Finance and Climate Change

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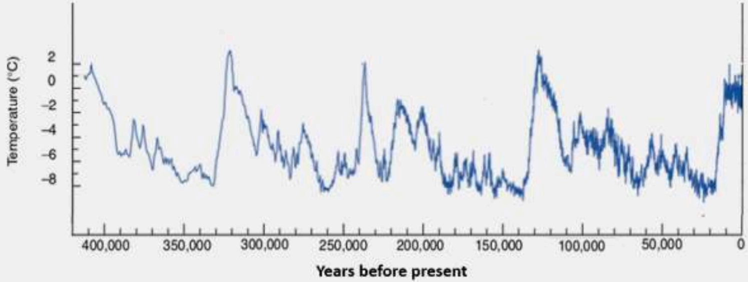
Climate has always changed

- In astronomical time scales, the primary drivers of climate change are the Milankovitch cycles.
- Eccentricity: 100,000 years cycle
- Axial Tilt: 41,000 years cycle
- Precession: 26,000 years cycle

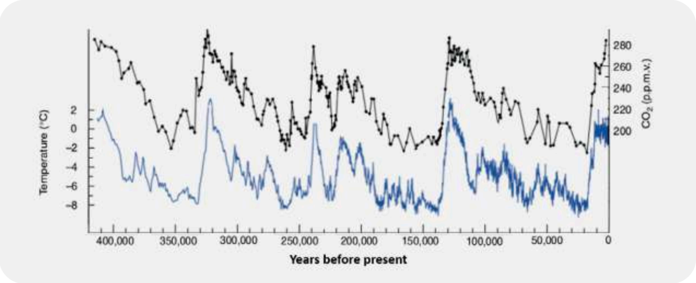
Temperature variation over long time periods



Evolution of the temperature above station Vostok.

Source: www.climatedata.info

Temperature and CO_2 variation over long time periods



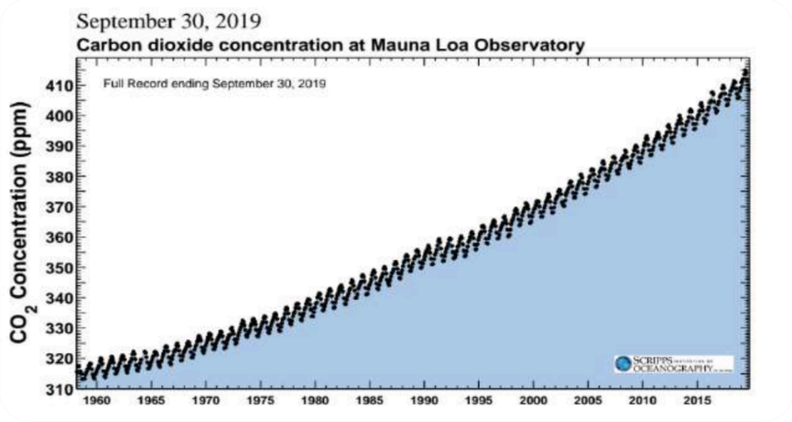
Joint evolution of temperature and CO_2 concentration above station Vostok.

Source: www.climatedata.info

Causality

- Throughout Earth's history, astronomical changes in the orbit of the Earth caused the increases in temperature which induced the increase in CO_2.
- Main mechanism is increase in release of CO_2 from upper ocean layers at higher temperatures.
- For current global warming, causality is reversed.
- Concentration of CO_2 increased from 314 ppm to 420 ppm in the past 50 years.
- This is a direct consequence of increased emissions, primarily from fossil fuels.
- Resulted in increase in temperature through greenhouse effect.

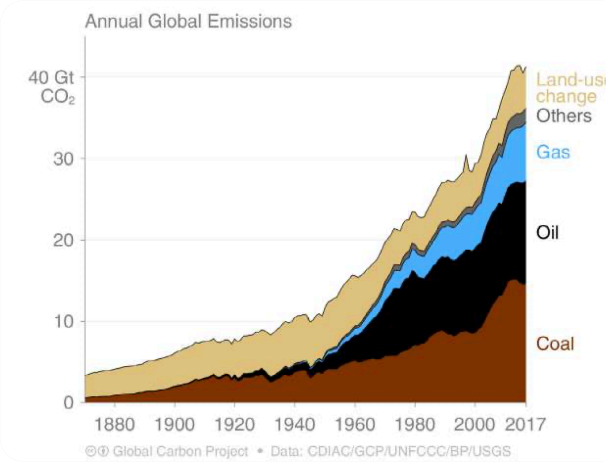
CO_2 variation in recent history



Keeling curve

Source: Website of Mauna Loa Observatory

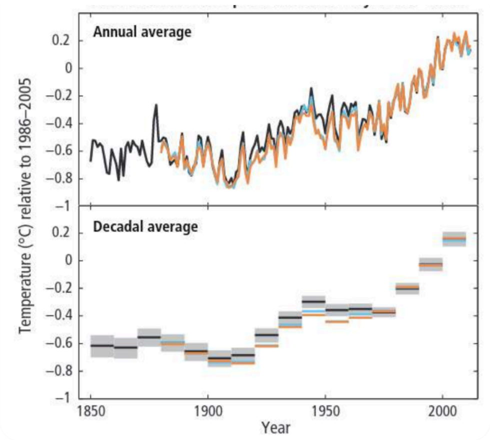
Global emissions since industrial revolution



Evolution of annual CO_2 emissions

Source: Global Carbon Project

Temperature anomaly since industrial revolution



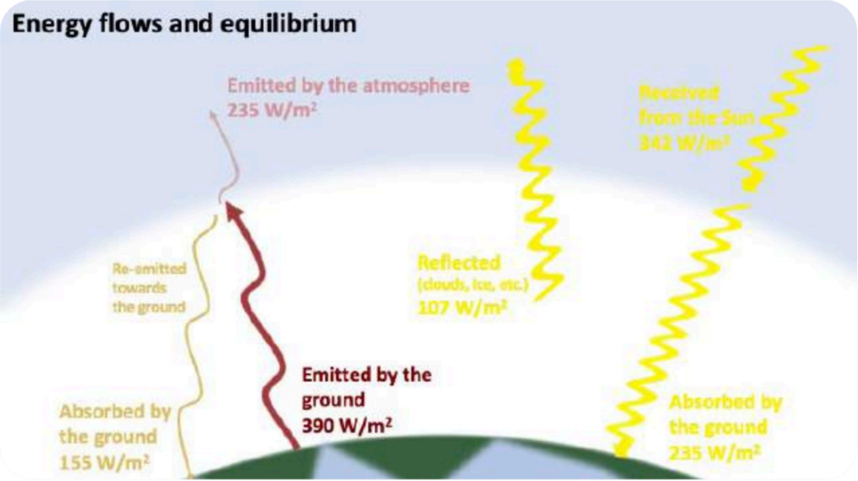
Temperature evolution since 1850, according to different series of measurements

Source: IPCC 2014 Report

Greenhouse effect and energy flows

- On average, the energy received from the Sun (visible light) at ground level is $R = 342\,\mathrm{W/m^2}$, with $M = 107\,\mathrm{W/m^2}$ reflected back (sea ice, glaciers), so that $E = 235\,\mathrm{W/m^2}$ is absorbed by the ground.
- The Earth then emits radiation back (infrared waves), which get absorbed by GHG and re-emitted back in all directions, with a portion H of it returning back to the ground.
- At equilibrium, the total radiation from the ground is therefore $G = E + H$.
- With no atmosphere ($H = 0$), we would have $G = 235\,\mathrm{W/m^2}$, corresponding to a temperature of -19^oC, on average.
- For the past 10,000 years, we have had $H = 155\,\mathrm{W/m^2}$, so that $G = 390\,\mathrm{W/m^2}$, corresponding to average temperature 15^oC.

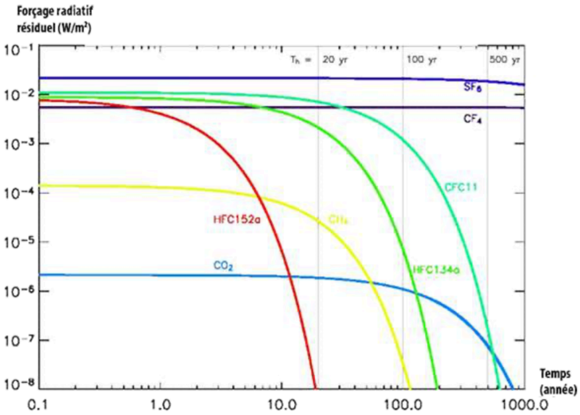
Earth's energy flows prior to industrial revolution



Forcing

- The difference between the total energy received and emitted by Earth is called **forcing** and is estimated to be $F = 3\text{W}/\text{m}^2$ in 2016.
- Incidentally, this is 2 orders of magnitude bigger than current global primary energy consumption (check!).
- As we discussed, several physical phenomena contribute to forcing (including astronomical variations in orbit, Sun cycles, etc), but the dominant effect over the last 200 years has been the increase in GHG.
- Different GHGs have very different potency and persistence times.

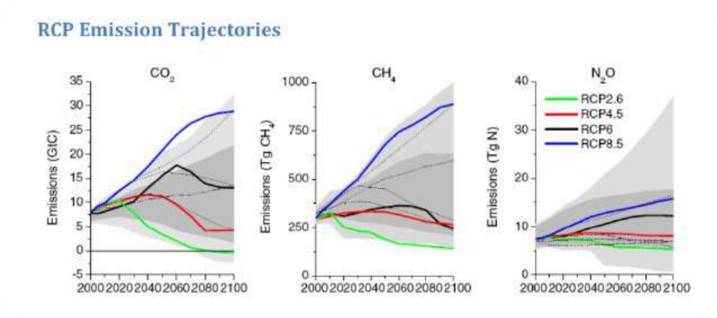
Forcing and GHG



Persistence of radiative forcing after emission

Source: D. Hauglustaine, LSCE, quoted in https://jancovici.com

IPCC Scenarios - Representative Concentration Pathways



Projected changes in CO_2 emissions, and CH_4 and N_2O emissions according to the different scenarios studied

Source: IPCC 2014 Report

Carbon budget

- To meet the goals of the Paris Agreement (keeping the increase in average temperatures below 2C by 2100), accumulated human-induced CO_2 emissions since 1850 would need to be less than 2,900 Gt of carbon.
- We were at 2,260 in 2020, and emissions that year were 40 Gt.
- If emissions stabilize at this level, the budget will be exhausted in 2036.
- The amount of carbon in fossil fuel reserves that are still available underground is much higher than the allowed budget.
- Two thirds of the fossil carbon needs to be left in the ground!

Climate-related Risks

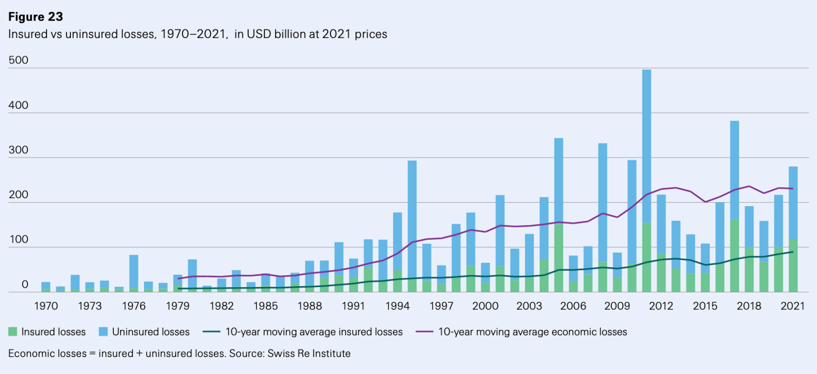
- Since 2018, the Network for Greening the Financial System (NFGS) formally recognizes that "climate-related risks are a source of financial risk" with the following distinct features:
- Far-reaching impact in breadth and magnitude: affects all agents
- Foreseeable nature: not "if", but "when" and "how much"
- Irreversibility
- Dependency on short-term actions

Taxonomy

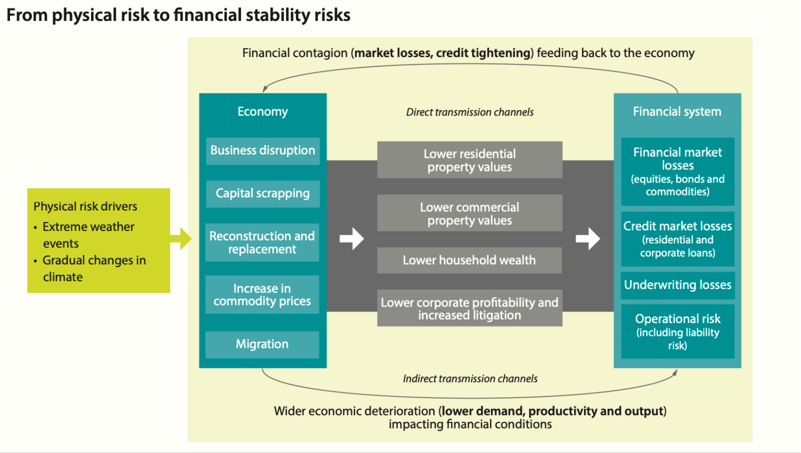
- **Physical risk:** economic costs and financial losses resulting from the increasing severity and frequency of extreme climate change-related weather events (such as heat waves, landslides, floods, wildfires and storms) as well as longer term progressive shifts of the climate (such as changes in precipitation, extreme weather variability, ocean acidification, and rising sea levels and average temperatures).
- **Transition risk:** adjustment towards a low-carbon economy, including net zero emissions to prevent further climate change.

Extreme-weather losses

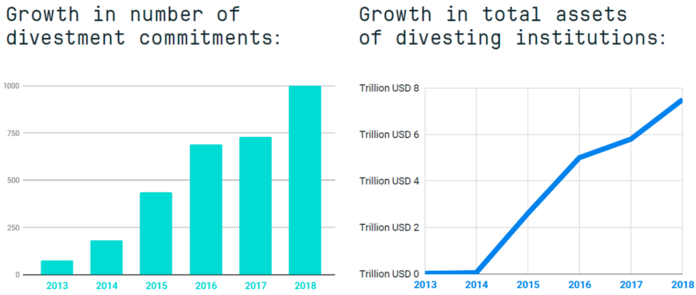
Losses from extreme events were $ 380 billion in 2017 and are estimated by Allianz (2018) to reach annual average of $1 trillion within 10 years



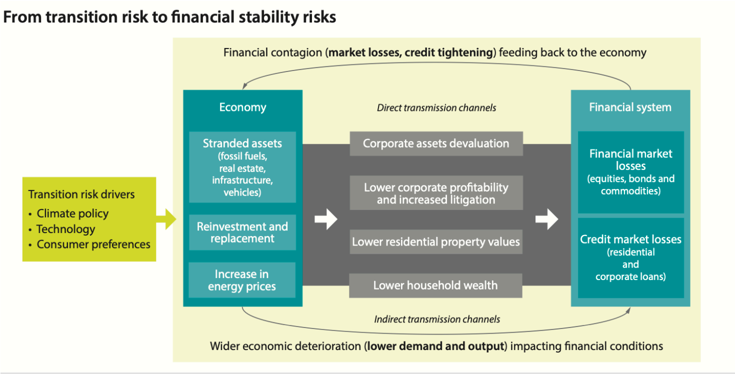
Physical Risk transmission channels (NGFS)



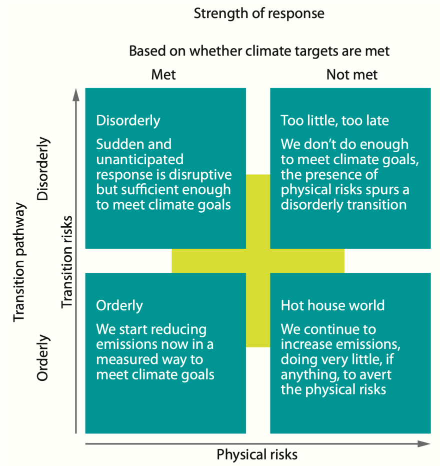
Portfolio Decarbonization - source: gofossilfree.org



Transition Risk transmission channels (NGFS)

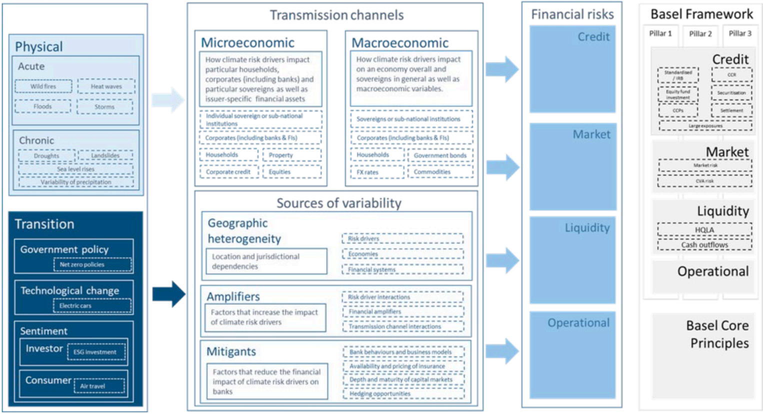


High-level scenario matrix (NGFS)

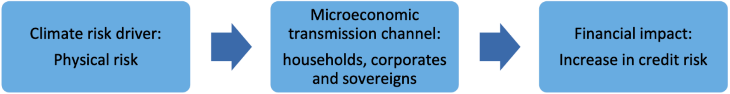


Mapping into Financial Risk Categories (BIS)

Figure 1: Financial risks from climate risk drivers



Example: from physical driver to credit risk



E.g: loss of physical capital (real estate, inventory, property, equipment, machinery) of households, corporations and governments because of extreme weather lead to reduced wealth and higher default risk.

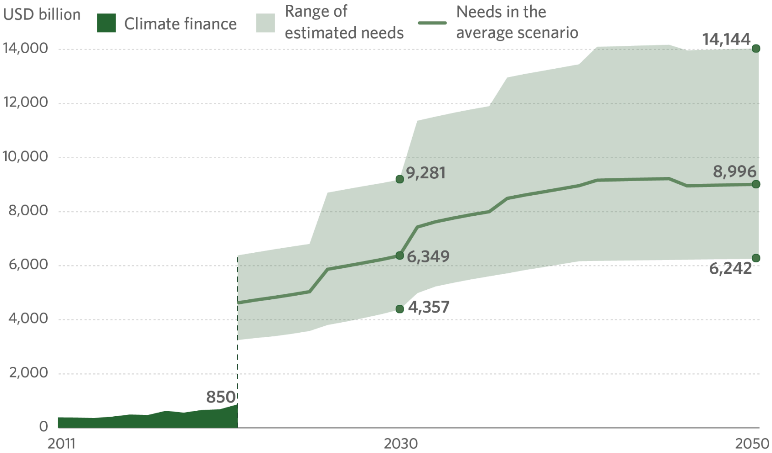
Example: from transition driver to credit risk

E.g: actual or anticipated change in regulation lead to higher borrowing costs for high polluting corporations.

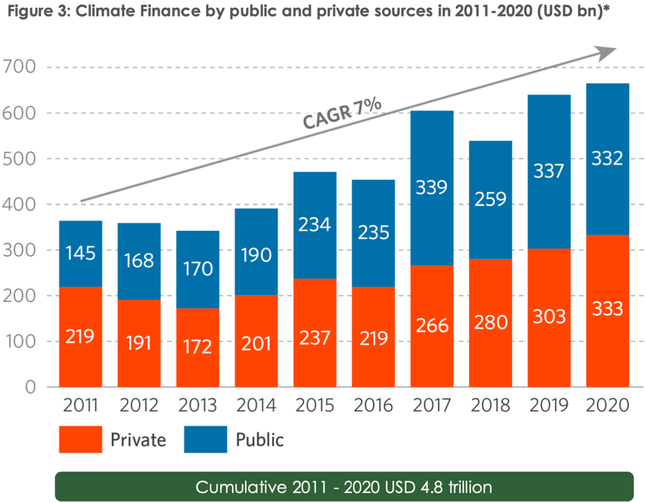
Investment needs and opportunities

- Required low-carbon infrastructure investment is \$4-9T annually between 2020 and 2050 (IPCC 2018).
- Cost of adaptation is estimated to be of the order of \$300B per year from 2020 to 2030 (GCA 2019).
- Current annual financial flow of \$800-900B directed towards green investment (CPI 2022).
- Cumulative Green Bond issuance to date is still less 2% of the \$130T global bond market (GBI 2022).

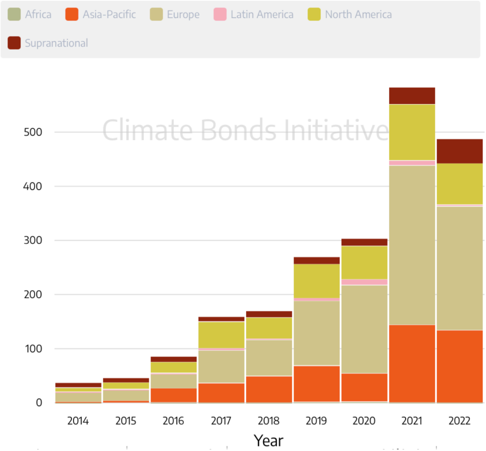
Green Finance flows - source: CPI (2022)



Green Finance by sector - source: CPI (2022)



Green bonds - source: CBI (2023)



Model taxonomy

Table 4. **Types of economic models to assess climate risks**

Lineage	Model type	Description	Example
Integrated climate-economy models[1]	Cost-benefit IAMs	Highly aggregated model that optimises welfare by determining emissions abatement at each step	DICE, DSICE (Cai et al., 2012, Barrage, 2020)
	IAMs with detailed energy system and land use	Detailed partial (PE) or general equilibrium (GE) models of the energy system and land use. General equilibrium types are linked to a simple growth model	PE: GCAM, IMAGE GE: MESSAGE, REMIND-MAgPIE, WITCH[2]
	Computable General Equilibrium (CGE) IAMs	Multi-sector and region equilibrium models based on optimising behaviour assumptions	G-CUBED, AIM, MIT-EPPA, GTAP, GEM-E3
	Macro-econometric IAMs	Multi-sector and region model similar to CGE but econometrically calibrated	E3ME, Mercure et al., 2018
	Stock-flow consistent IAMs	Highly aggregated model of climate change and the monetary economy that is stock-flow consistent	Bovari et al., 2018
Other climate-economy models	Input-output (IO) models	Model that tracks interdependencies between different sectors to more fully assess impacts	Ju and Chen, 2010 Koks and Thissen, 2016
	Econometric studies	Studies assessing impact of physical risks on macroeconomic variables (e.g. GDP, labour productivity) based on historical relationships	Khan et al., 2019 Burke et al., 2015 Dell et al., 2012
	Natural catastrophe models and micro-empirical studies	Spatially granular models and studies assessing bottom-up damages from physical risks	SEAGLASS (e.g. Hsiang et al., 2017)
Modified standard macroeconomic models	DSGE models	Dynamic equilibrium models based on optimal decision rules of rational economic agents	Golosov et al., 2014 Cantelmo et al. 2019
	E-DSGE	Slightly modified standard frameworks (that allow for negative production externalities)	Heutel, 2012
	Large-scale econometric models	Models with dynamic equations to represent demand and supply, coefficients based on regressions	NiGEM (e.g. Vermeulen et al., 2018)

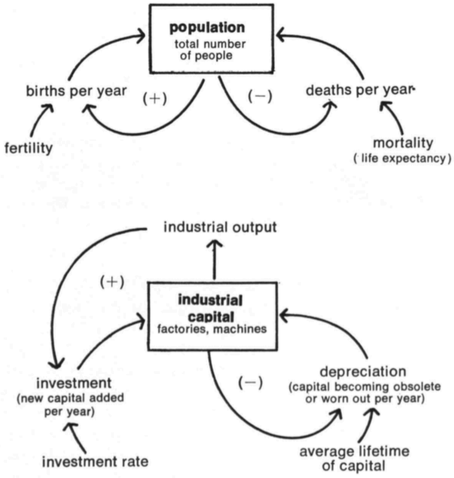
1 IAM taxonomy adapted from Nikas et al., 2019.

Integrated Assessment Models - early models

- Initially developed to estimate the impact of economic development on the environment.
- Most famous example is *The Limits of Growth* published in 1972 by the Club of Rome.
- Based on large scale computer simulations of physical and economic variables using the paradigm of *systems dynamics*.
- Predicted that "business as usual" would lead to "sudden and uncontrollable decline in both population and industrial capacity" within the next 100 years..
- However, trends *could* be altered so that sustainability could be achieved.
- Heavily criticized by: industry, economists, the Catholic church, and the political left.

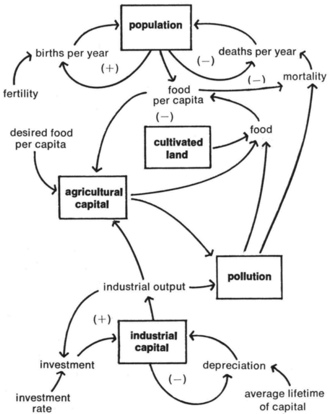
Simple Feedback Loops - LtG (1972)

Figure 23 POPULATION GROWTH AND CAPITAL GROWTH FEEDBACK LOOPS

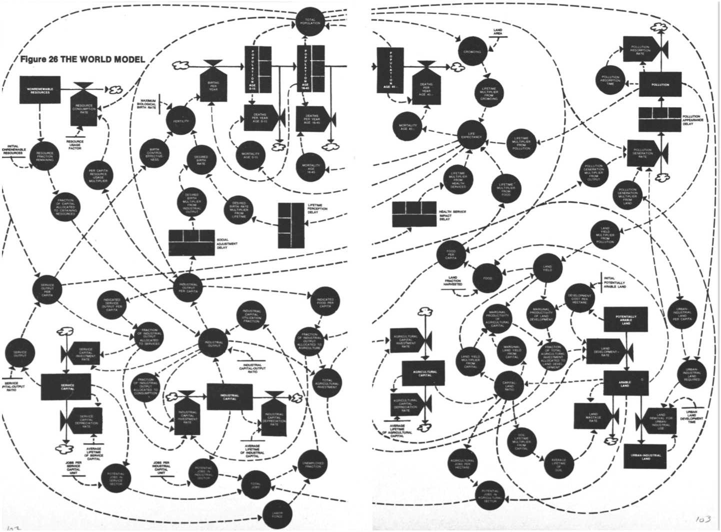


Less Simple Feedback Loops - LtG (1972)

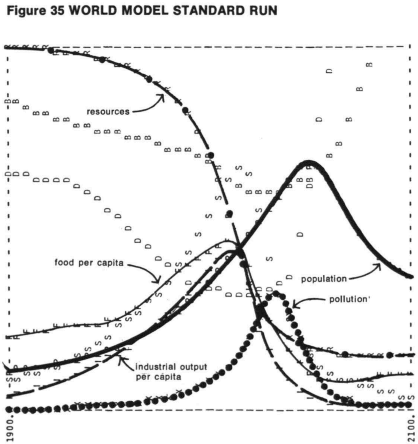
Figure 24 FEEDBACK LOOPS OF POPULATION, CAPITAL, AGRICULTURE, AND POLLUTION



The Full Model - LtG (1972)



Predictions - LtG (1972)



Integrated Assessment Models - current models

- Use of "sophisticated" economic models to assess the impact of climate change on the economy.
- Most famous example is the DICE (Dynamic Integrated Climate-Economy) model developed by William Nordhaus in 1992.
- Relies on welfare maximization, general equilibrium, partial equilibrium and cost minimization.
- Assumes an economy with a constant return to scale Cobb-Douglas technology combining labor and capital, where agents' decisions are made under perfect foresight.
- Precludes economic collapse (e.g mass unemployment, financial crises, over-indebtedness) by assumption.
- Outsized importance of discount rate.

Groups of climate economists

In a recent report of the Carbon Tracker Initiative, Steve Keen identifies four strand of climate economists:

1. Estimates of the total economic costs of global warming (the Total Cost of Carbon, or TCC), in terms of a decline in future GDP (damage functions);
2. Development of IAMs primarily by the same economists who develop estimates of damage functions;
3. Estimates of the Social Cost of Carbon (SCC), and the development of the Shared Socioeconomic Pathways (SSPs) using estimates of the TCC and IAMs
4. Criticism of all three of these research strands, sometimes by economists who had previously contributed to those research strands.

Methodological flaws in estimating TTC

Furthermore, Keen lists the following set of assumptions used for estimates of TTC:

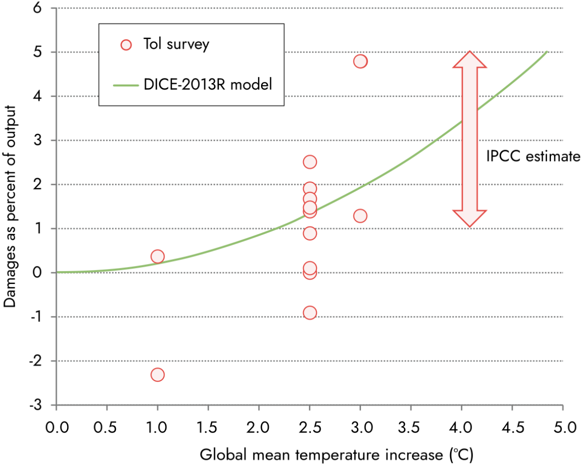
1. That industries not exposed to the weather will be unaffected by global warming ("enumeration method");
2. That relationship between temperature today and income today across different regions can be used as a proxy for the economic impact of global warming over time ("statistical method");
3. That data on change in temperature and GDP between 1960 and 2014 can be extrapolated to predict the impact of further temperature increases on GDP between now and 2100.

Nordhaus's Breakdown of impact of climate change on US Industries (Nordhaus 1991, p. 531)

Breakdown of economic activity by vulnerability to climatic change, U.S. 1981

Sector	National income: Value (billions)	National income: Percentage of total
Total national income	2415.1	100.0
Potentially severely impacted		
Farms	67.1	2.8
Forestry, fisheries, other	7.7	0.3
Moderate potential impact		
Construction	109.1	4.5
Water transportation	6.3	0.3
Energy and utilities		
Energy (electric, gas, oil)	45.9	1.9
Water and sanitary	5.7	0.2
Real estate		
Land-rent component	51.2	2.1
Hotels, lodging, recreation	25.4	1.1
Negligible effect		
Manufacturing and mining	627.4	26.0
Other transportation and communication	132.6	5.5
Finance, insurance, and balance real estate	274.8	11.4
Trade and other services	674.6	27.9
Government services	337.0	14.0
Rest of world	50.3	2.1

Nordhaus Quadratic Fit to Tol (2009) survey



Tol (2009) survey

Authors	Year	Warming °C	Change in future GDP, relative to a world without global warming
Nordhaus	1994	3	-1.3%
Nordhaus	1994	3	-4.8%
Fankhauser	1995	2.5	-1.4%
Tol	1995	2.5	-1.9%
Nordhaus and Yang	1996	2.5	-1.7%
Plambeck and Hope	1996	2.5	+2.5%
Mendelsohn Schlesinger and Williams	2000	2.5	0.0%
Nordhaus and Boyer	2000	2.5	1.5%
Tol	2002	1	+2.3%
Maddison	2003	2.5	0.1%
Rehdanz and Maddison	2005	1	0.4%
Hope	2006	2.5	0.9%
Nordhaus	2006	2.5	0.9%

The Ramsey model

- Representative household maximizes discounted utility of consumption.

$$U(c) = \int_0^\infty \frac{c(t)^{(1-\alpha)} - 1}{1-\alpha} \cdot e^{-\rho t} dt, \qquad c(t) = \frac{C(t)}{L(t)}$$

- Output Y is given by Cobb-Douglas production depending on total factor productivity A, labour L and capital K.

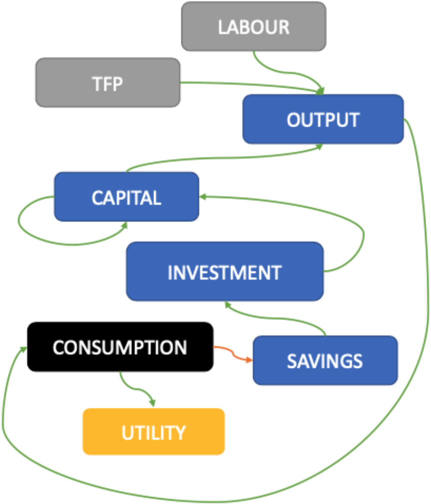
$$Y_G(t) = A(t)L(t)^{1-\gamma}K(t)^\gamma,$$

- Capital evolves because of investment $I = Y - C$ minus depreciation:

$$\frac{dK}{dt} = Y(t) - C(t) - \delta K(t)$$

- Implies a trade-off between consumption (utility today) and investment (future utility).

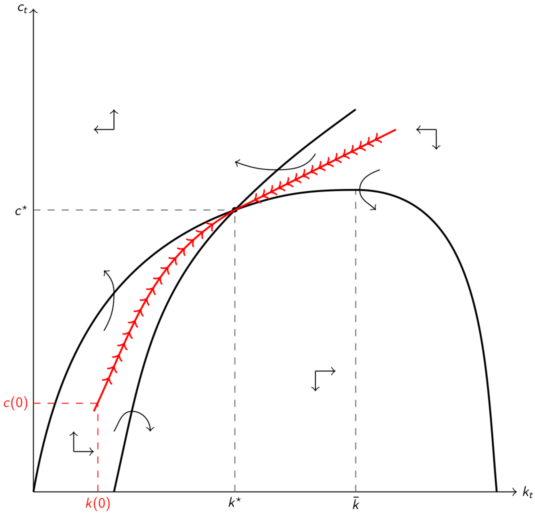
Schematics of the Ramsey model



Saddle-path stability of the Ramsey model

- The solution of the model leads to a two-dimensional system for consumption per capita $c(t)$ and capital per capita $k(t)$.
- The steady state of this system is always a saddle point: the model is inherently unstable.
- What happens if a shock moves the economy aways from the equilibrium path?
- Answer: assume that the variable c jumps back to equilibrium path instantaneously!

Saddle-path stability of the Ramsey model



Emissions, Carbon tax, Abatement

$$E = E_{ind} + E_{land},$$

$$E_{ind} = (1-\mu)\sigma Y_G, \quad E_{land} \to 0$$

$$T_C = p_C E_{ind} \quad \text{(carbon tax)}$$

$$A_C = \frac{p_{BS}\mu^\theta}{\theta}\sigma Y_G, \quad \theta > 1 \qquad \text{(abatement cost)}$$

$$\Rightarrow \qquad \mu \quad \text{(optimal emissions reduction)}$$

Temperature and Damages

- The climate cycle in the model operates as

$$E_{ind} \to E_T \to \mathrm{CO}_2^{AT} \to F_{ind} \to F \to T$$

- It is then assumed that gross output will be reduced to

$$Y_N = (1 - D(T))Y_G$$

where $D(T)$ is a damage function.

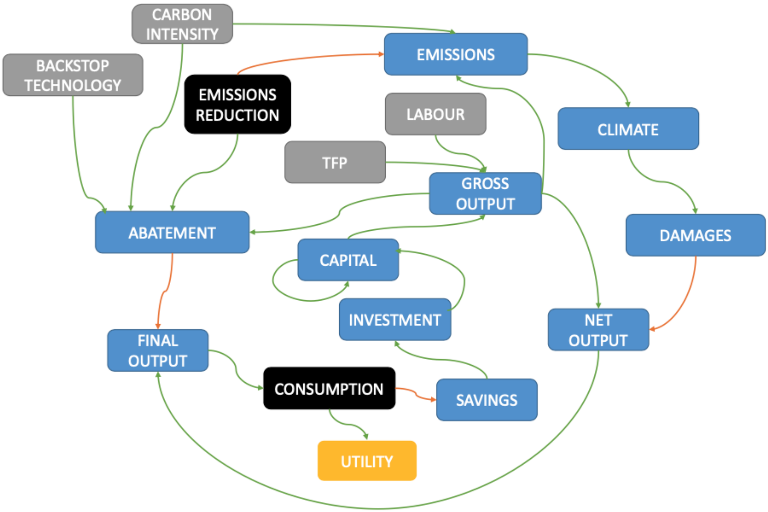
- For an emissions reduction rate μ, the available output is then given by

$$Y = (1 - \Lambda)(1 - D(\Delta T))Y_G,$$

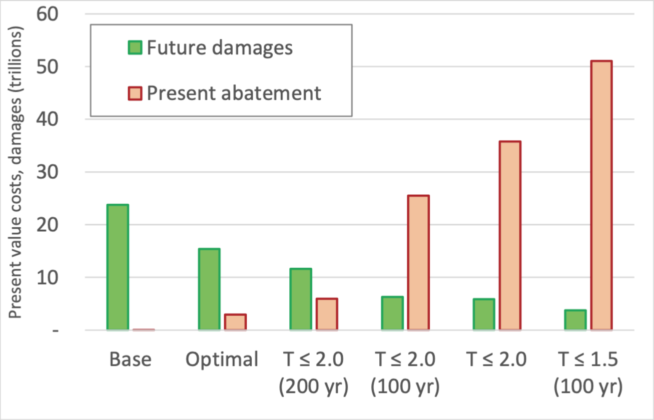
where $\Lambda = A_C/Y_N$.

- Implies a trade-off between abatement and damages.

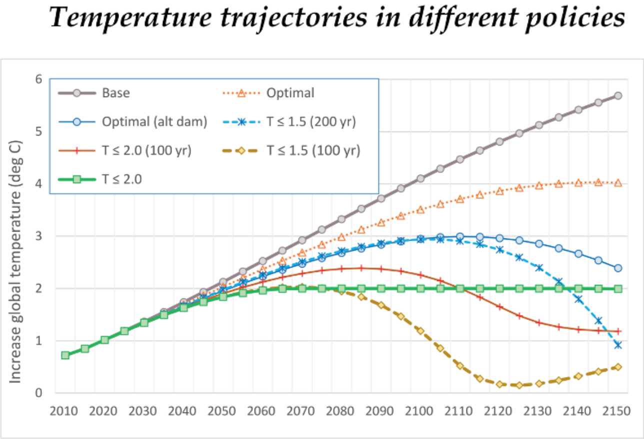
Schematics of the DICE model



Trade-offs in the DICE model

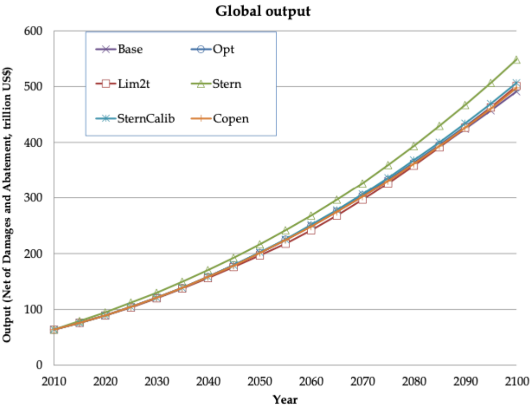


"Optimal" global warming according to Nordhaus



Slide 6 in Nordhaus's lecture, showing the "optimal" temperature path peaking at a 4°C increase by 2150

GDP according to the DICE model



Scenarios

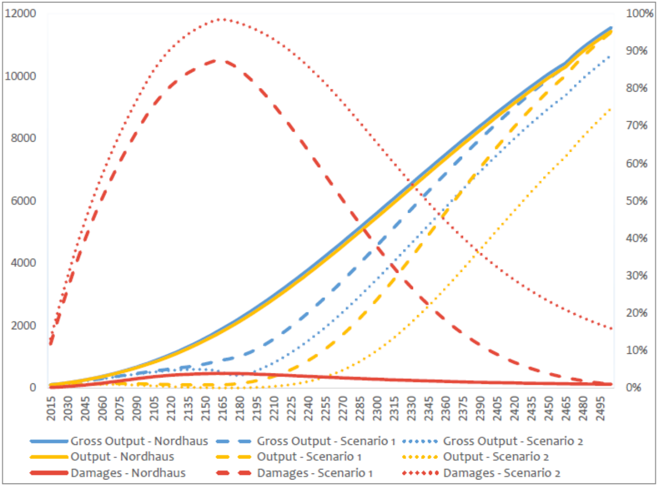
- To test the saddle-path stability of the DICE model, we use a damage function of the form:

$$D(T) = a \times T^2$$

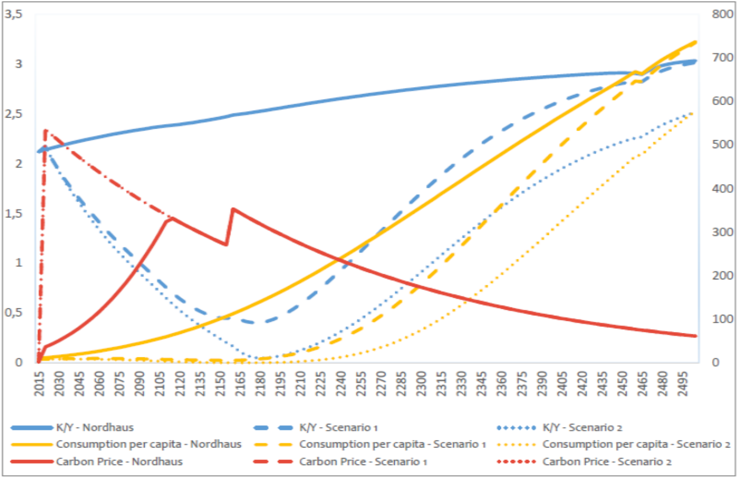
- We then devised the following scenarios.
  - Nordhaus: $a = 0.00236$ (DICE 2017)
  - Scenario 1: $a = 0.16236$
  - Scenario 2: $a = 0.18236$
- We also tried $a = 0.19236$, for which GAMS returns:

$<<$ Infeasible solution, reduced gradient less than tolerance $>>$.

DICE Sensitivity: output and damages



DICE Sensitivity: capital/output, consumption, carbon



The COPING Model

	Households	Firms		Banks	Sum
Balance Sheet					
Capital stock		pK			pK
Deposits	M^h	M^f		$-M$	
Loans		$-L$		L	
Equities	$E^b + E^f$	$-E^f$		$-E^b$	
Sum (net worth)	X^h	X^f		X^b	X
Transactions		current	capital		
Consumption	$-pC$	pC			
Investment		pI	$-pI$		
Accounting memo [GDP]		$[pY]$			
Wages	W	$-W$			
Dividends	$Di + r(L-M)$		$-Di$	$-r(L-M)$	
Interests on loans		$-rL$		rL	
Interests on deposits	$+rM^h$	$+rM^f$		$-rM$	
Financial Balances	S^h	Π	$-pI - Di$	0	
Flow of funds					
Gross Fixed Capital Formation		pI			pI
Change in Deposits	$\dot{M}^h$	$\dot{M}^f$		$-\dot{M}$	
Change in loans		$-\dot{L}$		$\dot{L}$	
Change in equities	$\dot{E}^f + \dot{E}^b$	$-\dot{E}^f$		$-\dot{E}^b$	
Column sum	S^h	$\Pi - Di$		0	pI
Change in net worth	$\dot{X}^h = S^h$	$\dot{X}^f = \Pi - Di + \left[\dot{p} - (\delta + \mathbf{D}^K + \frac{G}{\nu})p\right]K$		$\dot{X}^b = 0$	$\dot{X} = pI + \left[\dot{p} - (\delta + \mathbf{D}^K + \frac{G}{\nu})p\right]K$

Table 1: Balance sheet, transactions, and flow of funds in the economy

Basic Definitions

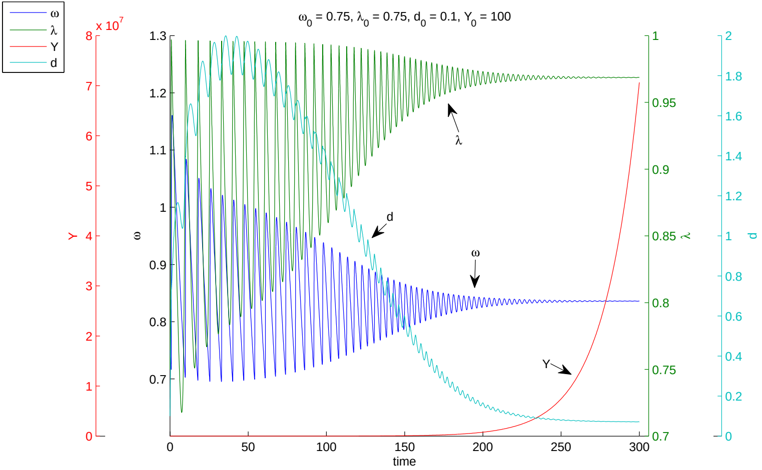
$$
\begin{aligned}
Y^0 &= \frac{K}{\bar{\nu}} = aL, \quad Y = (1-A)(1-\mathbf{D}^Y)Y^0 \\
\Pi &= pY - wL - rD + p(S_C - T_C) \\
\omega &= \frac{wL}{pY}, \quad d = \frac{D}{pY}, \quad \pi = \frac{\Pi}{pY}, \quad \lambda = \frac{L}{N} \\
I &= \kappa(\pi)Y, \quad \dot{K} = I - (\bar{\delta} + \mathbf{D}^K)K \\
\dot{D} &= pI - \Pi + Div \\
Div &= \Delta(\pi)pY \\
i &= \frac{\dot{p}}{p} = \bar{\eta}(\bar{\xi}c - 1) \\
\dot{w} &= w[\varphi(\lambda) + \bar{\gamma}i]
\end{aligned}
$$

Special case - the Keen model

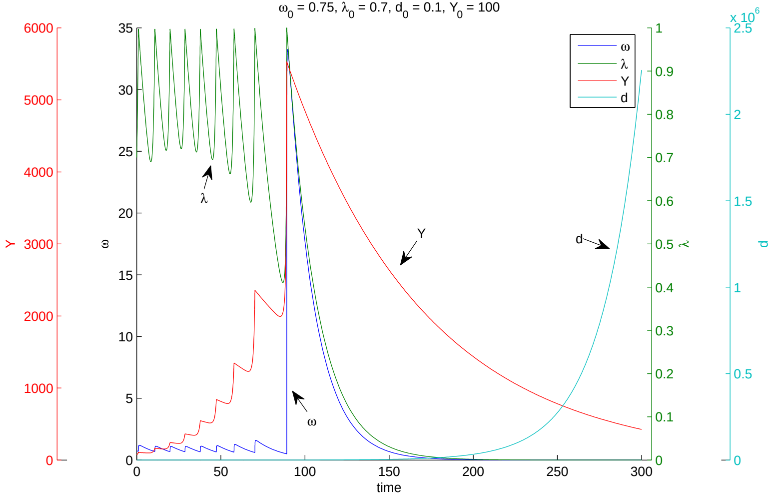
If we decouple this model from the climate, it reduces to

$$\begin{aligned}
\dot{\omega} &= \omega\left[\Phi(\lambda) - \bar{\alpha} - (1-\bar{\gamma})i(\omega)\right] \\
\dot{\lambda} &= \lambda\left[\frac{\kappa(\pi^0)}{\bar{\nu}} - \bar{\alpha} - \beta(N) - \bar{\delta}\right] \\
\dot{d} &= \kappa(\pi^0) - \pi^0 + \Delta(\pi^0) - \left[i(\omega) + \frac{\kappa(\pi^0)}{\bar{\nu}} - \bar{\delta}\right] \\
\dot{N} &= \beta(N)N
\end{aligned}$$

Example: convergence to the interior equilibrium in a Keen model



Example: explosive debt in a Keen model



Emissions

$$E = E_{ind} + E_{land}, \quad E_{ind} = \sigma(1-n)Y^0, \quad \dot{E}_{land} = \delta_{E_{land}} E_{land}$$

$$\dot{\sigma} = g_\sigma \sigma, \quad g_\sigma < 0 \quad \text{(carbon intensity)}$$

$$\dot{g_\sigma} = \delta_{g_\sigma} g_\sigma, \quad \delta_{g_\sigma} < 0$$

$$n = \min\left\{ \left(\frac{p_C}{p_{BS}}\right)^{\frac{1}{\theta-1}}, 1 \right\}, \quad \theta > 1 \quad \text{(emission rate)}$$

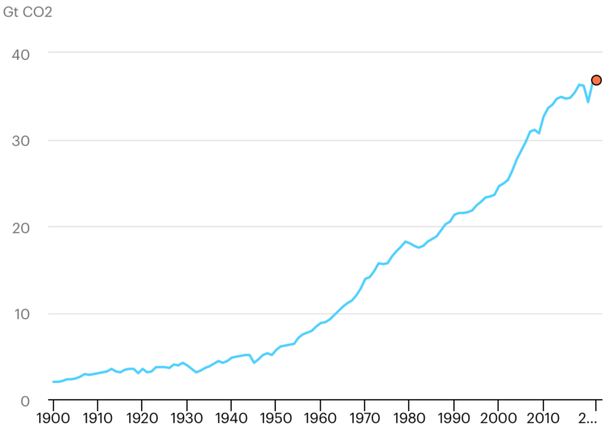
$$\frac{\dot{p_{BS}}}{p_{BS}} = \delta_{BS} \leq 0 \quad \text{(backstop technology)}$$

$$\frac{\dot{p_C}}{p_C} = \delta_C(\cdot) \geq 0 \quad \text{(carbon)}$$

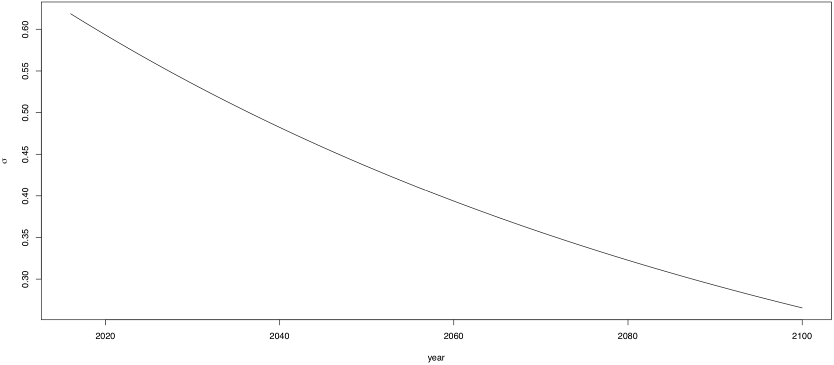
$$A = \frac{\sigma p_{BS} n^\theta}{\theta} \quad \text{(abatement cost)}$$

$$T_C = p_C E_{ind} \quad \text{(carbon tax)}$$

Global Industrial Emissions (source: IEA)



Carbon intensity

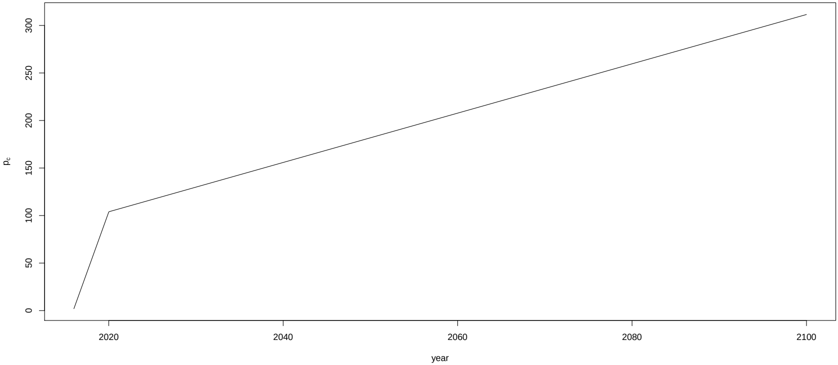


Backstop technology

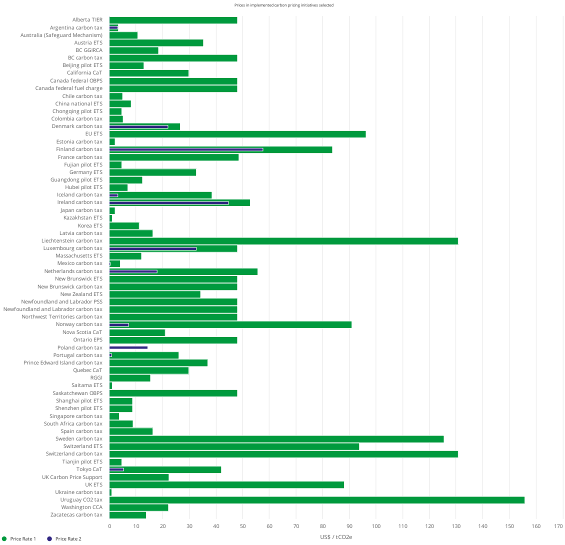
	Global Weighted-Average Cost of Electricity (USD/kWh)	Decrease in the Cost of Electricity 2017-2018 (%)
Bioenergy	0.062	14
Geothermal	0.072	1
Hydro	0.047	11
Solar PV	0.085	13
Offshore wind	0.127	1
Onshore wind	0.056	13

Table 2: Table depicting the 2018 prices of renewable energy and the percentage change in price

Carbon price



Carbon price dashboard 2020 - source: World Bank



Carbon cycle

$$\begin{pmatrix} \dot{CO_2}^{AT} \\ \dot{CO_2}^{UP} \\ \dot{CO_2}^{LO} \end{pmatrix} = \begin{pmatrix} E \\ 0 \\ 0 \end{pmatrix} + \Phi \begin{pmatrix} CO_2^{AT} \\ CO_2^{UP} \\ CO_2^{LO} \end{pmatrix}$$

where

$$\Phi = \begin{pmatrix} -\phi_{12} & \phi_{12} C_{UP}^{AT} & 0 \\ \phi_{12} & -\phi_{12} C_{UP}^{AT} - \phi_{23} & \phi_{23} C_{LO}^{UP} \\ 0 & \phi_{23} & -\phi_{23} C_{LO}^{UP} \end{pmatrix}$$

Radiative Forcing

The accumulation of CO_2 increases radiative forcing

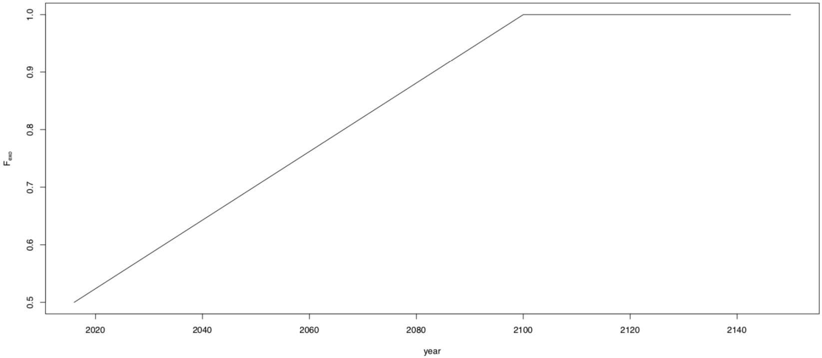
$$F := F_{ind} + F_{exo}$$

as follows

$$F_{ind} := \frac{F_{dbl}}{\log(2)} \log\left(\frac{CO_2^{AT}}{CO_{2preind}^{AT}}\right)$$

where F_{dbl} is an exogenous parameter that represents the effect on forcing of a doubling of pre-industrial CO_2 levels and F_{exo} increases exogenously over time.

Exogenous radiative forcing



Temperature and Damages

$$
\begin{aligned}
C\dot{T} &= F - \frac{F_{dbl}}{S}T - \gamma^*(T - T_{LO}) \\
C_{LO}\dot{T_{LO}} &= \gamma^*(T - T_{LO}) \\
\mathbf{D} &= 1 - \frac{1}{1 + \xi_1 T + \xi_2 T^2} \qquad \text{(Nordhaus)} \\
\mathbf{D}^K &= f_k \mathbf{D} \\
\mathbf{D}^Y &= (1 - f_k)\mathbf{D}
\end{aligned}
$$

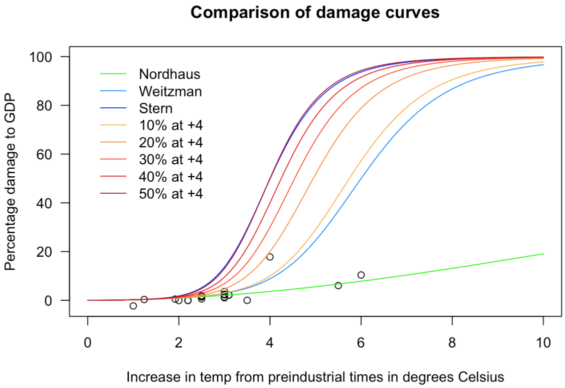
Alternative Damage Functions

$$\mathbf{D} = 1 - \frac{1}{1 + 2.84 \times 10^{-3}\, T^2} \qquad \text{(Nordhaus)}$$

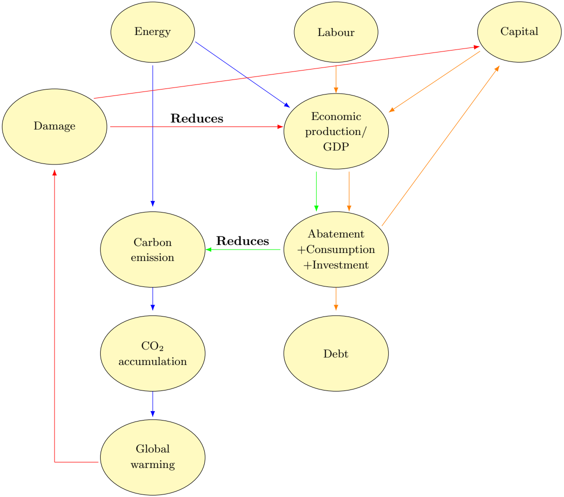
$$\mathbf{D} = 1 - \frac{1}{1 + 2.84 \times 10^{-3}\, T^2 + 5.070 \times 10^{-6}\, T^{6.754}} \qquad \text{(Weitzman)}$$

$$\mathbf{D} = 1 - \frac{1}{1 + 2.84 \times 10^{-3}\, T^2 + 8.19 \times 10^{-5}\, T^{6.752}} \qquad \text{(Dietz and Stern)}$$

Damage functions



Model Schematic



Example 1: No damages - Bovari et al (2018a)

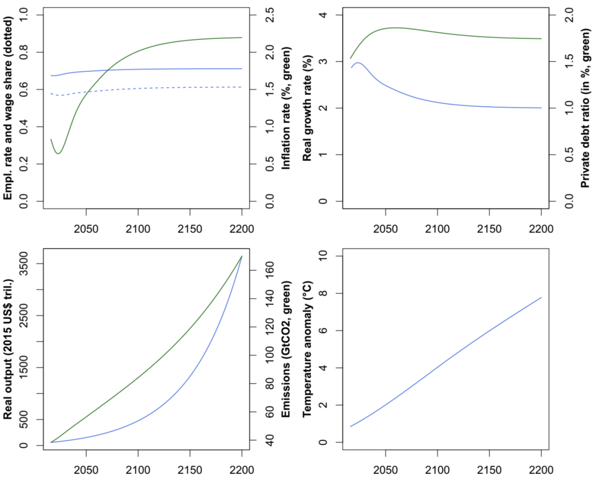


Fig. 1. Trajectories of the main simulation variables in the *No feedback loop scenario*.

Example 2: Bifurcation - Bovari et al (2018a)

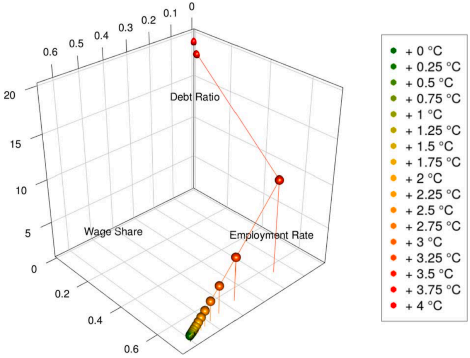


Figure: Temperature bifurcation with Weitzman damages, no policy.

Example 3: No-policy Collapse - Bovari et al (2018a)

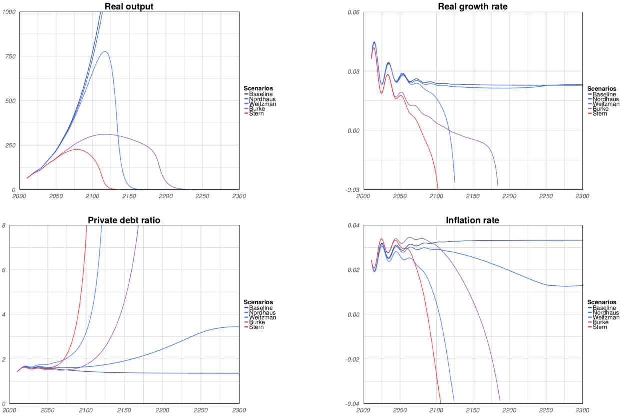


Figure: Outcomes with initial carbon price of $1 and growth rate of 2%.

Example 4: Effect of Policy - Bovari et al (2018a)

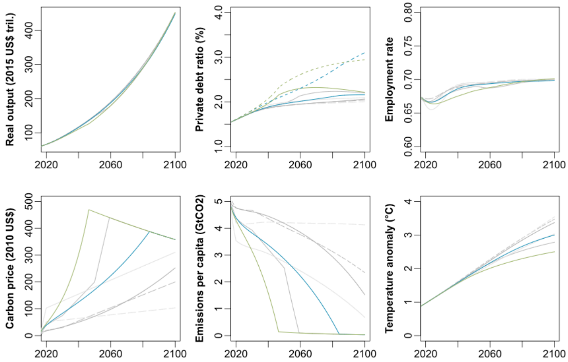


Figure: Outcomes with Nordhaus damages and different carbon prices.

Example 5: Sensitivity analysis - Bovari et al (2018b)

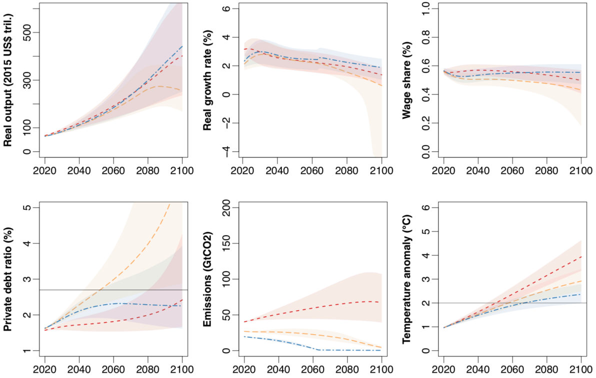


Figure 3: $[0.05; 0.95]$ probability interval of the *No policy*, *Carbon tax*, and *Carbon tax and subsidy* scenarios with a damage allocation to the stock of physical capital of $f_K = 33\%$ respectively in red, orange and blue shades (medians in small, long and mixed dashes)

Conclusions

- Climate change is the most formidable challenge faced by the human race
- Traditional macroeconomics is ill-equipped to contribute to it
- Integration of *dynamic* models with *disequilibrium* and *slowly adjusting variables* is needed
- Finance is likely to play a fundamental role in the low-carbon transition
- Should try *everything* that is available: carbon tax, subsidies, green bonds, green securitization, green central banking, etc
- We need a Green Bubble

Danke!