

How might climate change affect economic growth?

A review of the growth literature with a climate lens

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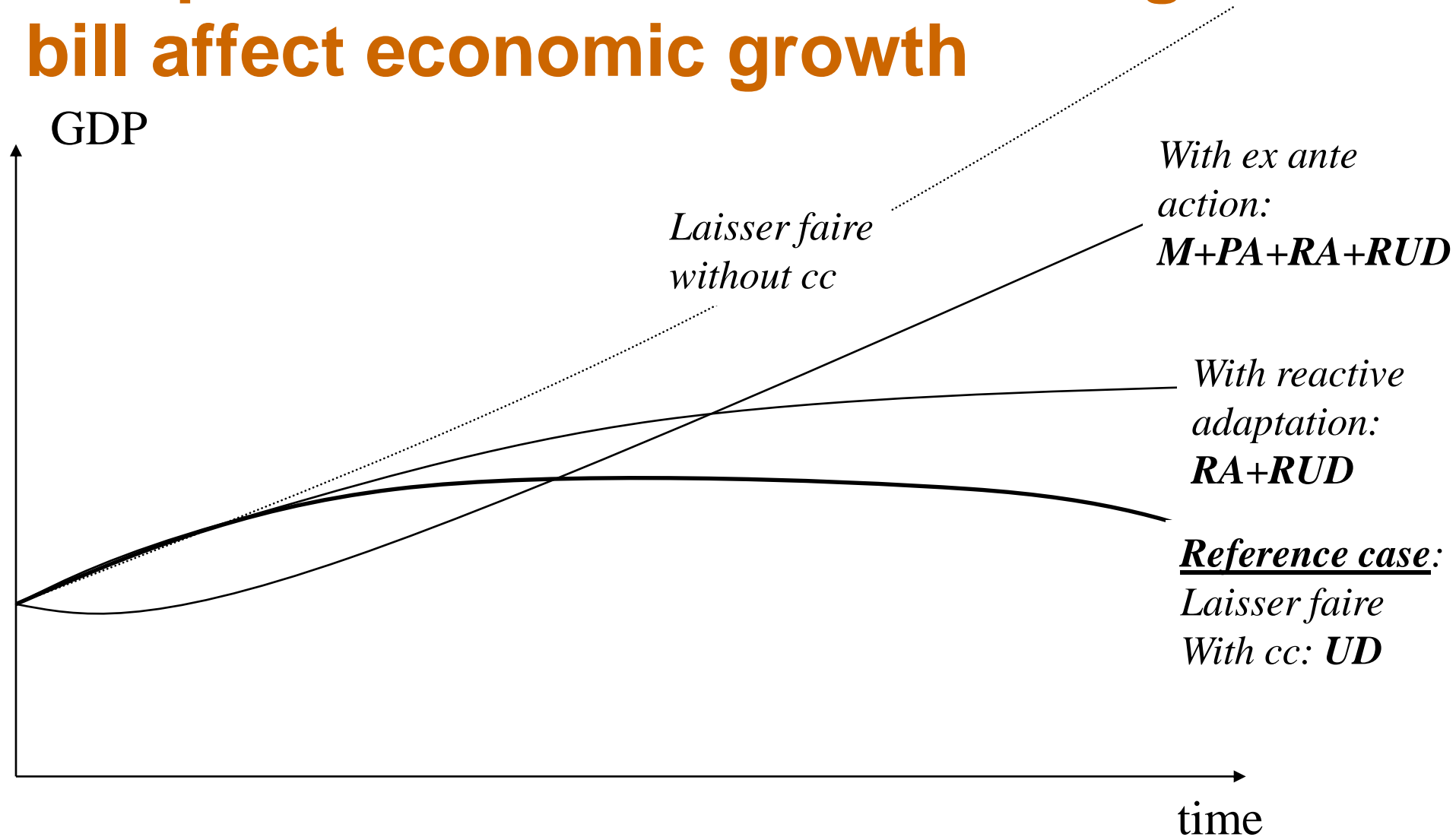
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Policy context

- Many countries see the need for continuous economic growth now and worry that growth will be harmed if they engage in mitigation (or in proactive adaptation)
- Yet in the absence of any action, climate change will generate damages that will also alter country growth trajectories
- The problem is to compare the implications for economic growth of the different components of the climate change bill: mitigation, proactive adaptation, reactive adaptation, and remaining ultimate damages

Objective: Examine how the components of the climate change bill affect economic growth



Methodology: Review the growth literature with a climate lens

- The modeling literature provides some discussion of the implications of climate change for economic growth. However,
 - Most models are partial equilibrium or static general equilibrium
 - Growth models often rely on basic growth engine
 - Few models include impact, virtually none adaptation
- The theoretical and empirical literature on economic growth hardly ever addresses climate change, but it touches on many issues that are directly relevant to climate change
 - One exception is Fankhauser and Tol (2005)

Outline

1. Qualitative insights
2. The Cass-Koopmans model...
3. ... And its limitations
4. Multi-sector models
5. Interaction between rigidities and shocks
6. Non-convexities in the production function

1. The different components of the climate change bill impact economic growth via different channels

Timing Nature	Might be smoothed out over time	Tend to be concentrated in time
Additional expenditures	Mitigation, proactive adaptation	Reactive adaptation
Direct impact on prod. factors (and their productivity)		Remaining ultimate damages

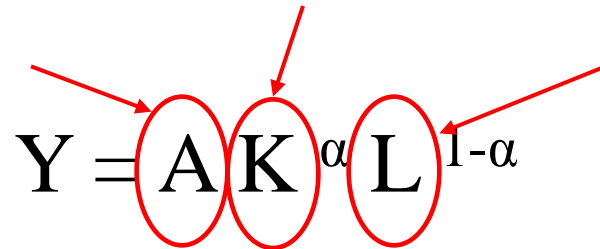
2. Implications of the climate change bill for economic growth in neoclassical growth models

$$Y = A K^\alpha L^{1-\alpha}$$

$$K_{t+1} = (1-\eta) K_t + Y - C$$

- The neoclassical (i.e. Cass-Koopmans) growth model simplest analytical framework to discuss impacts on economic growth
- It also underlies most numerical models on climate change


Variations in stocks / productivity of production factors affect transitional, but generally not long-run economic growth rates

$$Y = A K^\alpha L^{1-\alpha}$$


$$K_{t+1} = (1-\eta) K_t + Y - C$$

- The structure of the steady-state growth path, however, may vary (notably the capital to labor and consumption to labor ratios)

Variations in expenditures have typically only transitional impacts, except when proportional to output

$$Y = A K^\alpha L^{1-\alpha} - \Omega$$


$$K_{t+1} = (1-\eta) K_t + Y - C$$

- In the latter case, it is as if the marginal productivity of the whole economy was affected

Three key reasons for the limited effects of climate change on economic growth in the neoclassical model

$$Y = \mathbf{A} K^\alpha \mathbf{L}^{1-\alpha}$$

$$K_{t+1} = (1-\eta) K_t + Y - C$$

- Each factor has decreasing returns when others held constant
- The **engines of growth** (demographics and technological change) are exogenous
- All markets clear instantaneously

3. The Cass-Koopmans has limited explanatory power of observed growth patterns

$$g_Y = \alpha(t) g_K + [1-\alpha(t)] g_L + g_A$$

- Empirical studies consistently suggest that factor accumulation explains no more than half of observed growth rates, particularly in developing countries (Easterly and Levine, 2001, O'Connell and Ndulu, 2000)

There is no theoretical or empirical consensus on the determinants of the residual (Total Factor Productivity)

$$g_Y = \alpha(t) g_K + [1-\alpha(t)] g_L + v_1 + \dots + v_n$$

Four sets of factors play a role:

1. **Structural factors** (e.g., changing shares of agriculture and industry)
2. **Shocks**, of whatever nature (e.g., terms of trade, financial crises, natural hazards)
3. **Geographical factors** (e.g., landlocked vs. non-landlocked)
4. **Policy and institutional factors** (e.g., macroeconomic policy, etc.)

4. Climate change in multi-sector growth models: The importance of spillovers and factors mobility

$$\begin{aligned} K &= K_I + K_C & L &= L_I + L_C \\ K_{t+1} &= (1-\eta) K_t + A K_I^\alpha L_I^{1-\alpha} & C &= A K_C^b L_C^{1-b} \end{aligned}$$

- In neoclassical growth models with two or more sectors, impacts on one sector propagate to the other
- Under decreasing returns and full factor mobility assumptions, impacts in one sector cannot be fully compensated by positive implications in another
- Taking rigidities into account greatly complicate dynamics

Climate change in multi-sector growth models: The importance of spillovers and factors mobility

$$\begin{aligned} K &= K_I + K_C & L &= L_I + L_C \\ K_{t+1} &= (1-\eta) K_t + A K_I^\alpha L_I^{1-\alpha} & C &= A K_C^\alpha L_C^{1-\alpha} \end{aligned}$$

- Multi-sector models tend to be numerical, which raises the question of the extent to which their results depend on particular modeling assumptions, or on the very structure of the growth engine
- Yet understanding the reasons that underpin particular numerical results is very important for policy purposes

5. The interaction between shocks and rigidities leads to higher transitional costs

$$g_Y = \alpha(t) g_K + [1-\alpha(t)] g_L + \text{shock} + \dots + V_n$$

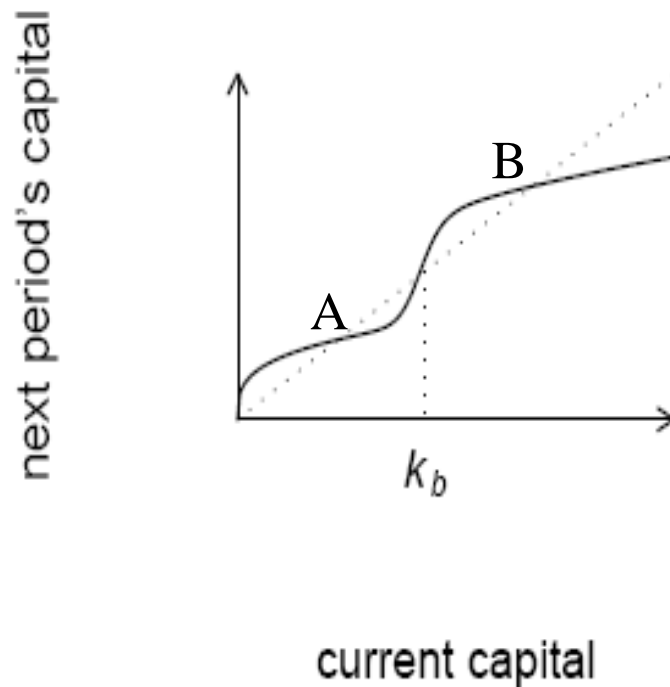
- Observed costs of shocks for growth are rather high in many economies and play a significant role in explaining cross-country economic performances (e.g., Easterly et al., 1993)
- For example, the IMF (2003) finds that large-scale natural disasters have occurred on average once every 20 years in LDCs over the 1977-2001 period, with an average impact on GDP ranging from -2.7% to -5.8%

Sensitivity of growth to shocks can be explained by several factors

$$g_Y = \alpha(t) g_K + [1-\alpha(t)] g_L + \mathbf{shock} + \dots + V_n$$

- Dependency on climate-sensitive sectors
- Rigidities, e.g., in price adjustment, factor mobility or in absorptive capacity
 - Hallegatte et al. (2007) estimate rigidities increase costs of extreme events 2-4 fold
- Institutional factors

6. Taking (local) non-convexities into account has important but ambiguous implications for the cc/growth relationship



Source: Azariadis and Starchuski, 2004

- Poverty trap models suggest that shocks may have long-lasting consequences by reducing the chance that a country grows out of the trap (or increasing the chance that it falls into it)

Taking (local) non-convexities into account has important but ambiguous implications for the cc/growth relationship

$$C + I_K + I_H = A \mathbf{H}^{1-\alpha} K^\alpha$$

$$K_{t+1} = (1-\eta) K_t + I_K$$

$$\mathbf{H}_{t+1} = (1-\gamma) \mathbf{H}_t + I_H$$

- In endogenous growth models, climate change impacts on population have potentially larger consequences for growth, at least in the short- and medium-term, but not necessarily in the long-term.

Taking (local) non-convexities into account has important but ambiguous implications for the cc/growth relationship

$$Y = A(\Sigma \text{past miti. efforts}) K^\alpha L^{1-\alpha}$$

- A consensus seems to be emerging that induced technological change is an important driver of costs of mitigation (and probably adaptation) policies, especially in the long-run

Taking (local) non-convexities into account has important but ambiguous implications for the cc/growth relationship

- Increasing returns also create the possibility of **lock-ins**, with potentially major but ambiguous implications for the climate change / growth relationship
- The concept has been developed for technology (Arthur, 1989), but it also applies to spatial patterns and to institutions

Taking (local) non-convexities into account has important but ambiguous implications for the cc/growth relationship

- Growth benefits from geographical concentration. Thus, localized impacts of climate change on a growth 'nucleus' could have disproportionate impacts on economic growth
- Similarly, implications for growth of impacts on infrastructure that links growth engines to markets (roads, ports) may be very large

Conclusions

- The Cass-Koopmans neoclassical framework that underlies most numerical models does not incorporate real-world growth processes
- The CK framework might underestimate impacts of climate change
- More theoretical and empirical research is required on key elements of growth, notably the relationships between rigidities and shocks, and the emergence of lock-ins
- There is material in the growth literature that numerical models can rely on beyond the CK framework: **multi-sector approaches**, **induced technological change**, or even crude representations of impacts of **shocks**
- Shocks, transitions, geography, and risks of ‘bad’ vs. ‘good’ lock-ins are key areas for research

Thank you!

Reference:

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<http://go.worldbank.org/G2EWXZ4EL0>