Potsdam Institute for
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PIK

Why Integrated Assessment Modellers should take Overlapping Generations Models seriously

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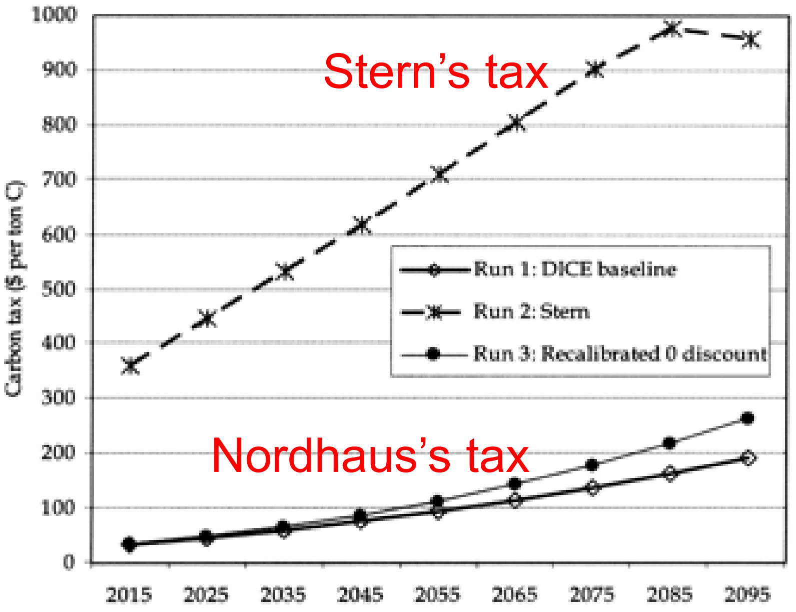
Leibniz
Gemeinschaft

Outline

1. **Introduction**
2. The basic structure of overlapping-generations models
3. What can be captured by OLG models?
   a. Intra- and inter-generational distribution
   b. Fiscal policies as redistribution mechanisms
   c. The role of asset prices

The discounting debate

How does Stern (2007) arrive at an optimal carbon tax that is an order of magnitude higher than that of Nordhaus (2007)?



Both authors use an infinitely-lived agent (ILA) model, but differ in the value of the social planner's pure rate of time preference (PRTP):

- Stern: normative argument for low PRTP
- Nordhaus: choose PRTP to match observed interest rates (descriptive)

$$\eta g + \rho_s = r$$

The discounting debate

$$\eta g + \rho_s = r$$

- **Nordhaus** calibrates the Ramsey model (which assumes perfectly altruistic saving) to market interest rates. Life-cycle saving is not modelled explicitly, even though it is an important savings motive (Gale & Scholz, 1994).
  - ➢ The resulting social pure rate of time preference is *too high*, as life-cycle saving is wrongly attributed to it.

- **Stern**’s Ramsey model (with a low PRTP) implicitly has to assume that the distributional conflict between generations is already solved, in order to match market interest rates.
  - ➢ Distributional conflict between generations is hidden in the Ramsey model.

Features of OLG models

By using an overlapping generations model (OLG), populated by finitely-lived generational cohorts with imperfect altruism:

- Life-cycle investment decisions are explicitly modeled
  - ➢ The private PRTP can be calibrated to observed market outcomes.
- Private and social discounting are naturally separated.
- Distribution and distributional conflict between generations can be modelled explicitly (Schneider et al., 2012).

Climate change, and it’s mitigation, *involve inter-generational re-distribution*:

➢ Overlapping generations models are suitable for that.

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Basic structure of OLG models

- Imperfect altruistic bequest motive.

- Two types:
  - Households facing constant probability of death (Blanchard, 1985)
  - finitely-lived, life-cycle saving households (Diamond, 1965)

- In both types, generational disconnectedness causes sub-optimal saving as an *additional externality:* **Second-best setting**.

The Yaari-Blanchard model

- Continuous time OLG model where households face an uncertain lifetime in the form of an constant instantaneous probability of death β, but total population is constant.
- This generational turnover leads to *sub-optimal savings*, as seen from the aggregate Euler equation:

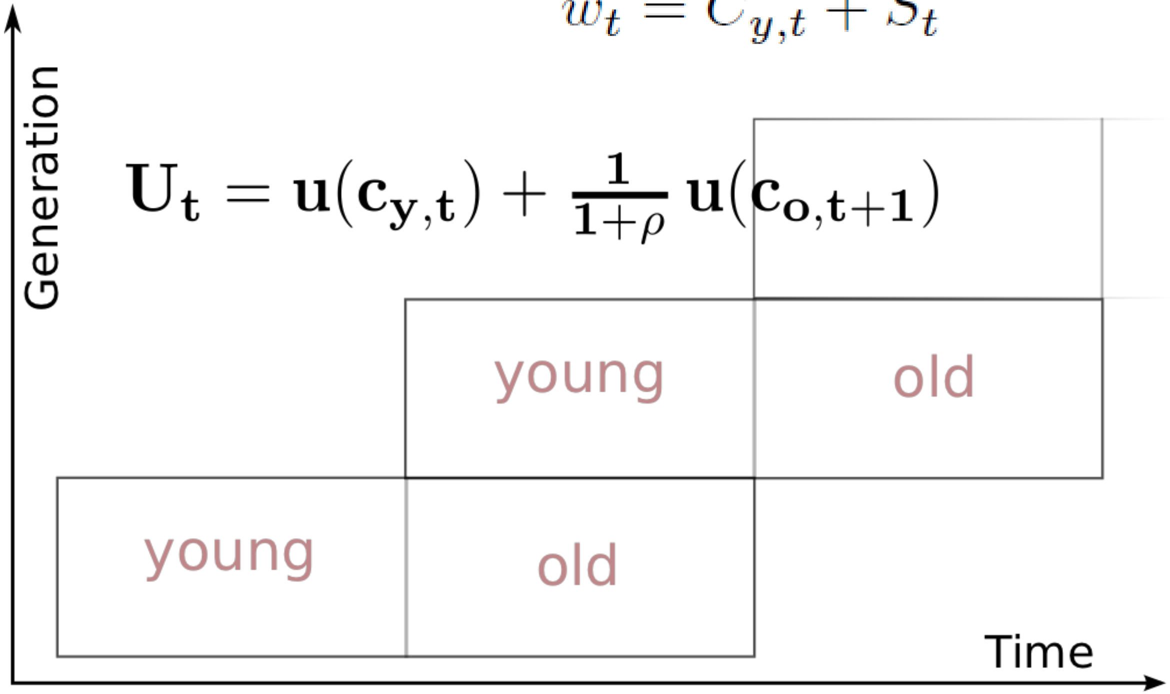
$$\frac{\dot{C}(t)}{C(t)} = r(t) - \rho \underbrace{-\beta(\rho+\beta)\frac{A(t)}{C(t)}}_{\text{vanishes for } \beta \to 0}$$

- The Ramsey (ILA) model is a *special case* of the Yaari-Blanchard model for vanishing generational turnover ($\beta \rightarrow 0$).

The Diamond-Samuelson model

- Non-altruistic agents with private PRTP ρ live for two periods (y,o).
- Receive wage when young, savings are used to smooth consumption over lifetime:

$$w_t = C_{y,t} + S_t \qquad C_{o,t+1} = (1 + r_{t+1})S_t$$



$$\mathbf{U_t = u(c_{y,t}) + \frac{1}{1+\rho} u(c_{o,t+1})}$$

FOC for optimal consumption smoothing:

$$\frac{\frac{\partial U}{\partial C_{y,t}}}{\frac{\partial U}{\partial C_{o,t+1}}} = 1 + r_{t+1}$$

The representative agent model is a *special case* of the Diamond model, assuming altruism and operative bequests.

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Inter- and intra-generational distribution

- Two aspects of distribution:
  - *Intra*-generational between households of the same age cohort.
  - *Inter*-generational distribution between young and old cohorts (at the same time or across time).

- Overlapping generations models are well suited to analyze both aspects.

Intra-generational distribution

- Accounting for differences in time preference or bequest motive is not feasible in ILA and leads to differences to standard literature when modeling the intra-generational distributional conflict:
  - ➢ Klenert, Mattauch, Edenhofer and Lessmann (2014) find inequality reducing effects of infrastructure investment, when different household types are taken into account.

- Chiroleu-Assouline and Fodha (2011, 2014): Possible Pareto-improvements by using carbon tax revenues to reduce distortive labor taxation.
  - ➢ A carbon tax reform can not only enhance efficiency but also be progressive at the same time.

Inter-generational distribution

- Climate policy needs to take the second externality (sub-optimal saving in the OLG) into account:
    - In general, two policy instruments are needed to address the two externalities.
    - Implementing optimal climate policy in an OLG economy may require inter-generational transfers (Howarth, 2000).
- Efficiency and inter-generational distribution are not separable in general (Stephan 1997; Leach, 2009).
- In OLG models, the second welfare theorem does not hold: The competitive equilibrium is not necessarily Pareto-efficient.

⇨ What are *instruments* for inter-generational redistribution?

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Public debt

- Ricardian Equivalence: Aggregate private consumption is independent of the time path of lump-sum taxes – this holds in the ILA model.

$$\underset{\text{total private wealth}}{\text{TPW}} = \int L_t\Big(\overset{\text{income}}{w_t} - \underbrace{\overset{\text{tax}}{\tau_t}}_{\tau_t = g_t - x_t} + \underset{\text{transfer}}{x_t}\Big)\mathrm{dt} = \int L_t\Big(w_t - \overset{\text{government expenditure}}{g_t}\Big)\mathrm{dt}$$

- In an OLG, taxes and transfers affect *distinct generations*.

➢ Ricardian equivalence broken in general (Debt is not neutral).

- Bovenberg & Heijdra (1998), Heijdra & Bovenberg (2002): Debt policy can be used to distribute the gains of avoided damages more equally across different generations (tax smoothing).

Debt consolidation and pension systems

- Rausch (2013): using carbon revenues for the repayment of public debt can lead to positive societal gains and can enhance support for climate policy

- Wendner (2001): using the revenues of a carbon pricing policy for partially funding the pension system can enhance real lifetime income compared to other recycling options.

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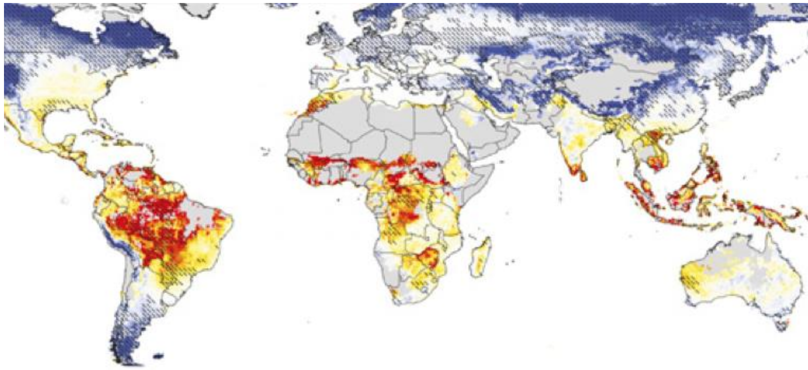
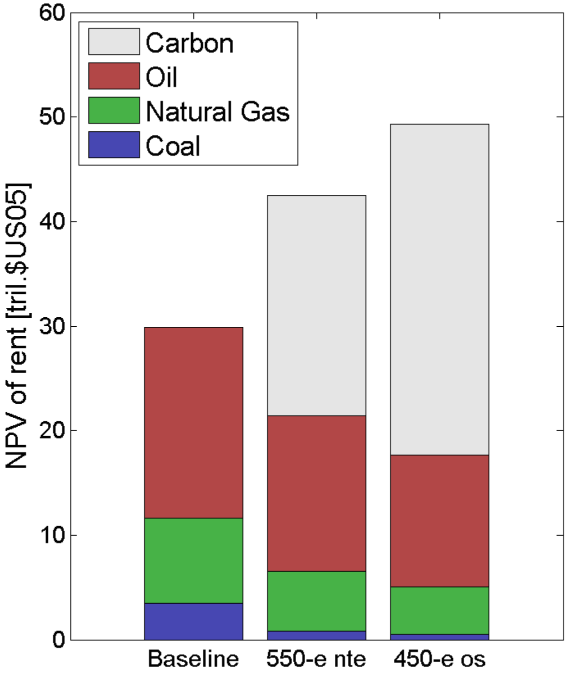
Scarcity rents and climate change



- Climate change damages impact future land rents (Rosenzweig et al., 2013)
- Mitigation policy
  - lowers fossil rents (Bauer et al., 2013),
  - may raise land rents through bioenergy deployment or land-use change based mitigation (IPCC AR5, 2014),
  - and creates new scarcity rents itself (Fullerton, 2001; Kalkuhl et al. 2013).

→ What are the distributional consequences of these rent changes?



Asset prices in OLG models

- In OLG models, changes in rents are *not neutral*, as property rights in the production factors are defined explicitly.
- Changes in future scarcity rents are capitalized into asset prices.
- Price changes have consequences
    - for *intra*-generational distribution today, e.g. through property prices (Fullerton, 2011)
    - for *inter*-generational distribution due to a change in capital accumulation through the portfolio effect (Edenhofer et al., 2013)
    - for the support of climate policy in a *political economy* setting (Karp & Rezai, 2014).

Asset prices in OLG as opposed to ILA models

As opposed to ILA models, in an OLG model

- a long lived asset, called fixed factor (e.g. land, capital s.t. adjustment costs, exhaust. resource stocks), is explicitly traded across generations.
- an endogenous asset price reacts to future rent changes caused by mitigation, for example
  - if there is some friction in the transformation between consumption and investment goods (e.g. adjustment costs),
  - or if damages in production are non-separable (impacts from climate change act directly on factors of production).

➢ In OLGs, the asset price forms an *inter-generational link* over time - which is not operational in most ILA models.

Model of Karp & Rezai (2014)

- The price of a fixed capital stock increases in response to future avoided damages.

$$\underbrace{\boxed{p_t}}_{\text{today's price}} = P_t^{\alpha} \sum_{i=1}^{\infty} (1+\rho)^{-i} P_{t+i}^{-\alpha} \underbrace{\boxed{\pi_{t+i}}}_{\text{future rents increase}}$$

- Today's asset owners (the old) profit from mitigation.

➢ In the resulting game between non-altruistic generations, it is Pareto-improving to do some mitigation, as the asset price transfers avoided damages to the present.

➢ Results contrary to conventional wisdom: Climate policy does (to a certain degree) not require consumption sacrifices today.

- Why is this not happening in the real world?
  - ➢ Reason may include myopia, imperfect stock markets – or much simpler, a *decreasing* asset price.

A two-asset mode with land and capital

In (Schultes, Leimbach and Edenhofer, mimeo)

- two assets exist: capital, and the fixed factor land (earning rents).
- Land price capitalizes future avoided damages, and damages act on land itself (breaking separability).

land rents

$$p_t = \sum_{i=1}^{\infty} \prod_{k=0}^{i} \frac{v_{t+i+1}}{1 + r_{t+k+1}}$$

today's price

endogenous interest rate

➢ Mitigation may also lower future scarcity rents, leading to a *decrease* in today's land prices. This would pose an incentive for asset owners to *oppose* mitigation.

➢ This model captures the interaction of changing future land rents, including the interaction with capital accumulation.

➢ Aggregation of damages may hide the full economic impacts. To capture the full impacts, damages should be specified acting on the asset (stock) itself.

Portfolio effect

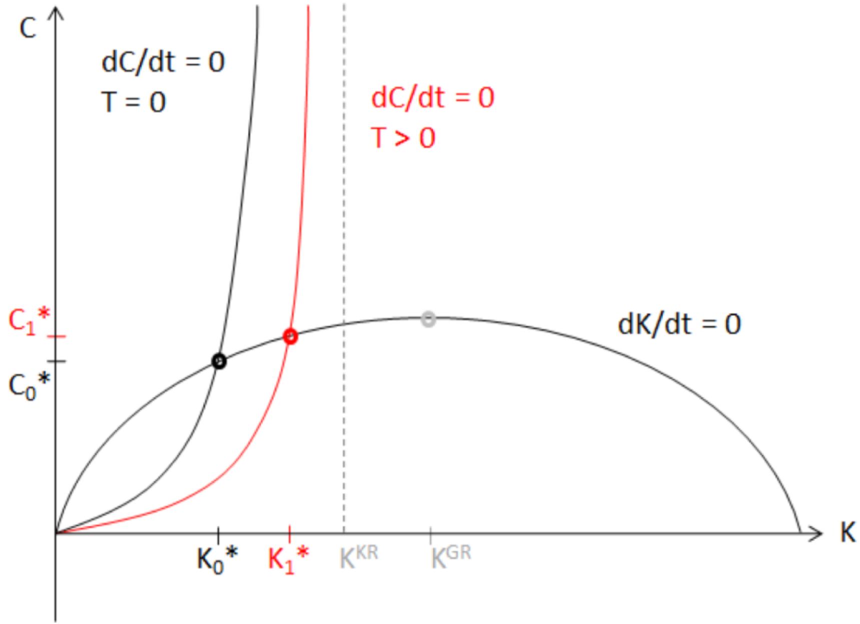
But shouldn't investors care only about the total value of their diversified portfolios, and not about single prices?

- ➢ For some assets (agricultural land, fossils), the ownership is quite concentrated.
- ➢ Macroeconomic consequences - the **portfolio effect**.

Portfolio effect

- Land price interacts with capital accumulation via portfolio effect (Feldstein, 1977).
- If capital is initially underprovided, taxing land rents increases capital accumulation, and is welfare-improving (Edenhofer et al., 2013):

$$\frac{(1-T)\,l}{p}+\frac{\dot{p}}{p}=r$$



- Similar: As climate policy appropriates some fossil rents, it redirects investments into capital, lowering mitigation costs. (Siegmeier, mimeo)

Conclusions

Climate economics needs OLG models for the following reasons:

- Private and social disounting are naturally separated.
- Intra- and inter-generational distribution can be made explicit.
- Public debt is not necessarily neutral, and can act as an inter-generational transfer mechanism (as can pensions).
- Asset prices form an inter-generational link and
  - constitute an additional degree of freedom for climate policy,
  - are important for inter-generational distribution,
  - affect support for climate policy in a political economy setting,
  - have efficiency consequences (Portfolio effect).
- Conjecture: Specifying damages on assets directly may affect the *economic impact* of these damages quite substantially.

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