Potsdam Institute for
Climate Impact Research

Why finance ministers favor carbon taxes, even if they do not take climate change into account

Ottmar Edenhofer, Max Franks, Kai Lessmann

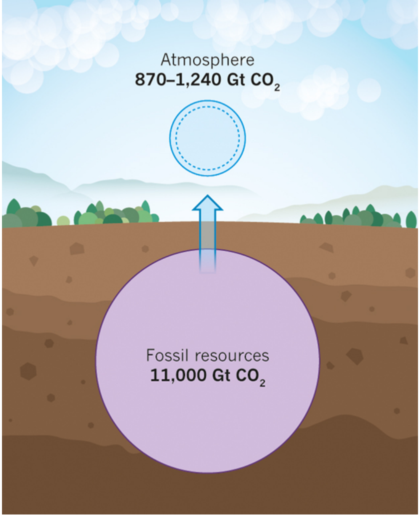
01.04.2015

MOTIVATION

MODEL SETUP

RESULTS

The climate problem at a glance

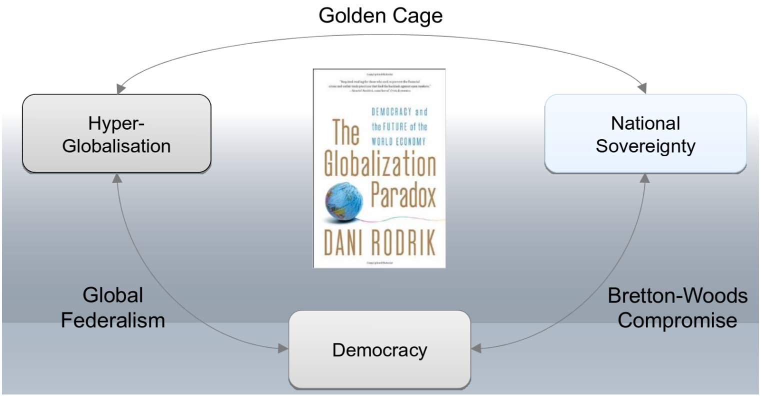


Resources and reserves to remain underground:

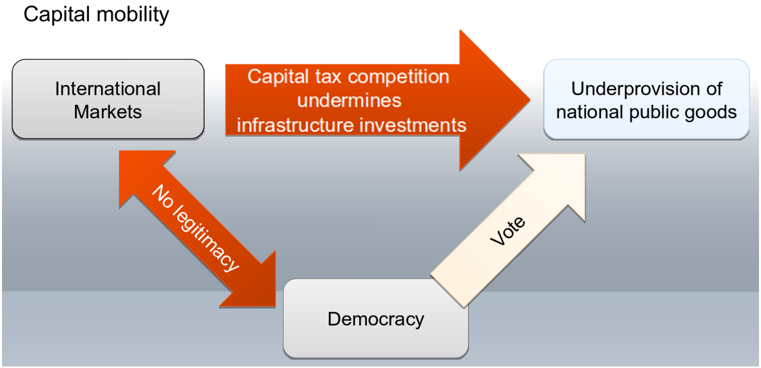
- 80 % coal
- 40 % gas
- 40 % oil

Source: Bauer et al. (2014), Jakob, Hilaire (2015)

The Globalisation Paradox: A Trilemma



The Globalisation Paradox: A Trilemma



The Globalisation Paradox: A Trilemma

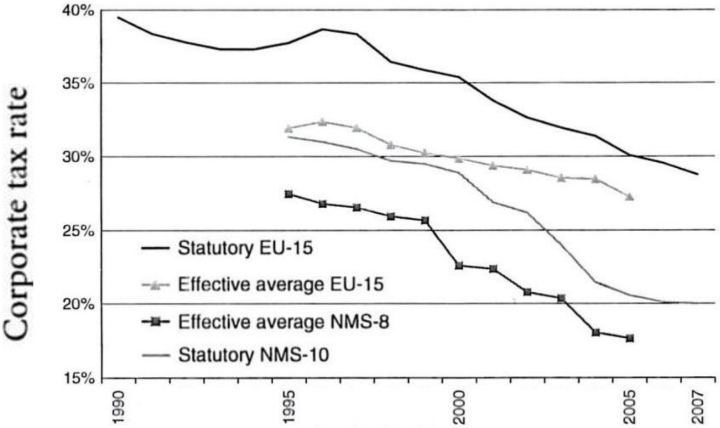
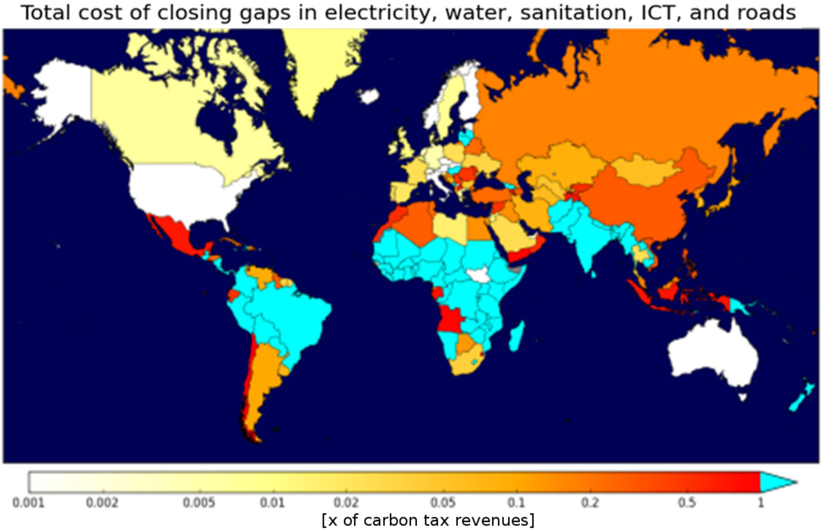


Figure 7.17 Taxing mobile and immobile tax bases in the EU.

Source: Benassy-Quere et al. (2010)

Carbon tax revenues for infrastructure investments



Source: Jakob et al. (2015)

Research questions

- Most economists agree on carbon pricing to address the climate externalty, many prefer taxes.

Research questions

- Most economists agree on carbon pricing to address the climate externalty, many prefer taxes.
- What is the role of a carbon tax under the assumption that no climate externality exists?

Research questions

- Most economists agree on carbon pricing to address the climate externalty, many prefer taxes.
- What is the role of a carbon tax under the assumption that no climate externality exists?
- Can carbon taxes finance infrastructure more efficiently than capital taxes when input factors are mobile?

Research questions

- Most economists agree on carbon pricing to address the climate externalty, many prefer taxes.
- What is the role of a carbon tax under the assumption that no climate externality exists?
- Can carbon taxes finance infrastructure more efficiently than capital taxes when input factors are mobile?
- What are the supply side dynamics when resource importing countries tax carbon?

Results

1. In Nash equilibrium, carbon tax more efficient than capital tax.

Results

1. In Nash equilibrium, carbon tax more efficient than capital tax.
    - Both taxes subject to race to the bottom.

Results

1. In Nash equilibrium, carbon tax more efficient than capital tax.
   - Both taxes subject to race to the bottom.
   - Carbon tax captures part of the Hotelling rent.

Results

1. In Nash equilibrium, carbon tax more efficient than capital tax.
   - Both taxes subject to race to the bottom.
   - Carbon tax captures part of the Hotelling rent.
2. No green paradox:

Results

1. In Nash equilibrium, carbon tax more efficient than capital tax.
   - Both taxes subject to race to the bottom.
   - Carbon tax captures part of the Hotelling rent.
2. No green paradox:
   - Demand side fully determines extraction.

Results

1. In Nash equilibrium, carbon tax more efficient than capital tax.
   - Both taxes subject to race to the bottom.
   - Carbon tax captures part of the Hotelling rent.
2. No green paradox:
   - Demand side fully determines extraction.
   - Carbon taxes postpone extraction,

Results

1. In Nash equilibrium, carbon tax more efficient than capital tax.
   - Both taxes subject to race to the bottom.
   - Carbon tax captures part of the Hotelling rent.
2. No green paradox:
   - Demand side fully determines extraction.
   - Carbon taxes postpone extraction,
   - and reduce cumulative emissions.

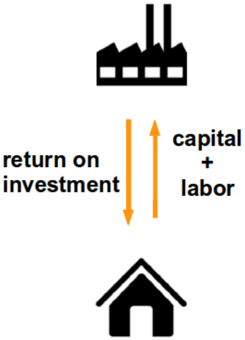
Results

1. In Nash equilibrium, carbon tax more efficient than capital tax.
   - Both taxes subject to race to the bottom.
   - Carbon tax captures part of the Hotelling rent.
2. No green paradox:
   - Demand side fully determines extraction.
   - Carbon taxes postpone extraction,
   - and reduce cumulative emissions.
3. Both results are robust under different strategic settings: (Non-)cooperative importers, (non-)strategic exporter.

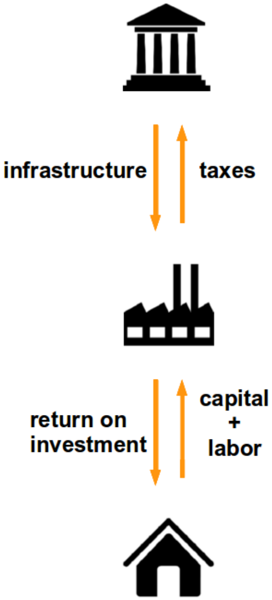
MOTIVATION

MODEL SETUP

RESULTS



return on
investment
capital
+
labor


infrastructure
taxes
return on
investment
capital
+
labor

Household:

$$\max_{C/L} W = \sum_{t=0}^{T} \frac{U(C_t/L_t)}{(1+\rho)^t},$$

$$C_t(1+\tau_{C,t}) = w_t L_t + r_t K_t - I_t + \Pi_t^F + Tax_t^{transfer}$$

Firm:

$$\max_{K,R,L} \Pi^F = F(K,G,R,L) - r(1+\tau_K)K - (p+\tau_R)R - w(1+\tau_L)L$$

Household:

$$\max_{C/L} W = \sum_{t=0}^{T} \frac{U(C_t/L_t)}{(1+\rho)^t},$$

$$C_t(1+\tau_{C,t}) = w_t L_t + r_t K_t - I_t + \Pi_t^F + Tax_t^{transfer}$$

Firm:

$$\max_{K,R,L} \Pi^F = F(K,G,R,L) - r(1+\tau_K)K - (p+\tau_R)R - w(1+\tau_L)L$$

$$\Longrightarrow F_K = r(1+\tau_K), \quad F_R = p+\tau_R, \quad F_L = w(1+\tau_L)$$

Household:

$$\max_{C/L} W = \sum_{t=0}^{T} \frac{U(C_t/L_t)}{(1+\rho)^t},$$

$$C_t(1+\tau_{C,t}) = w_t L_t + r_t K_t - I_t + \Pi_t^F + Tax_t^{transfer}$$

Government:

$$\max_{\tau_\zeta} W = \sum_{t=0}^{T} L_t \frac{U(C/L)}{(1+\rho)^t}, \quad \zeta \in \{K, R, C, L\}$$

$$I^G + Tax^{transfer} = r\tau_K K + \tau_R R + \tau_C C + w\tau_L L$$

$$G_{t+1} = G_t(1-\delta) + I_t^G$$

Firm:

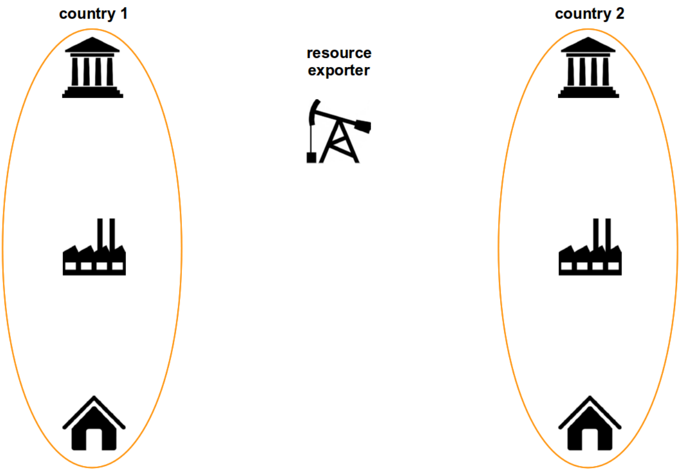
$$\max_{K,R,L} \Pi^F = F(K,G,R,L) - r(1+\tau_K)K - (p+\tau_R)R - w(1+\tau_L)L$$

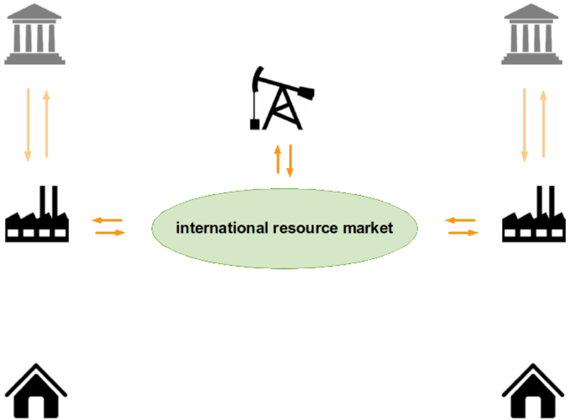
$$\Longrightarrow F_K = r(1+\tau_K), \quad F_R = p + \tau_R, \quad F_L = w(1+\tau_L)$$

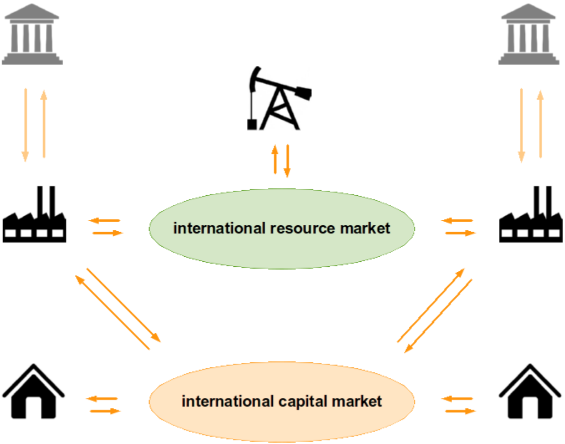
Household:

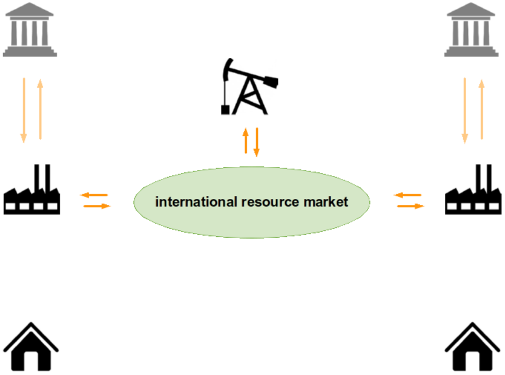
$$\max_{C/L} W = \sum_{t=0}^{T} \frac{U(C_t/L_t)}{(1+\rho)^t},$$

$$C_t(1+\tau_{C,t}) = w_t L_t + r_t K_t - I_t + \Pi_t^F + Tax_t^{transfer}$$


country 1
resource exporter
country 2


international resource market


international resource market
international capital market



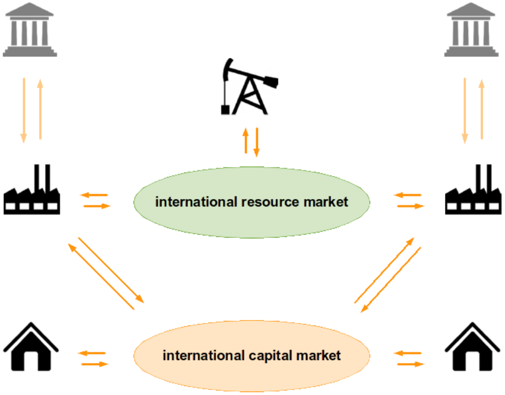
Resource exporter:

$$\max_{R_t} \sum_{t=0}^{T} \frac{p_t R_t - c_t}{\prod_{s=0}^{t}(1+r_s)}$$

Resource market:

$$R^{supply} = \sum_j R_j^{demand}$$

$$p = p_j \;\; \forall j$$



Resource exporter:

$$\max_{R_t} \sum_{t=0}^{T} \frac{p_t R_t - c_t}{\prod_{s=0}^{t}(1+r_s)}$$

Resource market:

$$R^{supply} = \sum_j R_j^{demand}$$

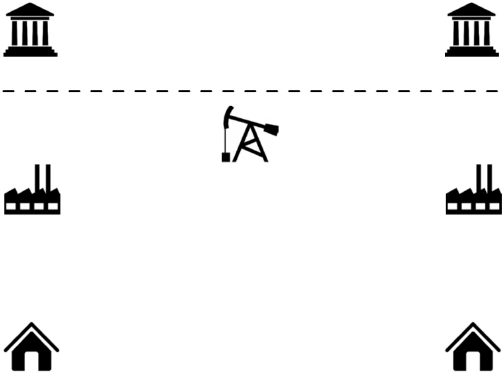
$$p = p_j \ \ \forall j$$

Capital market:

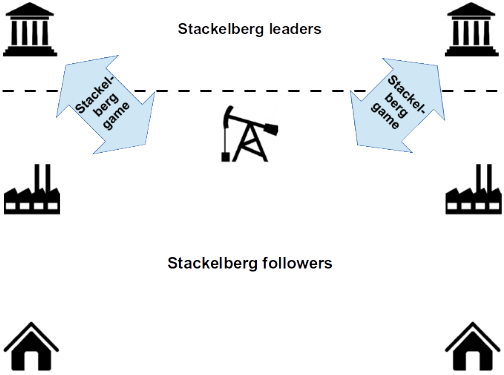
$$\sum_j K_j^{supply} = \sum_j K_j^{demand}$$

$$r = r_j \ \ \forall j$$

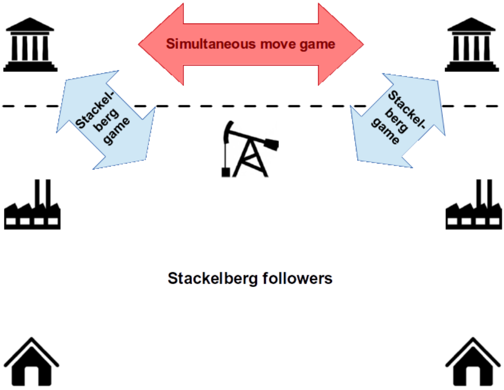
Nash equilibrium, two sub-games,



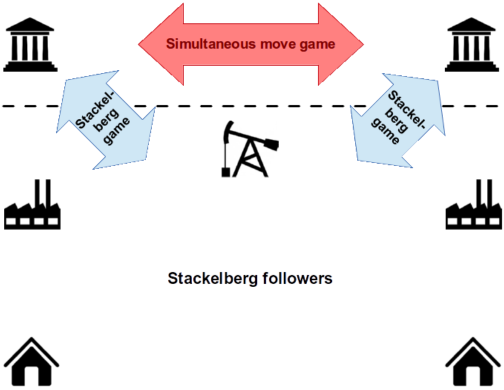
Nash equilibrium, two sub-games,



Nash equilibrium, two sub-games,



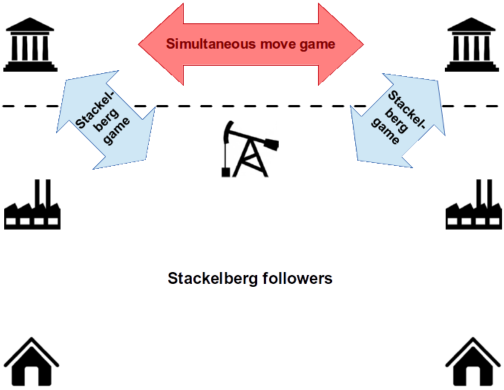
Nash equilibrium, two sub-games,



Nash equilibrium, two sub-games, solved for

non-cooperative behavior **or**

$$\max_{\tau_K^i,\tau_R^i} W_i, \text{ given } \tau_K^j, \tau_R^j, \;\; i \neq j$$



Nash equilibrium, two sub-games, solved for

non-cooperative behavior **or** **cooperative behavior of governments**

$$\max_{\tau_K^i,\tau_R^i} W_i, \text{ given } \tau_K^j, \tau_R^j, \quad i \neq j$$

$$\max_{\{\tau_K^i,\tau_R^i\}_{i=1,2}} \quad W_1 + W_2$$

MOTIVATION

MODEL SETUP

RESULTS

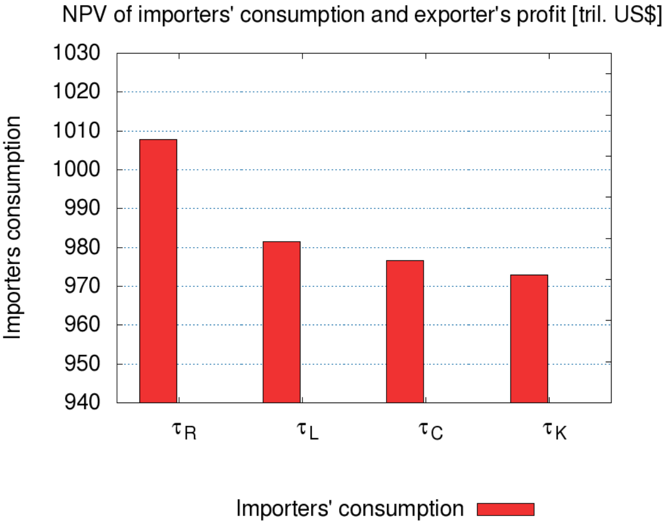
MOTIVATION

MODEL SETUP

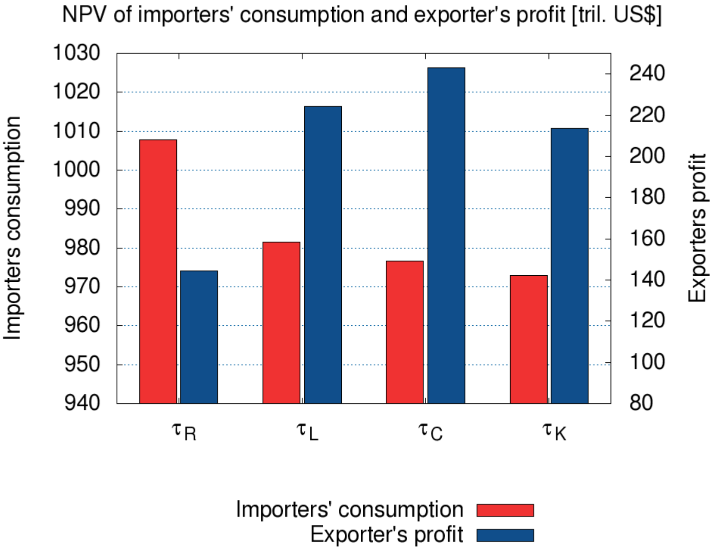
RESULTS

- Numerical solution due to high complexity (dual game structure, intertemporal optimization, two international markets, etc.)
- Calibration: Two symmetric countries to avoid that results are driven by asymmetries.
- Flexibility of modelling framework also allows for calibration to setups with specific regions (e.g. USA, EU, Australia, and OPEC).

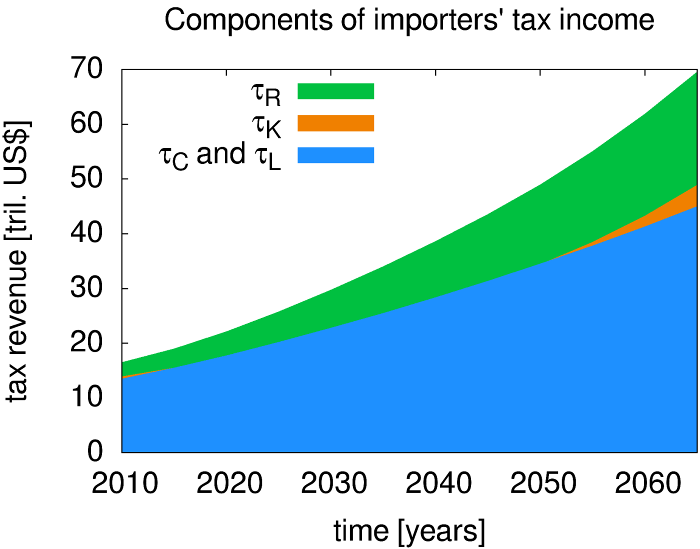
Single instrument portfolio



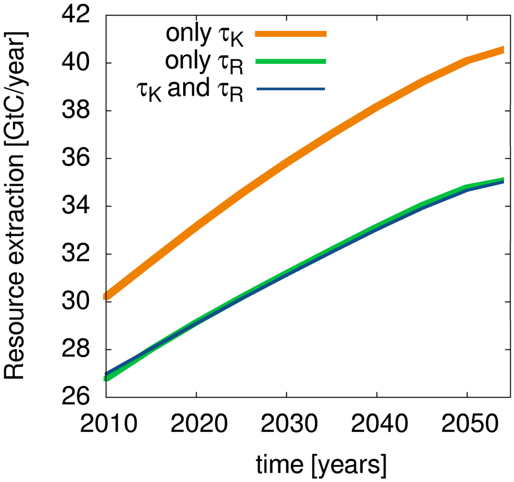
Single instrument portfolio



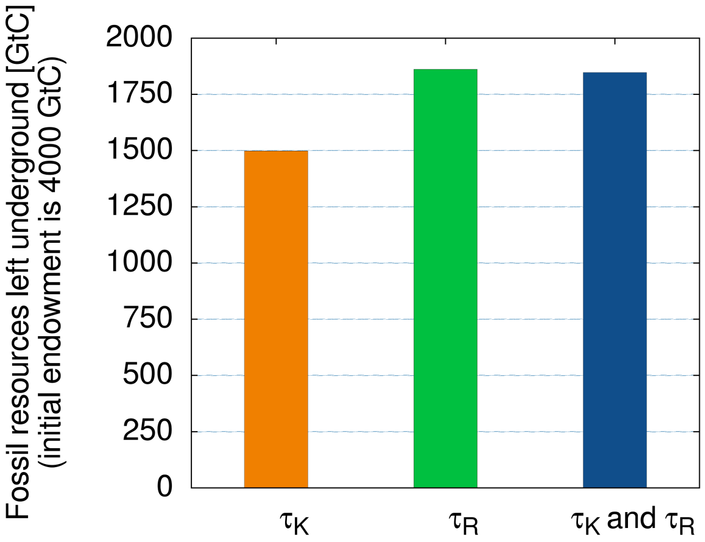
Mixed portfolio



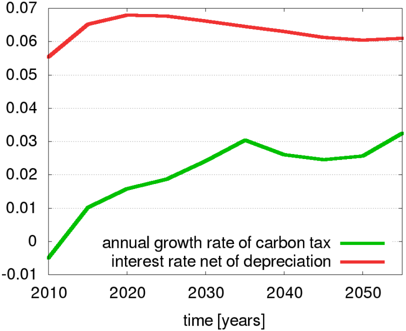
Timing and volume effects



Timing and volume effects

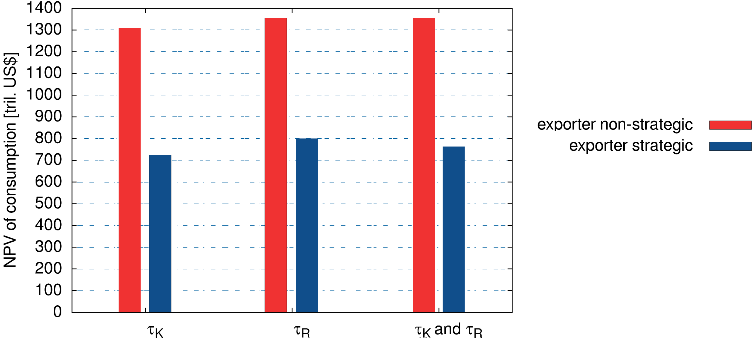


No green paradox: Demand for infrastructure fully determines supply side dynamics



The optimal financing of infrastructure with a carbon tax from an importing government's perspective implies $\frac{\tau_{R,t+1}-\tau_{R,t}}{\tau_{R,t}} < r_t - \delta$. Thus, extraction is postponed (see, e.g., Edenhofer and Kalkuhl, 2011).

Assumptions about strategic behavior of exporter



- Portfolios, which include the carbon tax τ_R yield higher NPV of consumption in importing countries.
- This finding is independent of whether the exporter may interact strategically or not.

Summary of results

1. Carbon tax more efficient than capital tax.

Summary of results

1. Carbon tax more efficient than capital tax.
   - asymmetry between capital and carbon as tax base,

Summary of results

1. Carbon tax more efficient than capital tax.
   - asymmetry between capital and carbon as tax base,
   - only the resource stock gives rise to rent.

Summary of results

1. Carbon tax more efficient than capital tax.
    - asymmetry between capital and carbon as tax base,
    - only the resource stock gives rise to rent.
2. Carbon tax delays extraction, reduces cumulative emissions. Timing of infrastructure demand fully determines supply side dynamics.

Summary of results

1. Carbon tax more efficient than capital tax.
   - asymmetry between capital and carbon as tax base,
   - only the resource stock gives rise to rent.
2. Carbon tax delays extraction, reduces cumulative emissions. Timing of infrastructure demand fully determines supply side dynamics.
3. Results are robust under different sorts of strategic behavior: Cooperating importers, strategic exporter.

Policy conclusions

- Carbon pricing can help to mitigate the race to the bottom.

Policy conclusions

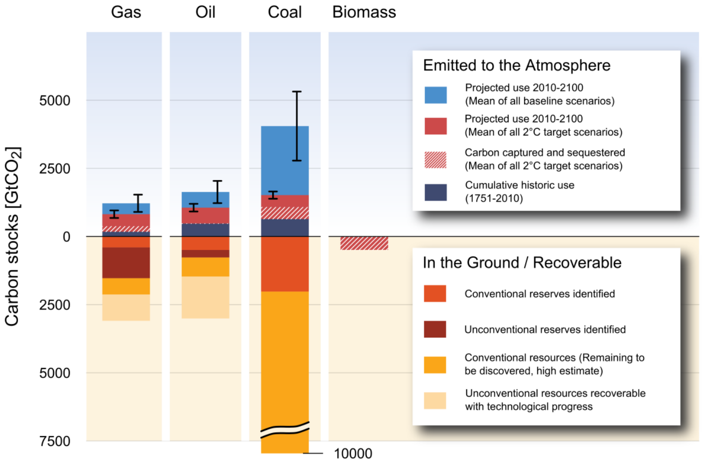
- Carbon pricing can help to mitigate the race to the bottom.
- The supply side dynamics of carbon pricing matter, but pose no environmental problem.

Policy conclusions

- Carbon pricing can help to mitigate the race to the bottom.
- The supply side dynamics of carbon pricing matter, but pose no environmental problem.
- Rethink role of environmental policy:
  Not only environmental ministers should favor carbon pricing, but also finance ministers.

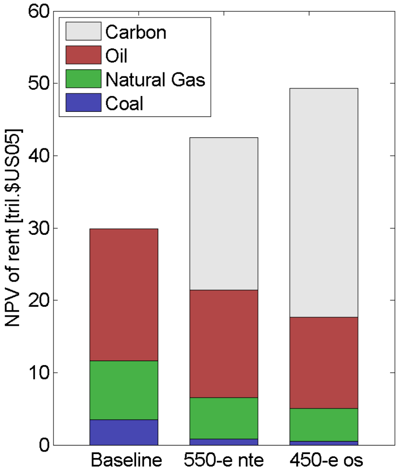
Backup slides

There is far more carbon in the ground than emitted in any basline scenario



Source: Edenhofer, Hilaire, Bauer

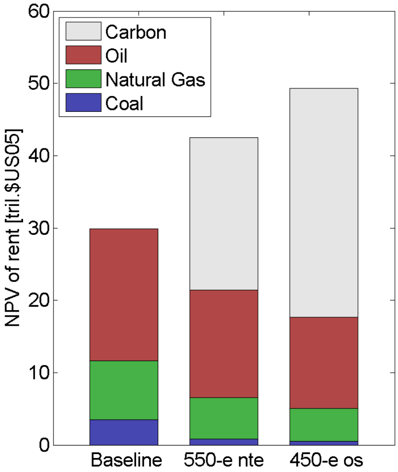
The scarcity rent of CO_2 emissions



- Fossil fuel rents decrease with the ambition of climate policy.

Source: Bauer et al. (2013)

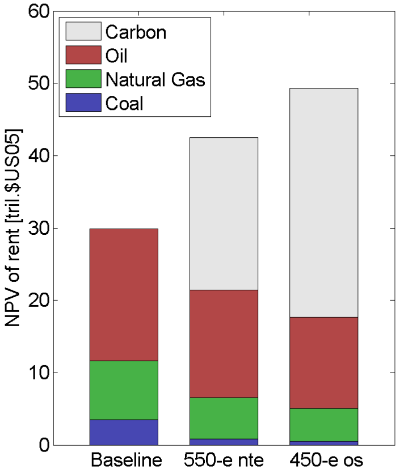
The scarcity rent of CO_2 emissions



- Fossil fuel rents decrease with the ambition of climate policy.
- If the optimal CO_2 price is implemented globally, this loss is **overcompensated** by the carbon rent.

Source: Bauer et al. (2013)

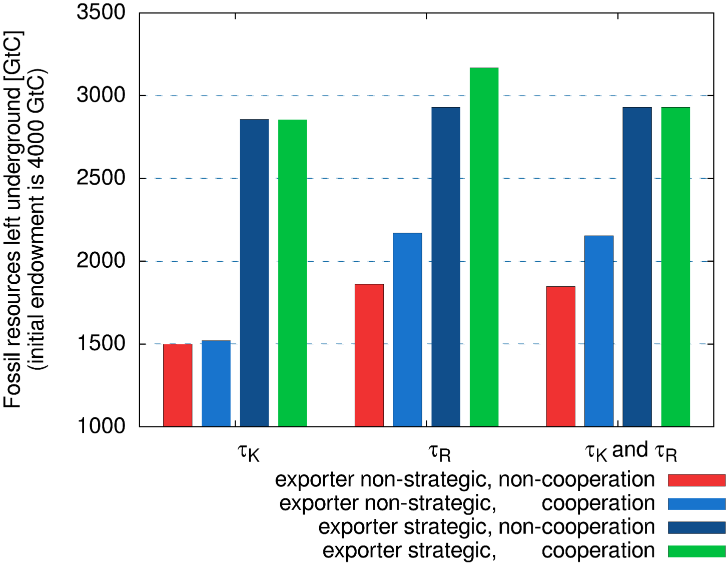
The scarcity rent of CO_2 emissions



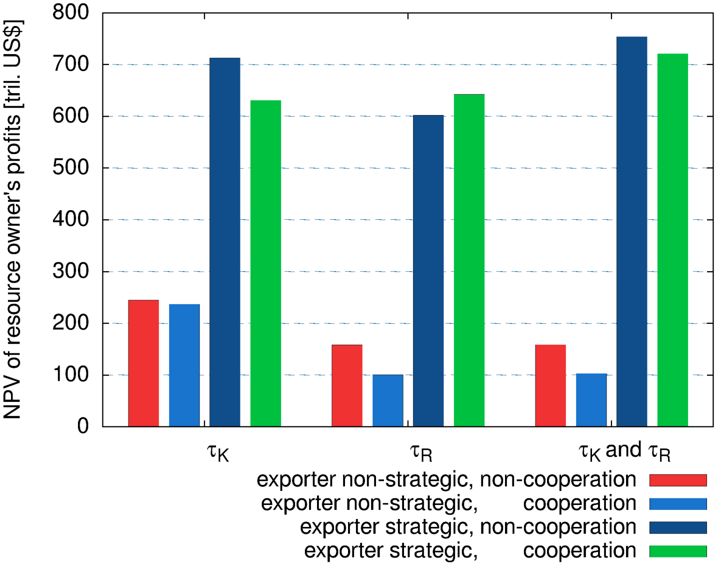
- Fossil fuel rents decrease with the ambition of climate policy.
- If the optimal CO_2 price is implemented globally, this loss is **overcompensated** by the carbon rent.
- The **revenues** of the carbon tax or auctioning of emission permits can be used to finance **tax reductions, infrastructure investments**, or **debt reduction**.

Source: Bauer et al. (2013)

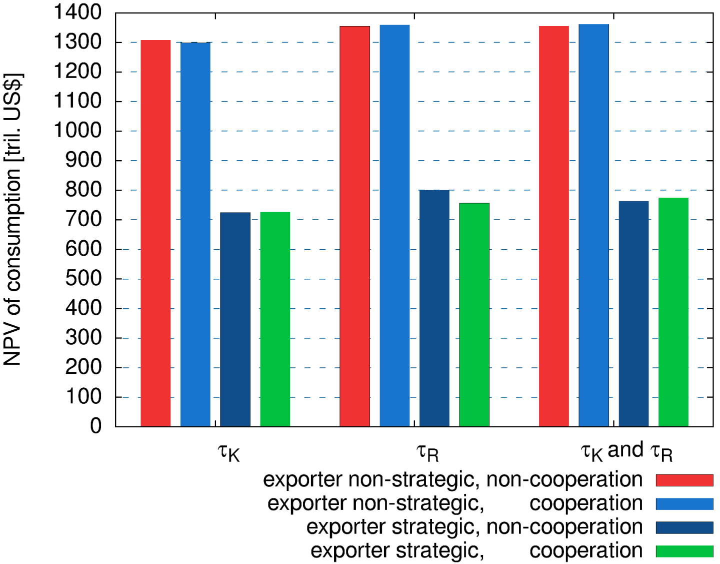
Volume effects under behavioral assumptions



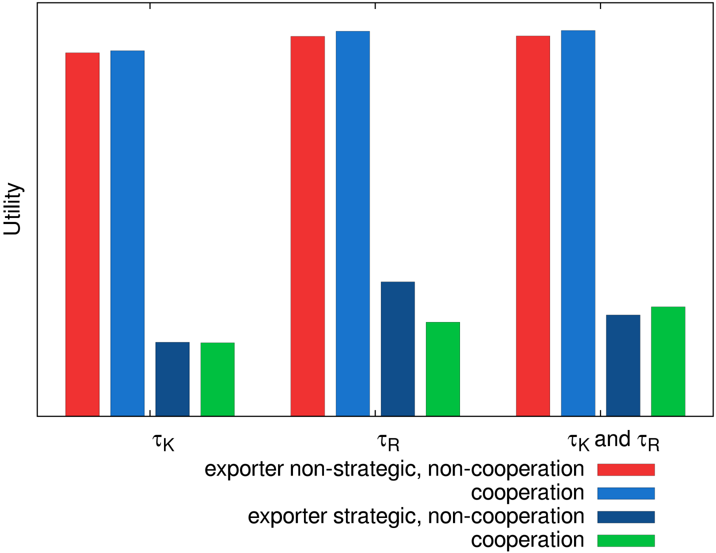
The resource rent



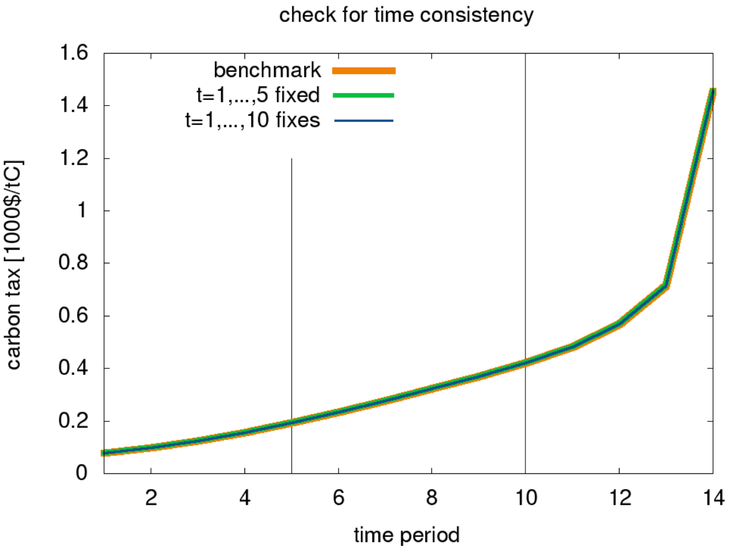
Welfare evaluation



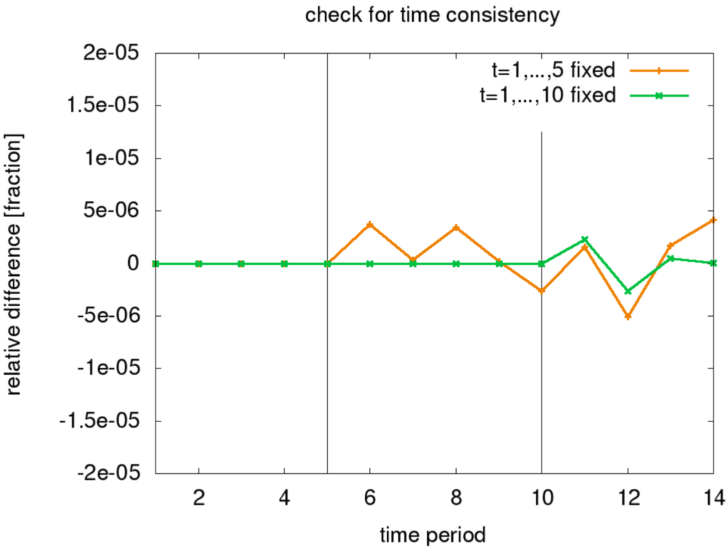
Welfare evaluation



No problem with time inconsistency



No problem with time inconsistency



If taxing carbon is so good, why do we not see more of it in reality?

1. In the past: **ignorance on the part of policy-makers**. Today not true anymore in many places.
2. **Practical problems**, caused e.g. by spacially differentiated taxes, complex trading rules for non-uniformly mixes pollutants, etc...
3. **Institutional problems**:
   - Cost-effectiveness ranked lower in regulators list of multiple policy objectives.
   - Ethical implications: Tax debases notion of environmental quality (Kelman, 1981); emission permits as 'right to pollute'.
4. Resistance from those with **vested interest** in preservation of existing system.

   '... all of the main parties involved [have] reasons to favor [command-and-control policies]: firms, environmental advocacy groups, organized labor legislators and bureaucrats' (Stavins, 1998, p.72).

Source: Hanley et al. (2007)

Why might public spending be too low? How can additional revenues from climate policy enhance welfare?

1. Weak institutions (non-OECD).
2. Existing allocation of public funds inefficient. New revenues from climate policy free to allocate.
3. Myopia towards projects with long term benefits. Climate policy might supply both funds and political momentum to implement such projects.
4. If in contrast projects with long term benefits were realized, there might be a lack of fiscal tools to finance high up-front costs, e.g. political debt-limit.

Source: Siegmeier et al. (2015)

Model setup - solution algorithm

- Households, firms and the resource owner are Stackelberg followers of governments.

Model setup - solution algorithm

- Households, firms and the resource owner are Stackelberg followers of governments.
- Governments engage in Nash game using policy instruments:

Model setup - solution algorithm

- Households, firms and the resource owner are Stackelberg followers of governments.
- Governments engage in Nash game using policy instruments:
- Repeat...
  - for each player j

Model setup - solution algorithm

- Households, firms and the resource owner are Stackelberg followers of governments.
- Governments engage in Nash game using policy instruments:
- Repeat...
  - for each player j
    - unfix avaliable policy instrument for j

Model setup - solution algorithm

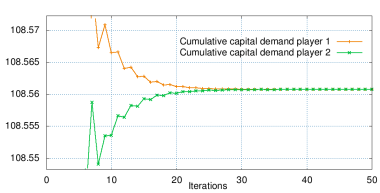
- Households, firms and the resource owner are Stackelberg followers of governments.
- Governments engage in Nash game using policy instruments:
- Repeat...
  - for each player *j*
    - unfix avaliable policy instrument for *j*
    - maximize objective for *j*

Model setup - solution algorithm

- Households, firms and the resource owner are Stackelberg followers of governments.
- Governments engage in Nash game using policy instruments:
- Repeat...
  - for each player *j*
    - unfix avaliable policy instrument for *j*
    - maximize objective for *j*
    - fix newly found policies

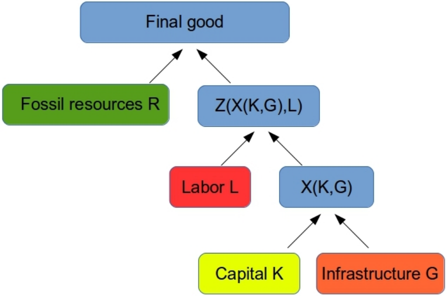
Model setup - solution algorithm

- Households, firms and the resource owner are Stackelberg followers of governments.
- Governments engage in Nash game using policy instruments:
- Repeat...
    - for each player *j*
        - unfix avaliable policy instrument for *j*
        - maximize objective for *j*
        - fix newly found policies
- ...until policy instruments converge.



Numerical Model: Details

CES production function



CES production function

$$F(K,G,R,L) = (\alpha_1 R^{s_1} + (1-\alpha_1) Z^{s_1})^{\frac{1}{s_1}}$$

$$Z(K,G,L) = (\alpha_2 X^{s_2} + (1-\alpha_2) L^{s_2})^{\frac{1}{s_2}}$$

$$X(K,G) = (\alpha_3 K^{s_3} + (1-\alpha_3) G^{s_3})^{\frac{1}{s_3}}$$

CiES social welfare function

$$W = \sum_t L_t \frac{(C_t/L_t)^{1-\eta}}{1-\eta} \frac{1}{(1+\rho)^t}$$

Parameter values

σ_1	α_1	σ_2	α_2	σ_3	α_3	η	ρ
0.5	0.1	0.7	0.42	1.1	0.65	1.1	0.03

, $s_i = \frac{\sigma_i - 1}{\sigma_i}$

Source: Empirical literature, details in appendix

Intertemporal optimization: Household

$$\max_{C/L} W = \sum_{t=0}^{T} \frac{U(C/L)}{(1+\rho)^t},$$
$$\text{s.t.} \quad C(1+\tau_C) = wL + rK^s + \Pi^F + Tax^{transfer} - I$$
$$I_t = K^s_{t+1} - (1-\delta)K^s_t$$

taking Π^F_t and Tax^{trans}_t as given.

Use *discrete* Maximum Principle with Hamiltonian:

$$\mathcal{H}^{HH}_t = U(C_t/L_t) + \lambda_t \Big[(1 + (r_t - \delta)) K^s_t + w_t L_t + \ldots$$
$$\ldots + \Pi^F_t + Tax^{trans} - C_t(1+\tau_{C,t}) \Big]$$

FOCs and TC:

$$L_t^{\eta-1}/C_t^{\eta} = \lambda_t(1+\tau_{C,t}),$$
$$\lambda_{t-1}(1+\rho) = \lambda_t \left(1 + r_t(1+\tau_{C,t}) - \delta\right),$$
$$0 = \left(I_T - (1-\delta)K^s_T\right)\lambda_T.$$

Intertemporal optimization: Resource exporter

$$\max_{R_t} \sum_{t=0}^{T} \frac{(p_t - c_t - \tau_{RO,t})R_t + \Psi_t}{\prod_{s=0}^{t}(1+r_s)}, \quad c_t(S_t) = r_t\left(1 + \frac{\chi_2}{\chi_1}\left((S_0 - S_t)/S_0\right)^{\chi_3}\right)$$

subject to

$$\sum_t R_t \leq S_0$$

where $R_t = S_t - S_{t+1}$, S_0 is given, and $\Psi_t = \tau_{RO,t} R_t$ is taken as given.

Hamiltonian:

$$\mathcal{H}_t^{RO} = (p_t - c_t - \tau_{RO,t})\, R_t + \lambda^R (S_t - R_t) + \Psi_t,$$

FOCs and TC:

$$\lambda_t^R = p_t(1 - \tau_{RO,t}) - c_t,$$

$$\lambda_t^R = \lambda_{t-1}^R(1 + r_t - \delta) - \frac{r_t R_t \chi_2 \chi_3}{\chi_1 S_0}\left(\frac{S_0 - S_t}{S_0}\right)^{\chi_3 - 1},$$

$$\lambda_{T-1}^R S_T = 0.$$

Intertemporal optimization: Government

$$\max_{\tau} W = \sum_{t=0}^{T} L_t \frac{U(C_t/L_t)}{(1+\rho)^t}$$

subject to

$$I^G + Tax^{transfer} = r\tau_K K + \tau_R R + \tau_C C + w\tau_L L$$
$$G_{t+1} = G_t + I_t^G - \delta G_t$$

and

- the international market clearing conditions,
- the maximization problems of households, firms, and the resource exporter,
- their respective FOCs and TCs

Some parameter values

Description	symbol	value	range	sources
Intertemporal elasticity of substitution	η	1.1		
Pure rate of time preference	ρ	0.03		
Annual depreciation rate of capital	δ	0.025		
Share parameter of fossil resource	α_1	0.11		Edenhofer et. al. (2005)
Elasticity of substitution btw. Z and R	σ_1	0.5	0.25 – 0.92	Hogan and Manne (1979)
				Kemfert and Welsch (2000)
				Burniaux et. al. (1992)
				Markandya et. al. (2007)
Share parameter of private capital	α_2	0.7		
Elasticity of substitution btw. K and G	σ_2	1.1	0.5 – 4	Baier and Glomm (2001)
				Coenen et. al. (2012)
				Otto and Voss (1998)
Total factor productivity	A	0.8		
Initial world capital [tril. US$]	K_0	165		
Initial world infrastructure [tril. US$]	G_0	50		
Initial world resource stock [GtC]	S_0	4000		
Fixed VAT rate [%]	τ_C	16		OECD (2014)
Fixed labor tax rate [%]	τ_L	16		World Bank (2014)
Time horizon [years]	T	75		

References (general)

Bénassy-Quéré, Agnès , *Economic Policy: Theory and Practice*, 2010, Oxford University Press

Edenhofer, Ottmar and Kalkuhl, Matthias, *When do increasing carbon taxes accelerate global warming? A note on the green paradox*, 2011, Energy Policy

Eichner, Thomas and Runkel, Marco, *Interjurisdictional Spillovers, Decentralized Policymaking, and the Elasticity of Capital Supply*, 2012, American Economic Review

Hanley, N., Shogren, J. F., White, B., *Environmental Economics in Theory and Practive, 2nd edition*, 2007, Palgrave Macmillan

Kelman, S. *Economists and the environmental policy muddle*, 1981, Public interest

van der Meijden, Gerard et. al., *International Capital markets, Oil Producers and the Green Paradox*, 2014, OxCarre Research Paper 130

OECD *Tax data base*, 2014, accessed: 2014-08-27, www.oecd.org/tax/tax-policy/tax-database.htm#vat

Siegmeier, J., Mattauch, L., Franks, M., Klenert, D., Schultes, A., *A public finance perspective on climate policy: Six interactions that may enhance welfare*, 2015, mimeo

Sinn, Hans-Werner, *Public policies against global warming: a supply side approach*, 2008, International Tax and Public Finance

Stavins, R., *What can we learn from the grand policy experiment? Lessons from SO2 allowance trading*, 1998, Journal of Economic Perspectives

Tahvonen, Olli, *International CO2 Taxation and the Dynamics of Fossil Fuel Markets*, 1995, International Tax and Public Finance

Withagen, Cees and Halsema, Alex, *Tax competition leading to strict environmental policy*, 2013, International Tax and Public Finance

World Bank, *World Development Indicators, Labor tax and contributions*, Accessed: 2014-08-27, data.worldbank.org/indicator/IC.TAX.LABR.CP.ZS