Potsdam Institute for Climate Impact Research

ENGAGE

Comparative analysis of climate change impact channels in an economic growth model

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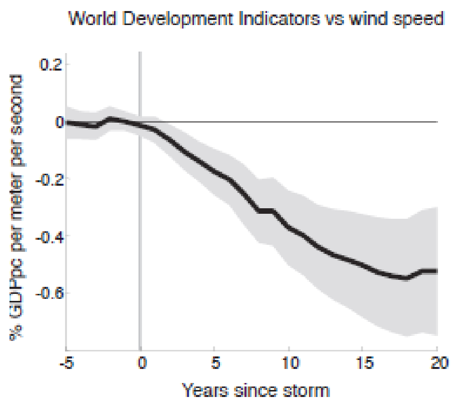
Leibniz Association

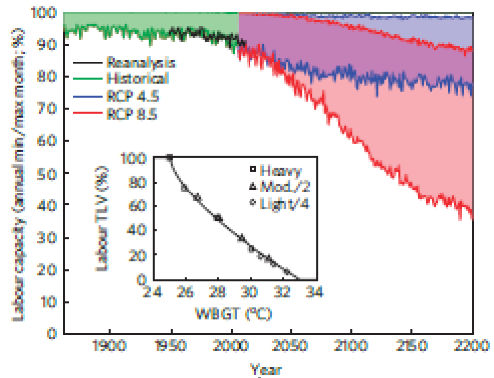
Channel-specific & aggregate damage information – how to model?

Output effect of hurricanes



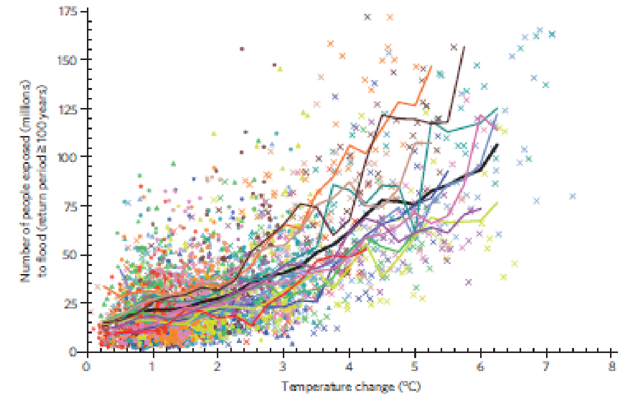
Hsiang 2013

Labor capacity



Dunne et al. 2013

People exposed to flooding



´Hirabayashi et al. 2013

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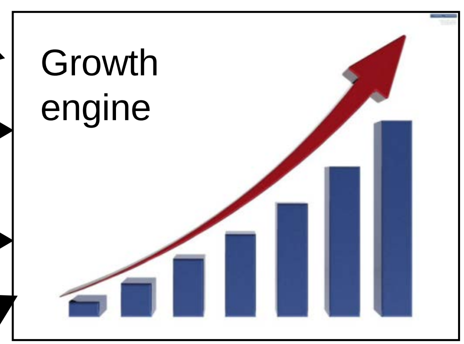
Capital

Human Capital

Exhaustible Resources

Land

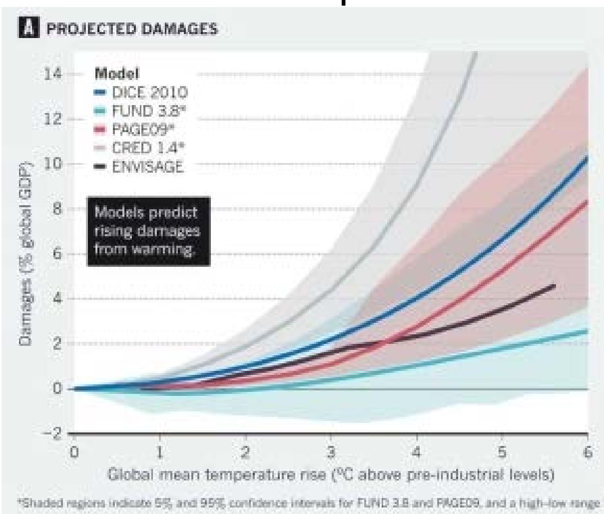


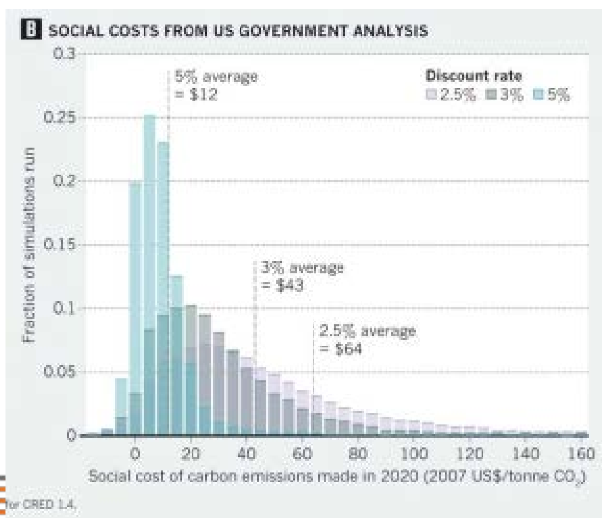
Output (Y)
(food, consumption, health)

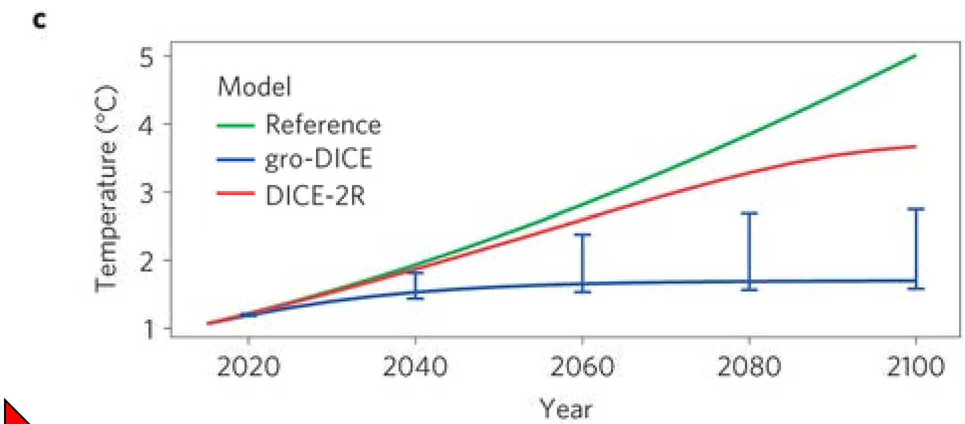
Growth damages are significant

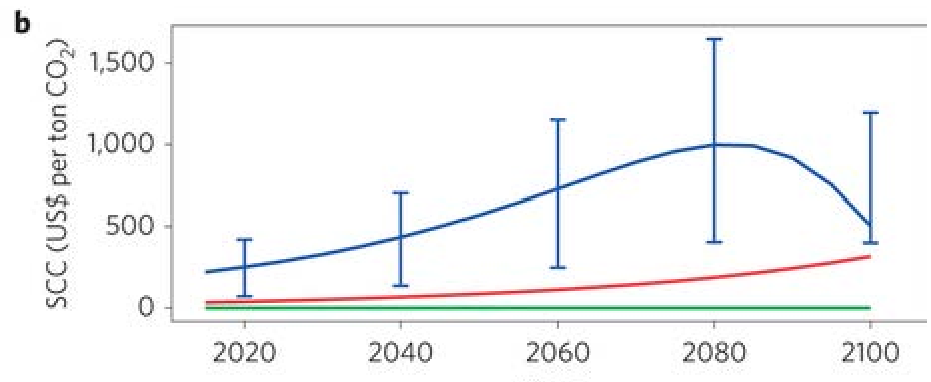
Standard damage functions on output

Empirically based damages testingTFP/capital depreciation









Moore & Diaz 2015

Revesz et al. 2014

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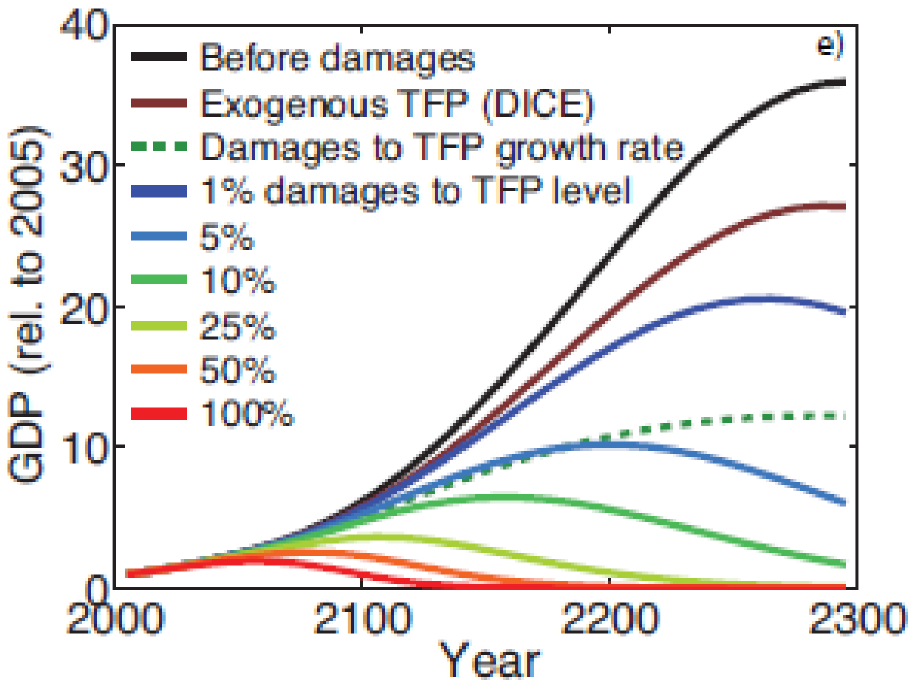
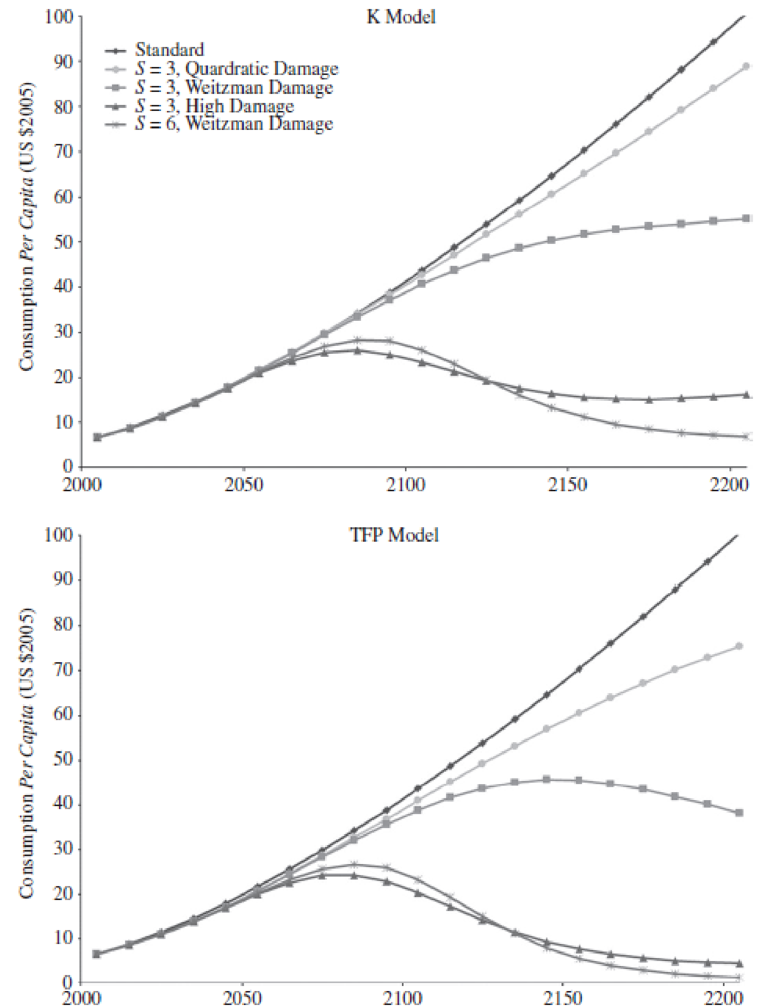
Growth effects in IAMs via alternative damage channels

Weisbach et al. 2013: TFP damage



Dietz & Stern 2015: TFP/δ damage in endogenous growth model



Open questions

- **How can we capture long-term growth damages of climate change and how significant are they?**
- **How should specific damages enter the economic model to correctly capture their short-term and long-term effects?**
- **What are the necessary „ingredients“ in the economic model to capture the effects?**
- **How do the channels compare in their long-term dynamics?**

Comprehensive, comparative analysis of different impact channels – what are the weak spots of the growth engine?

- **Builds on economic core of DICE2013**
- **No mitigation**
- **Endogenous savings rate**
- **CES production function with elasticity of substitution = 0.5:**

$$Y_t^G = a_0[\alpha {K_t}^\sigma + (1-\alpha)(\chi_t^L L_t)^\sigma]^{1/\sigma}$$

- **Different macro-economic dynamics: elasticity of substitution, capital adjustment costs, endogenous growth, savings rate**

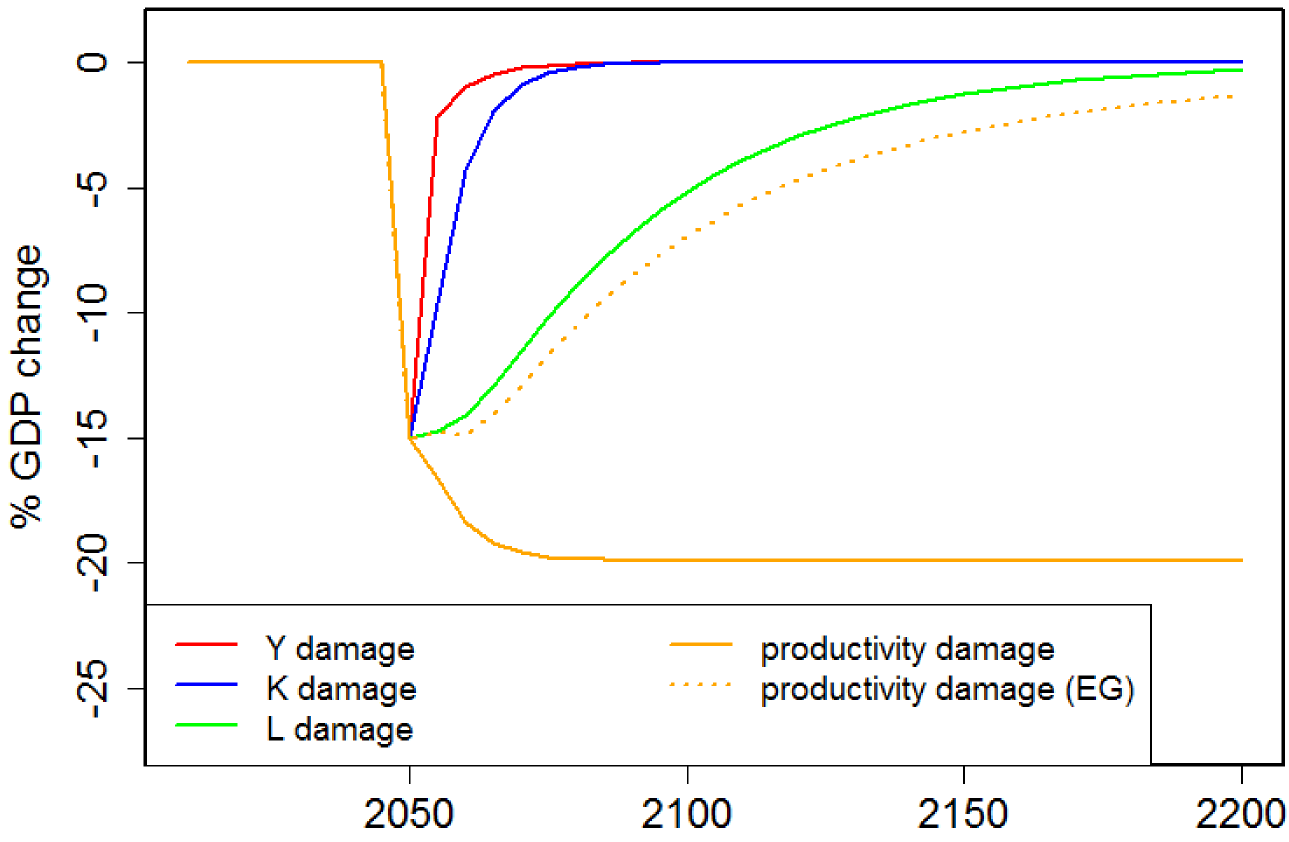
Damage channels

- **Net GDP:** $Y_t^N = \Omega_t^Y a_0 \left[\alpha {K_t^*}^{\sigma} + (1-\alpha)\left({\chi_t^L}^* L_t^*\right)^{\sigma}\right]^{1/\sigma}$
- **Stock vs flow damages:**
  - $Y_t^N = \Omega_t^Y Y_t^G = \Omega_t^Y a_0[\alpha K_t^{\sigma} + (1-\alpha)(\chi_t^L L_t)^{\sigma}]^{1/\sigma}$
  - $K_{t+1}^* = \Omega_{t+1}^K K_{t+1} = \Omega_{t+1}^K[(1-\delta^K)^{\Delta t} K_t^* + \Delta t I_t]$
  - **Similar for labor and labor productivity**

- **Comparability – same GDP effect at a given time step:**

$$\Omega_t = \frac{Y_t^{N,Y}}{Y_t^{G,Y}} = \frac{Y_t^{N,\chi^L}}{Y_t^{G,\chi^L}} = \frac{Y_t^{N,K}}{Y_t^{G,K}} = \frac{Y_t^{N,L}}{Y_t^{G,L}}$$

Single shock experiments (-15% GDP in 2050): different channels lead to different long-term effects



Productivity damage:

$$\chi_{t+1}^{L} = \Omega_{t+1}^{\chi_L} \frac{\chi_t^L}{1 - g_t^{\chi_L}}$$

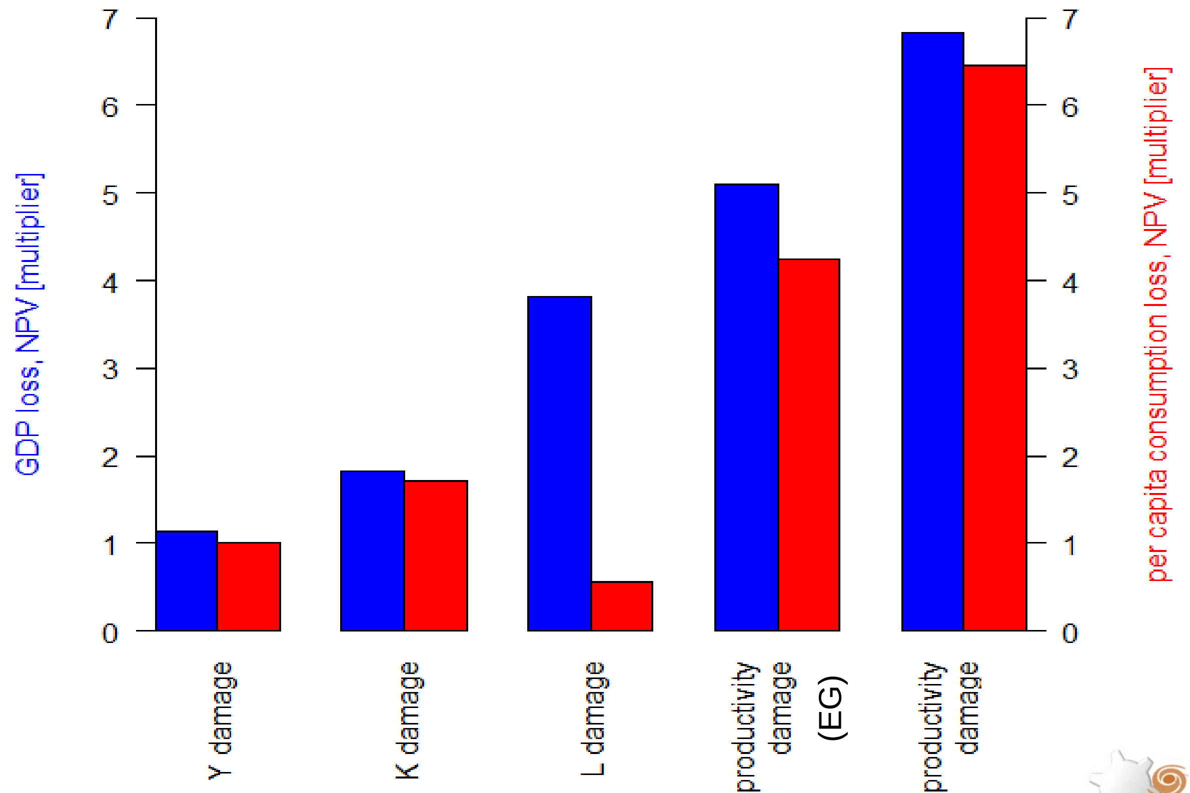
Productivity damage (EG):

$$\chi_{t+1}^{L} = \Omega_{t+1}^{\chi_L} [(1 - \delta^{\chi})\chi_t^L + g_t^{\chi_L}]$$

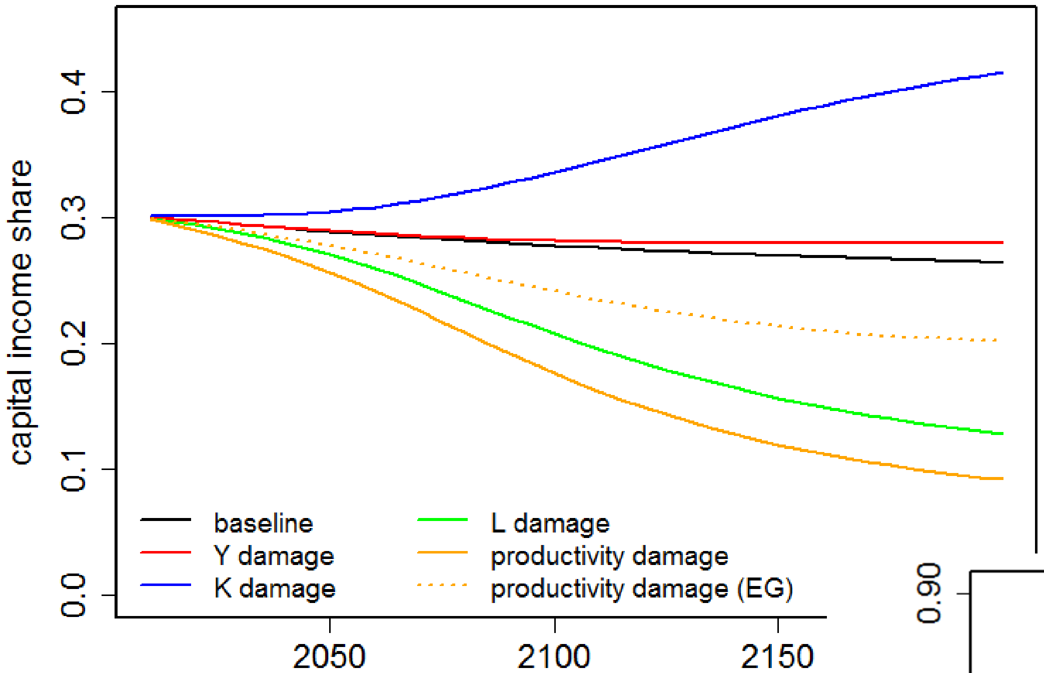
Continuous, cumulative damage

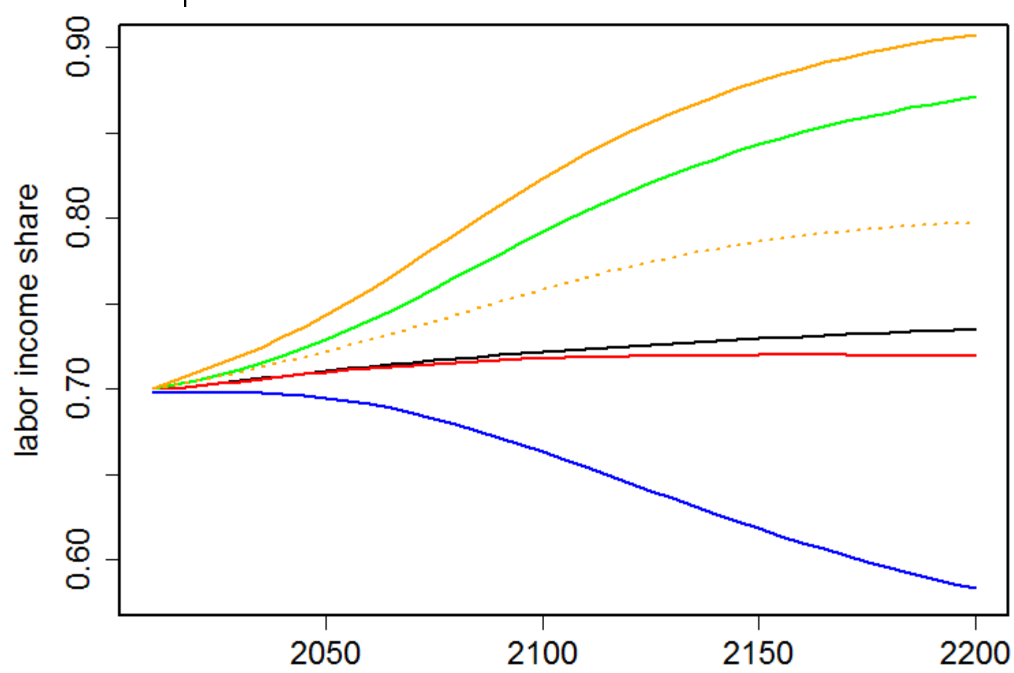
- **Exogenous DICE damage function:** $\Omega_t = 0.00267T_t^2$ **(6.7°C above preindustrial by 2200)**
- **Comparable damages at any given time step but different accumulation**

Net present value of losses (discount rate = 1.5%) compared to direct damage case



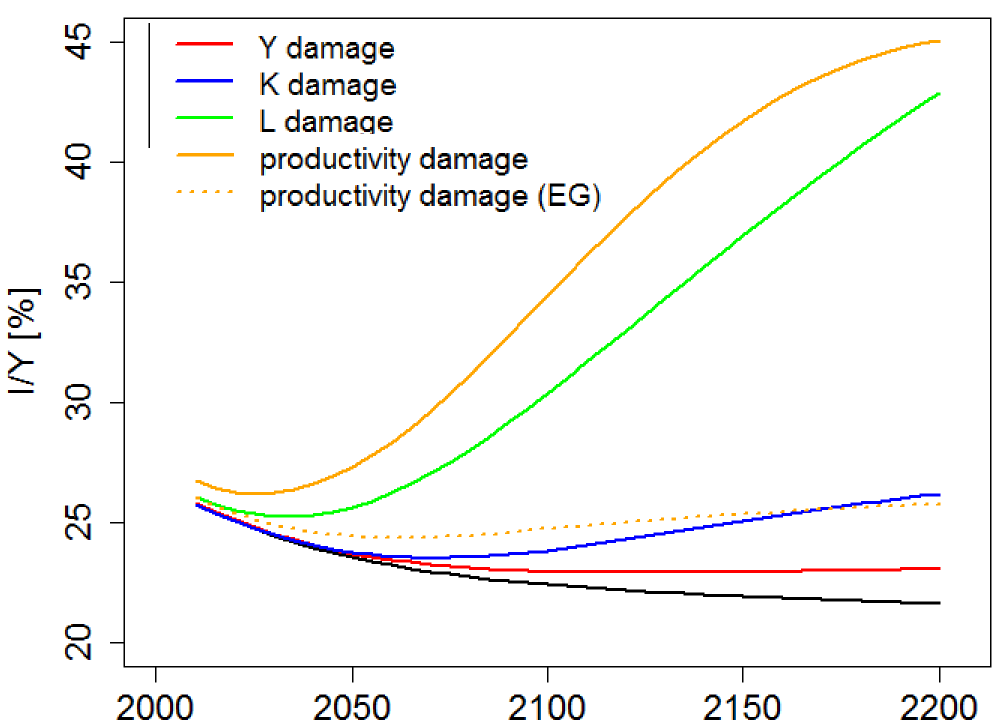
Income shares – complementary redistribution





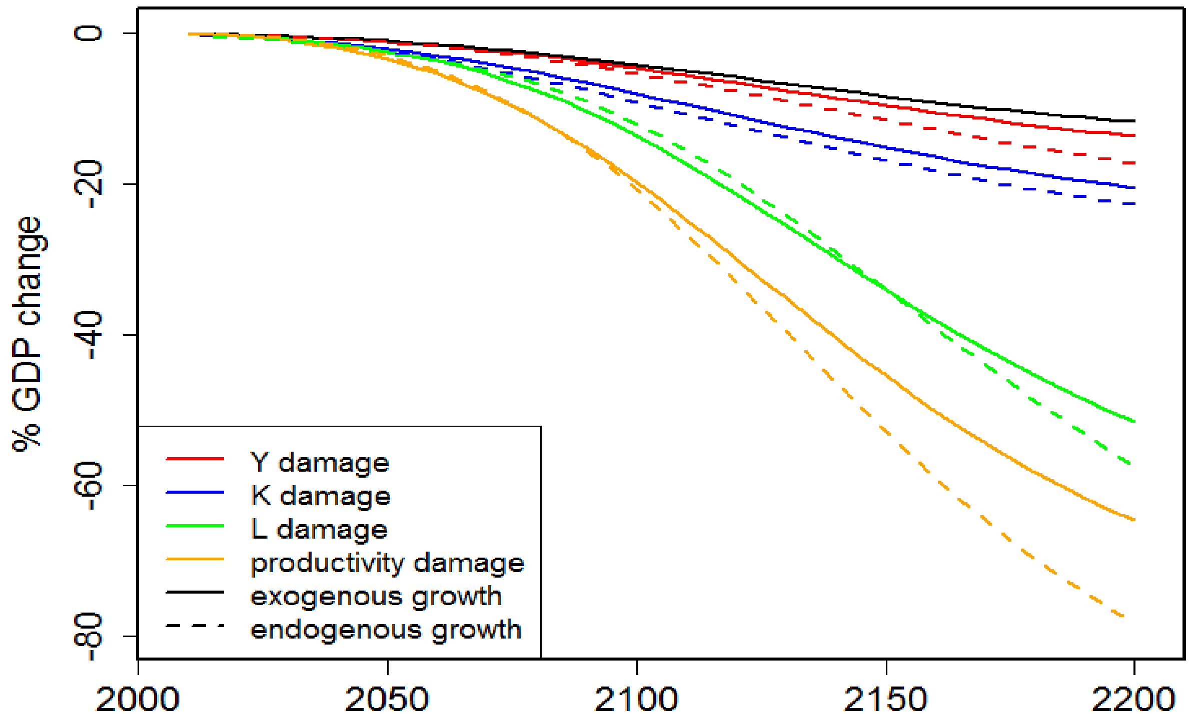
Adaptive effect through investment dynamics

NPV of GDP loss compared to baseline [trl US$]	Y channel	K channel	L channel	Productivity channel	Productivity channel (EG)
Standard run	1354	2167	4540	8113	6073
Exogenous saving	1550	2726	6090	9476	6576
Factor	1.14	1.26	1.34	1.17	1.08

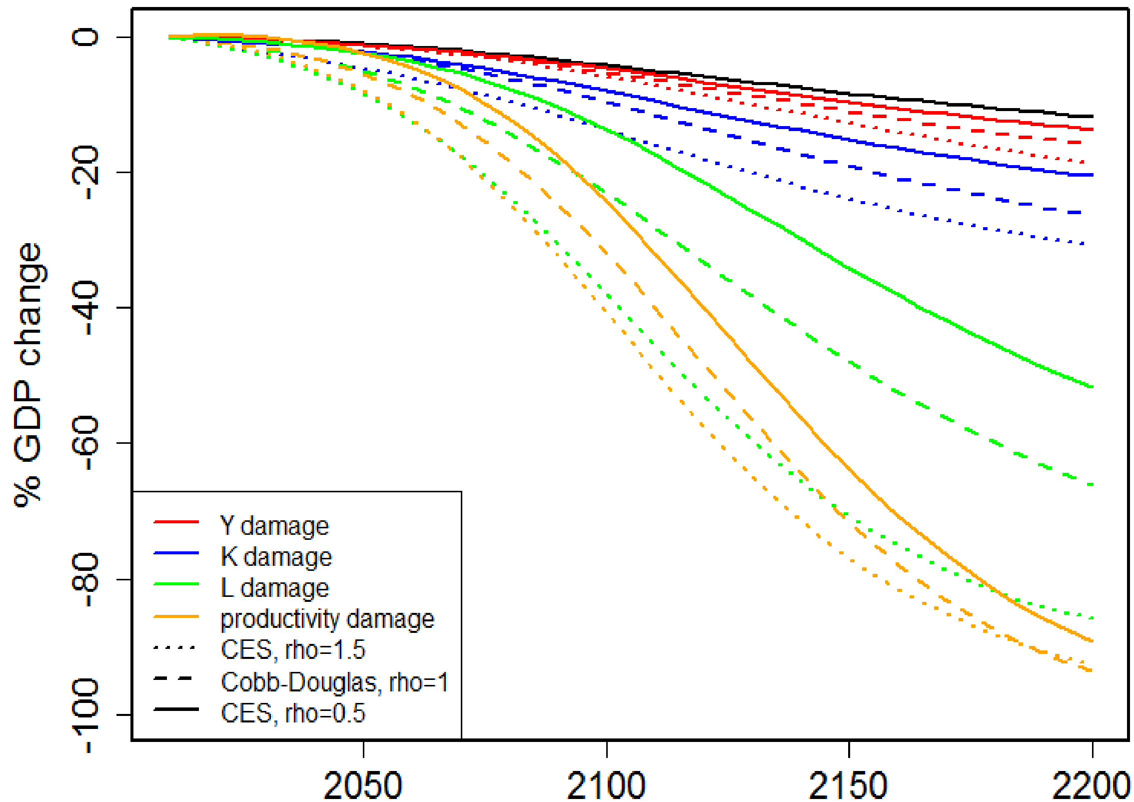


Endogenous growth

- **Follows Dietz & Stern (2015):** $\chi_{t+1}^{L} = (1-\delta)\chi_t^{L} + \gamma_1 I_t^{\gamma_2}$
- **Two-fold role: additional channel for indirect damages & for adaptation via incrased investment (though not part of the optimization)**



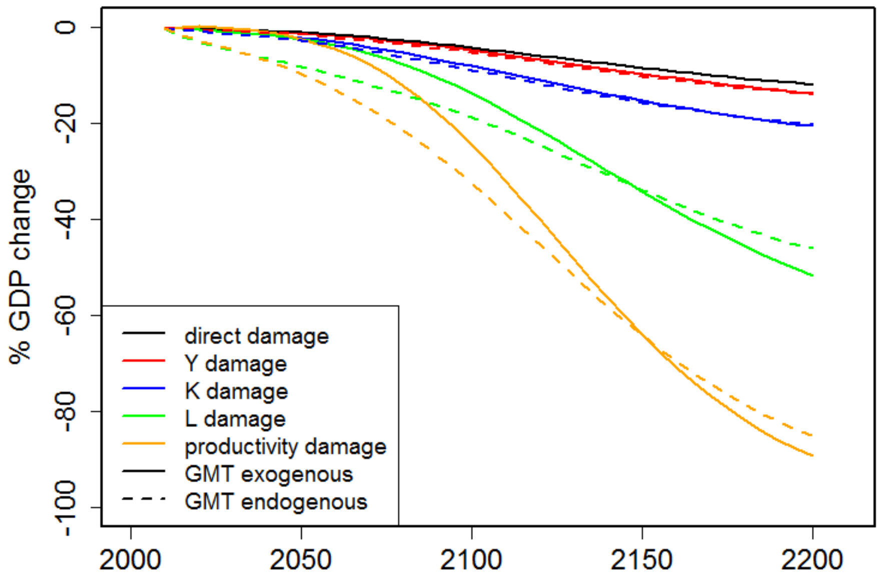
Factor substitutability: larger damages with better substitutability

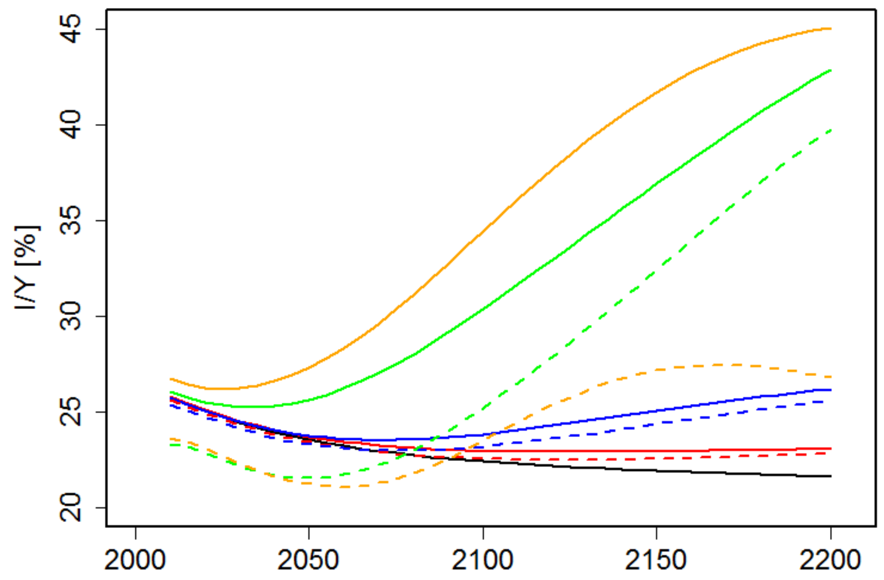


Enhanced by opposite investment dynamics

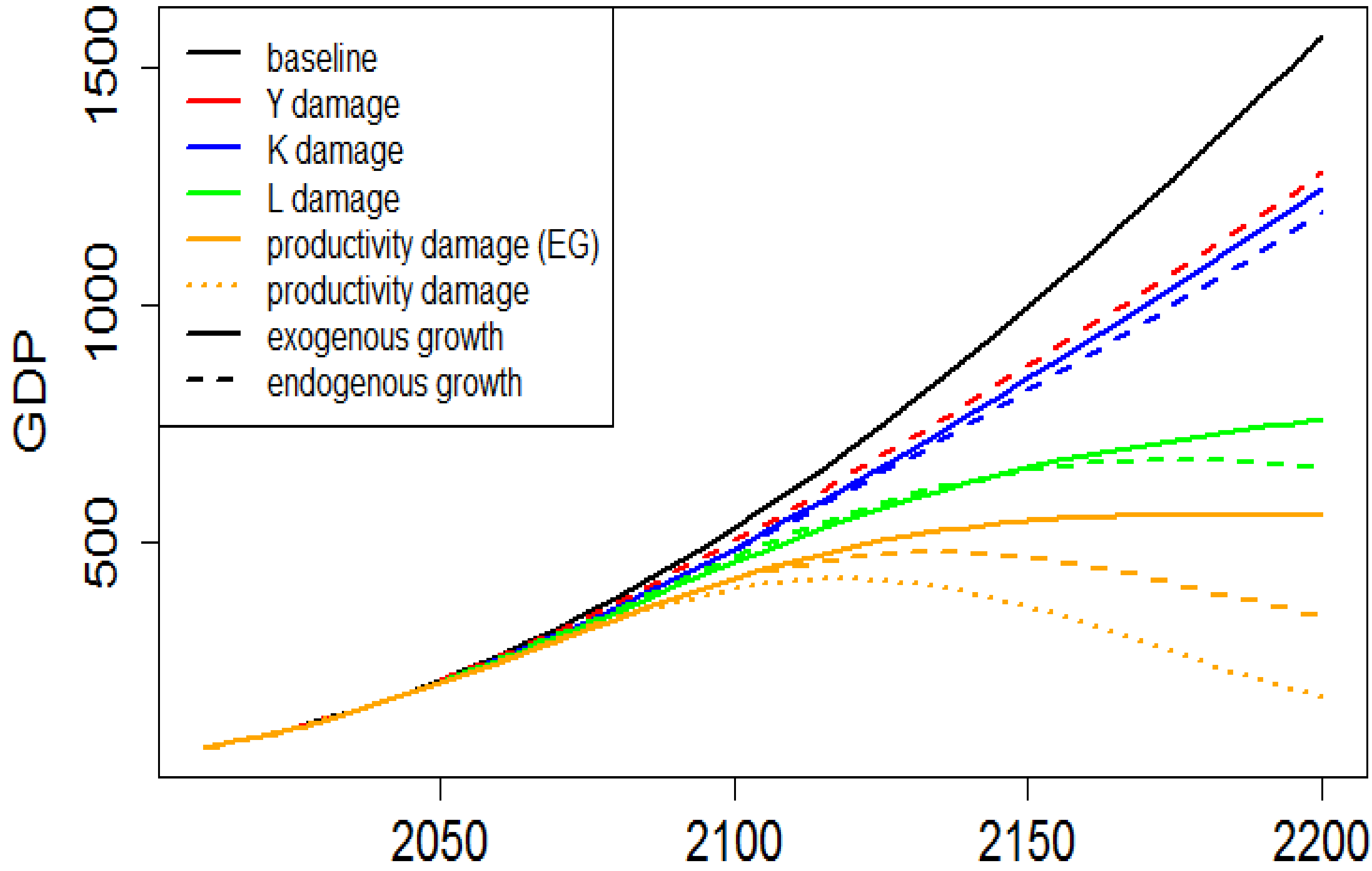
Endogenous temperature feedback

- **No comparability anymore → different GDP effect results in different temperature pathway**
- **Immediate investment reduction reduces GDP → „damage“, but long term climate-related damage smaller because of lower emissions, i.e. lower temperature (NPV effect over whole simulation period about equal)**





Effects on GDP growth

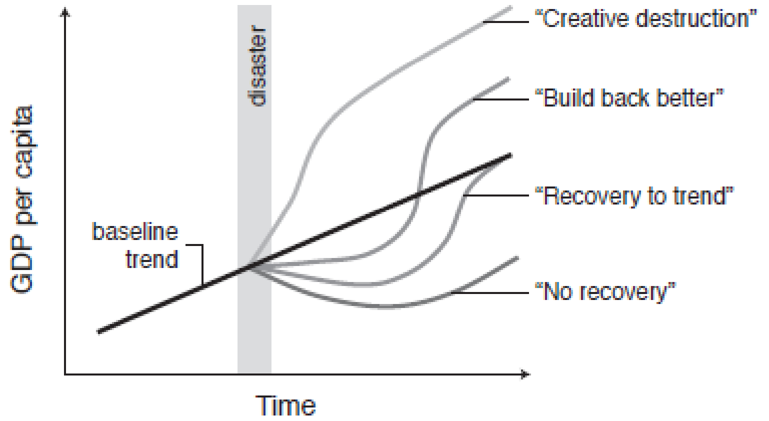


Next steps I – improvements of analysis

- **Additional production factors like land**
- **Multisectoral effects**
- **Improved endogenous growth model (human capital)**
- **Interregional effects**
- **Welfare damages**

Next steps II – quantification of channels

- **Hurricanes & floods**



→ challenge: How to represent damages from stochastic extreme events?

- **Land-related impacts**

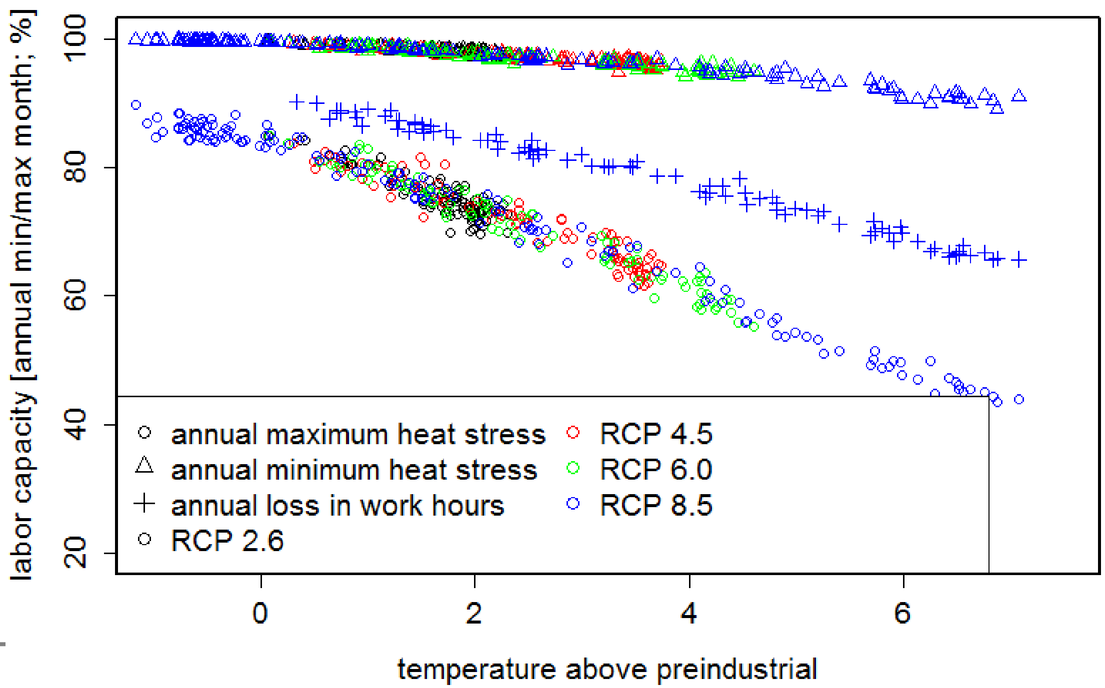
→ Integrated assessment framework at PIK

→ challenge: economic vs. welfare vs. distributional impacts

Next steps III – quantification of channels

Labor/labor productivity

- **Wet bulb global temperature → labor capacity loss (Dunne et al. 2013)**
- **Challenge: Aggregate labor force? Lost work hours? Lost productivity? Compounding or not? Related welfare impacts?**



Thank you!