Efficient and Equitable Climate Policy in a Dynamic World

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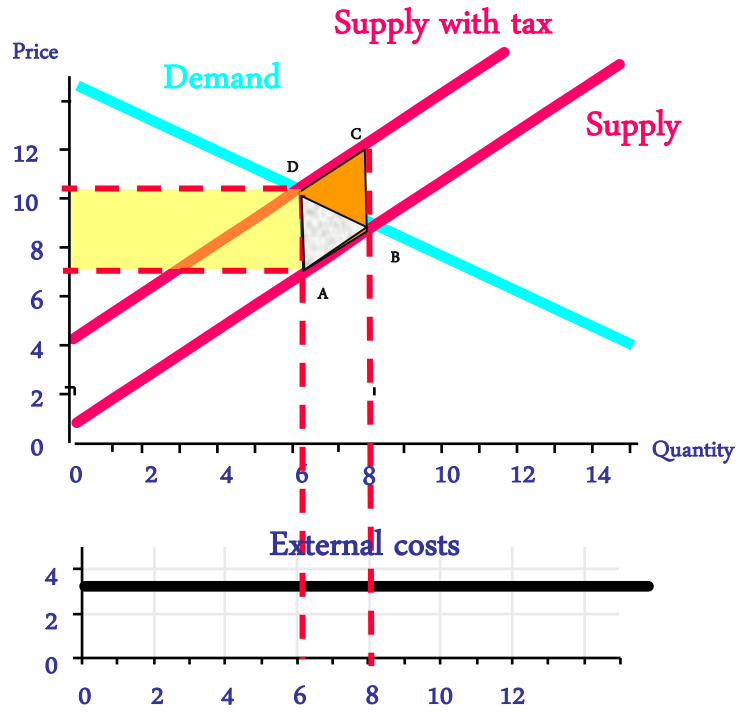
European Association
of Environmental and
Resource Economists
E A E R E

Public Perception

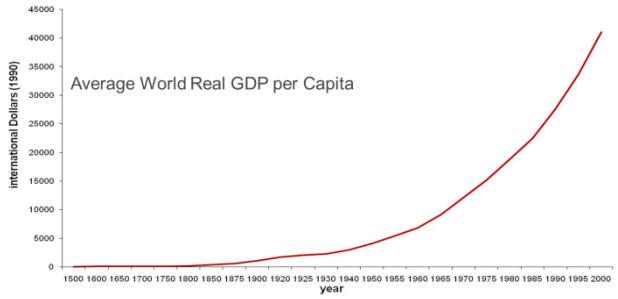
Public Perception

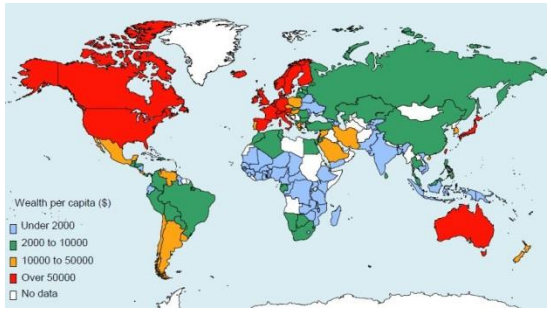
Economic Solution

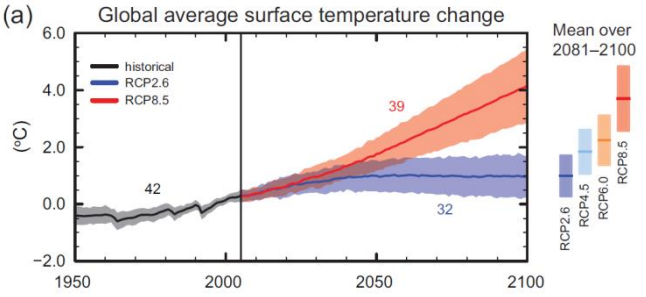


«All we need now is the political will»

Complex Reality







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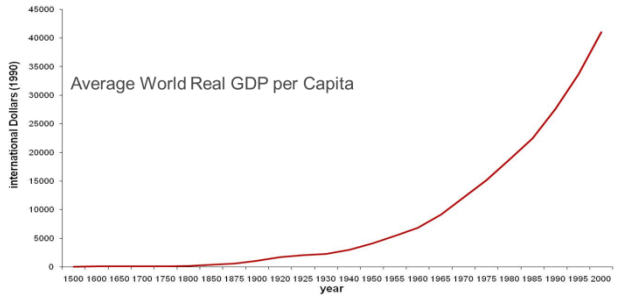

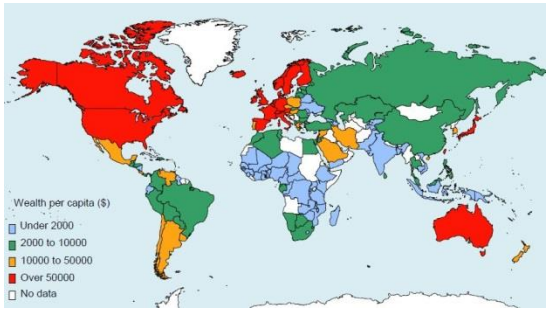

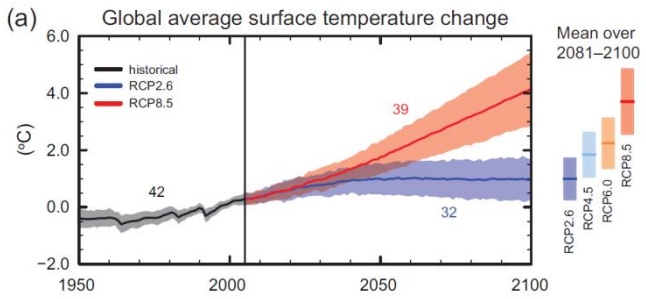

- Economic dynamics
- Long-run perspective
- Uncertainties
- Equity concerns
- International dimension
- Population issues
- Development debate
- Lifestyle issues
- Time mismatch
- Institutional deficiencies

→ Reasons for **lack of political will**

The Herculean Task

The twelve labors of Hercules, then:

The Herculean Task

The twelve labors of Hercules, then:

and now:

Research and Policy Questions

- Why are climate policies so **difficult to implement**?
- How can international **burden sharing** be realized?
- How should we link climate policy to the **sustainability discussion**?
- What are the most valuable **contributions** of the economists?
  - Get efficiency issues right
  - Separate efficiency from equity
  - Propose equitable solutions (international policy is 195x national policy)

Proposition

The political will to implement climate policies will grow when

- **dynamic impacts** of policies are taken into account,
- **uncertainties** are dealt with in a rational way
- burden sharing is considered as **fair**,
- international **asymmetries** are taken care of,
- the sustainability debate remains **focused**.

Topics of the Talk

Costs of climate policy

Resource use and growth

Impacts of climate change

Role of uncertainty

Equitable burden sharing

North-South perspective

Individual behavior and institutions

Population growth

Climate Modelling

- Policy recommendations should be based on **suitable models**
- **Numerical simulation models** dominate
- Analytical models with **closed-form solutions** help to identify basic mechanisms
- Long-run impacts: What is the policy effect on **economic dynamics**? Full-fledged dynamic models needed

Nordhaus (2000), Stern (2007), IPCC (2014), Gollier and Tirole (2015)

Costs of Climate Policy

- **Level effects**
  - Growth accounting: partial and static
  - Causal relationships between variables, sectors, and countries crucial
- **Growth effects**
  - Endogenous capital formation, induced innovation
  - May counteract level effects
  - Link to resource economics and growth theory
- Illustration: $$U = \int_0^{\infty} e^{-\rho t} \ln C(t)\, dt = \frac{1}{\rho}\left[\ln C(0) + \frac{g}{\rho}\right]$$

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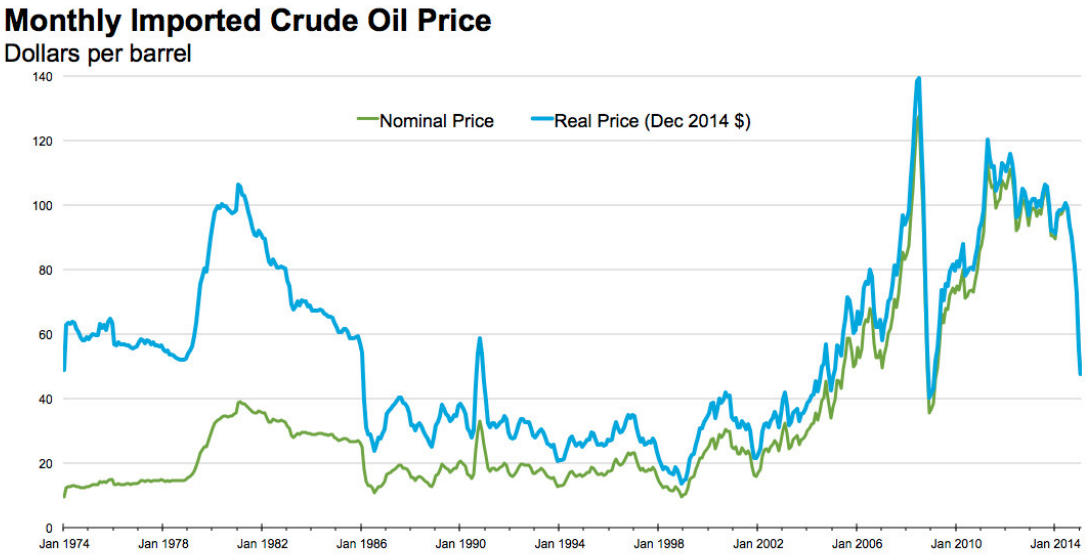
Affected by climate policy and linked by input use

- Illustration: $$U = \int_0^{\infty} e^{-\rho t} \ln C(t)\, dt = \frac{1}{\rho}\left[\ln C(0) + \frac{g}{\rho}\right]$$

Redirecting a Polluting Economy

- High costs of climate policy?
  - Oil price jumps in perspective



Redirecting a Polluting Economy

- High costs of climate policy?
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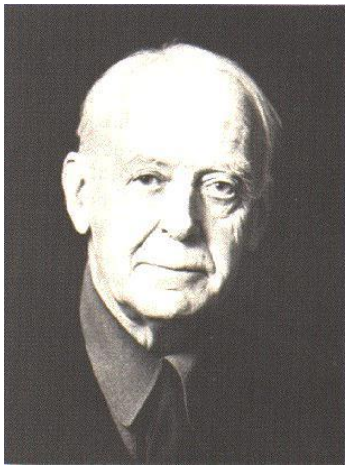
- Endogenous growth theory

Romer: JPE 1990
Suzuki: REStud 1976

Redirecting a Polluting Economy

- High costs of climate policy?
  - Oil price jumps in perspective
- Endogenous growth theory
- John Hicks' "Induced innovation"
  - resource prices
  - innovation
  - resource efficiency, capital productivity



Hicks (1932)

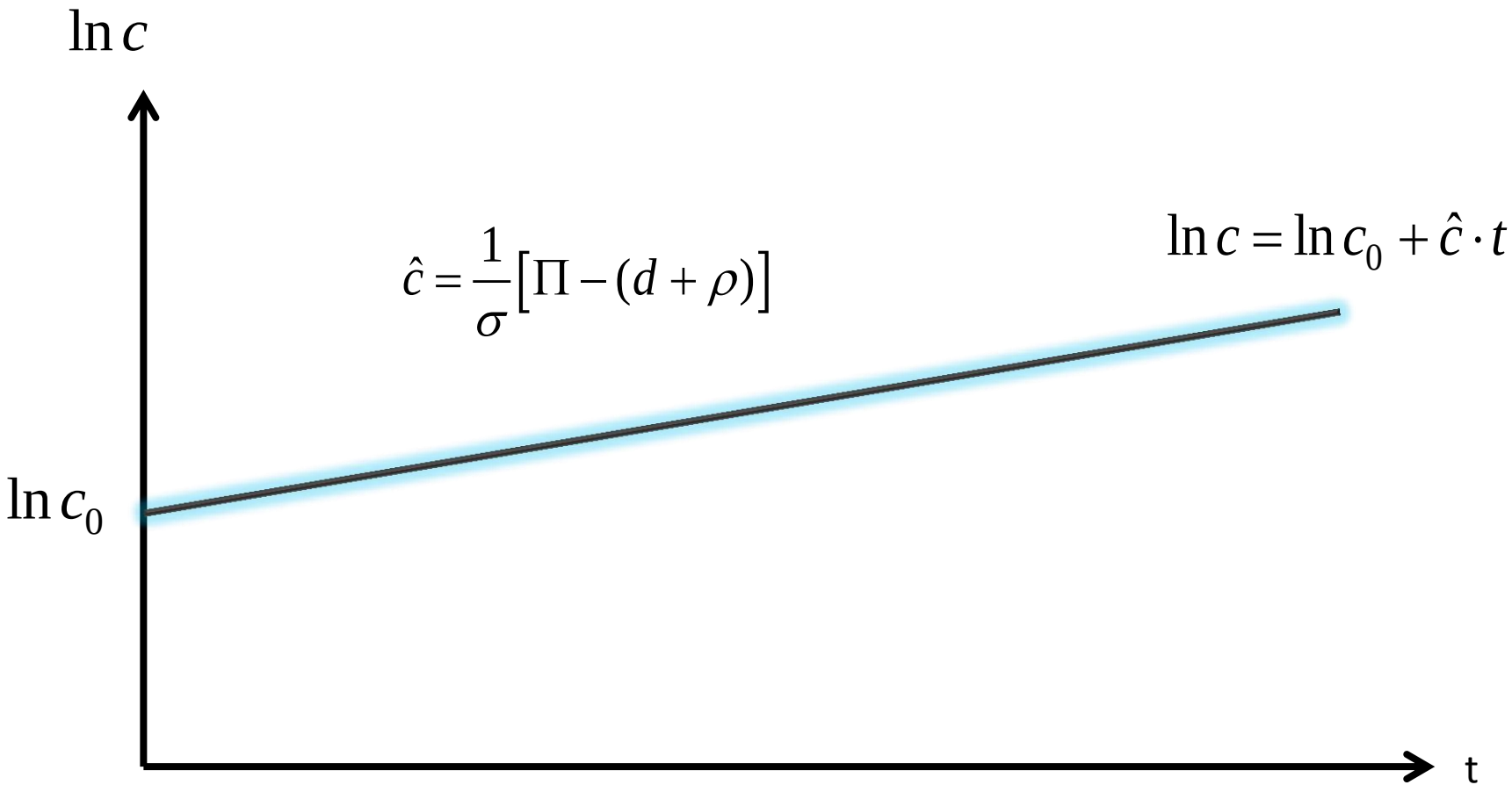
Achieving Sustainability

- Problem: too **low capital investments** due to
  - **Decreasing returns** to capital
  - Resource **depletion**
  - Increasing capital **depreciation**
- Solutions in **Capital Resource Models**
  - Assume **good input substitution**
  - Assume **technical progress**
  - Policy, e.g. enforce sufficient **savings** (Hartwick rule)
- Solutions with «New Macroeconomic» Approach
  - **Endogenous** capital formation, induced innovation, sectoral change
  - Include **risk and uncertainty, momentum** effects
  - Integrate sustainability topics (e.g. **population** etc.)
  - Appropriate policy mix

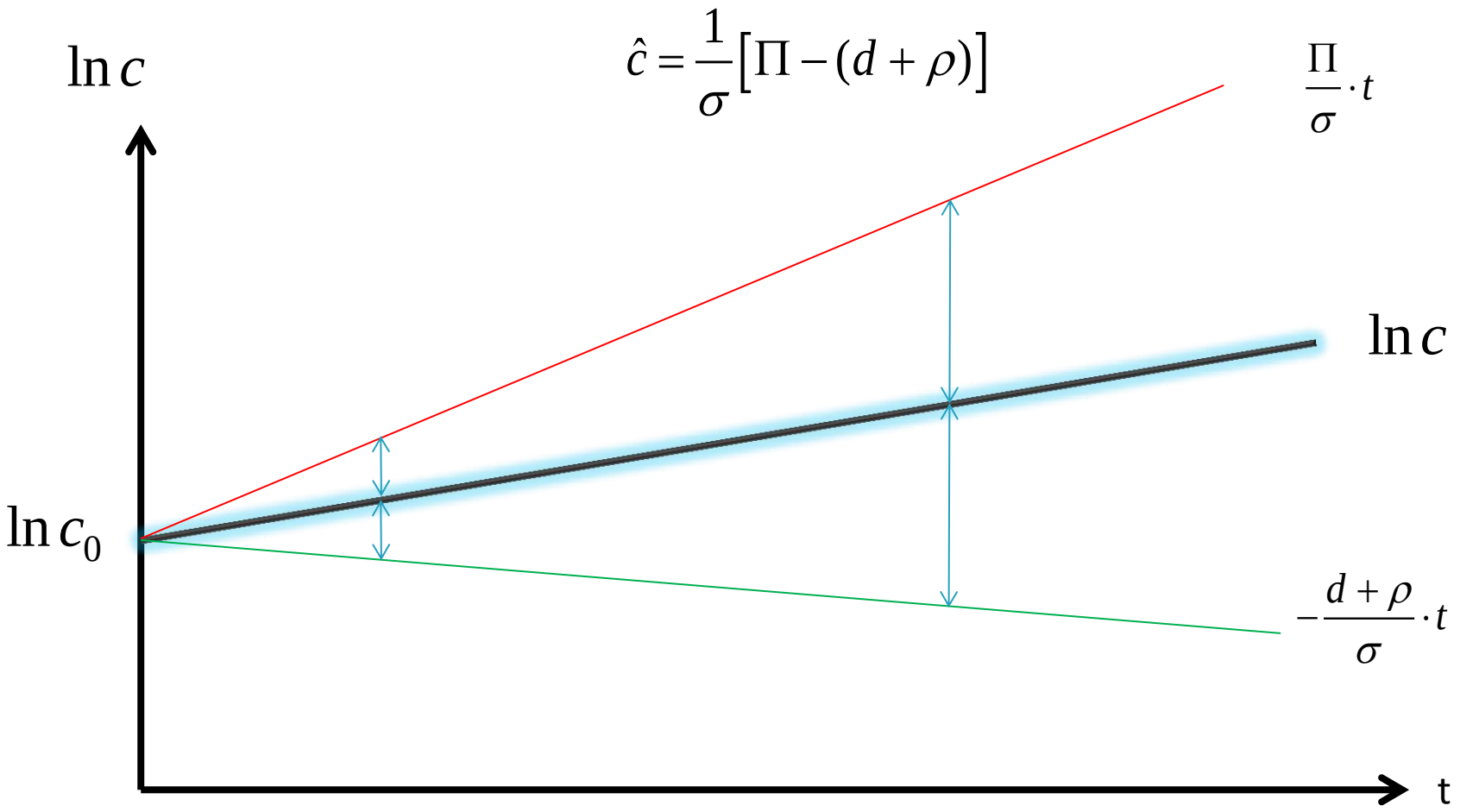
Applying Growth Theory

- Parameters
  - *Elasticity of intertemporal consumption substitution* $1/\sigma$
  - *Marginal return on (broad) capital* Π
  - *Depreciation rate* d
  - *Rate of impatience* ρ
- Keynes-Ramsey Rule
  - *Consumption growth* $\hat{C} = \frac{1}{\sigma}\left[\Pi - (d + \rho)\right]$
  - *Per capita consumption growth* $\hat{c}$
  - *Impact of population growth depends on model type → end of the talk*

Growth


$\ln c$
$\hat{c} = \frac{1}{\sigma}\left[\Pi - (d + \rho)\right]$
$\ln c = \ln c_0 + \hat{c} \cdot t$
$\ln c_0$
t

Growth Components



Growth Determinants

$$\hat{C} = \frac{1}{\sigma}\left[\Pi - (d + \rho)\right]$$

Important for development of income and welfare are:

- Preferences: Discount rate (ρ), curvature of utility function ($1/\sigma$)
- Marginal Return on Capital Π
- Capital depreciation *d*, affected by climate change
- Population growth, affects $\hat{c}$ via *d* and/or Π

Growth Determinants

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This talk

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Marginal Return on Capital Π

- Depends on
  - Marginal product: physical increase in output Γ
  - price of output p_Y and of capital p_K
  - Capital gains/losses Δp_K

$$\Pi = \frac{p_Y \Gamma + \Delta p_K}{p_K}$$

- One-sector models
  - $p_Y = p_K = \overline{p}_K = 1$
  - Π and Γ identical

Effects of Capital Prices

- **One-sector models**
  - ignore capital price levels
  - ignore capital price dynamics
- **Multisector models**
  - $p_Y \neq pK$,
  - $\%\Delta p_Y \neq \%\Delta p_K$,
  - Y_1, Y_2, Y_3 …. *with* p_{Y1}, p_{Y2}, p_{Y3} ..
- **Growth** effects: $p_K = p_K(K,..)$ through spillovers
- **Structural** effects: $\Delta(p_Y Y), \Delta(p_K K)$

Input Substitution

- Affects capital return with **increasing resource prices**
  - resource depletion
  - climate policy
- One-sector models
  - $\boldsymbol{\Pi}$ **is bounded from zero** when resource and other inputs are ***substitutes***
  - But: empirical evidence!
  - This is only the ***demand side*** effect

Dasgupta and Heal (1974)

Substitution Revisited

- Two-sector models (Consumer and capital goods)
  - Π is bounded from below when **inputs are complements** in consumer goods sector
  - Poor input substitution drives **inputs** out of the consumer goods into the **capital sector:** supply side effect
- Example:

$$Y = K^{\theta_K} R^{1-\theta_K} \quad \rightarrow \quad \Pi = \left[p_Y \theta_K \left(R / K \right)^{1-\theta_K} + \Delta p_K \right] / \, p_K$$

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Demand side effect

Decreasing

Supply side effect

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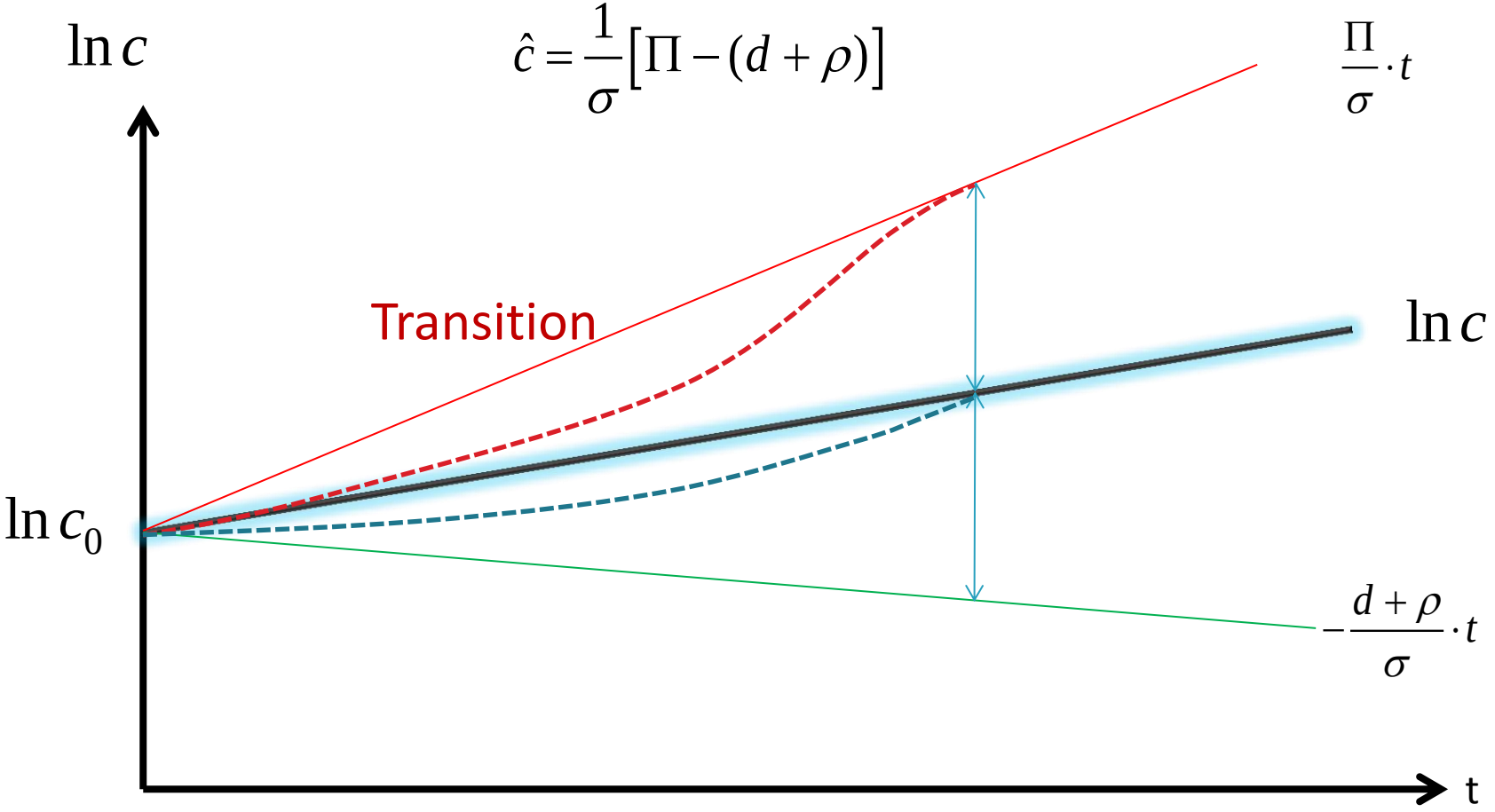
Decreasing

Supply side effect

- Multisector models
  - **Relative size** of sectoral substitution elasticities matters
  - Sustainability is feasible with poor input substitution

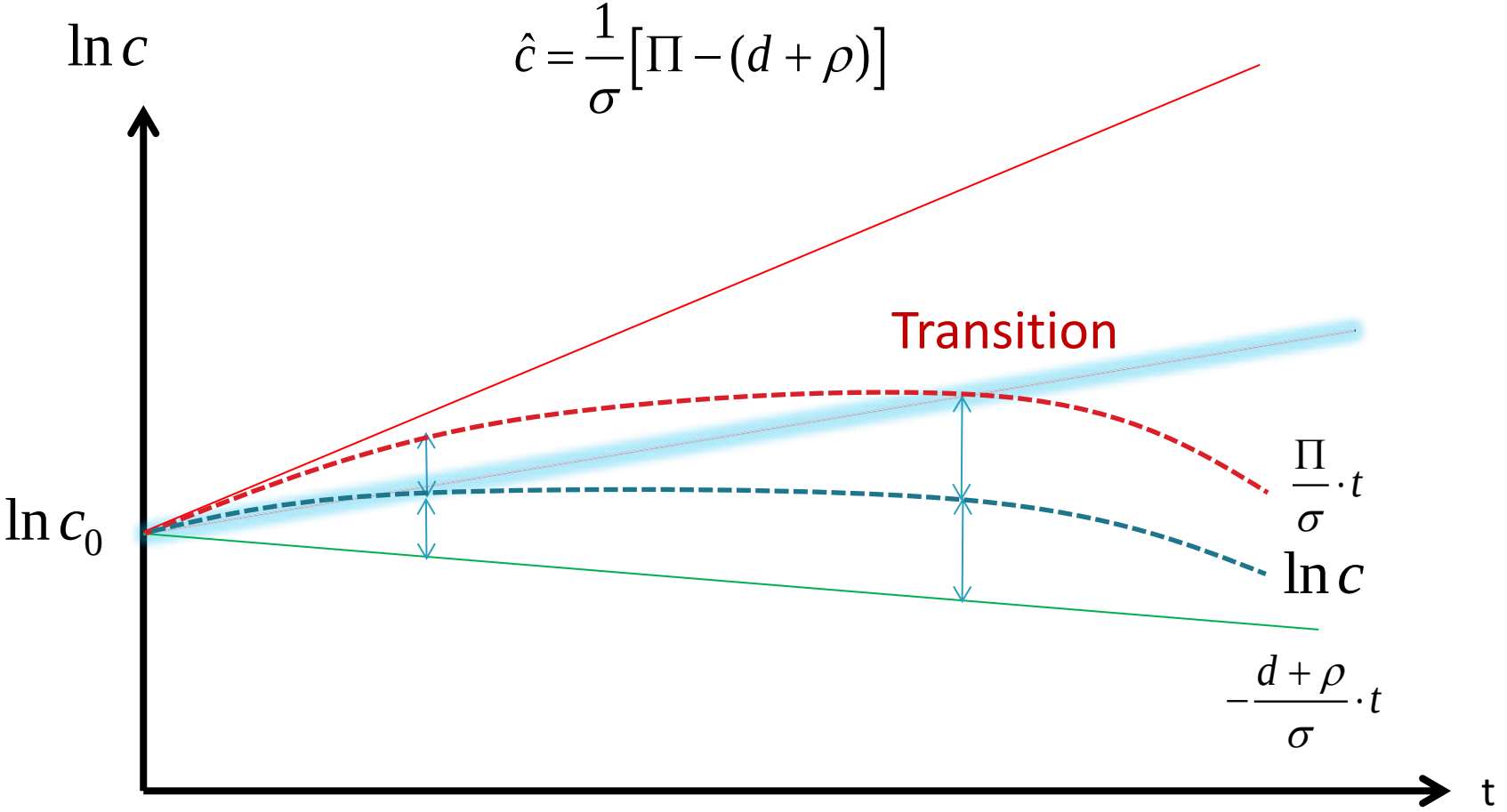
Bretschger (REE 2015), Bretschger and Smulders (JEDC 2012)

Multisector: «Good» Equilibrium



Bretschger and Smulders (JEDC 2012)

Multisector:«Bad» Equilibrium

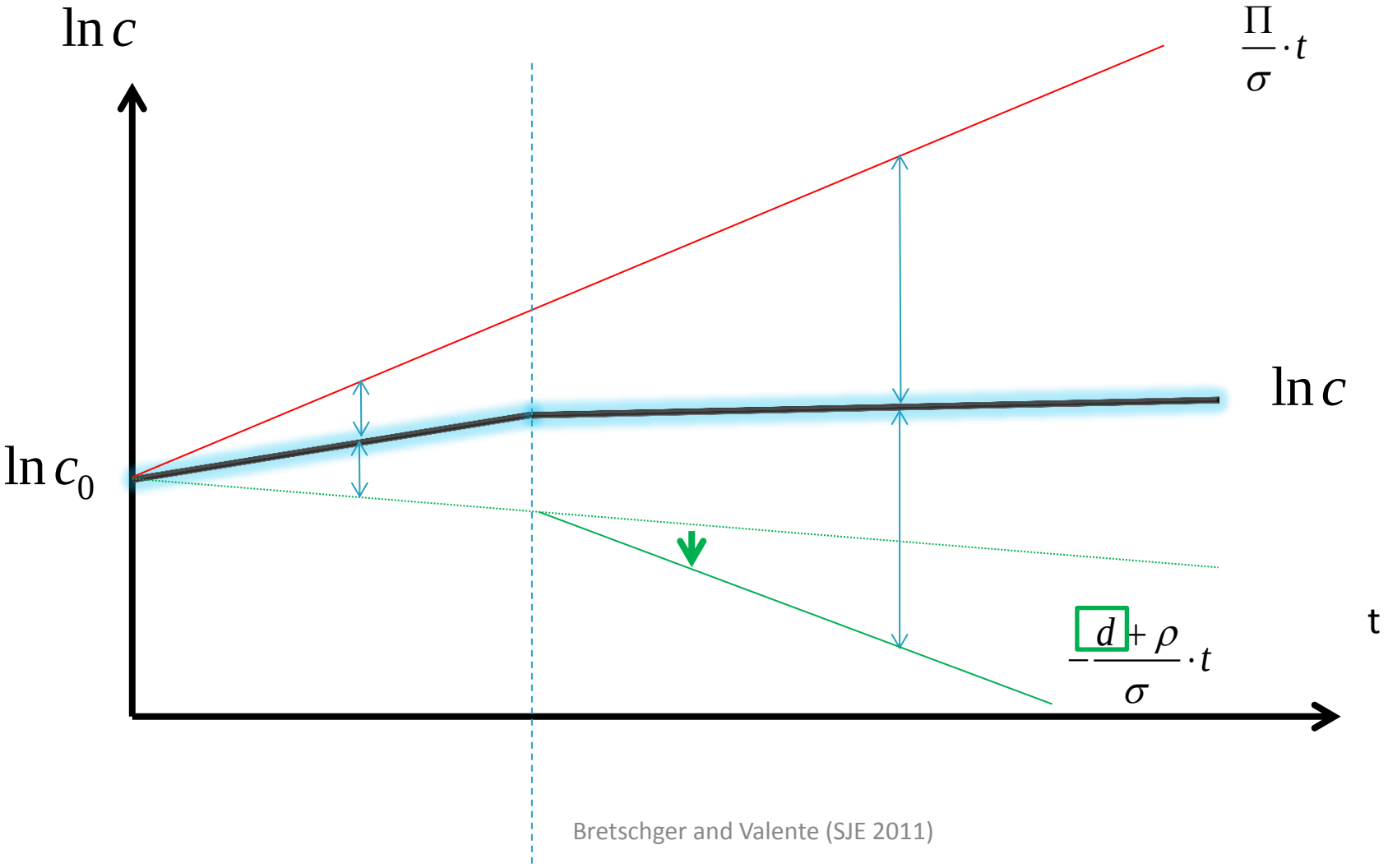


Bretschger and Smulders (JEDC 2012)

Climate Change

- **Stock pollution** in a **growing** economy
- Climate induced damages to **capital stock**

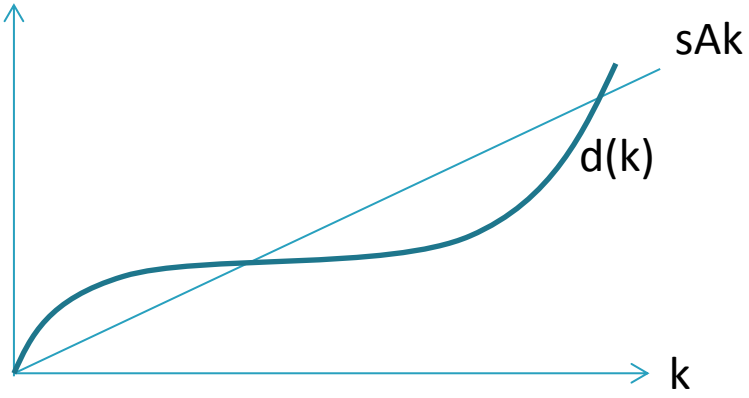
Climate change and growth



Bretschger and Valente (SJE 2011)

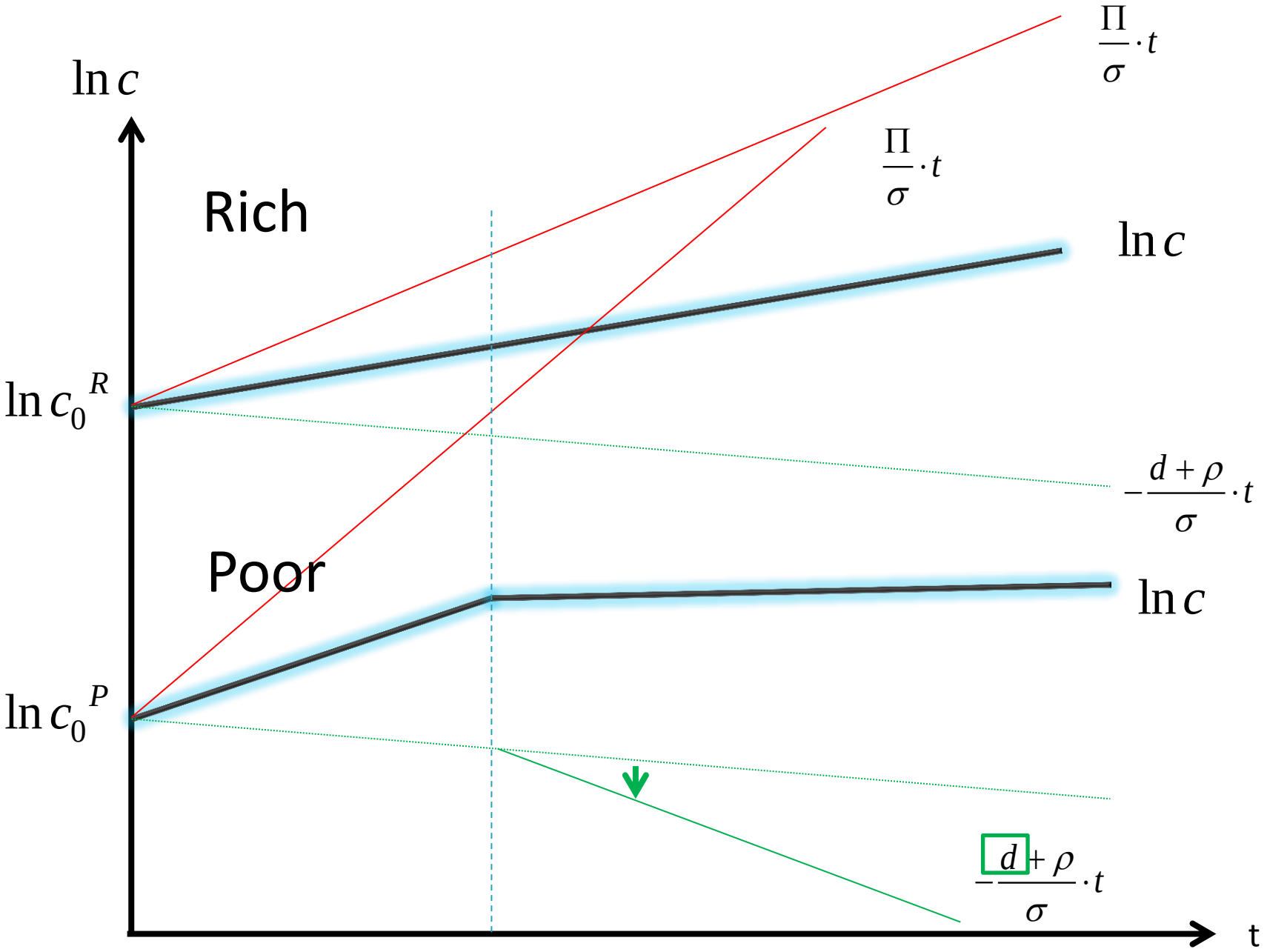
Climate Change: More Issues

- Emergence of new **poverty traps**



- **Lags** in emission (*E*) diffusion
  - Impact on optimal policy
- Delayed income **convergence**

Bretschger and Valente (SJE 2011), Gerlagh and Liski (2012), Bretschger and Karydas (ETH 2014)


$\ln c$
$\frac{\Pi}{\sigma} \cdot t$
$\frac{\Pi}{\sigma} \cdot t$
Rich
$\ln c$
$\ln c_0{}^R$
$-\frac{d+\rho}{\sigma} \cdot t$
Poor
$\ln c$
$\ln c_0{}^P$
$-\frac{d+\rho}{\sigma} \cdot t$
t

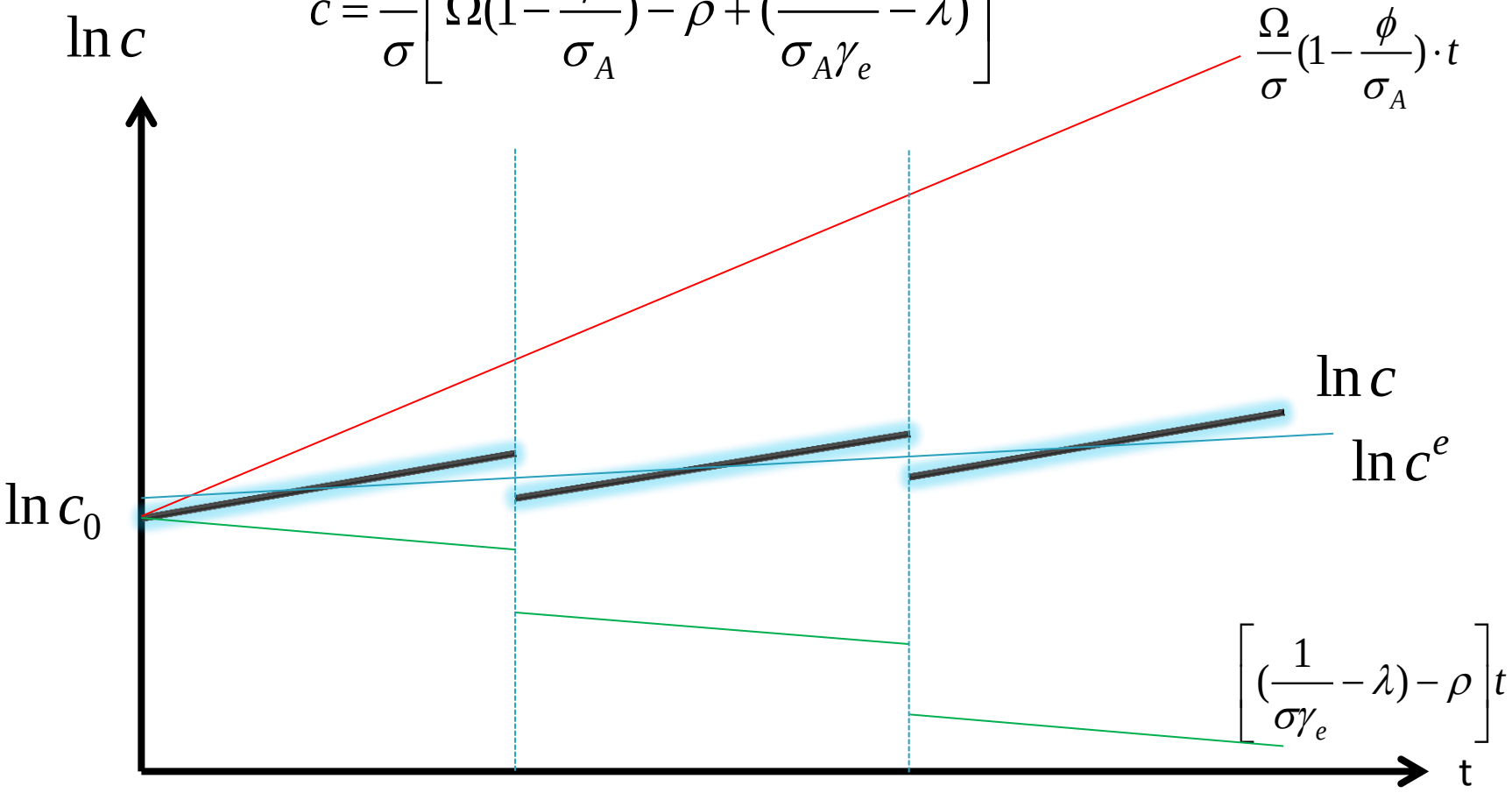
Uncertainty

- Central inherent problem with climate change
  - economy
  - ecological systems
  - policy making
- Uncertain **size, kind, arrival, and frequency** of climate disasters
- Recurring events and tipping points
- Need to derive **optimum growth** and **best policies** from first principles in **closed-form solutions**

Gollier (2012), Bretschger and Vinogradova (2014)

Climate Shocks and Growth

$$\hat{c} = \frac{1}{\sigma}\left[\Omega\left(1-\frac{\phi}{\sigma_A}\right)-\rho+\left(\frac{1}{\sigma_A\gamma_e}-\lambda\right)\right]$$



Bretschger and Vinogradova (2014)

Optimal Abatement Policy

- Theoretical result: with uncertainty, **more stringent** climate policies are warranted
- Optimal Abatement increases in
  - event **arrival rate**,
  - total **factor productivity**,
  - **polluting intensity** of output,
  - **damage intensity**.
- Model provides **closed-form solutions** and quantitative insights

Equity, a Major Concern

- Sustainability: **Avoid unequitable treatment** of different generations
- Climate policy
  - **without** climate policy, less developed and vulnerable countries will suffer disproportionately
  - **with** climate policies, polluting countries have to carry a substantial burden

Anand and Sen (WDev 2000), Posner and Weisbach (2010), Sterner (RFF 2011)

Equity, a Major Concern

- Sustainability: **Avoid unequitable treatment** of different generations
- Climate policy
  - **without** climate policy, less developed and vulnerable countries will suffer disproportionately
  - **with** climate policies, polluting countries have to carry a substantial burden
- World income distribution
  - "ethical universalism"
  - **priority** in politics and climate negotiations
  - carbon prices affect income distribution within countries → design (progressivity) of **overall tax system** decisive

Anand and Sen (WDev 2000), Posner and Weisbach (2010), Sterner (RFF 2011)

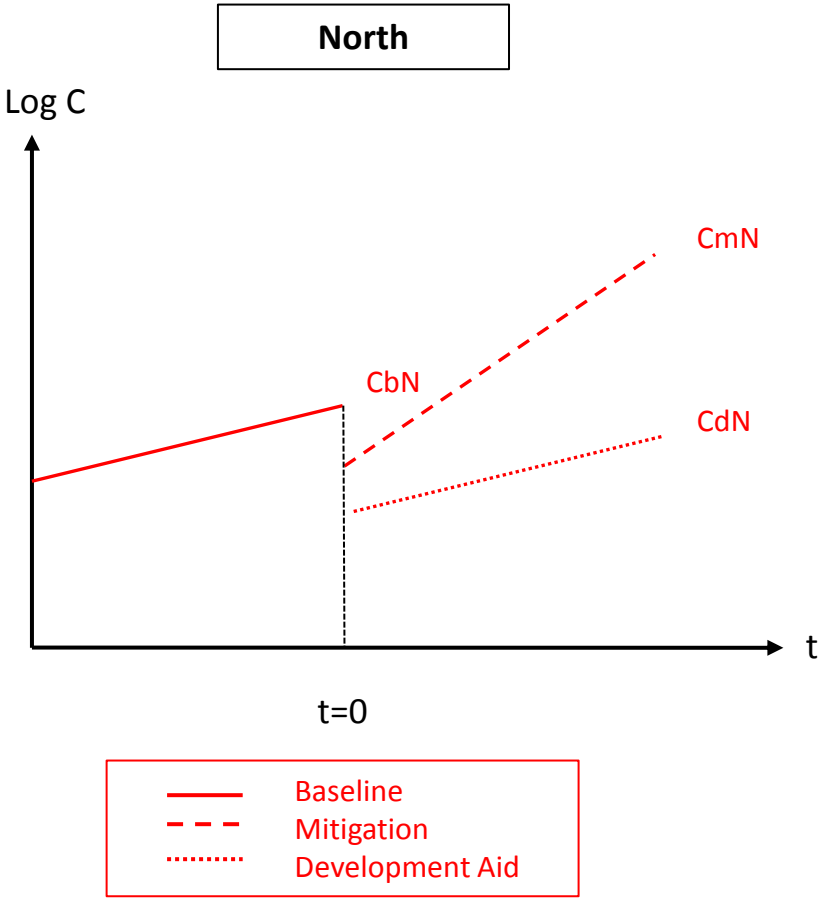
Mitigation and/or Financial Aid?

- Overall climate agreement, **no division** of the world
- **Right to development** for LDCs
  - Climate policy should not hamper development in LDCs
  - Foreign (technical) aid can support mitigation
- **Asymmetry**
  - South especially vulnerable to climate change
  - Climate policy costly for North
  - Foreign aid as substitute for climate policy?

  → Growth effects important!

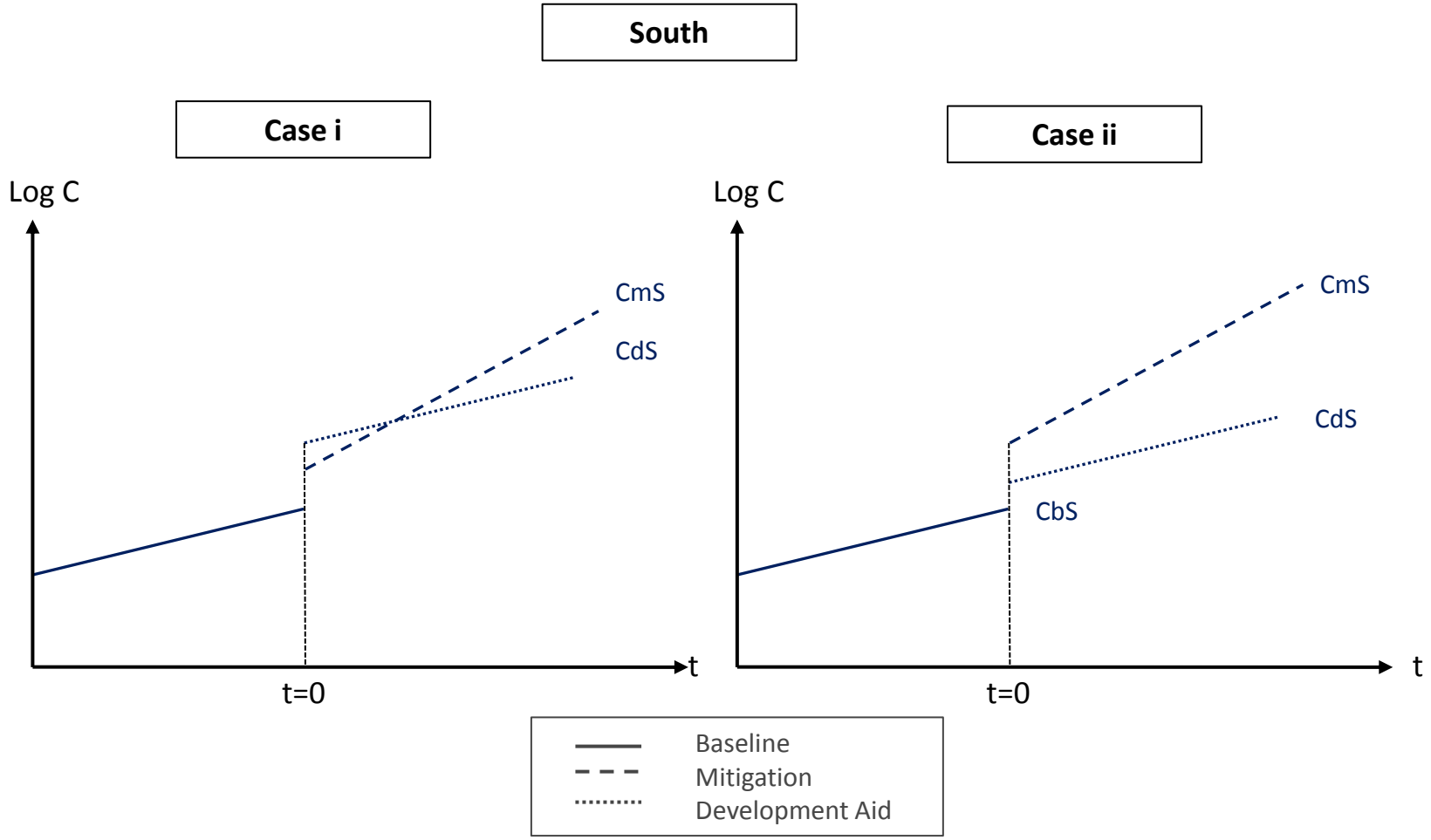
Bretschger and Vinogradova (IEEP 2015), Bretschger and Suphaphiphat (EER 2014)

Policy Comparison: North



Bretschger and Suphaphiphat (EER 2014)

Policy Comparison: South



Bretschger and Suphaphiphat (EER 2014)

World Carbon Budget

- Distribution according to:
  - **Equal** division of **carbon space**
  - **Uniform** world **carbon price**, domestic use of tax revenues (grandfathering)
  - **Equity-based allocation** of carbon budgets, synthetic approach
- Conditions
  - Responsibility period (time of "excusable ignorance“)
  - Foreign trade
  - Population growth

BASIC (2011), Weitzman (2013), Bretschger (EDE 2013)

Climate Agreement

- Finding consensus may **take time** we do not actually have
- But: Without time restrictions decisions are delayed
- “INDC Pledge and review” procedure: **What review**?

ETH Climate Calculator

- http://ccalc.ethz.ch/
- Calculates fair and equitable contributions
- Users of the tool can select according to their own evaluation:
  - the stringency of global climate policy (strict, medium, soft),
  - the number of countries you want to include in a binding agreement,
  - the importance of four major equity principles,
  - the degree of historic responsibility.
- The calculator provides carbon budget allocations for three different approaches:
  - budget based on equity principles
  - budget based on global carbon tax
  - budget based on equal per capita emissions.
- Budgets are compared to **INDCs**

ETH Climate Calculator

To obtain the carbon budget allocation for the different countries you are invited to make five general policy choices (see Introduction and Technical Explanation for details).

1. By choosing the size of the global carbon budget you assign a probability that the temperature increase will be below $2^{\circ}C$.
2. You either pick the number of countries or the amount of global emission that should be covered by an international climate agreement; the other number is given automatically.
3. You choose the importance of four different equity principles.
4. You determine the degree of responsibility for past emissions.
5. You determine on which basis the carbon tax is calculated.

Required

Total Budget

Scenario	Amount of CO_2 Emissions	Probability Temperature Increase < 2 °C	Choice
Strict	1,000 GT	75%	○
Medium	1,440 GT	50%	○
Soft	1,600 GT	25%	○

Number of countries (between 1 and 197)	
Percentage of worldwide emissions covered (between 0 and 100%, in %)	

Equity principles

Ability to pay (between 0 and 1)	
Cost sharing (between 0 and 1)	
Technical contribution (between 0 and 1)	
Technical development (between 0 and 1)	
Normalize to weights	
Responsibility factor (between 0 and 1)	

Carbon Tax

Price of : Gasoline ○ **Diesel** ○

Send

Setting the Frame

- **Institutions** are crucial for implementing good policies
- Personal **attitudes** are key drivers for making changes possible
- Concentration on the **right** policy issues is key

Institutions Matter, of Course

- "Nations fail because of bad institutions"

  And the world?

- Successful countries may be harmful and extractive on a global level
- Less developed countries use much fewer resources

Institutions Matter, of Course

- "Nations fail because of bad institutions"

  And the world?

- Successful countries may be harmful and extractive on a global level
- Less developed countries use much fewer resources
- "**Transvaluation of values**": "inclusive" institutions may be "extractive" with respect to nature
- We need **"super" inclusive** institutions that consider all kinds of investments

Acemoglu and Robinson (2012)

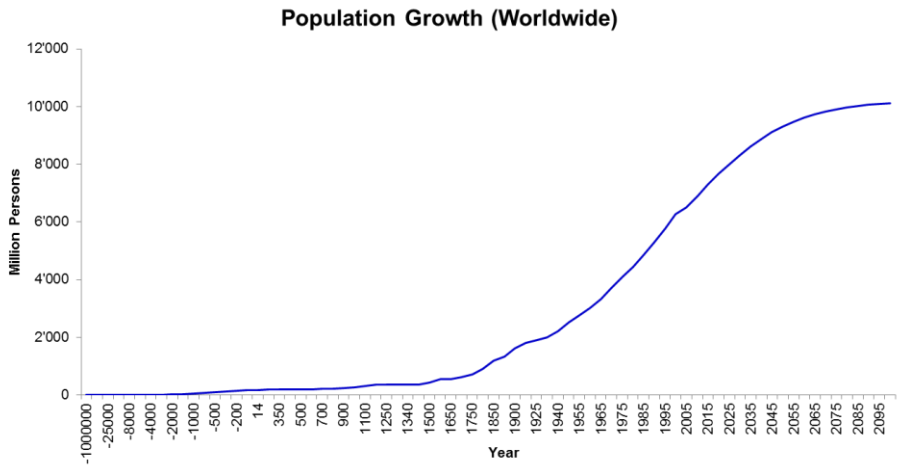
Sustainable lifestyle

- “Everybody talks of progress but nobody gets out of their routine”
  - Change everything without having to move?
  - Ambiguities and inconsistencies in political process
- Myth of national sovereignty

Sustainable lifestyle

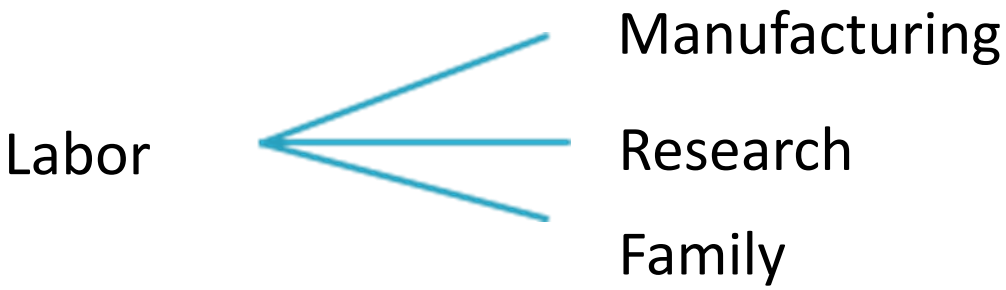
- "Everybody talks of progress but nobody gets out of their routine"
  - Change everything without having to move?
  - Ambiguities and inconsistencies in political process
- Myth of national sovereignty
- Habit persistence, imitation, status seeking
- **Nonlinearities: Speeding moments**
- Happiness is the ultimate purpose of human existence; it is the activity of the soul in accordance with virtue (Aristotle)

Population growth



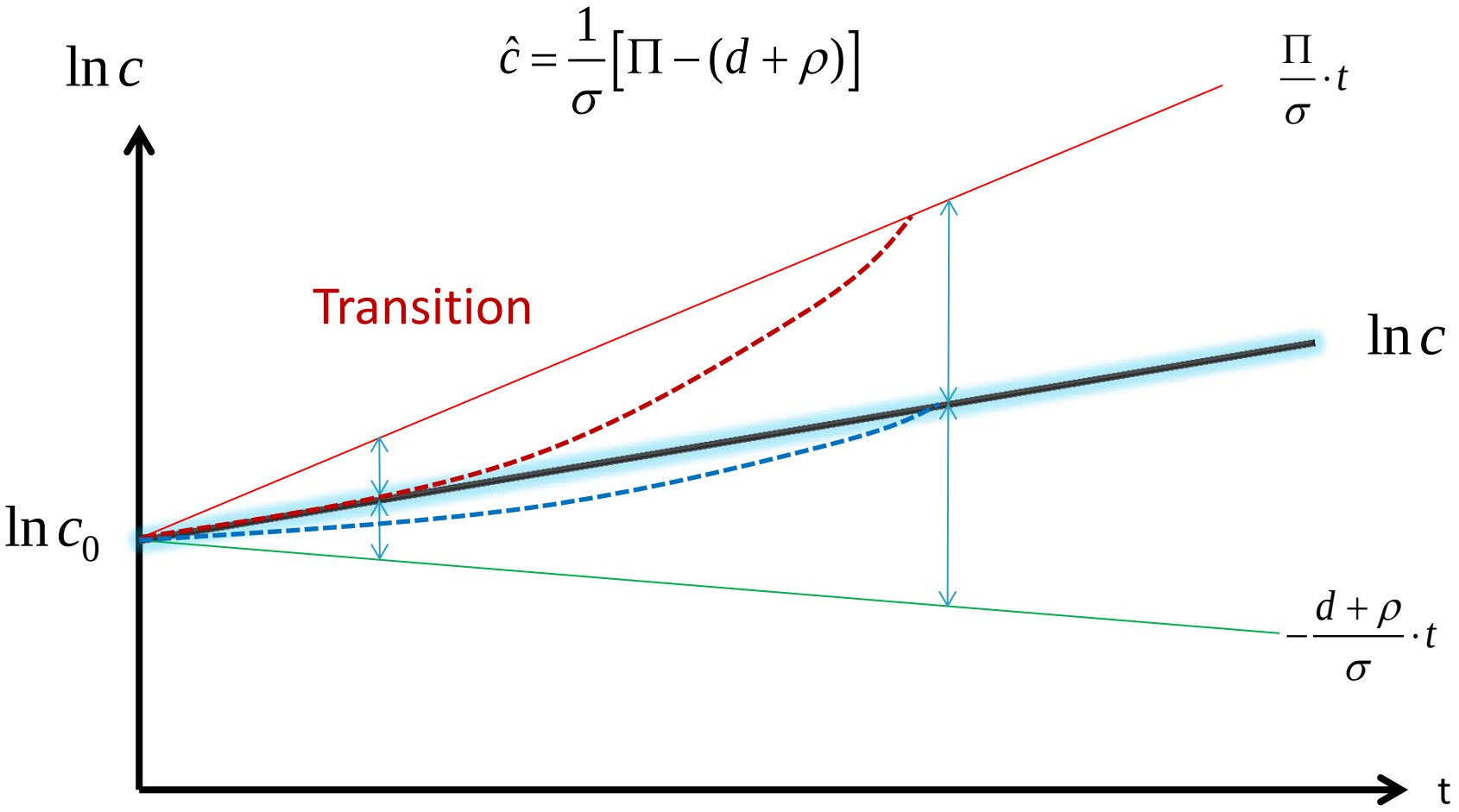
- Link to sustainability and climate debate
- Malthus: any population growth leads to “misery and vice” but “**Malthusian trap**” ceased to exist when invented
- Demographic **transition**, graying society
- Normative: Population Policy?

Population Growth Model



- Exhaustible resources, essential in research, poor input substitution, endogenous population growth
- Positive externalities of knowledge and child rearing
- Negative externalities of density

Population Model Solution



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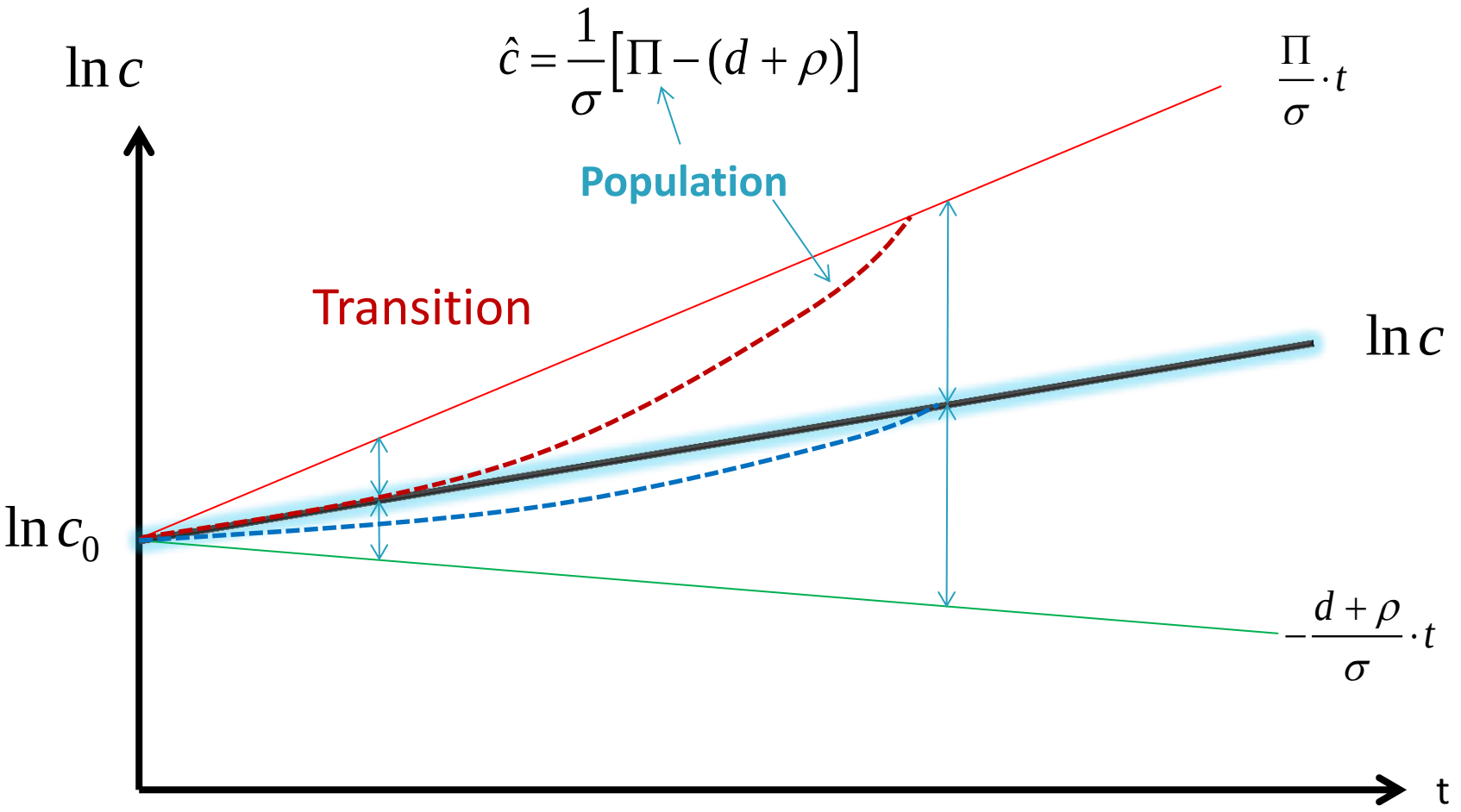
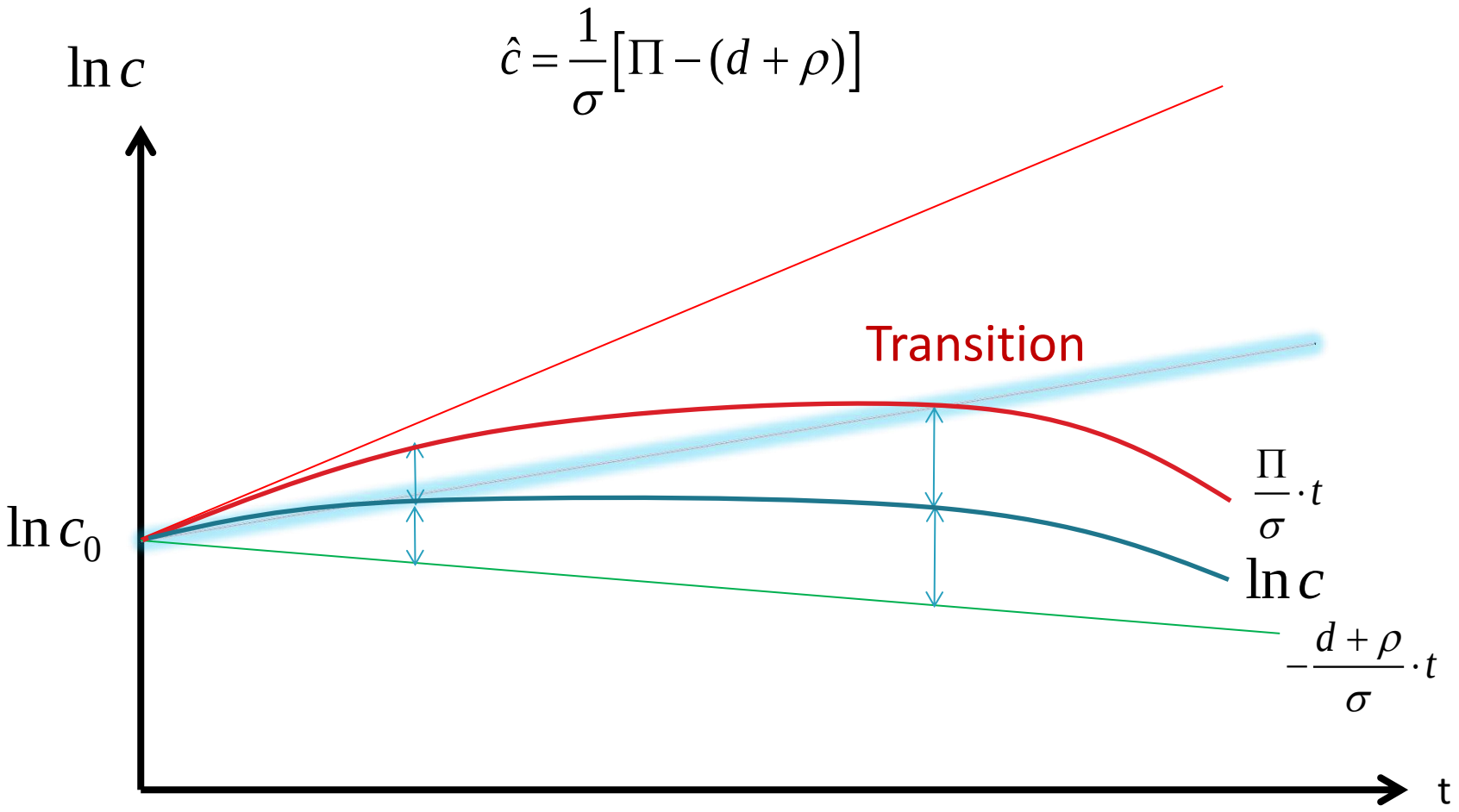


«Bad» equilibrium

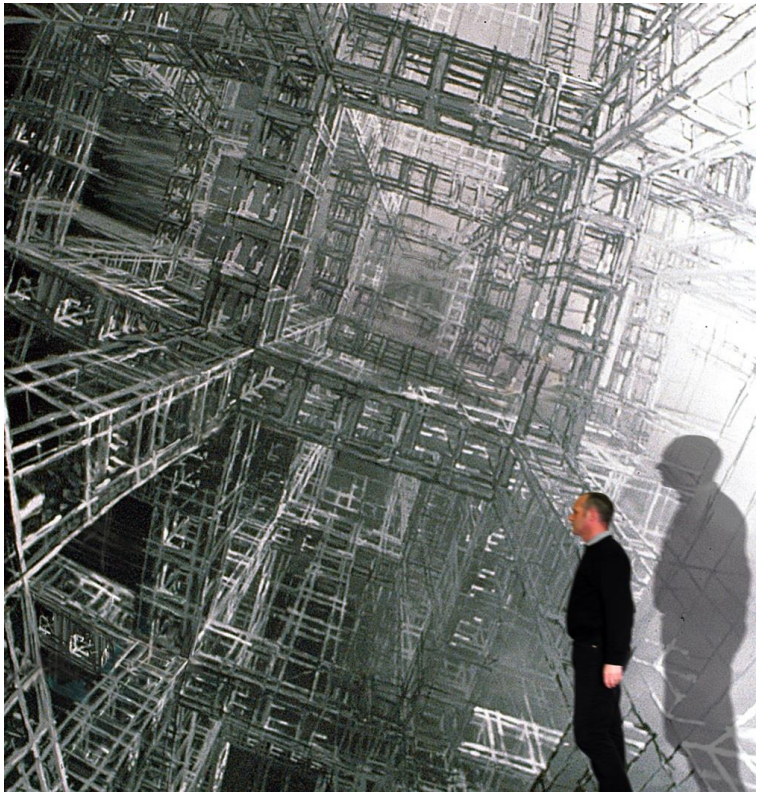


Population Growth Conclusions

- Model result: during transition to sustainability, **population growth is not detrimental** but may even be needed
- Labor is an essential **input to research**
- Hotelling rule enforces optimal depletion: Assumption on foresight
- Population **policy questionable** on regional and global scale

GREENING ECONOMY, GRAYING SOCIETY

LUCAS BRETSCHGER



CER-ETH PRESS

Book can be downloaded at
http://www.resec.ethz.ch/people/brlucas.html

Conclusions

- Efficient and equitable climate policies necessarily require that
  - **growth dividends** are properly included
  - environmental **benefits** are fully valued
  - international **burden sharing** is fair
  - **uncertainties** are considered in a rational manner
  - policy **focuses** on the climate issue now
- What will help:
  - **develop momentum**
  - **create role for expectations**

Thank you!

Consider going to EAERE 2016

European Association of Environmental and Resource Economists

EAERE
2016 | ZURICH

22nd Annual Conference
June 22nd - 25th | 2016