EPFL

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LEURE

Doctoral course
Climate Economics for Engineers

Integrated assessment models (IAM)

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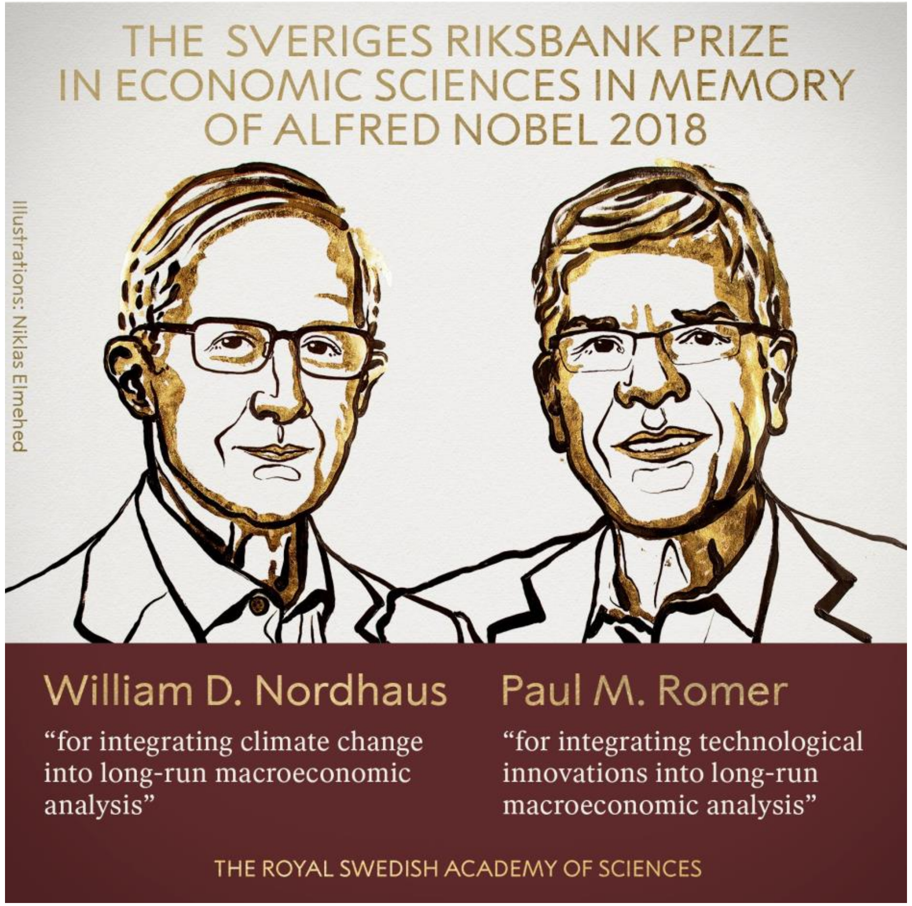
Integrated Assessment Models (IAM)

- Purpose: simulate future pathways for economic activity and climate change, and how they change in different policy scenarios
- Macroeconomic models: simple representation of the economies of large countries and groups of small countries, with trade of goods & services among them; <u>output</u>: GDP, social welfare
- Climate models: carbon cycle with atmospheric and oceanic chemistry; a planet divided into regions (sub-continents for FUND; deep ocean, shallow surface and atmosphere for DICE) that interact; <u>output</u>: CO_2 concentration, average temperature, precipitations, sea level rise, etc.
- Main models: DICE/RICE (William Nordhaus), FUND (Richard Tol), PAGE (Chris Hope, used for Stern Review 2007)

William D. Nordhaus



Early contribution of Bill Nordhaus

CAN WE CONTROL CARBON DIOXIDE?

William D. Nordhaus

June 1975 WP-75-63

Nordhaus, W. D. (1975). Can We Control Carbon Dioxide? Laxenburg, Austria, IIASA. *IIASA Working Paper*, published in *American Economic Review* 109(6), June 2019, pp.2015-2035, DOI: 10.1257/aer.109.6.2015

Father of the 2°C limit

Nordhaus, William D. (1977). Strategies for the Control of Carbon Dioxide. New Haven, CT, USA, Cowles Foundation for Research in Economics, Yale University Cowles Foundation Discussion Papers

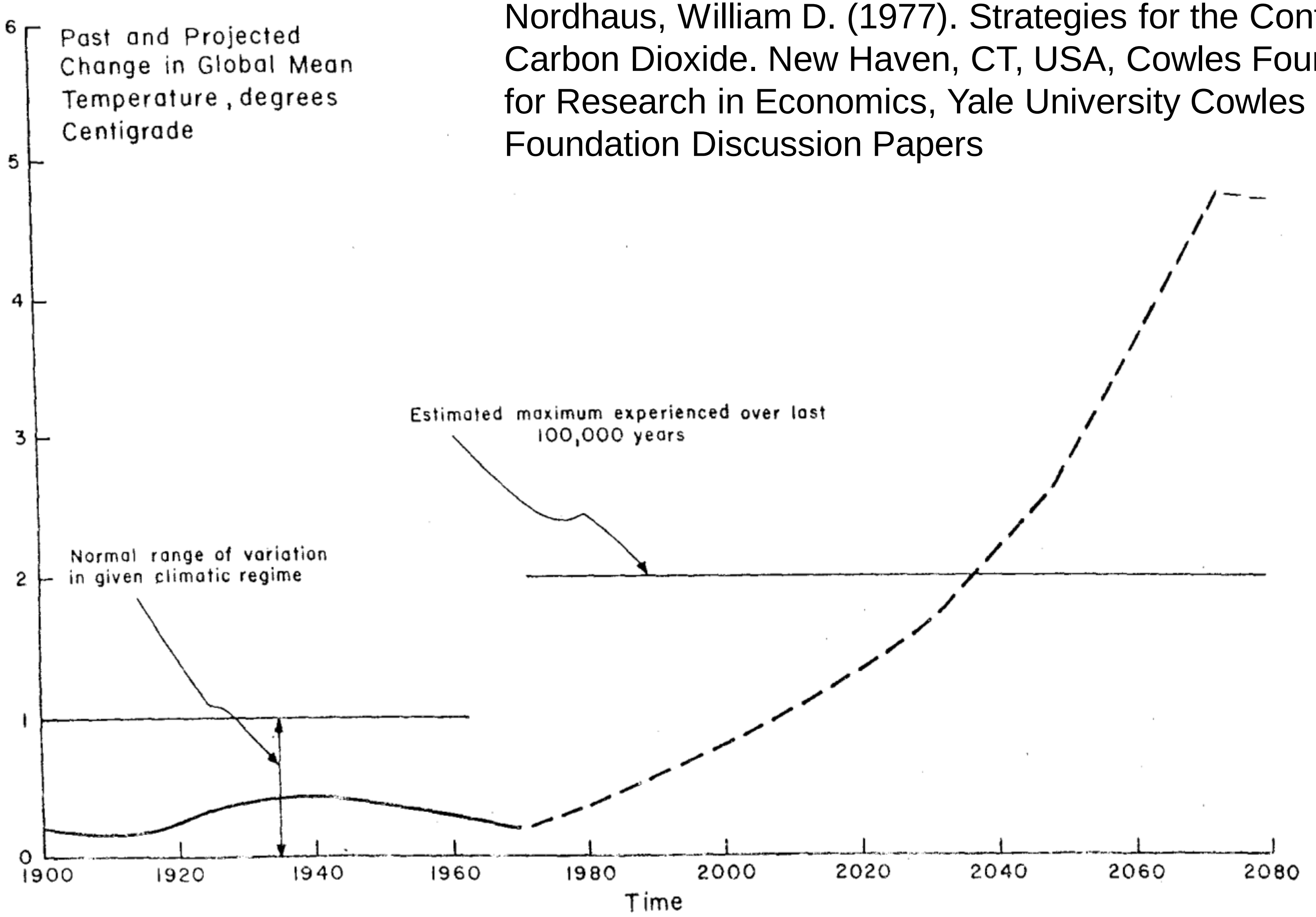
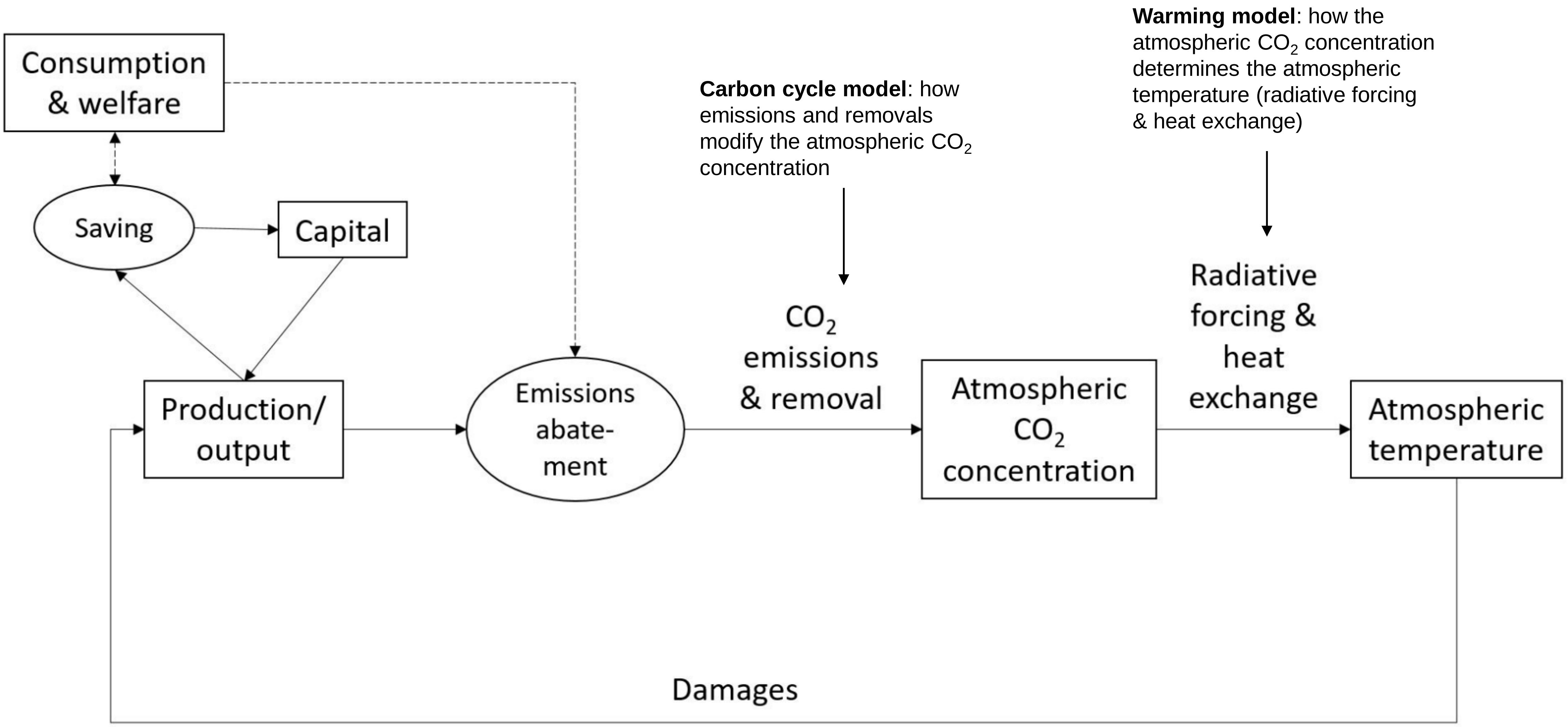


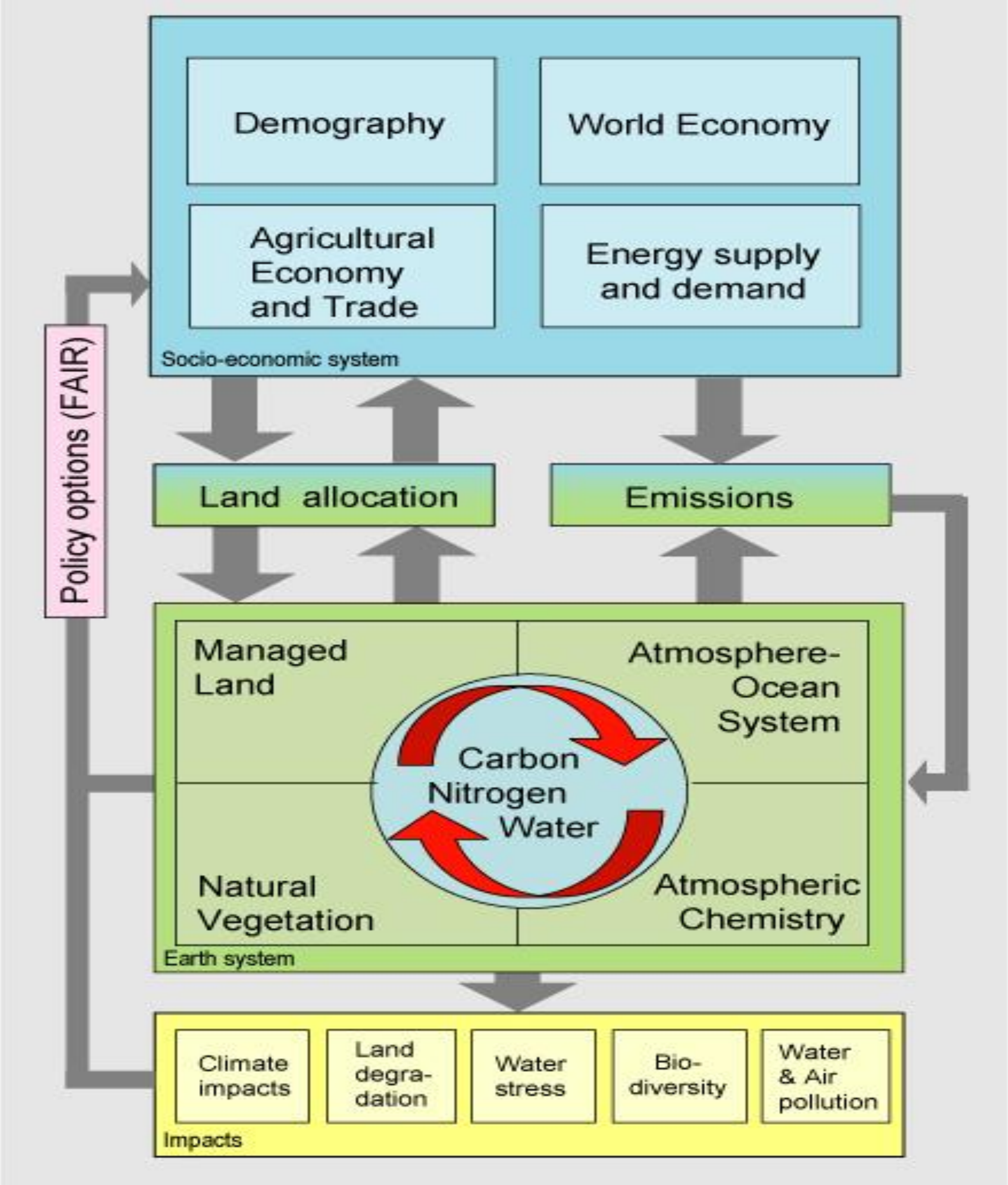
Figure 1. Past and projected global mean temperature, relative to 1880-84 mean. Solid curve up to 1970 is actual temperature. Broken curve from 1970 on is projection using 1970 actual as a base and adding the estimated increase due to uncontrolled buildup of atmospheric carbon dioxide.

Typical structure of an IAM



Dietz, S., et al. (2020). Are economists getting climate dynamics right and does it matter? *Manuscipt*

Another IAM



Netherlands' Environmental Assessment Agency
(http://www.mnp.nl/en/themasites/image/model_details/index.html)

The damage function

The DICE damage function in Nordhaus (2008), which is the basis for our later simulations in Section 4, has the following specification:

$$\Omega(t) = 1/[1 + 0.0028 T_{AT}(t)^2]. \qquad (1)$$

Here $\Omega(t)$ represents one minus the fraction of aggregate output (in trillion US$) lost due to climate change.

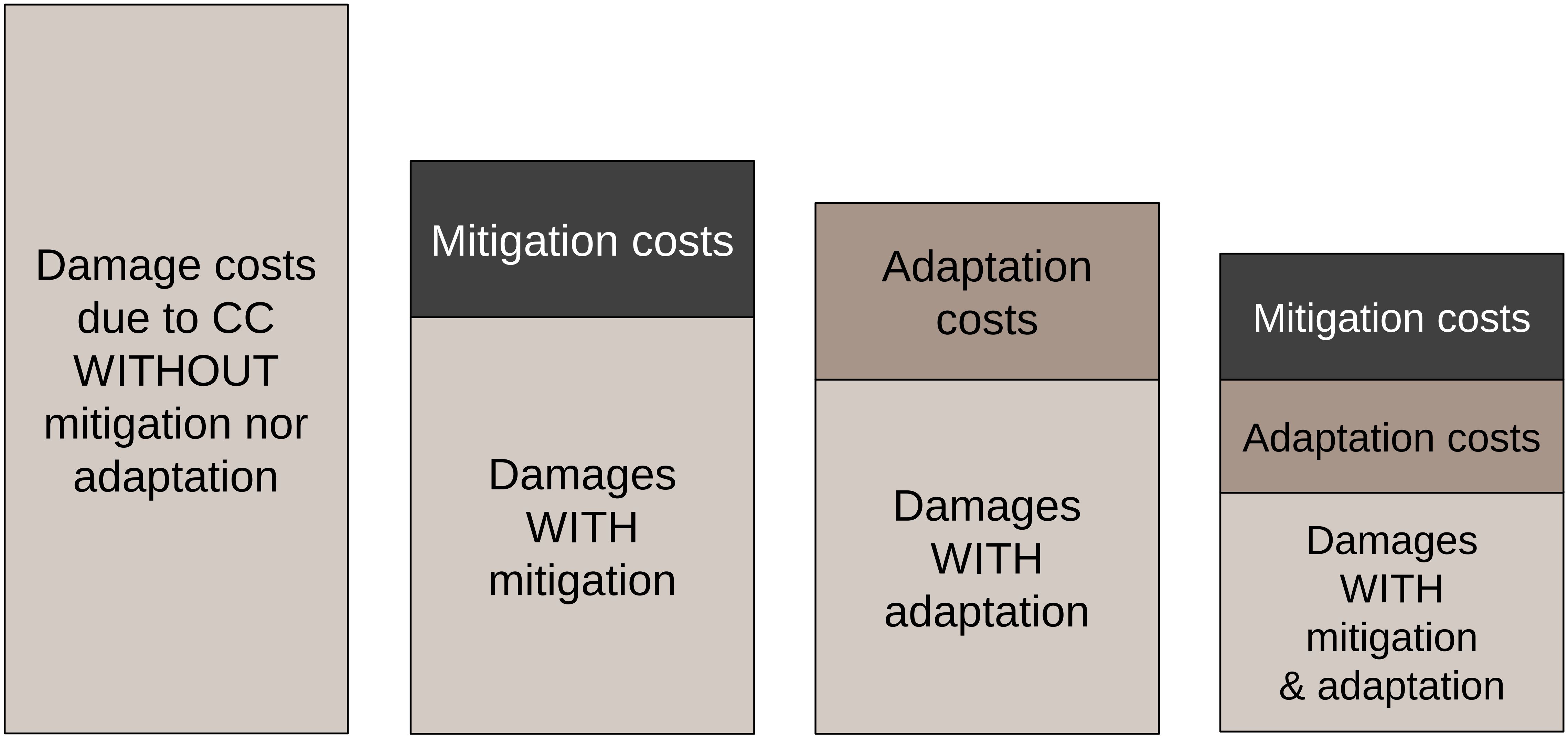
$$Q_t = \Omega(t)[1 - \Lambda(t)]A(t)K(t)^{\gamma}L(t)^{1-\gamma}.$$

In the above equations t is time (decades in DICE), $T_{AT}(t)$ is the global mean surface temperature, Q_t is aggregate output, $A(t)$ is total factor productivity (capturing Hicks-neutral technological progress), $K(t)$ is the capital stock, $L(t)$ is the labour population, γ is the capital elasticity of output, and $\Lambda(t)$ is the abatement cost function satisfying $\Lambda(t) \sim \mu(t)^{\theta}$ with $\mu(t)$ the emissions-control rate.

For a zero temperature change $\Omega(t) = 1$ (no damage) and for very large temperature changes it approaches 0 (maximum damage). The DICE damage function is calibrated to damages in the range of 2 to 4 °C.

Wouter Botzen, W. J. and J. C. J. M. van den Bergh (2012). "How sensitive is Nordhaus to Weitzman? Climate policy in DICE with an alternative damage function." Economics Letters 117(1): 372-374.

Costs with and without mitigation and adaptation



Conclusion on IAMs

- Very rough representation of impacts of CC
- Only impacts on GDP
- All the limitations of CBA
- These models tend to predict more gradual warming than climate models → impact costs are delayed, choice of discount rate is crucial*
- These models assume more natural absorption of CO_2 as its concentration increases, while climate models predict the inverse → increase of CO_2 concentration in atmosphere is underestimated*
- They tend to find optimal warmings of 3° and more by 2100…
- It seems hazardous to use these models to determine optimal warming paths or optimal mitigation paths to 2100

* Dietz, S., et al. (2020). Are economists getting climate dynamics right and does it matter? *Manuscipt*