DEFINE-CLIMATE

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www.define-model.org

1. Brief description

DEFINE-CLIMATE is a simplified module of DEFINE, which shows how climate change is affected by economic activity. In this module higher economic growth leads to the generation of higher carbon emissions (for a given level of energy intensity, carbon intensity, sequestration rate and share of non-fossil energy). These carbon emissions affect cumulative carbon emissions which in turn increase atmospheric temperature.

2. Module equations

Output: $Y_t = Y_{t-1}\left(1+g_Y\right)$ (1)

Total energy: $E_t = \varepsilon Y_t$ (2)

Fossil energy: $E_{Ft} = \left(1-\theta\right)E_t$ (3)

Industrial CO_2 emissions: $EMIS_{INt} = \omega\left(1-seq\right)E_{Ft}$ (4)

Land-use CO_2 emissions: $EMIS_{Lt} = EMIS_{Lt-1}\left(1-g_{EMISLt}\right)$ (5)

Growth rate of land-use CO_2 emissions: $g_{EMISLt} = g_{EMISLt-1}\left(1-\zeta_9\right)$ (6)

Total emissions: $EMIS_t = EMIS_{INt} + EMIS_{Lt}$ (7)

Cumulative CO_2 emissions: $CO2_{CUMt} = CO2_{CUMt-1} + EMIS_t$ (8)

Atmospheric temperature: $T_{ATt} = T_{ATt-1} + t_1\left(t_2\varphi CO2_{CUM-1} - T_{ATt-1}\right)$ (9)

3. Symbols and values

Symbol	Description	Value/calculation
	Parameters	
g_Y	Growth rate of GDP	0.029
ε	Energy intensity, i.e. energy use per unit of GDP (EJ/trillion US$)	Calculated from equation (2)
ϑ	Share of non-fossil energy in total energy	0.15
ω	CO_2 intensity, i.e. CO2 emissions per unit of non-renewable energy use (Gt/EJ)	Calculated from equation (4)
seq	Proportion of carbon that is sequestrated	0.002186
ζ_9	Rate of decline of the growth rate of $EMIS_L$	0.0140
t_1	Coefficient capturing the timescale of the initial adjustment of the climate system to an increase in cumulative emissions	0.5
t_2	Coefficient that captures the global warming that stems from non-CO2 greenhouse gas	1.1
φ	Transient Climate Response to cumulative carbon Emissions (TCRE) ($^{\circ}C/GtCO_2$)	0.0005
	Endogenous variables	
Y	Output (trillion US$)	85.9
E	Energy used for the production of output (EJ)	590.0
E_F	Energy produced from fossil sources (EJ)	Calculated from equation (3)
$EMIS_{IN}$	Industrial CO_2 emissions ($GtCO_2$)	36.6
$EMIS_L$	Land-use CO_2 emissions ($GtCO_2$)	5.5
g_{EMISL}	Growth rate of land emissions	0.016
$EMIS$	Total CO_2 emissions ($GtCO_2$)	Calculated from equation (7)
$CO2_{CUM}$	Cumulative CO_2 emissions ($GtCO_2$)	2210
T_{AT}	Atmospheric temperature over pre-industrial levels ($^{\circ}C$)	1.14