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The Impact of Climate Change on Social Security Systems: An Extension of the DICE Model

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joint work with Ivan Fonseca Diaz

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Context

- Social security systems have served as tools employed by governments to enhance societal well-being during significant socioeconomic transitions. In these situations, these systems have helped protect societies from potential vulnerabilities while also strengthening collective efforts to enhance overall social welfare.

  As a result, they have played a crucial role in shaping socioeconomic trends during difficult times.

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  → Climate change can be seen as the current major socioeconomic transition.

- Several questions may arise regarding the role of social security in the context of climate change: Are current schemes equipped to address the long-term effects of climate change? Are they adaptable to emerging challenges? Can social security play an active role in climate policy discussions?

Aim

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  $\rightarrow$ These scenarios are called the Shared Socioeconomic Pathways (SSPs) (O'Neill et al. [2014, 2017], Riahi et al. [2017]).

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General remarks

Integrated assessment models (IAMs) are the most widely used framework for economic analysis of climate change. However, these models often overlook considerations regarding social security. In this talk, we present an adaptation of the Dynamic Integrated Climate-Economy (DICE) model to incorporate social security systems.

General remarks

We extend these models to include consumption and savings across multiple generations, as well as a consistent model representation of a social security system for retirement benefit.

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- Develop a model for both defined benefits (DB) scheme and defined contributions (DC) scheme.

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- Allow the financial system to be funded or PAYG or mixed;
- Develop a model for both defined benefits (DB) scheme and defined contributions (DC) scheme.

$\rightarrow$ Contribution rates in each system is found by maximising consumption while ensuring financial sustainability.

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One of the pioneering IAMs in the analysis of the economic impact of climate change is the Dynamic Integrated Climate-Economy (DICE) model (Nordhaus [1992, 2017, 2018]).

→ Based on a neo-classical economic growth theory, which determines optimal future consumption through investments in capital, education and technology.

→ Incorporate the "natural capital" of climate system as a capital stock, thus incentivising carbon emission reductions.

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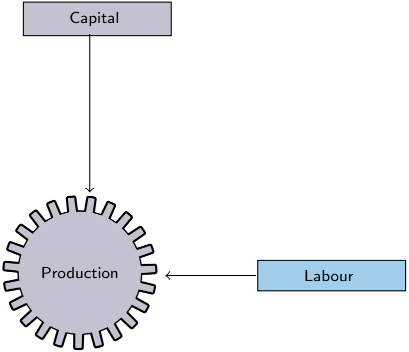
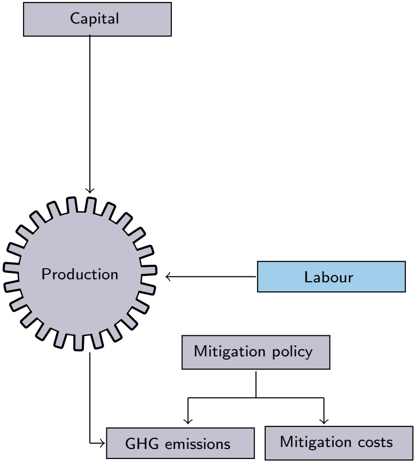
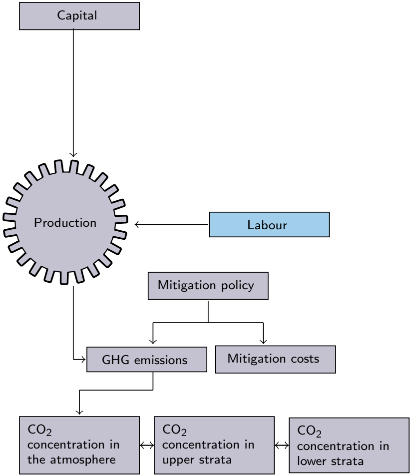



Capital
Production
Labour
Mitigation policy
GHG emissions
Mitigation costs

DICE Model


Capital
Production
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GHG emissions
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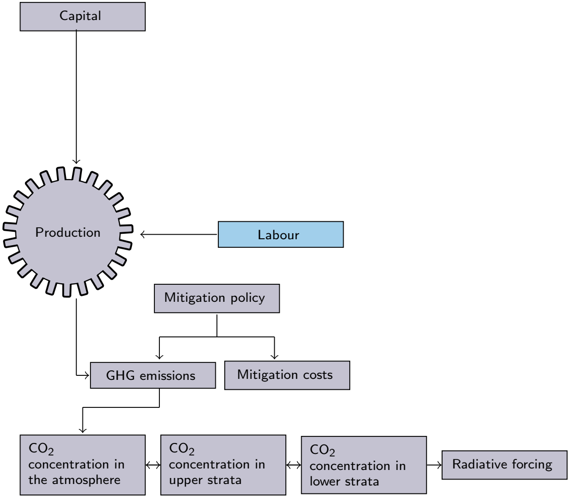
CO_2 concentration in the atmosphere
CO_2 concentration in upper strata
CO_2 concentration in lower strata

DICE Model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Radiative forcing

DICE Model

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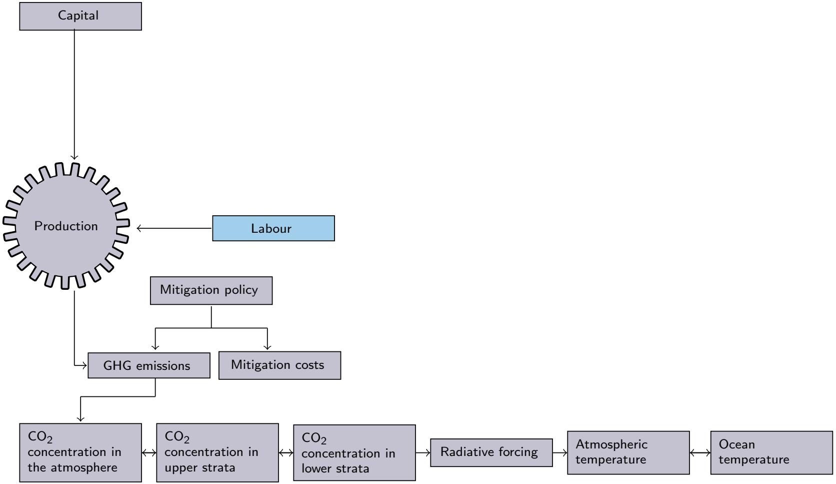
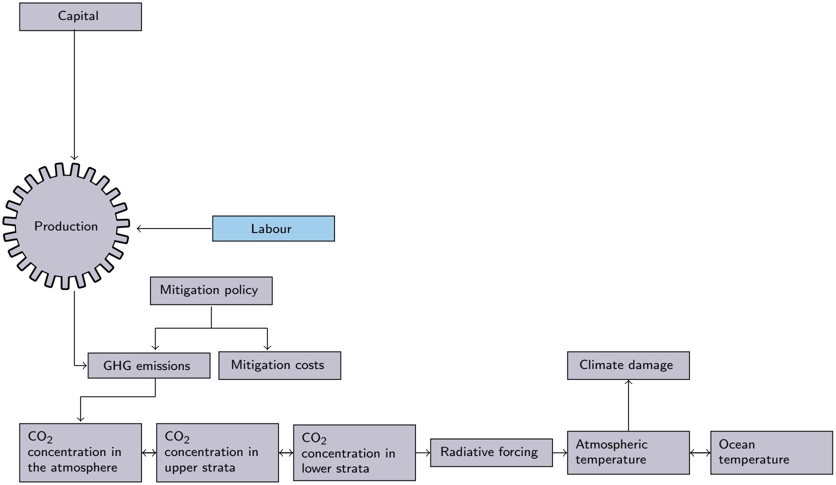


DICE Model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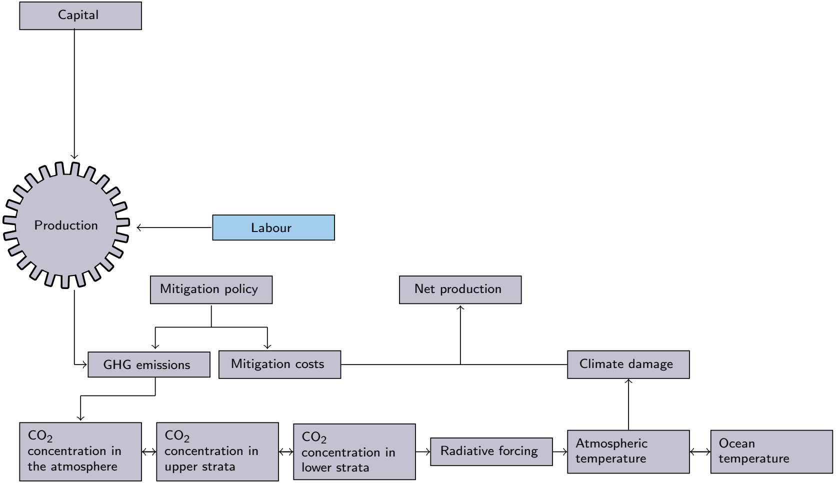
Atmospheric temperature
Ocean temperature



Capital
Production
Labour
Mitigation policy
Net production
GHG emissions
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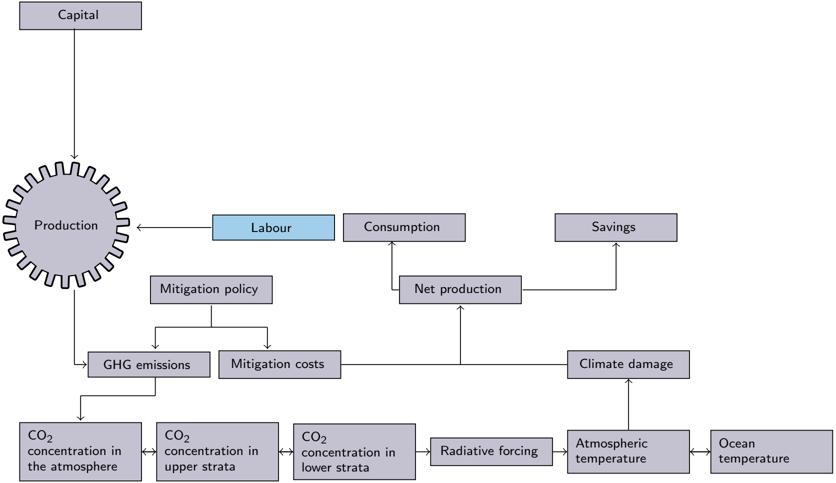
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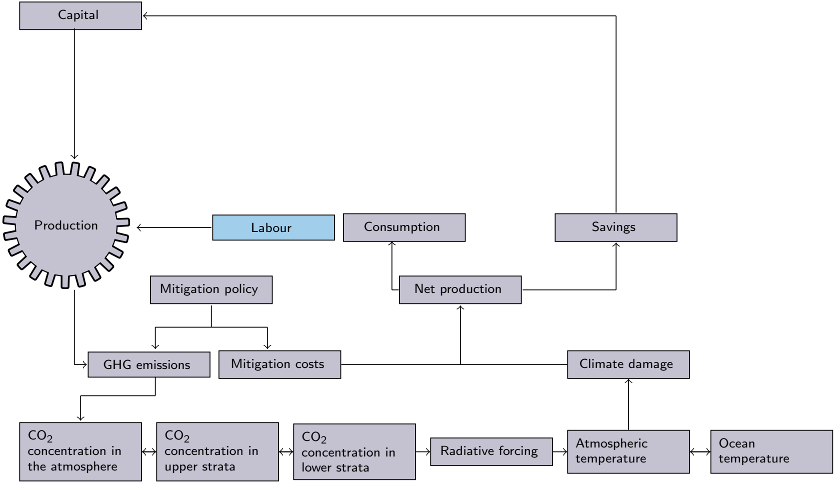
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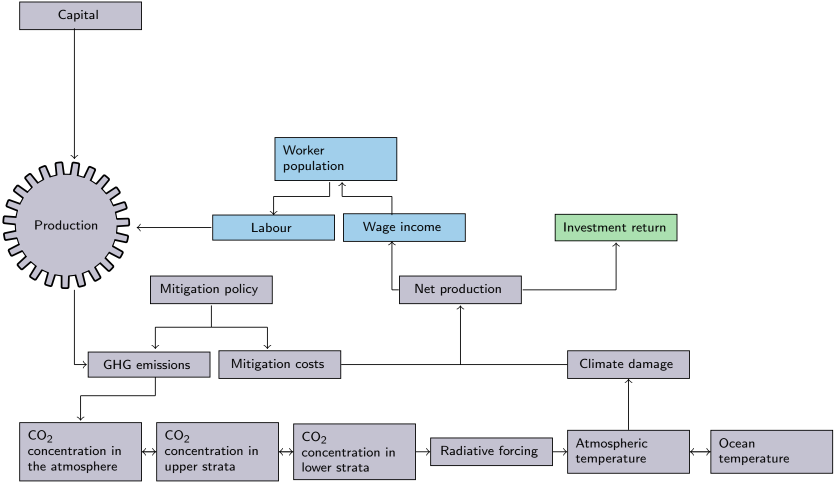

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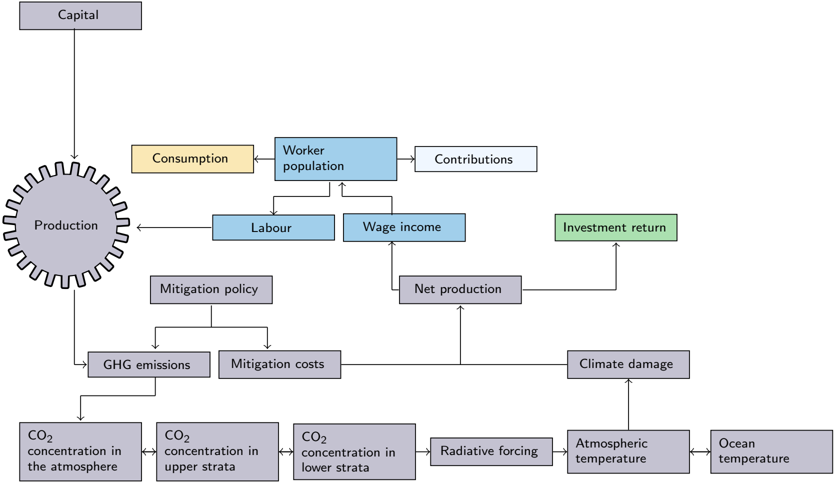

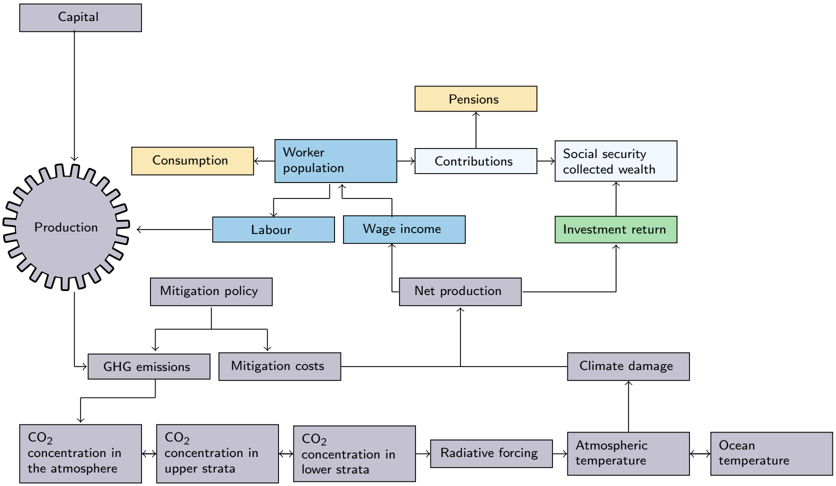
Capital
Pensions
Consumption
Worker population
Contributions
Social security collected wealth
Production
Labour
Wage income
Investment return
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DICE-SS Model

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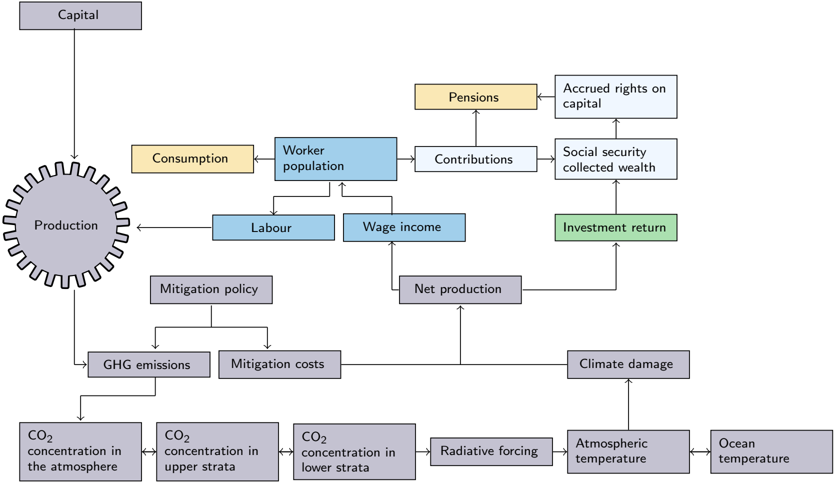

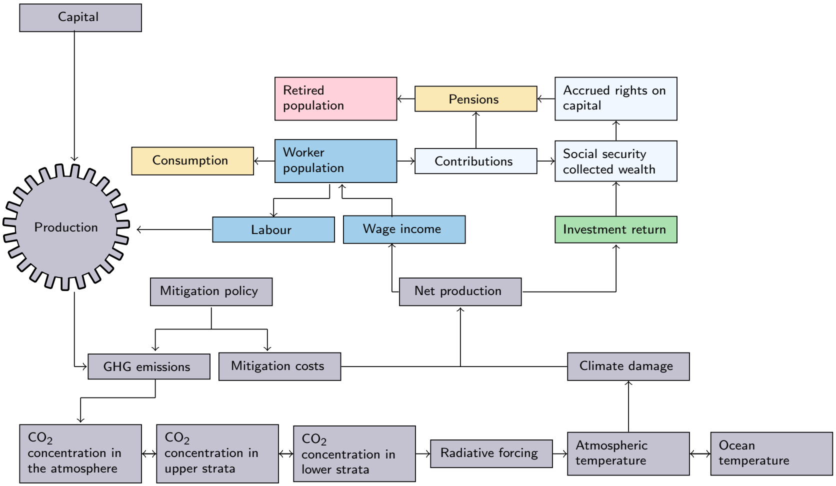

Capital
Retired population
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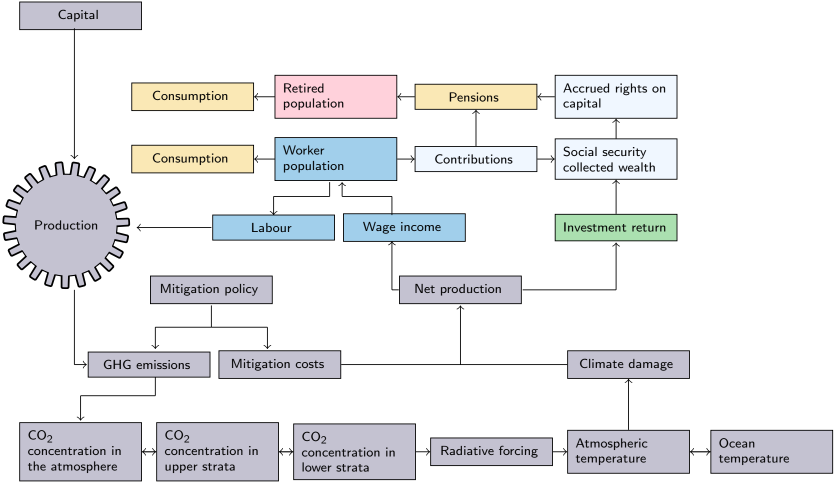

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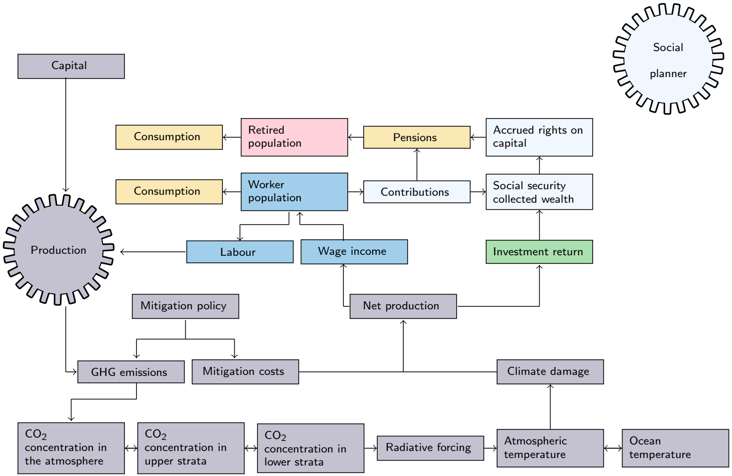

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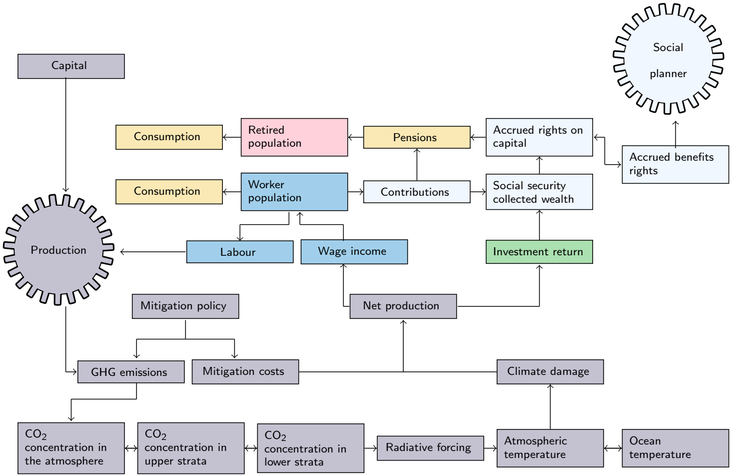

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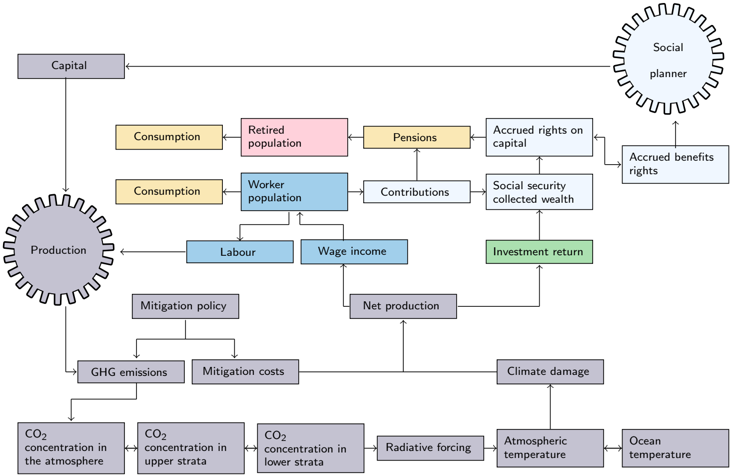

DICE-SS: Decision problem

A social planner should work to ensure that the system's capital resources can potentially meet the total accrued benefits:

$$\begin{aligned} V(t) = &\text{a.p.v of benefits of current members} - \\ &\text{a.p.v of future contributions of curent workers}. \end{aligned}$$

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Finally, the decision problem faced by the social planner is defined by

$$\max_{\mu,\tau_p,\tau_f} \sum_{j=1}^{T+1} \left\{ u\left(\frac{C_\mathrm{w}(t)+C_\mathrm{r}(t)}{l_\mathrm{w}(t)+l_\mathrm{r}(t)}\right) \cdot \left(l_\mathrm{w}(t)+l_\mathrm{r}(t)\right) \right\} \cdot e^{-\delta\cdot(j-1)},$$

$$\text{subjet to: } \mathrm{V}(t) - K(t) \leq 0$$

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	DB		DC	
Scenario	PAYGO	Funded	PAYGO	Funded
SSP1	0.07	0.05	0.00	0.22
SSP2	0.00	0.21	0.04	0.19
SSP3	0.21	0.00	0.08	0.12
SSP4	0.10	0.01	0.00	0.03
SSP5	0.00	0.28	0.00	0.26

Table 1: Optimal social security contributions under the SSP1-5

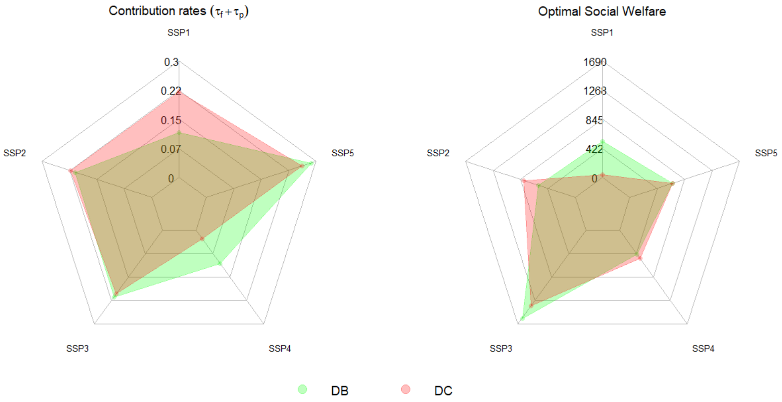

Figure 1: Optimal social security contributions and resulting social optimum under the SSP1-5

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Contents

- When considering multiple generations, decision rules that prioritize higher returns do not necessarily determine the most efficient allocation of resources for consumption. While pay-as-you-go systems may provide lower returns, they play a vital role in supporting pension expenditures, thereby allowing productive capital returns to be used to recover from climate-related losses. In contrast, fully funded systems often lead to an earlier consumption of these returns.

Conclusion

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→ This analysis need to be extended to specific regions or countries.

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$\rightarrow$ Work-in-progress.

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Thank you very much for your attention!

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