

# We live in the same planet but are we on the same boat? Analysis of the distributive impact of the climate crisis

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Demand and Growth Regimes: Expanding the Debate  
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# Literature review

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**Integrated Assessment models:** class of macro models that combine economic and climatic considerations, built by integrating together a number of separate “modules”. (Nordhaus, 1993; Proctor, 2023)

# Literature review II

## Post Keynesian Economics:



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No ecological macro model, to the best of my knowledge, maps the channels of transmissions through which the climate crisis impacts the economy and the within country income distribution and assess the relative impact of each channel.

Models which are the closest to the one I am developing are the DEFINE (Dafermos et al., 2017) and the EUROGREEN (D'Alessandro et al., 2020).

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- It has an **ecological module** that keeps track of the exchanges between the economy and the ecosystem
- The **industries** are modeled through an Input-Output system

# Households

**3 classes:**





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All the classes pay a flat tax over total income. Managers and capitalists decide their real consumption demand according to a consumption function:

$$c_j = \alpha_{1j} \cdot yd_{ej} + \alpha_{2j} \cdot \frac{V_{hj-1}}{p_C} \quad (1)$$

with capitalists having lower propensities to consume:  $\alpha_{1r} < \alpha_{1m}$ ;  $\alpha_{2r} < \alpha_{2m}$ .

# Productive sector



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$$\mathbf{u}_k = \hat{\mathbf{x}}^*_k \cdot \mathbf{x}^{-1} \quad (2)$$

$$\mathbf{i}_{nv} = \gamma \cdot \hat{\mathbf{k}}_{-1} \cdot (\mathbf{u}_{k-1} - \mathbf{u}_k^T) + \delta \cdot \mathbf{k}_{-1} \quad (3)$$

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Production level is determined through a Leontief inverse matrix

# Labor market



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- **Wages** are modeled in a conflict inflation framework (Cripps and Godley, 1976; Hein and Stockhammer, 2010), in which, in each sector, the workers wages growth rate depends on the inflation rate, on the sectoral level unemployment and on labor productivity.

$$\mathbf{g}_w = w_0 + w_u \cdot \Delta \mathbf{u}_w + w_p \cdot \pi + w_l \cdot \mathbf{g}_{pr_l} \quad (5)$$



# Other sectors



## Other sectors

**Foreign sector:** stylized rest of the world, import is divided into consumption, investment and intermediate goods.

**Government:** exogenously growing public expenditures and social contributions to unemployed and households outside the labor force.

### Central Bank

**Ecological module:** 4 ecological commodities (inputs: water and energy, outputs: hazardous waste and CO<sub>2</sub>) and 7 ecosystem variables

# Input-Output representation

The output is computed through an inverse Leontief matrix, while the computation of ecological inputs and outputs follows an EEIO approach (Aguilar-Hernandez et al., 2018; Miller and Blair, 2021)

|  |                 | Processing Sectors                  |       |       | Total Demand |             |       |           |              | Ecological outputs                  |                 |
|--|-----------------|-------------------------------------|-------|-------|--------------|-------------|-------|-----------|--------------|-------------------------------------|-----------------|
|  |                 | $s_1$                               | $s_2$ | $s_3$ | Cons         | Investments | Govt  | Exports   | Total Output | $CO_2$                              | Hazardous Waste |
| Processing Sector                          | $s_1$           | <b>Z</b>                            |       |       | $c_1^{dom}$  | $i_1^{dom}$ | $g_1$ | $e_1$     | $x_1$        | <b>N = R · <math>\hat{x}</math></b> |                 |
|  | $s_2$           |                                     |       |       | $c_2^{dom}$  | $i_2^{dom}$ | $g_2$ | $e_2$     | $x_2$        |                                     |                 |
|  | $s_3$           |                                     |       |       | $c_3^{dom}$  | $i_3^{dom}$ | $g_3$ | $e_3$     | $x_3$        |                                     |                 |
| Labor<br>Other<br>value<br>added<br>Import | $w_1$           | $w_2$                               | $w_3$ | $ub$  |              |             |       | $wb + ub$ |              |                                     |                 |
|  | $n_1$           | $n_2$                               | $n_3$ |       |              |             |       | $OVA$     |              |                                     |                 |
|  | $m_1$           | $m_2$                               | $m_3$ | $m_C$ | $m_I$        |             |       | $m$       |              |                                     |                 |
| Total outlays                              |                 | $x_1$                               | $x_2$ | $x_3$ | $c$          | $i$         | $g$   | $e$       | Tot          |                                     |                 |
| Ecological inputs                          | Energy<br>Water | <b>M = Q · <math>\hat{x}</math></b> |       |       |              |             |       |           |              |                                     |                 |

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- **Demand side effects:** Energy consumption, total consumption and investment
- **Financial side effects:** Flight-to-safety mechanisms and credit constraints

# Supply side I



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**Mortality:** Mortality and temperatures have a U shape relationship (Deschênes and Greenstone, 2011). The overall effect in south Europe is positive (Gasparrini et al., 2017). Linear relationship included TITANIC (Cromar et al., 2022)

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Sector specific labor supply loss function included in the model (Graff Zivin and Neidell, 2014).

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**Labor productivity:** will tend to decrease in Italy, with sectoral heterogeneity depending on the work intensity. Labor productivity loss function included in the model. (Hsiang et al., 2017; Martinich and Crimmins, 2019; Graff Zivin and Neidell, 2014; Orlov et al., 2019).

# Supply side II





# Supply side II

**Capital Destruction:** an increase in extreme events frequency (Intergovernmental Panel On Climate Change (Ipcc), 2023) is gonna have a **strong impact on the installed capital**. In TITANIC stochastic damages are included as in **Hallegatte et al. (2007)**.

# Supply side II

**Capital Destruction:** an increase in extreme events frequency (Intergovernmental Panel On Climate Change (Ipcc), 2023) is gonna have a **strong impact on the installed capital**. In TITANIC stochastic damages are included as in **Hallegatte et al. (2007)**.

**Production relocation:** Firms might relocate in places with better climatic conditions (Linnenluecke et al., 2011) due to direct (Dasgupta et al., 2021) or indirect effects, such as change in energy costs (Koch and Basse Mama, 2019) and in climatic regulations (Misch and Wingender, 2021).

In the model the productive sector **increases the amount of intermediate goods that imports from abroad** and **decreases the amount of intermediate goods that produces domestically** as temperatures increase.

# Demand side I



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The effect on domestic consumption depends on the social classes considered (De Cian and Sue Wing, 2019; Du et al., 2020), hence in the model, the **energy consumption increases** as temperatures increase, with the increase being larger for the workers and smaller for the capitalists.

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The effect on productive energy consumption is positive (van Ruijven et al., 2019; De Cian and Sue Wing, 2019). Hence, in TITANIC the **energy required to produce a unit of output** increases as temperature increases, with a larger increase for the **manufacturing sector**. (van Ruijven et al., 2019).

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The effect of climate change on **consumption** could be negative (Chen et al., 2024; Hsiang et al., 2017) or positive due to adaptation strategies (Aggarwal, 2021)

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In TITANIC, following the IAM literature it is assumed that total consumption and investments decrease according to a **climate damage function** (Dafermos et al., 2017):

$$D_T = \frac{1}{1 + \pi_1 \cdot T_{AT} + \pi_2 T_{AT}^2 + \pi_3 \cdot T_{AT}^{6.754}} \quad (6)$$

# Financial Side: Credit Constraints

As climate change gets worse, the economic conditions through which the productive sector must operate become tougher. This could lead to an **increase of firms rate of failures**, altering the financial sector balance sheet, which could react limiting the **credit availability**.



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In order to investigate this channel, the model is augmented with credit rationing mechanism, in which the banking sector provides only a part of the credit, based on their capital and on the liquidity of the productive sector.

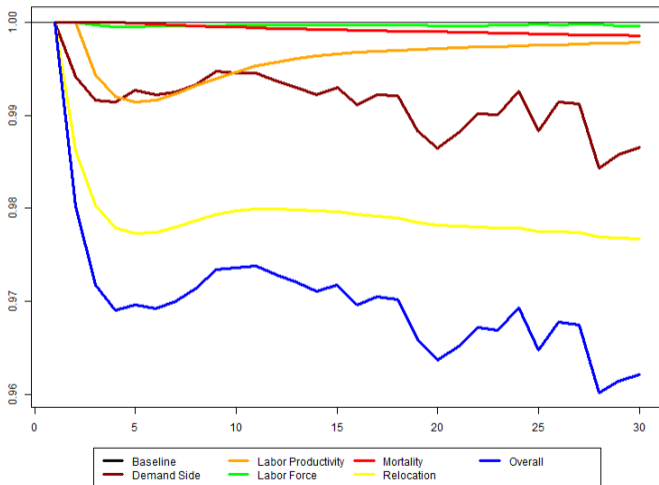
Finally, the productive sector default rate increase as temperature increases.

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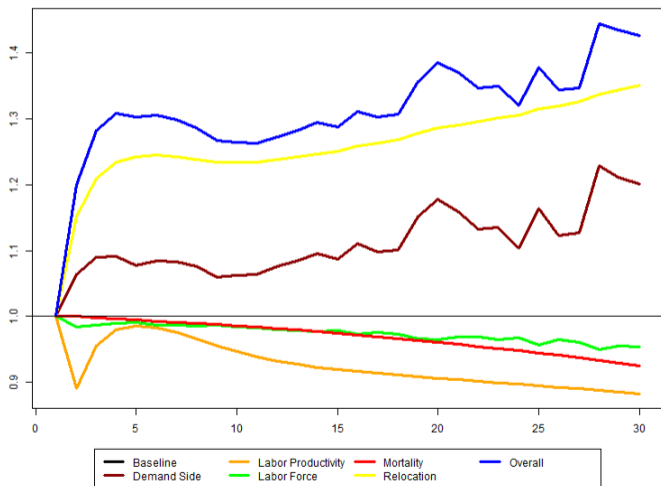
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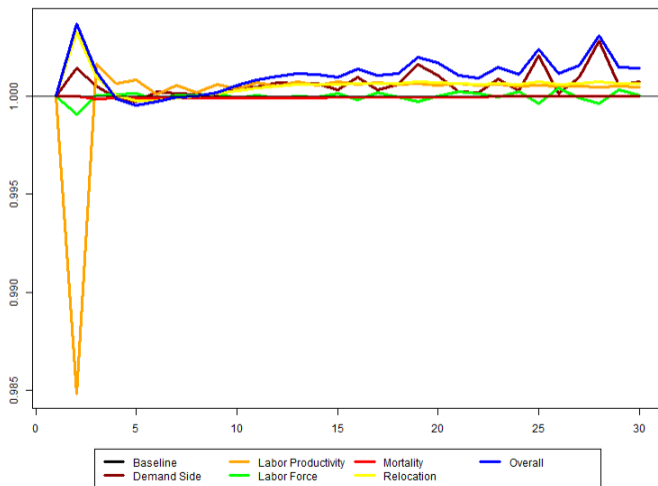
# Effect of climate change on GDP



# Effect of climate change on Unemployment



# Effect of climate change on Profit share



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The work is conducted with a methodology (**Eco-SFC-IO**), that allows to keep track of sectoral dynamics of the productive sector and of the ecosystem main variables.

## To sum up

With this work I have so far developed a **medium scale ecological model** with a disaggregated household sector.

The work is conducted with a methodology (**Eco-SFC-IO**), that allows to keep track of sectoral dynamics of the productive sector and of the ecosystem main variables.

With the continuation of such work, it will be possible to assess the impact of climate change on within country income distribution, highlighting the different impact of the different channels of transmission, contributing to expanding the literature.

# Thanks for the attention!

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# Q&A

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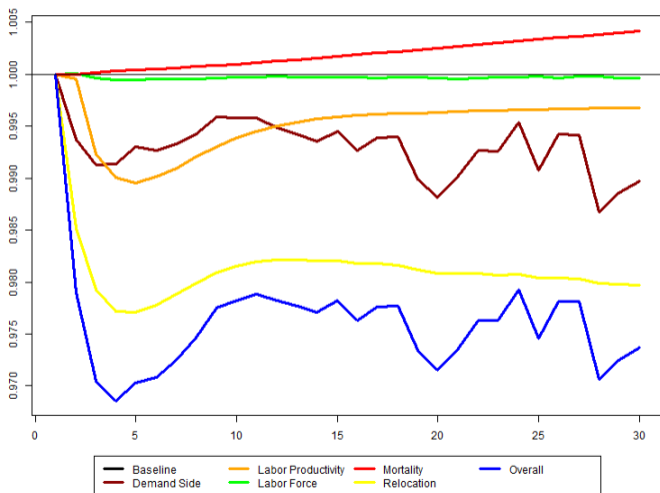


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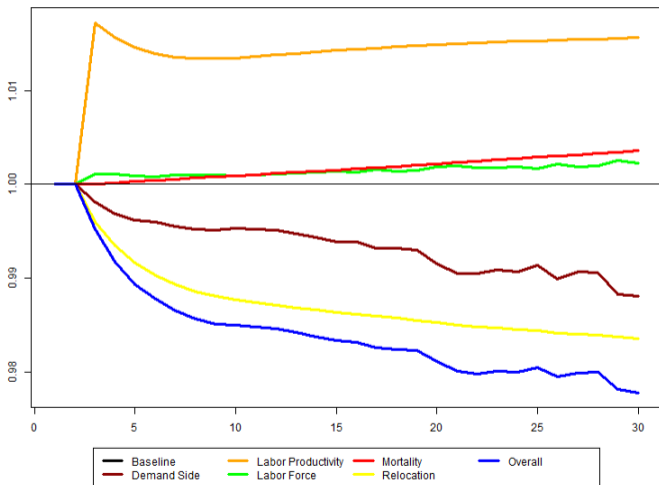
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# Effect of climate change on per capita disposable Income

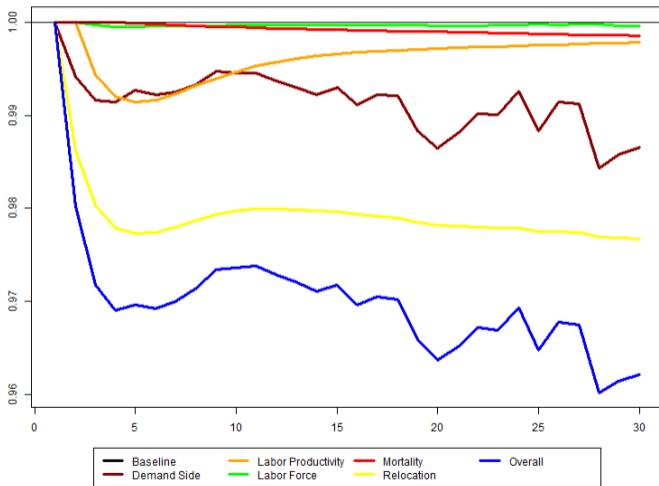


# Effect of climate change on Price Level





# Baseline GDP Growth



# Transaction Flow Matrix

|                          | Households                 |                            |                           | Production Firms         |                  | Banks                     | Government           | Central Bank              | Foreign Sector             | Sum |
|--------------------------|----------------------------|----------------------------|---------------------------|--------------------------|------------------|---------------------------|----------------------|---------------------------|----------------------------|-----|
|                          | Capitalists                | Managers                   | Workers                   | Current                  | Capital          |                           |                      |                           |                            |     |
| Consumption              | $-C_c$                     | $-C_m$                     | $-C_w$                    | $+C^{dom}$               |                  |                           |                      |                           | $+M_C$                     | 0   |
| Investment               |                            |                            |                           | $+I^{dom}$               | $-I$             |                           |                      |                           | $+M_I$                     | 0   |
| Government Expenditures  |                            | $+UB_m$                    | $+UB_w$                   | $+G$                     |                  |                           | $-G - UB$            |                           |                            | 0   |
| Intermediate Good Import |                            |                            |                           | $-M_Z$                   |                  |                           |                      |                           | $+M_Z$                     | 0   |
| Export                   |                            |                            |                           | $+E$                     |                  |                           |                      |                           | $-E$                       | 0   |
| Wages                    |                            | $+WB_m$                    | $+WB_w$                   | $-WB$                    |                  |                           |                      |                           |                            | 0   |
| Depreciation Allowances  |                            |                            |                           | $-AF$                    | $+AF$            |                           |                      |                           |                            | 0   |
| Taxes                    | $-T_c$                     | $-T_m$                     | $-T_w$                    |                          |                  |                           | $+T$                 |                           |                            | 0   |
| Central Bank profits     |                            |                            |                           |                          |                  |                           | $+F_{cb}$            | $-F_{cb}$                 |                            | 0   |
| Firms Profits            | $+FD_{fc}$                 | $+FD_{fm}$                 |                           | $-F_f$                   | $+FU_f$          |                           |                      |                           |                            | 0   |
| Banks Profits            | $+F_{bc}$                  | $+F_{bm}$                  |                           |                          |                  | $-F_b$                    |                      |                           |                            | 0   |
| Interests on loans       |                            |                            |                           | $-r_{l-1} \cdot L_{h-1}$ |                  | $+r_{l-1} \cdot L_{s-1}$  |                      |                           |                            | 0   |
| Interests on deposits    | $+r_{m-1} \cdot M_{hc-1}$  | $+r_{m-1} \cdot M_{hm-1}$  | $+r_{m-1} \cdot M_{hw-1}$ |                          |                  | $-r_{m-1} \cdot M_{s-1}$  |                      |                           |                            | 0   |
| Interests on Bills       | $+r_{b-1} \cdot B_{hbc-1}$ | $+r_{b-1} \cdot B_{hbm-1}$ |                           |                          |                  | $+r_{b-1} \cdot B_{hb-1}$ | $-r_{b-1} \cdot B_s$ | $+r_{b-1} \cdot B_{cb-1}$ | $+r_{b-1} \cdot B_{row-1}$ | 0   |
| Interests on Advances    |                            |                            |                           |                          |                  | $-r_{a-1} \cdot A_{h-1}$  |                      | $+r_{a-1} \cdot A_{s-1}$  |                            | 0   |
| Change in Cash           | $-\Delta H_{hbc}$          | $-\Delta H_{hbm}$          |                           |                          |                  | $-\Delta H_{hb}$          |                      | $+\Delta H_s$             | $-\Delta H_{row}$          | 0   |
| Change in Deposits       | $-\Delta M_{hc}$           | $-\Delta M_{hm}$           | $-\Delta M_{hw}$          |                          |                  |                           | $+\Delta M_s$        |                           |                            | 0   |
| Change in Bills          | $-\Delta B_{hbc}$          | $-\Delta B_{hbm}$          |                           |                          |                  | $-\Delta B_{hb}$          | $+\Delta B_s$        | $-\Delta B_{cb}$          | $-\Delta B_{row}$          | 0   |
| Change in Loans          |                            |                            |                           |                          | $+\Delta L_d$    | $-\Delta L_s$             |                      |                           |                            | 0   |
| Change in Advances       |                            |                            |                           |                          |                  | $+\Delta A_h$             |                      | $-\Delta A_s$             |                            | 0   |
| Change in Equity         | $-\Delta E_{hc}$           | $-\Delta E_{hm}$           |                           |                          | $+\Delta E_{sf}$ | $+\Delta E_{sb}$          |                      |                           |                            | 0   |
| Sum                      | 0                          | 0                          | 0                         | 0                        | 0                | 0                         | 0                    | 0                         | 0                          | 0   |

# Balance Sheet Matrix

|               | Households  |            |           | Firms     | Banks     | Government | Central Bank | Foreign Sector | Sum  |
|---------------|-------------|------------|-----------|-----------|-----------|------------|--------------|----------------|------|
|               | Capitalists | Managers   | Workers   |           |           |            |              |                |      |
| Cash          | $+H_{hbc}$  | $+H_{hbm}$ |           |           | $+H_{hb}$ |            | $-H_s$       | $+H_{row}$     | 0    |
| Deposits      | $+M_{hc}$   | $+M_{hm}$  | $+M_{hw}$ |           | $-M_s$    |            |              |                | 0    |
| Bills         | $+B_{hbc}$  | $+B_{hbm}$ |           |           | $+B_{hb}$ | $-B_s$     | $+B_{cb}$    | $+B_{row}$     | 0    |
| Loans         |             |            |           | $-L_d$    | $+L_s$    |            |              |                | 0    |
| Advances      |             |            |           |           | $-A_h$    |            | $+A_s$       |                | 0    |
| Equity        | $+E_{hc}$   | $+E_{hm}$  |           | $-E_{sf}$ | $-E_{sb}$ |            |              |                | 0    |
| Fixed Capital |             |            |           | $+K$      |           |            |              |                | $+K$ |
| Net worth     | $-V_{hc}$   | $-V_{hm}$  | $-V_{hw}$ | $-V_f$    | $-V_b$    | $+GD$      |              | $-V_{row}$     | $-V$ |
| Sum           | 0           | 0          | 0         | 0         | 0         | 0          | 0            | 0              | 0    |

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