{cb,b}QE_{cb,b,-1} + i_{cb,g}QE_{cb,g,-1} + i_{cp,b}QE_{cp,b,-1} + i_{cp,g}QE_{cp,g,-1}$$
$$+ i_{gb}QE_{gb,-1} + i_{cbk}A_{s,bk,-1} - i_{mr}H_{d,mr,-1} - i_{df}H_{xs,-1}$$

The "INVESTMENT (ASSETS)" section includes:
Quantitative easing operations: determines green or brown investment by the central bank in bank debt of social businesses and listed corporations, as well as in corporate bonds, commercial papers, and government bonds.
High powered money: shows the amount of high powered money from the central bank, i.e., new reserve loans to banks, flows of QE, Treasury purchases, and cash issued in response to household demand.

The "FINANCING (LIABILITIES)" section includes:
Reserve liabilities: shows the counterparts of central bank investments in QE, government bonds, loans to banks, and money issued to households.
Equity: determines the equity of the central bank.

**Sections in module 07-centralbank**

'CENTRAL BANK

'## INVESTMENT (ASSETS)
'Quantitative easing operations
'High powered money

'## FINANCING (LIABILITIES)
'Reserve liabilities
'Equity

## 4.8) Module 8: Rates and Returns (08-ratesreturns)

To understand the investment choices of different institutional sectors, it's important to know the rates applied to various financial assets.

$$i_{cbk} = \widehat{i_{cbk}} + i_{df}$$
$$greenium = \sigma_0 \, \gamma_{ecs} \, dmg_{ecs,-1}$$

This part is divided into 4 sections: Rates returns, Bank realized capital gains when QE is active, Central bank realized capital gains without QE, and Stock market.

The "Rates Returns" section includes:
Money market rates: shows the interbank market rate, deposit facility rate, and mandatory reserves requirement rate.
Bank lending rates: provides loan rates for bank loans (green and brown) (to social businesses or listed corporations), commercial papers (green and brown), corporate bonds (green and brown), deposit rate, and government bond rate.
Total returns: determines the return including interest rate and price variation for bank loans (green and brown), commercial papers (green and brown), corporate bonds (green and brown), government bonds, and investment fund equities.
Realized capital gains: shows realized price variation for different assets.

Expected capital gains: estimates expected price variation for different assets.

The "Bank realized capital gains when QE is active" section shows realized price variation for different assets for the banking sector when QE is active.

The "Central bank realized capital gains without QE and stock market" section shows realized price variation for different assets for the central bank without QE.

The "Stock market" section shows the price of various assets.

**Sections in module 08-ratesreturns**

'RATES RETURNS

'Money market rates
'Bank lending rates
'Total returns
'Realized capital gains
'Expected capital gains

'BANK REALIZED CAPITAL GAINS WHEN QE IS ACTIVE

'CENTRAL BANK REALIZED CAPITAL GAINS WITHOUT QE

'## STOCK MARKET

## 4.9) Module 9: Public sector (09-public)

To determine the budget balance (BB) and the profit (PnL: Profit and Loss) generated by the public sector (government and public sector firms, respectively), this module is divided into 2 sections: Investment (Assets) and Financing (Liabilities).

$$BB_p = T + E_{cbk} + P_{cbk} - G - i_{gb}GB_{s,-1}$$
$$P_p = C_p - WB_p + I_{s,p} - DA_p$$

The "INVESTMENT (ASSETS)" section includes:
The government's budget constraint: determines the amount of public spending benefiting social businesses and listed firms.
Public sector firms: estimates green and brown investment levels of public sector firms, and thus changes in their capital stock.

The "FINANCING (LIABILITIES)" section includes:
Tax payments: reports tax revenue collected by the state from worker households, rentier households, social businesses, and listed companies.
Treasury issues: gives the amount of government bonds used to finance the public sector.

**Sections in module 09-public**

'PUBLIC SECTOR

'## INVESTMENT (ASSETS)
'The government's budget constraint
'Public sector firms

'## FINANCING (LIABILITIES)

'Tax payments
'Treasury issues

## 4.10) Module 10: Ecosystem (10-ecosystem)

This module determines the following resulting variables that are influencing the economic system.

$$dep_{mat} = \frac{MAT_{ext}}{MAT_{rev-1}}$$

$$dep_{en} = \frac{EN_{nre}}{EN_{rev-1}}$$

$$dmg_{ecs} = 1 - \frac{1}{\left[1 + \varrho_1 TEMP_{atm} + \varrho_2 TEMP_{atm}^2 + \varrho_3 TEMP_{atm}^{\varrho_4}\right]}$$

Earth system: shows how material is extracted from nature and transformed to grow the socioeconomic stock.

Energy system: shows how resources are exploited and transformed to generate non-renewable energy instead of renewable energy.

Emissions: covers industrial emissions from non-renewable energy use, which, combined with land emissions, increase the carbon mass.

The carbon cycle: explains how increased carbon mass affects atmospheric CO2 concentration, which in interaction with biosphere and ocean reservoirs, increases radiative forcing, resulting in higher atmospheric and ocean temperatures.

Ecological efficiency: determines energy efficiency coefficients based on the share of green and brown capital in total capital.

Ecosystemic retroaction: highlights how growth in the socioeconomic stock leads to material depletion ("Earth system"), energy resource depletion ("Energy system"), and CO2 emissions, which raise temperatures and cause ecosystem damage.

**Sections in module 10-ecosystem**

'ECOSYSTEM

'Earth system
'Energy system
'Emissions
'The carbon cycle
'Ecological efficiency
'Ecosystemic retroaction

## 4.11) Module 11: Biomimicry (11-biomimicry)

The money trophic flows is used to describe how money moves through different levels of an economic system, from producers to consumers, and between various economic actor (listed firms, social businesses, public sector firms, working households, and rentier households). This module computes the fitness for evolution score (FIT). This post-growth welfare metric indicates where the economy stands in terms of the optimal trade-off between throughput (measuring the intensity of monetary flows)

and resilience (linked to the diversity of flows, and measuring the ability of the economy to adapt to shocks).

## 4.12) Module 12: Stationarity (12-stationarity)

Module 12 ensures that the economic block of the model reaches a steady state, where all major economic and financial variables grow at the same steady rate. It checks this convergence by calculating stationary ratios—comparing the growth of GDP, capital, and wealth (see sub-section 2.4).

## 4.13) Module 13: Monte Carlo (13-montecarlo)

Module 13 evaluates how stable and reliable the model is when faced with uncertainty. By running hundreds of Monte Carlo simulations with small random changes in key behavioral parameters, it measures how sensitive outcomes like GDP, capital, wealth, and temperature are to these shocks, revealing the model's overall robustness and resilience (see section 3).
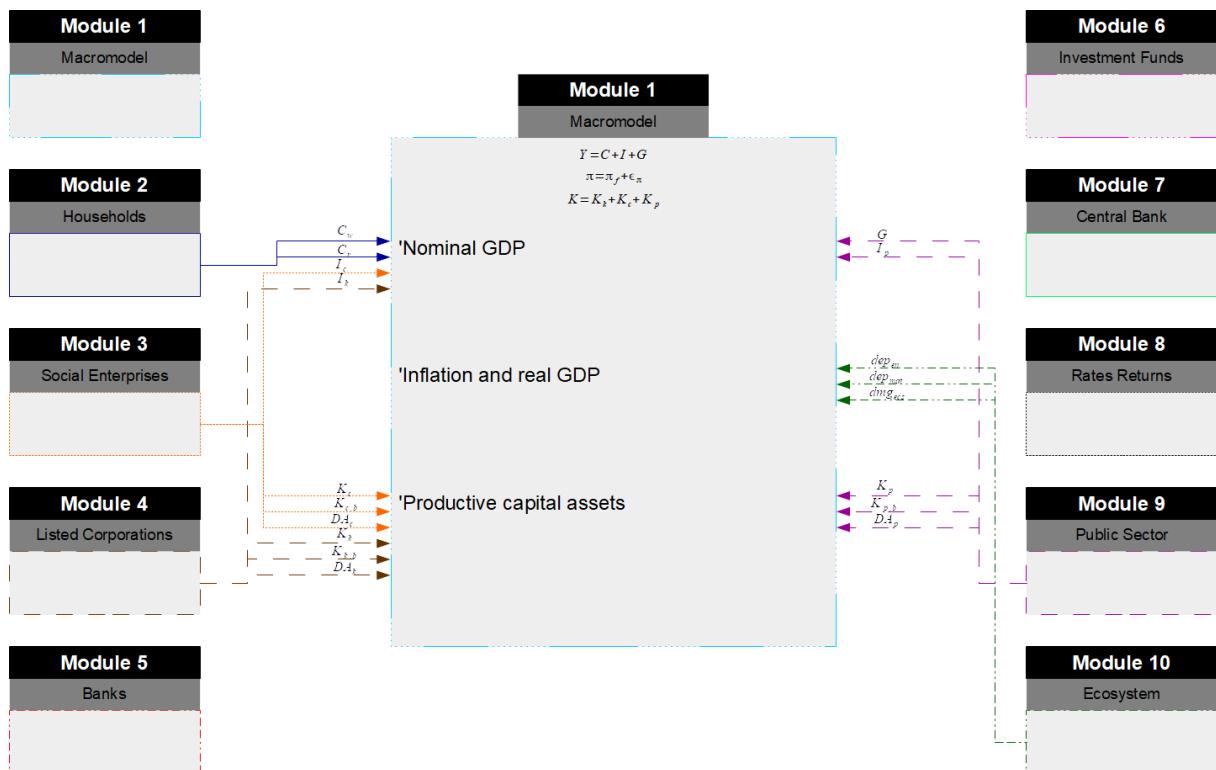
# 5) Interactions between the different economic modules

In this section, for each module, the variables retrieved from other modules are specified. This makes it possible to identify the variables required for the proper functioning of each module.
The place in the model where a variable is first introduced is represented schematically, although the number of times it is reused is not indicated. However, in the following sections, the reasons and methods for introducing these retrieved variables are explained in detail.

## 5.1) Module 1: Macroeconomic model (01-macromodel)

In this module, the economic variables are aggregated and result from: household consumption (**Module 2**), investment, capital stock, and depreciation for social enterprises (**Module 3**), listed corporations (**Module 4**), and the public sector (**Module 9**). On the other hand, the ecosystem affects inflation through energy depletion, material depletion, and ecosystem damage (**Module 10**).
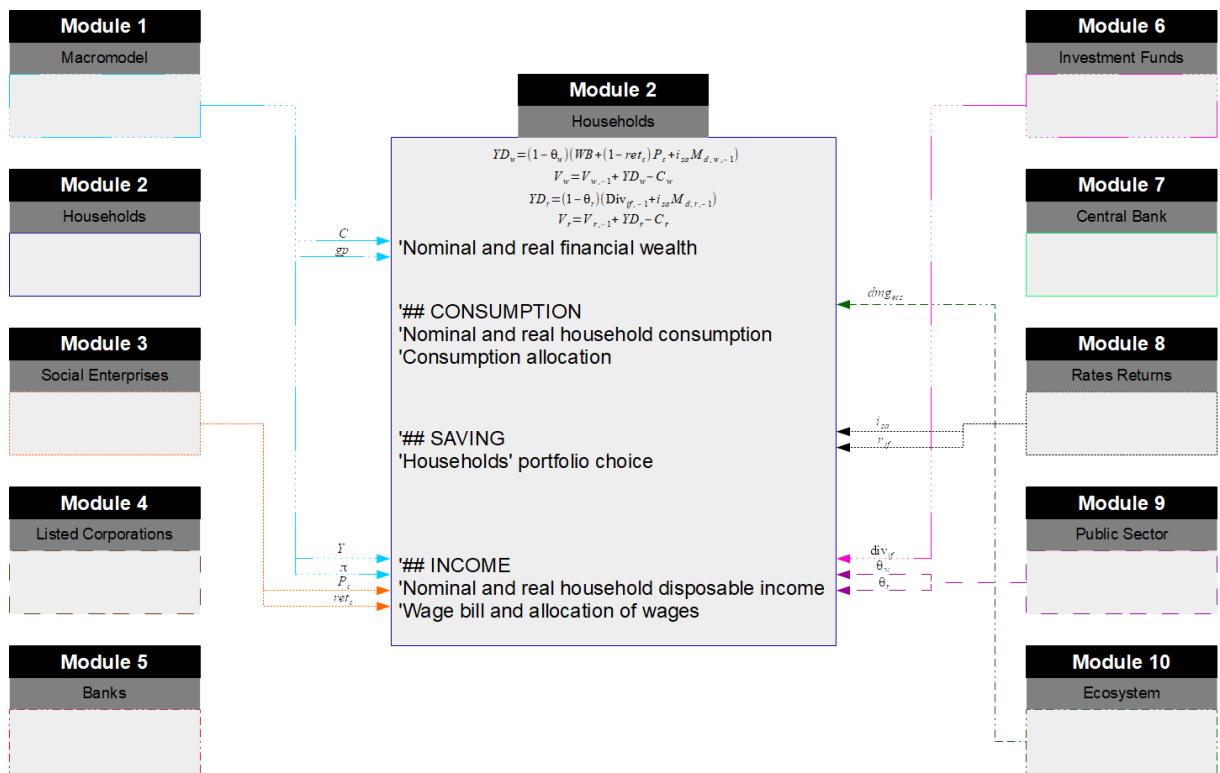
## 5.2) Module 2: Households (02-households)

This module determines household disposable income and financial wealth (nominal and real). It requires certain macroeconomic variables such as GDP (to derive wages), consumption (to separate the share of workers and rentiers), and general price levels and price indices (to obtain real values) — all from **Module 1**.

Households also receive part of the profits redistributed by social enterprises (**Module 3**) and dividends paid by investment funds (**Module 6**). A tax rate (from **Module 9**) is applied to total income earned by both workers and rentiers.

Their investment choices depend on the interest rate on savings accounts and the returns offered by investment funds (**Module 8**).

However, both consumption and investment choices of households are influenced by potential ecosystem damages (**Module 10**).
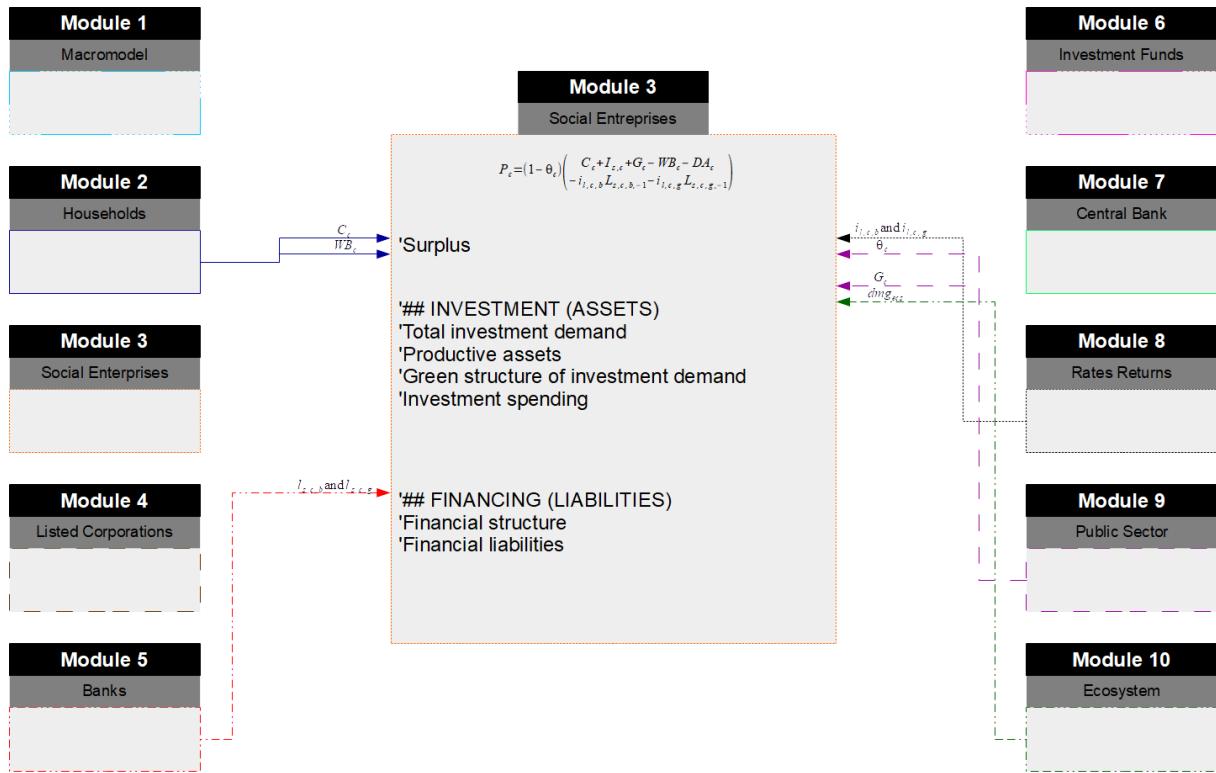
## 5.3) Module 3: Social Businesses (03-social)

This module determines the profit of social enterprises, to which a tax rate (**Module 9**) is applied. This profit depends on household consumption (**Module 2**) and public expenditure (**Module 9**).
It is reduced by wages paid to households (**Module 2**) and by interest payments according to applicable rates (**Module 8**).
Investment decisions between green and brown capital are influenced by ecosystem damages (**Module 10**), while the financing of social enterprises depends on the loan supply from banks (**Module 5**).
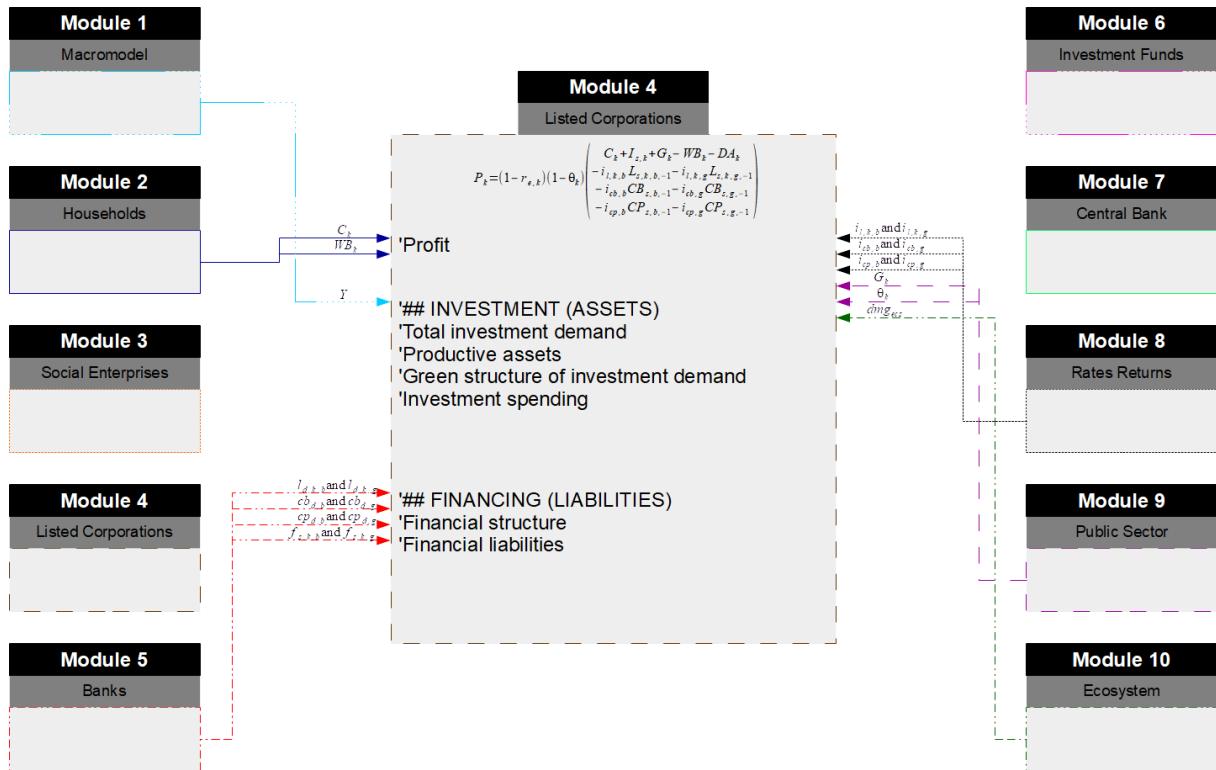
## 5.4) Module 4: Listed Corporations (04-capitalist)

The goal of this module is to determine the profit of listed corporations, which is taxed (**Module 9**). Profits are driven by household consumption (**Module 2**) and public spending (**Module 9**), but must cover wages (**Module 2**) and interest payments at different rates (**Module 8**).
Investment by listed corporations depends on GDP (**Module 1**) and is influenced by ecosystem damages (**Module 10**).
Financing is determined by the balance between the demand for funds by listed corporations and the supply of funds by banks, in the form of loans, corporate bonds, and commercial papers (**Module 5**).

## 5.5) Module 5: Banks (05-bank)

In this module, determining bank profit requires knowledge of the interest rates applied to different financial instruments: loans (green and brown), corporate bonds (green and brown), commercial papers (green and brown), government bonds, mandatory reserves, deposit facilities, savings accounts, and the interbank market rate (**Module 8**). The volumes of loans, corporate bonds, and commercial papers (green and brown) held by banks result from the supply of credit by social enterprises (**Module 3**) and listed corporations (**Module 4**), adjusted for quantitative easing by the central bank (**Module 7**).

Investment in social enterprises requires knowing the loan demand (**Module 3**). For listed corporations, it requires the total funds requested (**Module 4**) and the returns on various financial instruments (**Module 8**). Both green and brown investment choices are governed by risk, which depends on the leverage ratio of social enterprises (**Module 3**) and listed corporations (**Module 4**), growth (**Module 1**), the interbank rate (**Module 8**), and ecosystem damage (**Module 10**).
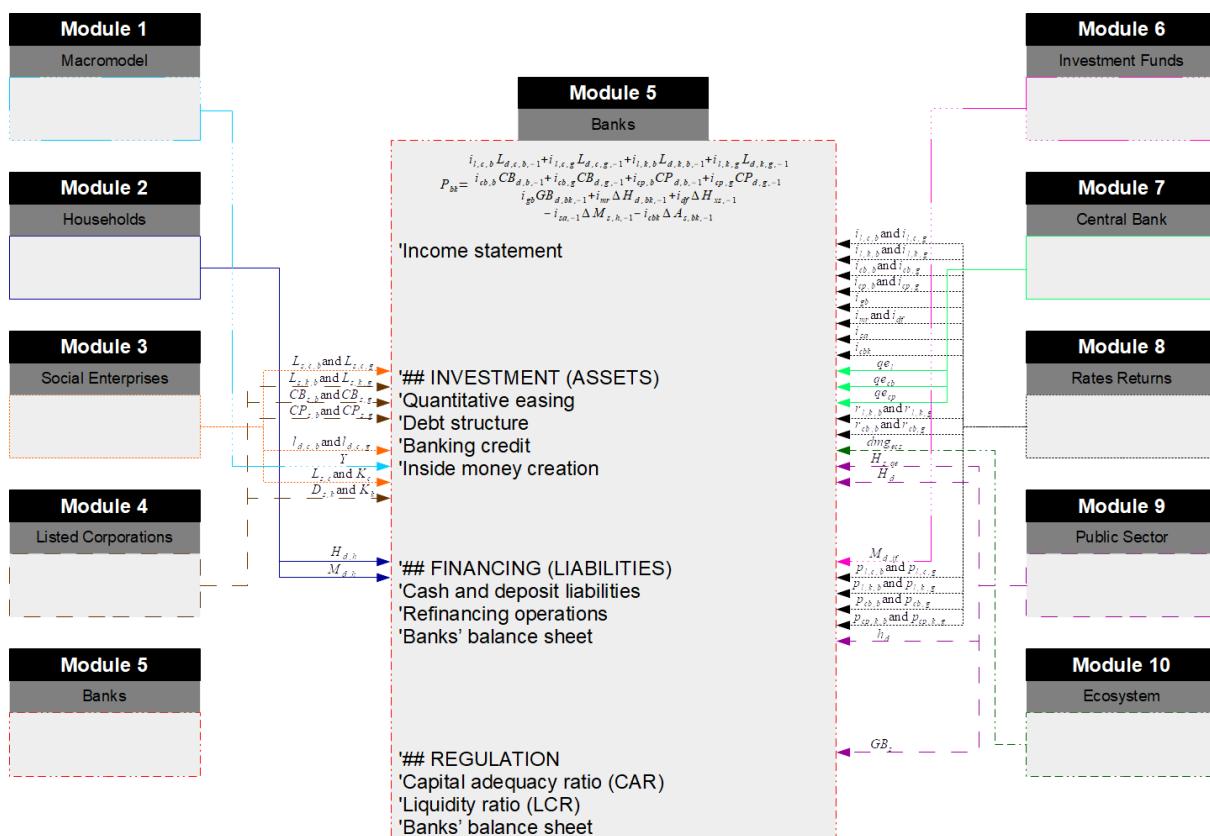
Bank financing comes from household deposits (**Module 2**) and investment funds' deposits (**Module 6**).

Banks also meet liquidity demands from households (**Module 2**).

Reserves supplied by the central bank through quantitative easing (**Module 7**) are subtracted from required reserves to determine the stock of central bank loans. To calculate excess reserves held at the deposit facility, the total reserves (**Module 7**) and liquidity provided to households (**Module 2**) must be known.

High-powered money (**Module 7**) and the estimated prices of financial assets (**Module 9**) are used to determine bank equity, i.e., the difference between total assets and total liabilities.
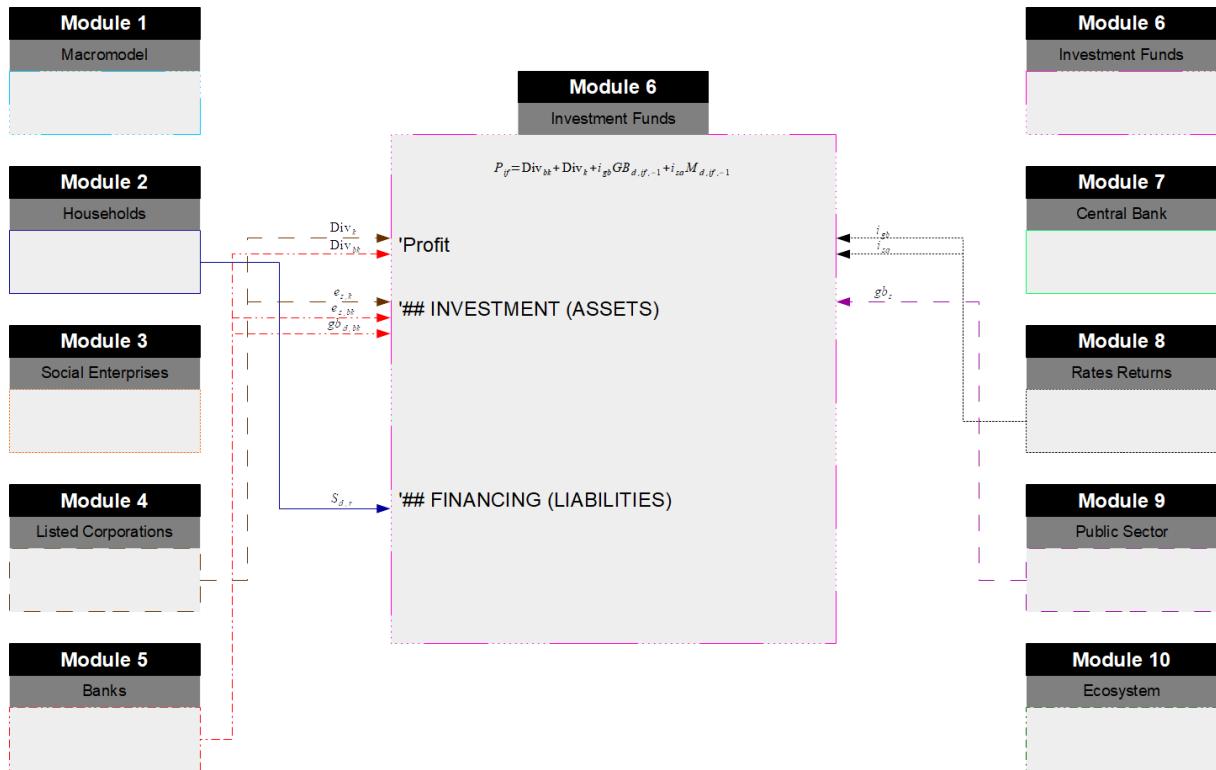
Regulatory ratios are also computed using financial asset prices (**Module 9**) and total reserves (**Module 7**). To meet these ratios, banks can purchase government bonds (**Module 9**) and benefit from quantitative easing (**Module 7**).

## 5.6) Module 6: Investment Funds (06-fund)

In this module, the profit of investment funds comes from dividends paid by listed corporations (**Module 4**) and banks (**Module 5**), as well as interest income from government bonds and savings accounts (**Module 8**).

On the investment side, funds acquire equity from listed corporations (**Module 4**) and banks (**Module 5**), as well as a portion of government bonds (**Module 9**)—the portion not purchased by banks (**Module 5**)—and deposit any excess liquidity in interest-bearing bank accounts.
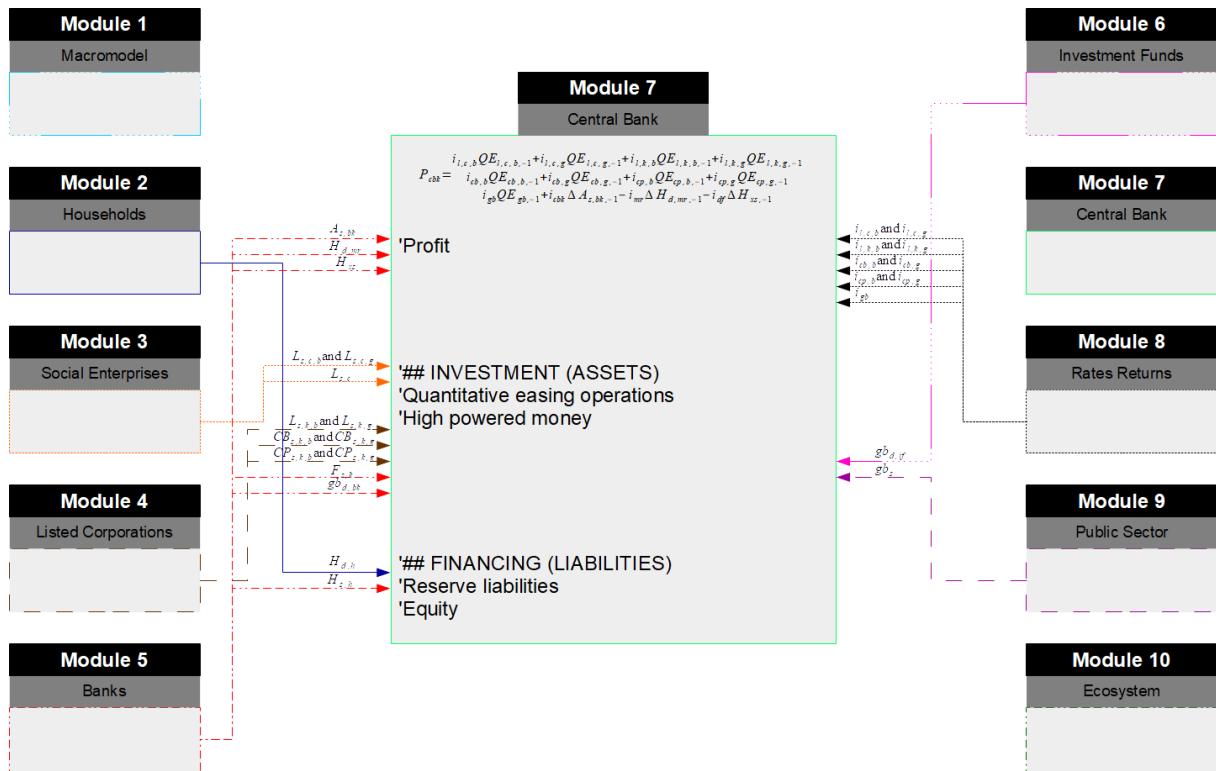
## 5.7) Module 7: Central Bank (07-centralbank)

The profit of the central bank depends on the interest rates applied to different financial instruments (**Module 8**): loans, corporate bonds, commercial papers (green or brown), government bonds, mandatory reserves, deposit facilities, and the interbank market rate. In its transactions with banks, the central bank receives interest on refinancing operations but pays interest on mandatory and excess reserves (**Module 5**).

To conduct its investment policy, the central bank needs to know the supply of loans, corporate bonds, and commercial papers. It can also acquire any remaining government bonds (**Module 9**) after purchases by banks (**Module 5**) and investment funds (**Module 6**).

Through its lending operations, the central bank provides liquidity to banks (**Module 5**) and households (**Module 2**) via high-powered money, recorded under reserve liabilities in the financing structure.
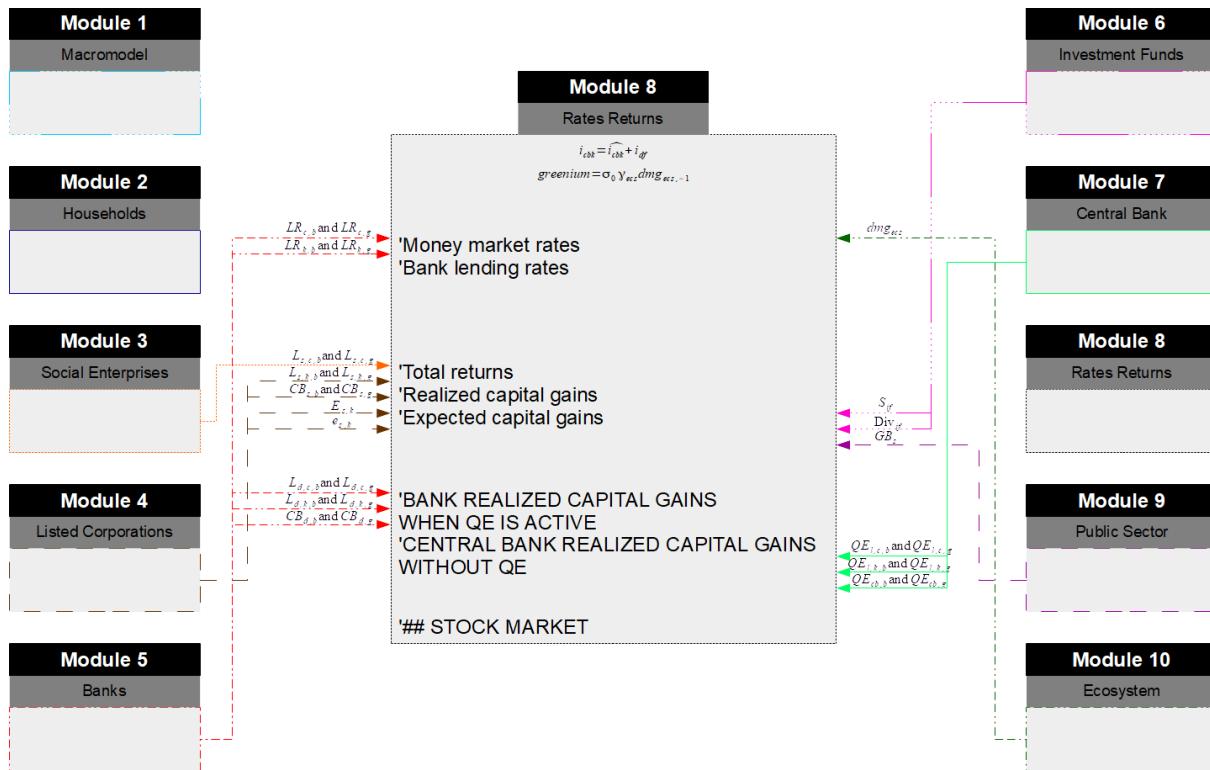
## 5.8) Module 8: Rates and Returns (08-ratesreturns)

In this module, interest rates and returns are determined to reflect investment choices and to guide future investment decisions.

Rates depend on risk, incorporating both lending risk (**Module 5**) and ecosystem damage (**Module 10**). To determine returns, several amounts are collected: bank loans (green and brown) to social enterprises (**Module 3**) and listed corporations (**Module 4**), corporate bonds (green and brown) and equity (**Module 4**), shares and dividends from investment funds (**Module 6**), and government bonds from the public sector (**Module 9**).

Additional returns are calculated for:
- banks, using the amounts of bank loans (green and brown) and corporate bonds (green and brown) (**Module 5**);
- and the central bank, using the amounts involved in quantitative easing for loans (green and brown) to social enterprises and listed corporations, plus corporate bonds (green and brown) (**Module 7**).
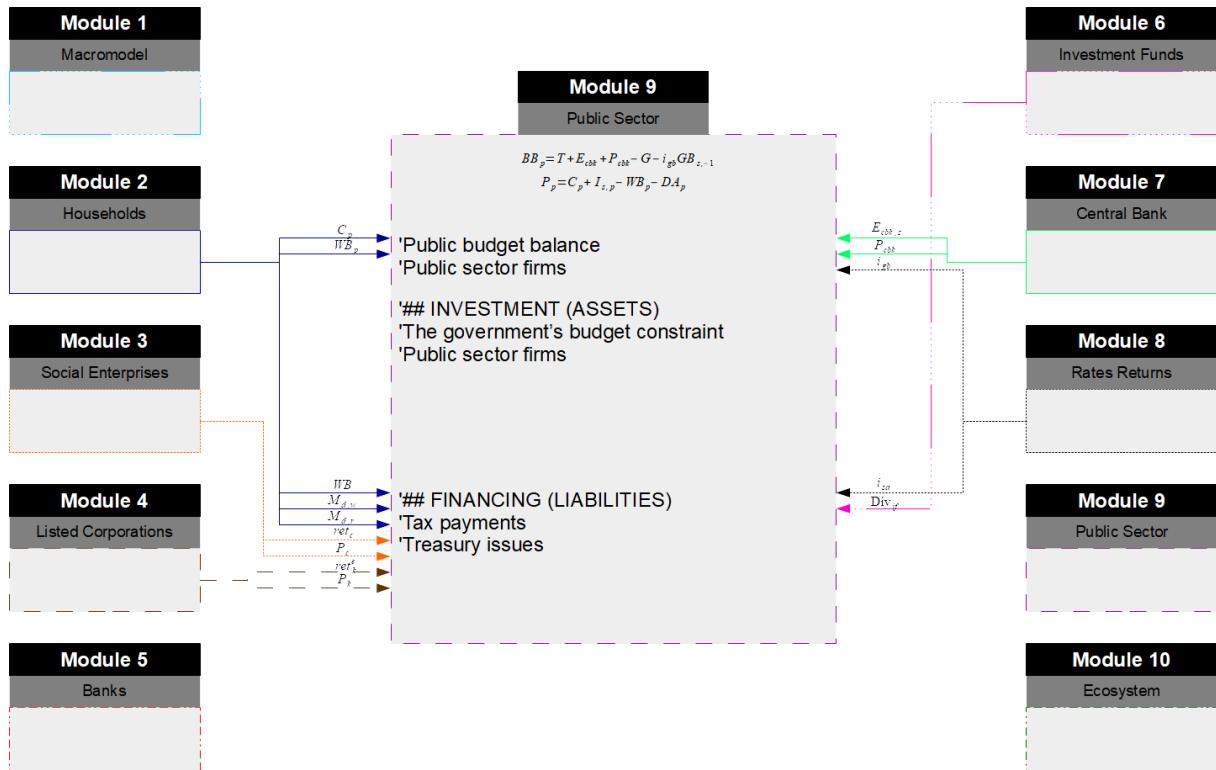
## 5.9) Module 9: Public sector (09-public)
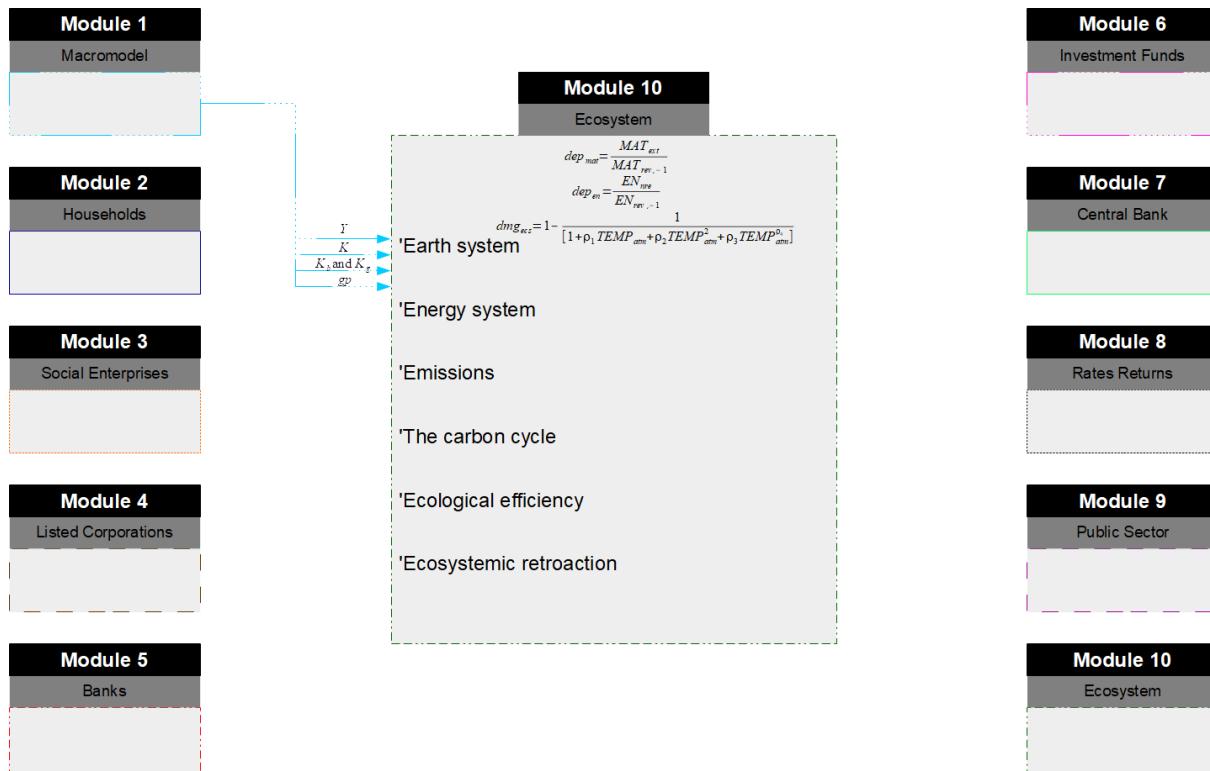
This module determines the public budget balance and the profits of public sector firms. The budget balance benefits from the equity and profits of the central bank (**Module 7**) and interest on government bonds (**Module 8**). Public sector profits arise from household consumption but are reduced by wages paid to households (**Module 2**).

Public sector financing relies on tax rates applied to: household wages and savings interest (**Module 2**), the untaxed share of profits from social enterprises (**Module 3**) and listed corporations (**Module 4**), and dividends from investment funds (**Module 6**).

## 5.10) Module 10: Ecosystem (10-ecosystem)

In this module, the amount of material extraction depends on GDP (**Module 1**). The obsolescence of capital goods, represented by depreciation (**Module 1**), affects the discarded socio-economic stock. The productive structure of the economy—i.e., the share of green and brown capital (**Module 1**)—in turn influences both material extraction and energy consumption.



## 5.11) Module 11: Biomimicry (11-biomimicry)

This module has no interaction with other modules. It collects the flow of money to compute a post-growth metrics of throughput, resilience and fitness for evolution.

# 6) Results, graphs and simulations

## 6.1) Generating simulation scenarios

To illustrate how Philia 1.0 can be used to perform simulations and analyze post-Keynesian dynamics, we present here two basic scenarios. Both simulations start from the model's steady state and exclude the ecosystemic block in order to focus on macroeconomic dynamics.

The procedure is as follows:

Define the scenario using the command philia.scenario(n) "scenario name".

Set the sample period for which variables are modified using smpl.

Introduce the desired shock (temporary or permanent).

Solve the model with philia.solve to compute the results.

Below is the exact EViews code used to generate the two scenarios:

```
philia.scenario(n) "scenario 2"

smpl 150 210
ecosystemic_shock=0

smpl 152 152
g_start = 6000*(1.01)

smpl @all
philia.solve


philia.scenario(n) "scenario 3"

smpl 150 210
ecosystemic_shock=0

smpl 152 210
g_start = 6000*(1.01)

smpl @all
philia.solve
```

Interpretation of the code:
- The command philia.scenario(n) initializes a new scenario with a specific label (e.g., "scenario 2").
- The smpl command defines the time span over which changes are applied.
- In both cases, ecosystemic_shock=0 ensures that the ecological feedback mechanisms remain inactive.
- The variable g_start represents government expenditure.
  - In Scenario 2, it increases by 1% only in period 152 (a one-shot fiscal expansion).

○ In Scenario 3, the 1% increase persists from period 152 onward (a permanent fiscal expansion).
- Finally, philia.solve runs the model under each specified scenario. Successive simulations are displayed with the suffixes _0, _1, _2, and so on.

## 6.1.1) Economic interpretation of the results

It is possible to visualize the evolution of data over time as well as generate graphs. To highlight the post-Keynesian features of the model, we ran two basic scenarios starting from the steady state, without activating the ecosystemic block:
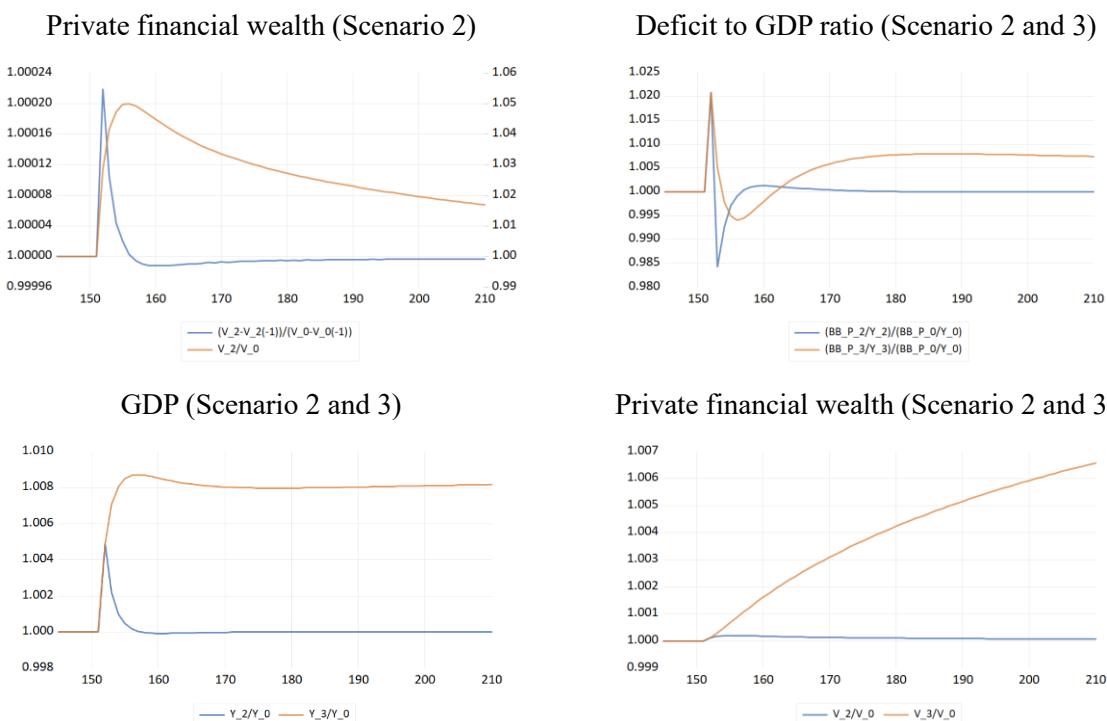
- Scenario 2 features a one-shot 1% increase in government expenditure in period 152.
- Scenario 3 features a permanent 1% increase in government expenditure starting at period 152.

As shown in figure 5, under Scenario 2, the public deficit-to-GDP ratio increases in the first year, then declines sharply as the multiplier effect kicks in. In the long run, it stabilizes back to the baseline level. Under Scenario 3, the public deficit-to-GDP ratio also increases initially, decreases (though less markedly) in the second year, and stabilizes above the baseline in the long run.

A natural consequence of the model's consistent accounting structure is that private financial savings emerge as an outcome—not a precondition—of higher public expenditure. Following a temporary fiscal impulse, private financial wealth rises in the first year and then gradually declines, while the stock of private wealth continues to grow.

Finally, GDP remains higher than the baseline under Scenario 3, demonstrating the potential of a permanent fiscal expansion to sustain higher output in the long term. These mechanisms, initially described in Godley and Lavoie (2012), are characteristic of post-Keynesian stock-flow consistent models integrating money, credit, and production.

**Figure 5: Impact of a temporary and permanent fiscal expansion (in proportion to baseline)**



Private financial wealth (Scenario 2)

Deficit to GDP ratio (Scenario 2 and 3)

GDP (Scenario 2 and 3)

Private financial wealth (Scenario 2 and 3)

## 6.1.2) Visualizing the results in EViews

To make the analysis more intuitive, it is often useful to visualize how key variables evolve under different scenarios. EViews allows you to create clear and customizable graphs comparing series, ratios, or growth rates over time.
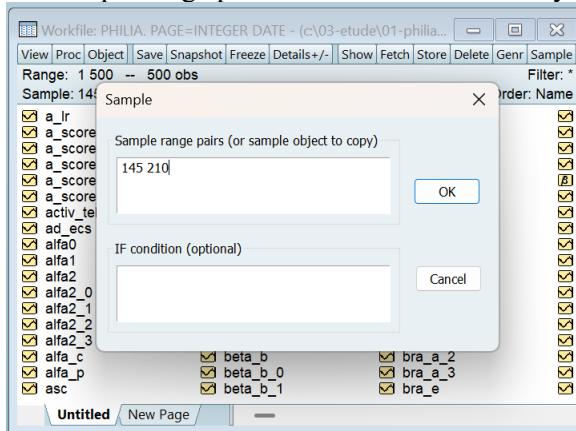
Suppose you want to display, for the sample from 145 to 210, the ratio and growth of two variables, v_2 and v_0, as follows:

$$\frac{v\_2 - v\_2(-1)}{v\_0 - v\_0(-1)} \quad \text{and} \quad \frac{v\_2}{v\_0}$$

From the workfile generate, you can create the graph in EViews using the following steps:

Step 1 – Define the sample range
In the first step, open the Sample window and specify the range of observations you want to display. Here, we enter 145 210 in the Sample range pairs field to restrict the analysis to this period.
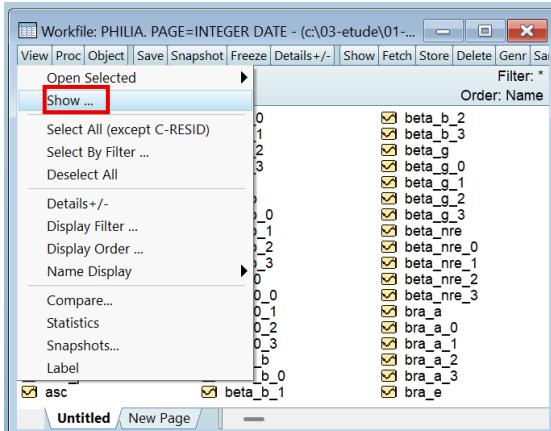


Click OK to confirm.

This ensures that all calculations and graphs will be based on the selected timeframe.

Step 2 – Select and display variables
Then select View, and choose Show → ... from the contextual menu.
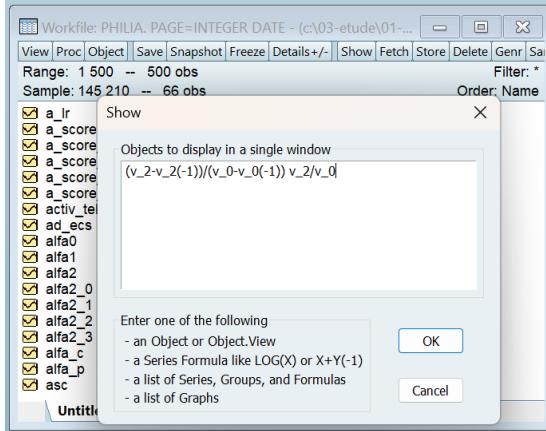


This opens a dialog box where you can define the formula(s) you want to plot or compare.

Step 3 – Enter the graph formula
In the Show dialog, type the following expression: (v_2-v_2(-1))/(v_0-v_0(-1)) v_2/v_0



Then click OK.

This command instructs EViews to display two series in the same window:
- The first term, (v_2-v_2(-1))/(v_0-v_0(-1)), represents the relative growth rate of v_2 compared with v_0.
- The second term, v_2/v_0, shows the level ratio between the two variables.
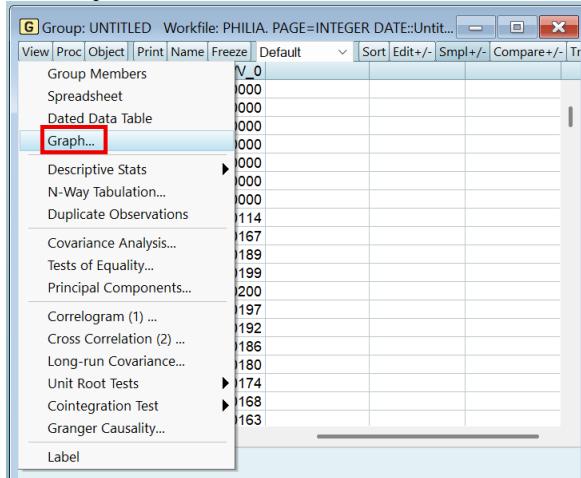
The window with the data opens for both series:
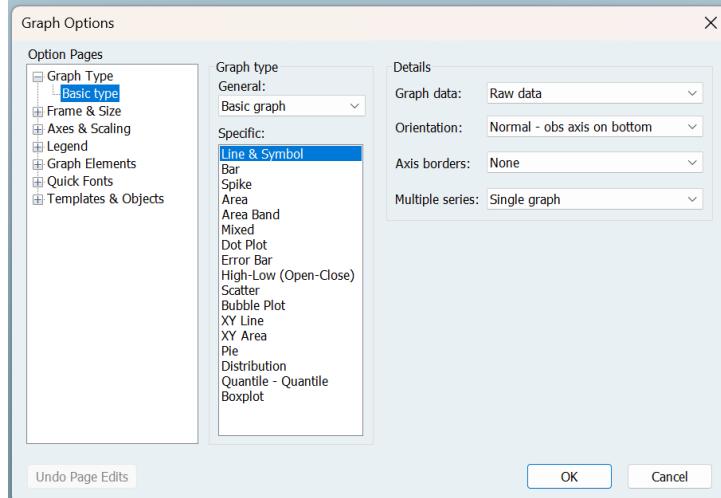


Step 4 – Adjust the graph display
Then select View, and choose Graph → ... from the contextual menu.
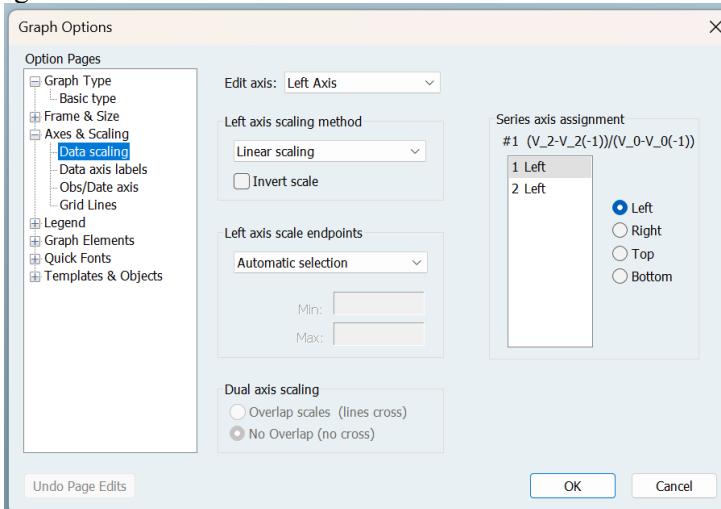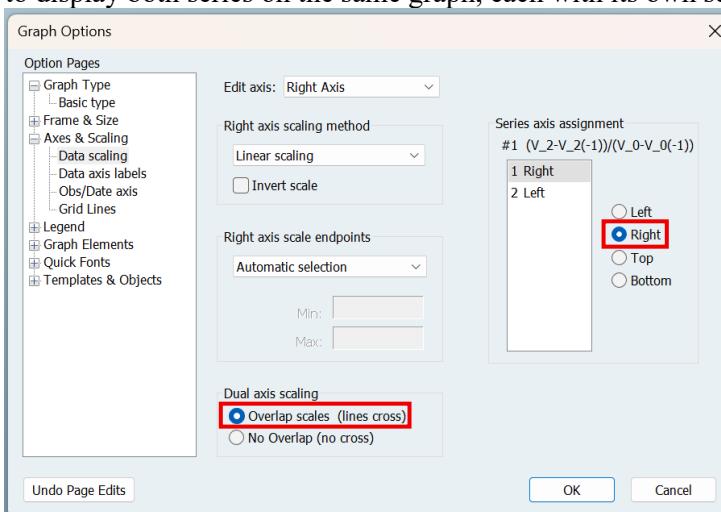
Once the Graph options window opens:



Select Axes & Scaling:



And assign the first equation (v_2-v_2(-1))/(v_0-v_0(-1)) to the right-hand Y-axis.
Tick Overlap scales to display both series on the same graph, each with its own scale.
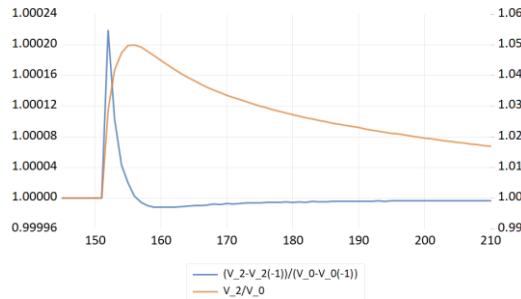


Optionally, customize colors, line styles, and axis titles for clarity.
This layout allows you to view both the short-term relative changes (growth rate) and the long-term proportion between the variables on a single plot.

Step 5 – Interpret the results

In this example:

- The right-axis curve (growth ratio) highlights how quickly v_2 changes compared to v_0 from one period to the next.
- The left-axis curve (level ratio) shows the relative magnitude of v_2 to v_0 over time.



Together, these visualizations help assess the dynamics of the two variables under different scenarios, such as the impact of temporary or permanent fiscal shocks.

## 6.2) User-adjustable data

The program allows the user to simulate alternative scenarios by modifying country-specific data, adjusting parameters to reflect changing economic conditions, or fixing certain parameters over the entire simulation horizon.

To facilitate this process, all variables and parameters are organized into four categories: Country data, Parameters, Fixed parameters, and Initial data.

- Country data: These are values that must be adapted to the specific economy or group of economies under study. They should be updated when the model is applied to different countries or regions in order to reflect their structural characteristics.
- Parameters: These correspond to initial values that can evolve dynamically during simulations according to economic conditions. Their baseline values are chosen to ensure model stability and are grounded in empirical evidence and the existing economic literature. Users may adjust them, but only within theoretically consistent and empirically plausible ranges.
- Fixed parameters: These parameters remain constant throughout all simulation periods. They generally do not require modification, except in sensitivity analyses or when testing specific alternative scenarios.
- Initial data: These values serve as starting points for the model's endogenous dynamics. They are automatically updated as the simulation progresses and usually do not need to be modified manually.

A detailed description and classification of all variables and parameters are provided in **Section 6, "Variables and Parameters."**

## 6.3) Simulation of sustainable policies

The richness of economic, financial mechanisms in Philia 1.0 allows to analyze the impact of various sustainability policy scenarios. Examples include:

- Green fiscal spending
- Green monetary policy
- Macroprudential lending restrictions to the brown sector

- Stranded brown assets and quantitative easing
- Acceleration of ecological awareness amongst households
- Acceleration of green technological change
- Schemes to support the development of local complementary currencies
- …

Academic papers using Philia 1.0 include:

Didier, R., Lagoarde-Ségot, T., 2024. Ecological money and finance. Introducing sustainable monetary diversity. *International Review of Financial Analysis* 95, 103383. https://doi.org/10.1016/j.irfa.2024.103383

Lagoarde-Ségot, T., Le Quang, G., & Scialom, L., 2025. Sustainable economic policies: exploring the effects of ecosystemic macroprudential regulations. *Journal of Post Keynesian Economics*, 1–37. https://doi.org/10.1080/01603477.2025.2544047

Lagoarde-Ségot, T., Revelli, C., 2023. Ecological money and finance. Introducing ecological risk-free assets. *International Review of Financial Analysis* 90, 102871. https://doi.org/10.1016/j.irfa.2023.102871

# 7) Variables and Parameters

## 7.1) Module 1: Macroeconomic model (01-macromodel)

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|
| $Y$ | Y | 10000 | Country data | nominal GDP |
| $I$ | Inv | 2500 | Country data | investment |
| $C$ | C_total | 5000 | Country data | consumption |
| $\pi$ | pi | 1% | Initial data | inflation rate |
| $\varepsilon_\pi$ | epsilon_pi | 0 | Initial data | cumulative ecosystem inflation |
| $\pi_{ecs}$ | pi_ecs | pi | Initial data | inflation rate |
| $\pi_f$ | pi_f | 0 | Initial data | inflation rate |
| $gp$ | gp | 1 | Initial data | general price level |
| $\widehat{Y}$ | Y_real | 10000 | Country data | real GDP |
| $\iota_{wb}$ | iota_wb | 0.6 | Parameter | wage share |
| $\iota_{wb}^T$ | iota_wb_Tgt | 0.6 | Parameter | wage share |
| $\Omega_{wb}$ | omega_wb | 0.6667 | Parameter | workers negotiation power |
| $o_{ecs}$ | omicron_ecs | 0.1 | Fixed parameter | ecosystem inflation impact |
| $\Psi_f$ | psi_f | 1 - omega_wb | Fixed parameter | firms product market power |
| $\iota_f^T$ | iota_f_Tgt | 0.6 | Fixed parameter | wage share |
| $K$ | K | 15000 | Country data | stock of physical capital assets |
| $K_k$ | K_k | 5000 | Country data | stock of physical capital assets |
| $K_c$ | K_c | 5000 | Country data | stock of physical capital assets |
| $K_p$ | K_p | 5000 | Country data | stock of physical capital assets |
| $DA$ | DA | 1500 | Country data | depreciation expenditures |
| $DA_k$ | DA_k | 0 | Initial data | depreciation expenditures |
| $DA_c$ | DA_c | 0 | Initial data | depreciation expenditures |
| $DA_p$ | DA_p | 0 | Initial data | depreciation expenditures |
| $K_b$ | K_b | 11250 | Country data | stock of physical capital assets |
| $K_g$ | K_g | 3750 | Country data | stock of physical capital assets |
| | | | | |

## 7.2) Module 2: Households (02-households)

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|
| $V$ | V | 15400 | Country data | financial wealth |
| $V_w$ | V_w | 11550 | Country data | financial wealth |
| $V_r$ | V_r | 3850 | Country data | financial wealth |
| $\widehat{V}$ | V_real | 14000 | Country data | financial wealth |
| $\widehat{V_w}$ | V_w_real | 3500 | Country data | financial wealth |
| $\widehat{V_r}$ | V_r_real | 10500 | Country data | financial wealth |
| $C_w$ | C_w | 2500 | Country data | consumption |
| $C_r$ | C_r | 2500 | Country data | consumption |
| $\widehat{C_w}$ | C_w_real | C_w | Country data | consumption |
| $\widehat{C_r}$ | C_r_real | C_r | Country data | consumption |
| $\alpha_2$ | alfa2 | 0.02 | Parameter | consumption coefficient from financial wealth |
| $\alpha_0$ | alfa0 | 100 | Country data | minimum consumption |

| | | | | |
|---|---|---|---|---|
| $\alpha_1$ | alfa1 | 0.85 | Country data | consumption coefficient from disposable income |
| $\upsilon$ | upsilon | 0.005 | Fixed parameter | eco-systemic destruction impact on consumption from wealth |
| $C_c$ | C_c | 1000 | Country data | consumption |
| $C_p$ | C_p | 1000 | Country data | consumption |
| $C_k$ | C_k | 3000 | Country data | consumption |
| $\alpha_c$ | alfa_c | 0.15 | Country data | share of total consumption |
| $\alpha_p$ | alfa_p | 0.15 | Country data | share of total consumption |
| $M_{d,w}$ | M_d_w | 10500 | Country data | savings account |
| $H_{d,w}$ | H_d_w | 0 | Initial data | high powered money (cash and reserve assets) |
| $M_{d,r}$ | M_d_r | 3500 | Country data | savings account |
| $S_{d,r}$ | S_d_r | 0 | Initial data | investment funds shares |
| $H_{d,r}$ | H_d_r | 0 | Initial data | high powered money (cash and reserve assets) |
| $H_{d,h}$ | stock_H_d_h | 1400 | Country data | high powered money (cash and reserve assets) |
| $M_{d,h}$ | M_d_h | 14000 | Country data | savings account |
| $\gamma_{10}$ | gamma10 | 0.3 | Parameter | rentier assets allocation factors |
| | gamma10_n | 0.3 | Parameter | rentier assets allocation factors |
| $\gamma_{20}$ | gamma20 | 0.6 | Parameter | rentier assets allocation factors |
| | kappa10 | 0.9 | Fixed parameter | wealth share in savings deposits |
| | kappa11 | 0.0001 | Fixed parameter | deposit rate factor |
| | kappa12 | 0.0001 | Fixed parameter | transaction rate factor |
| $\gamma_{11}$ | gamma11 | 0.01 | Fixed parameter | rentier assets allocation factors |
| $\gamma_{12}$ | gamma12 | 0.005 | Fixed parameter | rentier assets allocation factors |
| $\gamma_{14}$ | gamma14 | 0.01 | Fixed parameter | rentier assets allocation factors |
| $\gamma_{15}$ | gamma15 | 0.005 | Fixed parameter | rentier assets allocation factors |
| $\gamma_{21}$ | gamma21 | 0.005 | Fixed parameter | rentier assets allocation factors |
| $\gamma_{22}$ | gamma22 | 0.01 | Fixed parameter | rentier assets allocation factors |
| $\gamma_{24}$ | gamma24 | 0.005 | Fixed parameter | rentier assets allocation factors |
| $\gamma_{25}$ | gamma25 | 0.005 | Fixed parameter | rentier assets allocation factors |
| $\Omega$ | omega | 0.05 | Fixed parameter | ecosystemic events impact on liquidity preference |
| $YD_w$ | YD_w | 6500 | Country data | disposable income |
| $YD_r$ | YD_r | 6500 | Country data | disposable income |
| $\widehat{YD}_w$ | YD_w_real | $YD_w$ | Country data | disposable income |
| $\widehat{YD}_r$ | YD_r_real | $YD_r$ | Country data | disposable income |
| $WB$ | WB | 6000 | Country data | wage bill |
| $WB_c$ | WB_c | 3000 | Country data | wage bill |
| $WB_k$ | WB_k | 2000 | Country data | wage bill |
| $WB_p$ | WB_p | 1000 | Country data | wage bill |
| $\rho_c$ | rho_c | 0.10 | Country data | share of total wages |
| $\rho_k$ | rho_k | 0.75 | Country data | share of total wages |
| $\rho_p$ | rho_p | 0.15 | Country data | share of total wages |

## 7.3) Module 3: Social Businesses (03-social)

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|
| $P_c$ | PnL_c | 0 | Initial data | profit |
| $K_c$ | K_c | 5000 | Country data | stock of physical capital assets |
| $DA_{c,b}$ | DA_c_b | 0 | Initial data | depreciation expenditures |
| $DA_{c,g}$ | DA_c_g | 0 | Initial data | depreciation expenditures |
| $\lambda$ | lambda | 0.07 | Fixed parameter | obsolescence rate of productive capital assets |
| $K_{c,g}$ | K_c_g | 1250 | Country data | stock of physical capital assets |
| $K_{c,b}$ | K_c_b | 3750 | Country data | stock of physical capital assets |
| $K_c^T$ | K_c_Tgt | 0 | Initial data | stock of physical capital assets |
| $I_{d,c}$ | Inv_d_c | 0 | Initial data | investment |
| $\iota_1$ | iota1 | 0.25 | Fixed parameter | surplus accelerator factor on investment |
| $\iota_2$ | iota2 | 0.0005 | Fixed parameter | debt modulator factor on investment |
| $\nu_c$ | nu_c | 0.07 | Fixed parameter | partial adjustment of capital stock |
| $I_{d,c,g}$ | Inv_d_c_g | 1500 | Country data | investment |
| $I_{d,c,b}$ | Inv_d_c_b | 1500 | Country data | investment |
| $\omega_{1,c}$ | omega1_c | 0.25 | Fixed parameter | proportion of total gross investment |
| $ad_{ecs}$ | ad_ecs | 0.075 | Fixed parameter | adaptation parameter to the eco-systemic damage |
| $\omega_{2,c}$ | omega2_c | 0.05 | Fixed parameter | relative cost of debt (brown vs green) |
| $I_{s,c,g}$ | Inv_s_c_g | 1500 | Country data | investment |
| $I_{s,c,b}$ | Inv_s_c_b | 1500 | Country data | investment |
| $ret_c$ | ret_c | 0.05 | Country data | retention rate (self-financing rate) |
| $I_{s,c}$ | Inv_s_c | 0 | Initial data | investment |
| $l_{d,c,g}$ | l_d_c_g | 0 | Initial data | annual credit flow |
| $l_{d,c,b}$ | l_d_c_b | 0 | Initial data | annual credit flow |
| $l_{d,c}$ | l_d_c | 0 | Initial data | annual credit flow |
| $l_{s,c}$ | l_s_c | 0 | Initial data | annual credit flow |
| $L_{s,c,g}$ | stock_L_s_c_g | 1500 | Country data | stock of bank loans |
| $L_{s,c,b}$ | stock_L_s_c_b | 1500 | Country data | stock of bank loans |
| $L_{s,c}$ | stock_L_s_c | 3000 | Country data | stock of bank loans |

## 7.4) Module 4: Listed Corporations (04-capitalist)

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|
| $P_k$ | PnL_k | 0 | Initial data | profit |
| $Div_k$ | div_k | 0 | Initial data | dividend |
| $Div_d$ | div_d | 0 | Initial data | dividend |
| $RE_k$ | RE_k | 0 | Initial data | retained earnings |
| $r_{e,k}$ | r_exp_k | 0.35 | Fixed parameter | assets rate of return |
| $K_k$ | K_k | 5000 | Country data | stock of physical capital assets |
| $K_{k,b}$ | K_k_b | 3750 | Country data | stock of physical capital assets |
| $K_{k,g}$ | K_k_g | 1250 | Country data | stock of physical capital assets |
| $DA_k$ | DA_k | 0 | Initial data | depreciation expenditures |
| $DA_{k,b}$ | DA_k_b | 0 | Initial data | depreciation expenditures |
| $DA_{k,g}$ | DA_k_g | 0 | Initial data | depreciation expenditures |

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|
| $K_k^T$ | K_k_Tgt | 0 | Initial data | stock of physical capital assets |
| $I_{d,k}$ | Inv_d_k | 2000 | Country data | investment |
| $\kappa_k$ | kappa_k | 2.5 | Fixed parameter | capital stock target parameter |
| $\nu_k$ | nu_k | 0.09 | Fixed parameter | partial adjustment of capital stock |
| $I_{d,k,g}$ | Inv_d_k_g | 500 | Country data | investment |
| $I_{d,k,b}$ | Inv_d_k_b | 1500 | Country data | investment |
| $\omega_{1,k}$ | omega1_k | 0.25 | Fixed parameter | proportion of total gross investment |
| $\omega_{2,k}$ | omega2_k | 0.05 | Fixed parameter | relative cost of debt (brown vs green) |
| $I_{s,k,g}$ | Inv_s_k_g | 500 | Country data | investment |
| $I_{s,k,b}$ | Inv_s_k_b | 1500 | Country data | investment |
| $I_{s,k}$ | Inv_s_k | 0 | Initial data | investment |
| $f_{s,k}$ | f_s_k | 2100 | Country data | external financing |
| $f_{d,k,g}$ | f_d_k_g | 0 | Initial data | external financing |
| $f_{d,k,b}$ | f_d_k_b | 0 | Initial data | external financing |
| $e_{d,k}$ | e_d_k | 8341 | Country data | annual flow of equities issues |
| $e_{s,k}$ | e_s_k | 8341 | Country data | annual flow of equities issues |
| $E_d$ | E_d | $e_{s,k}$ | Country data | stock of equities |
| $l_{s,k,b}$ | l_s_k_b | 0 | Initial data | annual credit flow |
| $l_{s,k,g}$ | l_s_k_g | 0 | Initial data | annual credit flow |
| $cb_{s,b}$ | cb_s_k_b | 1000 | Country data | annual flow of corporate bonds issues |
| $cb_{s,g}$ | cb_s_k_g | 500 | Country data | annual flow of corporate bonds issues |
| $cp_{s,b}$ | cp_s_k_b | 75 | Country data | annual flow of commercial papers issues |
| $cp_{s,g}$ | cp_s_k_g | 25 | Country data | annual flow of commercial papers issues |
| $L_{s,k}$ | stock_L_s_k | 6000 | Country data | stock of bank loans |
| $L_{s,k,b}$ | stock_L_s_k_b | 5000 | Country data | stock of bank loans |
| $L_{s,k,g}$ | stock_L_s_k_g | 1000 | Country data | stock of bank loans |
| $CB_{s,k}$ | stock_CB_s_k | 1500 | Country data | stock of corporate bonds |
| $CB_{s,b}$ | stock_CB_s_k_b | 1000 | Country data | stock of corporate bonds |
| $CB_{s,g}$ | stock_CB_s_k_g | 500 | Country data | stock of corporate bonds |
| $CP_s$ | stock_CP_s_k | 100 | Country data | stock of commercial papers |
| $CP_{s,b}$ | stock_CP_s_k_b | 75 | Country data | stock of commercial papers |
| $CP_{s,g}$ | stock_CP_s_k_g | 25 | Country data | stock of commercial papers |
| $E_{s,k}$ | stock_E_s_k | 8341 | Country data | stock of equities |
| $D_{s,k}$ | stock_D_s_k | 0 | Initial data | stock of private sector debt |
| $D_{s,k,b}$ | stock_D_s_k_b | 0 | Initial data | stock of private sector debt |
| $D_{s,k,g}$ | stock_D_s_k_g | 0 | Initial data | stock of private sector debt |
| $L_s$ | stock_L_s | 0 | Initial data | stock of bank loans |

## 7.5) Module 5: Banks (05-bank)

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|
| $P_{bk}$ | PnL_bk | 0 | Initial data | profit |
| $Div_{bk}$ | Div_bk | 0 | Initial data | dividend |
| $L_{d,c,b}$ | stock_L_d_c_b | 0 | Initial data | stock of bank loans |
| $L_{d,c,g}$ | stock_L_d_c_g | 0 | Initial data | stock of bank loans |
| $L_{d,k,b}$ | stock_L_d_k_b | 0 | Initial data | stock of bank loans |
| $L_{d,k,g}$ | stock_L_d_k_g | 0 | Initial data | stock of bank loans |
| $L_{s,b}$ | stock_L_s_b | 0 | Initial data | stock of bank loans |

| | | | | |
|---|---|---|---|---|
| $L_{s,g}$ | stock_L_s_g | 0 | Initial data | stock of bank loans |
| $L_d$ | stock_L_d | 0 | Initial data | stock of bank loans |
| $L_{d,b}$ | stock_L_d_b | 0 | Initial data | stock of bank loans |
| $L_{d,g}$ | stock_L_d_g | 0 | Initial data | stock of bank loans |
| $CB_{d,b}$ | stock_CB_d_k_b | 0 | Initial data | stock of corporate bonds |
| $CB_{d,g}$ | stock_CB_d_k_g | 0 | Initial data | stock of corporate bonds |
| $CB_d$ | stock_CB_d_k | 0 | Initial data | stock of corporate bonds |
| $CP_{d,b}$ | stock_CP_d_k_b | 0 | Initial data | stock of commercial papers |
| $CP_{d,g}$ | stock_CP_d_k_g | 0 | Initial data | stock of commercial papers |
| $CP_d$ | stock_CP_d_k | 0 | Initial data | stock of commercial papers |
| $D_{d,g}$ | stock_D_d_g | 1000 | Country data | stock of private sector debt |
| $D_{d,b}$ | stock_D_d_b | 3000 | Country data | stock of private sector debt |
| $F_{s,k}$ | stock_F_s_k | 2100 | Country data | stock of external financing |
| $cb_{d,b}$ | cb_d_k_b | 0 | Initial data | annual flow of corporate bonds issues |
| $l_{d,k,b}$ | l_d_k_b | 0 | Initial data | annual credit flow |
| $cb_{d,g}$ | cb_d_k_g | 0 | Initial data | annual flow of corporate bonds issues |
| $l_{d,k,g}$ | l_d_k_g | 0 | Initial data | annual credit flow |
| $cp_{d,b}$ | cp_d_k_b | 0 | Initial data | annual flow of commercial papers issues |
| $cp_{d,g}$ | cp_d_k_g | 0 | Initial data | annual flow of commercial papers issues |
| $l_{d,k}$ | l_d_k | 4000 | Country data | annual credit flow |
| $cb_d$ | cb_d_k | 1500 | Country data | annual flow of corporate bonds issues |
| $cp_d$ | cp_d_k | 100 | Country data | annual flow of commercial papers issues |
| $\chi_{10}$ | chi10 | 0.4 | Fixed parameter | debt term structure parameters |
| $\chi_{20}$ | chi20 | 0.4 | Fixed parameter | debt term structure parameters |
| $\chi_{11}$ | chi11 | 0.5 | Fixed parameter | debt term structure parameters |
| $\chi_{21}$ | chi21 | 0.25 | Fixed parameter | debt term structure parameters |
| $\chi_{12}$ | chi12 | 0.25 | Fixed parameter | debt term structure parameters |
| $\chi_{22}$ | chi22 | 0.5 | Fixed parameter | debt term structure parameters |
| $\chi_{13}$ | chi13 | 0.25 | Fixed parameter | debt term structure parameters |
| $\chi_{23}$ | chi23 | 0.25 | Fixed parameter | debt term structure parameters |
| $l_{s,c,g}$ | l_s_c_g | 0 | Initial data | annual credit flow |
| $l_{s,c,b}$ | l_s_c_b | 0 | Initial data | annual credit flow |
| $f_{s,k,g}$ | f_s_k_g | 0 | Initial data | external financing |
| $f_{s,k,b}$ | f_s_k_b | 0 | Initial data | external financing |
| $LR_{c,g}$ | LR_c_g | 0 | Initial data | lender credit risk score |
| $LR_{k,g}$ | LR_k_g | 0 | Initial data | lender credit risk score |
| $LR_{c,b}$ | LR_c_b | 0 | Initial data | lender credit risk score |
| $LR_{k,b}$ | LR_k_b | 0 | Initial data | lender credit risk score |
| $\gamma_{LR}$ | gamma_lr | 0.05 | Fixed parameter | banks collateral requirements (social firm) |
| $a_{LR}$ | a_lr | 0.01 | Fixed parameter | coefficient on leverage level |
| $b_{LR}$ | b_lr | -0.002 | Fixed parameter | coefficient on economic growth |
| $c_{LR}$ | c_lr | 0.2 | Fixed parameter | coefficient on cost of refinancing |
| $\Psi_{LR}$ | psi_lr | 0.5 | Fixed parameter | banks internalization of eco-systemic damage |
| $m_{bk}$ | m_bk | 0 | Initial data | flow of credit granted to firms |
| $m_{bk,g}$ | m_bk_g | 0 | Initial data | flow of credit granted to firms |
| $m_{bk,b}$ | m_bk_b | 0 | Initial data | flow of credit granted to firms |
| $M_{bk}$ | stock_M_bk | $M_{d,h}$ | Country data | savings account |

| | | | | |
|---|---|---|---|---|
| $H_{s,h}$ | H_s_h | 0 | Initial data | high powered money (cash and reserve assets) |
| $M_{s,h}$ | M_s_h | 0 | Initial data | savings account |
| $H_{d,mr}$ | stock_H_d_mr | 0 | Initial data | high powered money (cash and reserve assets) |
| $A_{d,bk}$ | stock_A_d_bk | 0 | Initial data | stock of Central Bank reserve loan |
| $A_{s,bk}$ | stock_A_s_bk | 0 | Initial data | stock of Central Bank reserve loan |
| $H_{d,qe}$ | stock_H_d_qe | 0 | Initial data | savings account |
| $H_{xs}$ | stock_H_xs | 0 | Initial data | savings account |
| $\rho_{mr}$ | rho_mr | 0.01 | Country data | mandatory reserve requirement |
| $E_{bk,a}$ | stock_E_bk_a | 0 | Initial data | stock of equitie |
| $E_{bk,e}$ | stock_E_bk_e | 0 | Initial data | stock of equitie |
| | e_s_bk | 0 | Initial data | annual flow of equities issues |
| | gb_d_bk | 0 | Initial data | annual flow of government bonds issues |
| $TA_{bk,a}$ | TA_bk_a | 0 | Initial data | total assets |
| $TA_{bk,e}$ | TA_bk_e | 0 | Initial data | total assets |
| $TL_{bk}$ | TL_bk | 0 | Initial data | total liabilities |
| $RWA^e$ | RWA_e | 1 | Initial data | risky weighted assets |
| $RWA^a$ | RWA_a | 1 | Initial data | risky weighted assets |
| | QE_s_Tgt | 0 | Initial data | stock of Central Bank's assets |
| $QE^T$ | QE_Tgt | 0 | Initial data | stock of Central Bank's assets |
| $RWA^{max}$ | RWA_max | 1 | Initial data | risky weighted assets |
| $CAR^T$ | CAR_Tgt | 0.12 | Fixed parameter | capital adequacy ratio |
| $CAR^a$ | CAR_a | 0.0305 | Fixed parameter | capital adequacy ratio |
| $CAR^e$ | CAR_e | 0.0305 | Fixed parameter | capital adequacy ratio |
| $\eta$ | eta | 4 | Fixed parameter | risk weight |
| $GB_{d,bk}^T$ | stock_gb_d_bk_Tgt | 0 | Initial data | stock of government bonds |
| $gb_{d,bk}^T$ | gb_d_bk_Tgt | 0 | Initial data | annual flow of government bonds issues |
| $LCR^T$ | LCR_Tgt | 1 | Initial data | liquidity coverage ratio |
| $LCR^a$ | LCR_a | $LCR^T$ | Initial data | liquidity coverage ratio |
| $LCR^e$ | LCR_e | 1 | Initial data | liquidity coverage ratio |
| $GB_{d,bk}$ | stock_GB_d_bk | 0 | Initial data | stock of government bonds |
| $GB_s$ | stock_GB_s | 35000 | Country data | stock of government bonds |

## 7.6) Module 6: Investment Funds (06-fund)

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|
| $P_{if}$ | PnL_if | 0 | Initial data | profit |
| $Div_{if}$ | Div_if | 0 | Initial data | dividend |
| $E_{d,k}$ | E_d_k | 8341 | Country data | stock of equities |
| $GB_{d,if}$ | stock_GB_d_if | 0 | Initial data | stock of government bonds |
| $gb_{d,if}$ | gb_d_if | 0 | Initial data | annual flow of government bonds issues |
| $m_{d,if}$ | m_d_if | 0 | Initial data | flow of credit granted to firms |
| $M_{d,if}$ | stock_M_d_if | 0 | Initial data | savings account |
| $S_{if}$ | S_if | 0 | Initial data | investment funds shares |
| | | | | |

## 7.7) Module 7: Central Bank (07-centralbank)

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|
| $P_{cbk}$ | PnL_cbk | 0 | Initial data | profit |
| $qe_{l,c,b}$ | qe_l_c_b | 0 | Initial data | flow of quantitative easing issues |
| $qe_{l,c,g}$ | qe_l_c_g | 0 | Initial data | flow of quantitative easing issues |
| $qe_{l,k,b}$ | qe_l_k_b | 0 | Initial data | flow of quantitative easing issues |
| $qe_{l,k,g}$ | qe_l_k_g | 0 | Initial data | flow of quantitative easing issues |
| $qe_{cb,b}$ | qe_cb_b | 0 | Initial data | flow of quantitative easing issues |
| $qe_{cb,g}$ | qe_cb_g | 0 | Initial data | flow of quantitative easing issues |
| $qe_{cp,b}$ | qe_cp_b | 0 | Initial data | flow of quantitative easing issues |
| $qe_{cp,g}$ | qe_cp_g | 0 | Initial data | flow of quantitative easing issues |
| $qe_l$ | qe_l | 0 | Initial data | flow of quantitative easing issues |
| $qe_{l,b}$ | qe_l_b | 0 | Initial data | flow of quantitative easing issues |
| $qe_{l,g}$ | qe_l_g | 0 | Initial data | flow of quantitative easing issues |
| $qe_{cb}$ | qe_cb | 0 | Initial data | flow of quantitative easing issues |
| $qe_{cp}$ | qe_cp | 0 | Initial data | flow of quantitative easing issues |
| $qe_{gb}$ | qe_gb | 0 | Initial data | flow of quantitative easing issues |
| $GB_{d,cbk}$ | stock_GB_d_cbk | 1500 | Country data | stock of government bonds |
| $QE_{l,k,b}$ | stock_QE_l_k_b | 0 | Initial data | stock of Central Bank's assets |
| $QE_{l,k,g}$ | stock_QE_l_k_g | 0 | Initial data | stock of Central Bank's assets |
| $QE_{l,c,b}$ | stock_QE_l_c_b | 0 | Initial data | stock of Central Bank's assets |
| $QE_{l,c,g}$ | stock_QE_l_c_g | 0 | Initial data | stock of Central Bank's assets |
| $QE_{cb,b}$ | stock_QE_cb_b | 0 | Initial data | stock of Central Bank's assets |
| $QE_{cb,g}$ | stock_QE_cb_g | 0 | Initial data | stock of Central Bank's assets |
| $QE_{cp,b}$ | stock_QE_cp_b | 0 | Initial data | stock of Central Bank's assets |
| $QE_{cp,g}$ | stock_QE_cp_g | 0 | Initial data | stock of Central Bank's assets |
| $QE_l$ | stock_QE_l | 0 | Initial data | stock of Central Bank's assets |
| $QE_{cb}$ | stock_QE_cb | 0 | Initial data | stock of Central Bank's assets |
| $QE_{cp}$ | stock_QE_cp | 0 | Initial data | stock of Central Bank's assets |
| $h_d$ | h_d | 0 | Initial data | flow of high powered money |
| $M_{s,h}$ | stock_M_s_h | $M_{d,h}$ | Country data | savings account |
| $H_d$ | stock_H_d | $0.1 \times M_{s,h}$ | Country data | high powered money (cash and reserve assets) |
| $H_{s,qe}$ | stock_H_s_qe | 0 | Initial data | high powered money (cash and reserve assets) |
| $H_{s,gb}$ | stock_H_s_gb | 0 | Initial data | high powered money (cash and reserve assets) |
| $H_s$ | stock_H_s | 0 | Initial data | high powered money (cash and reserve assets) |
| $E_{cbk}$ | E_cbk | 1500 | Country data | stock of equities |
| $e_{cbk}$ | e_cbk_s | 1500 | Country data | annual flow of equities issues |

## 7.8) Module 8: Rates and Returns (08-ratesreturns)

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|
| $i_{cbk}$ | i_cbk | 0.0045 | Initial data | interest rate |
| $\widehat{i_{cbk}}$ | i_cbk_spread | 0.0045 | Initial data | interest rate |
| $i_{df}$ | i_df | 0 | Initial data | interest rate |

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|
| $i_{mr}$ | i_mr | 0 | Initial data | interest rate |
| $i_{mr}$ | i_mr_spread | 0.0001 | Initial data | interest rate |
| $greenium$ | greenium | 0 | Initial data | brown to green market spread |
| $i_{cp,b}$ | i_cp_b | pi | Initial data | interest rate |
| $i_{cp,g}$ | i_cp_g | pi | Initial data | interest rate |
| $i_{l,k,b}$ | i_l_k_b | pi | Initial data | interest rate |
| $i_{l,k,g}$ | i_l_k_g | pi | Initial data | interest rate |
| $i_{cb,b}$ | i_cb_b | pi | Initial data | interest rate |
| $i_{cb,g}$ | i_cb_g | pi | Initial data | interest rate |
| $i_{l,c,b}$ | i_l_c_b | pi | Initial data | interest rate |
| $i_{l,c,g}$ | i_l_c_g | pi | Initial data | interest rate |
| $i_{sa}$ | i_sa | 0.0001 | Initial data | interest rate |
| $i_{gb}$ | i_gb | 0.0113 | Initial data | interest rate |
| $\sigma_0$ | sigma0 | 0.01 | Fixed parameter | baseline greenium parameter |
| $\gamma_{ecs}$ | gamma_ecs | 1 | Fixed parameter | greenium modulation parameter |
| $\sigma_1$ | sigma1 | $i_{gb} - i_{cbk}$ | Initial data | liquidity risk premium |
| $\sigma_2$ | sigma2 | 0.05 | Fixed parameter | liquidity risk premium |
| $\sigma_3$ | sigma3 | 1 | Fixed parameter | mark-up to the refinancing rate |
| $r_{cb,b}$ | r_cb_b | 0 | Initial data | assets rate of return |
| $r_{cb,g}$ | r_cb_g | 0 | Initial data | assets rate of return |
| $r_{l,k,b}$ | r_l_k_b | 0 | Initial data | assets rate of return |
| $r_{l,k,g}$ | r_l_k_g | 0 | Initial data | assets rate of return |
| $r_{l,c,b}$ | r_l_c_b | 0 | Initial data | assets rate of return |
| $r_{l,c,g}$ | r_l_c_g | 0 | Initial data | assets rate of return |
| $r_{gb}$ | r_gb | 0 | Initial data | assets rate of return |
| $r_{if}$ | r_if | 0 | Initial data | assets rate of return |
| $CG_{cb,b}$ | CG_cb_b | 0 | Initial data | capital gains |
| $CG_{cb,g}$ | CG_cb_g | 0 | Initial data | capital gains |
| $CG_{l,k,b}$ | CG_l_k_b | 0 | Initial data | capital gains |
| $CG_{l,k,g}$ | CG_l_k_g | 0 | Initial data | capital gains |
| $CG_{l,c,b}$ | CG_l_c_b | 0 | Initial data | capital gains |
| $CG_{l,c,g}$ | CG_l_c_g | 0 | Initial data | capital gains |
| $CG_{gb}$ | CG_gb | 0 | Initial data | capital gains |
| $CG_e$ | CG_e | 0 | Initial data | capital gains |
| $CG_{cb,b}^e$ | CG_exp_cb_b | 0 | Initial data | capital gains |
| $CG_{cb,g}^e$ | CG_exp_cb_g | 0 | Initial data | capital gains |
| $CG_{l,k,b}^e$ | CG_exp_l_k_b | 0 | Initial data | capital gains |
| $CG_{l,k,g}^e$ | CG_exp_l_k_g | 0 | Initial data | capital gains |
| $CG_{l,c,b}^e$ | CG_exp_l_c_b | 0 | Initial data | capital gains |
| $CG_{l,c,g}^e$ | CG_exp_l_c_g | 0 | Initial data | capital gains |
| $CG_{gb}^e$ | CG_exp_gb | 0 | Initial data | capital gains |
| $CG_e^e$ | CG_exp_e | 0 | Initial data | capital gains |
|  | psi_ecg | 0.05 | Fixed parameter | adaptive expectation parameters (capital gains) |

## 7.9) Module 9: Public sector (09-public)

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|

| $BB_p$ | BB_p | 0 | Initial data | budget balance |
|---|---|---|---|---|
| $P_p$ | PnL_p | 0 | Initial data | profit |
| $RE_p$ | RE_p | 0 | Initial data | retained earnings |
| $Div_p$ | Div_p | 0 | Initial data | dividend |
| $G$ | G | 0 | Initial data | government spending |
| $G_c$ | G_c | 0 | Initial data | government spending |
| $G_k$ | G_k | 0 | Initial data | government spending |
| $\bar{G}$ | G_start | 6000 | Country data | government spending |
| $\mu_c$ | mu_c | 0.2 | Fixed parameter | share of government spending in social firms |
| $K_p^T$ | K_p_Tgt | 1875 | Country data | stock of physical capital assets |
| $K_p$ | K_p | 5000 | Country data | stock of physical capital assets |
| $I_{d,p}$ | inv_d_p | 500 | Country data | investment |
| $DA_p$ | DA_p | 250 | Country data | depreciation expenditures |
| $I_{d,p,g}$ | inv_d_p_g | 200 | Country data | investment |
| $I_{d,p,b}$ | inv_d_p_b | 300 | Country data | investment |
| $I_{s,p}$ | inv_s_p | 0 | Initial data | investment |
| $\kappa_{1,p}$ | kappa1_p | 0.0090 | Fixed parameter | target growth rate of the total productive capital |
| $\kappa_{2,p}$ | kappa2_p | 0.3 | Fixed parameter | fraction of the total demand for capital goods |
| $T$ | T | 0 | Initial data | taxes |
| $T_w$ | T_w | 0 | Initial data | taxes |
| $T_r$ | T_r | 0 | Initial data | taxes |
| $T_c$ | T_c | 0 | Initial data | taxes |
| $T_k$ | T_k | 0 | Initial data | taxes |
| $\theta_w$ | teta_w | 0.25 | Country data | income tax rate |
| $\theta_r$ | teta_r | 0.2 | Country data | income tax rate |
| $\theta_c$ | teta_c | 0 | Country data | income tax rate |
| $\theta_k$ | teta_k | 0.35 | Country data | income tax rate |
| $gb_s$ | gb_s | 0 | Initial data | annual flow of government bonds issues |
| $GB_s$ | stock_GB_s | 35000 | Country data | stock of government bonds |

## 7.10) Module 10: Ecosystem (10-ecosystem)

| Variable | Code | Value | Data type | Description |
|---|---|---|---|---|
| $SES$ | SES | $K_c + K_p + K_k$ | Country data | socio-economic stock |
| $SES_{dis}$ | SES_dis | 0 | Initial data | discarded socioeconomic stock |
| | dc | $C$ | Country data | stock of durable goods |
| $MAT_Y$ | MAT_y | 0 | Initial data | material production (Annual matter used) |
| $MAT_{ext}$ | MAT_ext | 0 | Initial data | annual matter extraction |
| $SES_{rec}$ | SES_rec | 0 | Initial data | recycled socio-economic stock |
| $SES_{wa}$ | SES_wa | 0 | Initial data | annual material waste emissions |
| $MAT_{rev}$ | MAT_rev | 6438 | Initial data | annual material reserves |
| $MAT_{con}$ | MAT_con | 0 | Initial data | conversion of natural reserves into material stocks |
| $MAT_{res}$ | MAT_res | 834490000 | Initial data | annual material resources |
| $\mu_{mat}$ | mu_mat | 0 | Initial data | share of material production |
| $\mu_g$ | mu_g | 0.71 | Fixed parameter | share of material production |

| | | | | |
|---|---|---|---|---|
| $\mu_b$ | mu_b | 0.86 | Fixed parameter | share of material production |
| $\zeta$ | zeta | 0.015 | Fixed parameter | share of socio-economic stock |
| $\rho_{rec}$ | rho_rec | 0.05 | Fixed parameter | proportion of the discarded socio-economic stock that is recycled |
| $\sigma_{mat}$ | sigma_mat | 0.001 | Fixed parameter | conversion of material resources |
| $EN_{rev}$ | EN_rev | 38000 | Country data | annual variations of the stock of non-renewable energy |
| $EN_{con}$ | EN_con | 0 | Initial data | conversion of energy resources into reserves |
| $EN_{res}$ | EN_res | 543000000000 | Country data | energy reserves |
| $EN_{nre}$ | EN_nre | 93200 | Country data | non-renewable energy |
| $EN_{re}$ | EN_re | 0 | Initial data | renewable energy |
| $EN$ | EN | 93200 | Country data | energy required for the production |
| $EN_{dis}$ | EN_dis | 0 | Initial data | dissipated energy |
| $\sigma_{en}$ | sigma_en | 0.0177 | Fixed parameter | conversion of energy resources |
| $\xi_Y$ | xi_Y | 1/(0.0000035) | Fixed parameter | conversion of production to energy coefficient |
| $\kappa_{tek}$ | kappa_tek | 150 | Fixed parameter | eco-efficiency technological capacities |
| $CO2_{em}$ | CO2_em | 36.17 | Initial data | annual CO2 emissions |
| $CO2_{lnd}$ | CO2_lnd | 4 | Initial data | land emissions |
| $CO2_{ind}$ | CO2_ind | (CO2_ob-CO2_lnd) | Initial data | industrial emissions |
| 02 | O2 | 0 | Initial data | oxygen stock |
| $CO2_{mas}$ | CO2_mas | 0 | Initial data | carbon mass |
| $\beta_0$ | beta0 | 0 | Initial data | initial value of CO2 emissions |
| $g_{lnd}$ | g_lnd | 0 | Initial data | land emissions declining rate |
| $car$ | car | 0.0305 | Fixed parameter | conversion coefficient of carbon in CO2 |
| $F$ | F | 2.3 | Initial data | radiative forcing |
| $F_2$ | F2 | 3.8 | Fixed parameter | increase factor of radiative forcing |
| $CO2_{pre}$ | CO2_atm_pre | 2156.2 | Fixed parameter | pre-industrial atmospheric concentration of CO2 |
| $F_{ex}$ | F_ex | 0.28 | Initial data | radiative forcing due to non-CO2 greenhouse gases |
| $fex$ | fex | 0.005 | Fixed parameter | increase in radiative forcing due to non-CO2 greenhouse gases |
| $TEMP_{atm}$ | Temp_atm | 0.91 | Initial data | atmospheric temperature |
| $TEMP_{ocn}$ | Temp_ocn | 0 | Initial data | oceanic temperature |
| $CO2_{atm}$ | CO2_atm | 2156.2 | Initial data | atmospheric concentration of CO2 |
| $CO2_{br}$ | CO2_br | 4950.5 | Initial data | biosphere reservoir |
| $CO2_{ocn}$ | CO2_ocn | 36670 | Initial data | ocean reservoir |
| $t_1$ | t1 | 0.027*0.026 | Fixed parameter | atmospheric temperature adjustment coefficient |
| $t_2$ | t2 | 0.018 | Fixed parameter | atmosphere heat loss transfer coefficient from lower ocean |
| $sens$ | sens | 3 | Fixed parameter | climate sensitivity |
| $t_3$ | t3 | 0.005 | Fixed parameter | lower ocean heat gain transfer coefficient from atmosphere |
| $\varphi_{11}$ | phi11 | 0.9817 | Fixed parameter | CO2 transfer coefficient |
| $\varphi_{21}$ | phi21 | 0.0080 | Fixed parameter | CO2 transfer coefficient |
| $\varphi_{12}$ | phi12 | 0.0183 | Fixed parameter | CO2 transfer coefficient |
| $\varphi_{22}$ | phi22 | 0.9915 | Fixed parameter | CO2 transfer coefficient |
| $\varphi_{32}$ | phi32 | 0.0001 | Fixed parameter | CO2 transfer coefficient |
| $\varphi_{23}$ | phi23 | 0.0005 | Fixed parameter | CO2 transfer coefficient |
| $\varphi_{33}$ | phi33 | 0.9999 | Fixed parameter | CO2 transfer coefficient |
| $\beta_g$ | beta_g | 0.048154-0.01 | Fixed parameter | Green non renewable energy coefficient |

| $\beta_b$ | beta_b | 0.048154+0.01 | Fixed parameter | Brown non renewable energy coefficient |
|---|---|---|---|---|
| $\varepsilon_g$ | epsilon_g | 7.65 | Fixed parameter | Green energy coefficient |
| $\varepsilon_b$ | epsilon_b | 9.32 | Fixed parameter | Brown energy coefficient |
| $\varepsilon_{en}$ | epsilon_en | @recode (@date< @dateval("2020") ,epsilon_b ,(epsilon_g *(K_g/K) +epsilon_b *(K_b/K))) | Parameter | proportion of energy required for GDP |
| $\eta_g$ | eta_g | 0.075 | Fixed parameter | Green renewable energy coefficient |
| $\eta_b$ | eta_b | 1-0.075 | Fixed parameter | Brown renewable energy coefficient |
| $\eta_{re}$ | eta_re | 0 | Parameter | share of renewable energy |
| $dep_{mat}$ | dep_mat | 0 | Initial data | depletion of material resource |
| $dep_{en}$ | dep_en | 0 | Initial data | depletion of energy resource |
| $dmg_{ecs}$ | dmg_ecs | 0.0028 | Initial data | climate-related damage |
| $\varrho_1$ | dmg1 | 0 | Fixed parameter | damage coefficient |
| $\varrho_2$ | dmg2 | 0.00284/3 | Fixed parameter | damage coefficient |
| $\varrho_3$ | dmg3 | 0.000005/3 | Fixed parameter | damage coefficient |
| $\varrho_4$ | dmg4 | 6.6754/3 | Fixed parameter | damage coefficient |