The Modern Environmental Macroeconomics

George Economides

Athens University of Economics and Business, and *CESifo*

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- In equilibrium, the resulting net short-wave radiation must be balanced by the outgoing long-wave radiation.
- At a pre-industrial equilibrium state the incoming and outgoing energy fluxes were equal, and the global mean temperature was therefore constant on the average.

Modelling the Climate after the Industrial Revolution-2

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- Because of the perturbation, the incoming energy flux is larger than the outgoing flux, which leads to increasing temperature.

Modelling the Climate after the Industrial Revolution-3

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- The parameter σ determines how quickly the temperature changes due to a given imbalance in the fluxes.

Modelling the Climate after the Industrial Revolution-4

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- That is, it generates a positive forcing F.
- Gases with this property are called greenhouse gases (GHGs). Even a small concentration of such gases has a large effect on the energy balance of the earth.

Modelling the Climate after the Industrial Revolution-5

Carbon dioxide

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- where $S(t)$ and S_0 represent the current and preindustrial atmospheric CO_2 concentrations, respectively.

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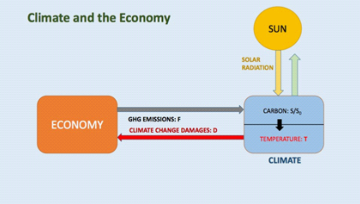
- The coefficient $\lambda = \frac{\eta}{\kappa - \xi}$ is called the equilibrium climate sensitivity and captures the response in the global mean temperature to a doubling of the CO_2.

Modelling the Climate after the Industrial Revolution-7

The link with the Economy-1



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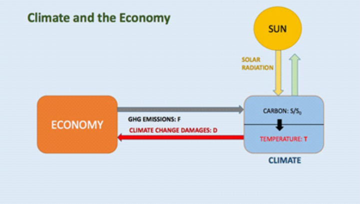
The link with the Economy-1



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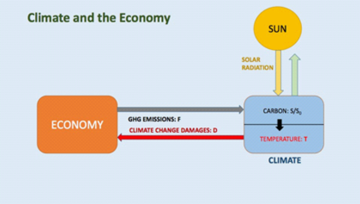

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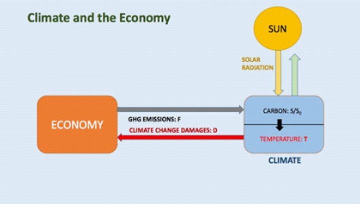

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- where d_{t-s} is the carbon depreciation function.

Modelling the Climate after the Industrial Revolution-8

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- the remainder decays with a half-life of a few centuries

- The coupled dynamic system describing climate and the impact of the economy, that is the impact from GHG emissions on temperature, is given, in continuous time by:

$$\dot{T}(t) = \frac{\gamma}{\ln 2} \ln\left(\frac{S}{S_0}\right) + F_{EX} + \delta T(t)$$

$$\delta = \xi - \kappa,\ \gamma = \sigma\eta,\ F_{EX}\text{: exogenous forcing}$$

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- The coupled dynamics can be expanded by introducing the ocean temperature and taking into account that atmospheric temperature increases much faster than the oceans.

- Emissions can be expresses as a by product of output, that is:

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- or can be regarded as an input in the production function representing the use of fossil fuels:

$$Y(t) = f(K, L, E)$$

$$Y(t) = A(t)K(t)^{\alpha}L(t)^{\beta}E(t)^{1-\alpha-\beta}$$

Modelling the Climate after the Industrial Revolution-11

Emissions vs Temperature: A Linear Relationship-1

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- The constant of proportionality is called the transient carbon response parameter (TCRE). This parameter is defined as the ratio of temperature change to cumulative carbon emissions, and it is approximately independent of both the atmospheric CO2 concentration and its rate of change over different time scales.

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- The constant of proportionality is called the transient carbon response parameter (TCRE). This parameter is defined as the ratio of temperature change to cumulative carbon emissions, and it is approximately independent of both the atmospheric CO2 concentration and its rate of change over different time scales.
- The TCRE is estimated to be in the range of $1.3 - 2.1^o C$ per trillion tones of carbon (TtC) [or per 1000 PgC] emitted).

- The linear model has been derived and verified over the relevant range of emissions by MacDougal and Friedlingstein (2015) with the TCRE defined as:

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- where, $\Delta T(t)$ is change in global average temperature up to time t; and $CE(t)$ are cumulative carbon emissions up to time t.

- In the context of the near proportional relationship between $CE(t)$ and $\Delta T(t)$, the anthropogenic impact on the global temperature increase can be approximated in continuous time by

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- where, $CE(t) = \int_{s=0}^{\infty} E(s)ds$ denotes cumulative global carbon emissions up to time t and Λ is the TCRE. Taking the time derivative of this expression, we obtain

$$\dot{T}(t) = \Lambda E(t),\ \Lambda = 1.7 \pm 0.4^{o}C \text{ per TtC}$$

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- After the presentation of the basic mechanism driving the global mean temperature and the basic links with the economy, we proceed to present the coupled economy-climate models which are used for policy design, and to provide the modern approach to the study of macroeconomic policy under conditions of climate change.