Tax Competition, Globalization, and the Green Paradox

or

Why finance ministers may favor a carbon tax even if they do not believe in climate change

Max Franks, Ottmar Edenhofer, Kai Lessmann

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Capital mobility leading to tax competition and tighter budgets

Figure 3.8 Public expenditure and receipts in the OECD countries.

Source: Benassy-Quere et. al. (2010)
Capital mobility leading to tax competition and tighter budgets

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

Source: Benassy-Quere et. al. (2010)
Demand for public expenditures, e.g. infrastructure

Highways to hell

A harsh winter and tight budgets mean lots of potholes

ONLY the drunk, they say, drive in a straight line in Chicago. The sober

Deutschland kaputt
Motivation and research questions

- What is the role of a carbon tax under the assumption that no climate externality exists?
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• What are the short term benefits of a carbon tax?

• Can carbon taxes finance infrastructure more efficiently than capital taxes?

• Could the fiscal motive for carbon taxation facilitate negotiations within the UNFCCC?
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- Tax competition with intertemporal dynamics:
  - Eichner and Runkel (2012): Decentralized policy making inefficient
  - Withagen and Halsema (2013): Race to the top in carbon taxes
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  - Sinn (2008): Green paradox
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  - van der Meijden et. al. (2014): Possible reversal of green paradox in general equilibrium
    \[\rightarrow\text{ No endogenous policy instruments, no infrastructure}\]
Our contribution

First model to combine:

• decentralized market solution, general equilibrium
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- strategic interaction, endogenous optimal policy instruments
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- intertemporal capital accumulation and resource extraction
- productivity enhancing infrastructure
MODEL SETUP
return on investment -> capital
Household:

\[
\max_{C_t} W = \sum_{t=0}^{T} \frac{U(C_t)}{(1 + \rho)^t},
\]

\[
C_t = r_t K_t - I_t + \Pi_t^F + \text{Tax}_t^{\text{transfer}} \text{ (lump-sum)}
\]
Firm:

$$\max_{K_t, R_t} \Pi^F_t = F(K_t, G_t, R_t) - r_t(1 + \tau_{K,t})K_t - (p_t + \tau_{R,t})R_t$$

Household:

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

$$C_t = r_t K_t - I_t + \Pi^F_t + Tax_t$$

(lump-sum)
**Firm:**

\[
\max_{K_t, R_t} \Pi_t^F = F(K_t, G_t, R_t) - r_t(1 + \tau_{K,t})K_t - (p_t + \tau_{R,t})R_t
\]

\[\implies F_{K,t} = r_t(1 + \tau_{K,t})\]

\[F_{R,t} = p_t + \tau_{R,t}\]

**Household:**

\[
\max_{C_t} W = \sum_{t=0}^{T} \frac{U(C_t)}{(1 + \rho)^t},
\]

\[C_t = r_t K_t - I_t + \Pi_t^F + Tax_t^{\text{transfer}} \text{ (lump-sum)}\]
Government:

\[
\max_{\tau_{K,t}, \tau_{R,t}} W = \sum_{t=0}^{T} \frac{U(C_t)}{(1 + \rho)^t}
\]

\[
l_t^G + Tax_t^{\text{transfer (lump-sum)}} = r_t \tau_{K,t} K_t + \tau_{R,t} R_t
\]

Firm:

\[
\max_{K_t, R_t} \Pi_t^F = F(K_t, G_t, R_t) - r_t (1 + \tau_{K,t}) K_t - (p_t + \tau_{R,t}) R_t
\]

\[
\Rightarrow F_{K,t} = r_t (1 + \tau_{K,t})
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Household:

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\max C_t W = \sum_{t=0}^{T} \frac{U(C_t)}{(1 + \rho)^t},
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\[
C_t = r_t K_t - I_t + \Pi_t^F + Tax_t^{\text{transfer (lump-sum)}}
\]
Resource exporter:

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

Resource market:

\[
\begin{align*}
R^{\text{supply}} &= \sum_j R_j^{\text{demand}} \\
p &= p_j \quad \forall j
\end{align*}
\]
Resource exporter:
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\]

Resource market:
\[
R_{\text{supply}} = \sum_j R_{j, \text{demand}}
\]
\[
p = p_j \ \forall j
\]

Capital market:
\[
\sum_j K_{j, \text{supply}} = \sum_j K_{j, \text{demand}}
\]
\[
r = r_j \ \forall j
\]
Nash equilibrium, two sub-games,
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Nash equilibrium, two sub-games, solved for non-cooperative behavior or

\[
\max W_i, \text{ given } \tau^j_K, \tau^j_R, \ i \neq j
\]
Nash equilibrium, two sub-games, solved for

non-cooperative behavior or cooperative behavior of governments

\[
\begin{align*}
\max_{\tau^K_i, \tau^R_i} W_i, \text{ given } \tau^K_i, \tau^R_i, \quad i \neq j \\
\max_{\{\tau^K_i, \tau^R_i\}_{i=1,2}} W_1 + W_2
\end{align*}
\]
Numerical Model: Details

CES production function

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

\[ Z(K, G) = (\alpha_2 K^{s_2} + (1 - \alpha_2) G^{s_2})^{\frac{1}{s_2}} \]
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CiES social welfare function

\[ W = \sum_t \frac{C_t^{1-\eta}}{1-\eta} \frac{1}{(1+\rho)^t} \]
Numerical Model: Details

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\[ F(K, G, R) = \left( \alpha_1 R^{s_1} + (1 - \alpha_1) Z^{s_1} \right)^{1/s_1} \]

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\[ W = \sum_t C_t^{1-\eta} \frac{1}{1-\eta} \frac{1}{(1+\rho)^t} \]

Parameter values

<table>
<thead>
<tr>
<th>( \sigma_1 )</th>
<th>( \alpha_1 )</th>
<th>( \sigma_2 )</th>
<th>( \alpha_2 )</th>
<th>( \eta )</th>
<th>( \rho )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.1</td>
<td>1.1</td>
<td>0.7</td>
<td>1.1</td>
<td>0.03</td>
</tr>
</tbody>
</table>

, where \( s_i = \frac{\sigma_i - 1}{\sigma_i} \)

Source: Empirical literature, details in appendix
Intertemporal optimization: Household

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

subject to

$$C_t + I_t = r_t K^s_t + \Pi^F_t + Tax_t^{\text{transfer}}$$

$$I_t = K^s_{t+1} - (1 - \delta)K^s_t$$

taking $\Pi^F_t$ and $Tax_t^{\text{transfer}}$ as given.

Lagrangian:

$$\mathcal{L}^{HH}_t = \sum_{t=0}^{T} \left[ \frac{U(C_t)}{(1 + \rho)^t} + \lambda_t \left( K^s_{t+1} - K_t - (I_t - \delta K_t) \right) \right]$$

FOCs and TC:

$$U'(C_t) = \frac{1}{C_t^{\eta'}} = \lambda_t,$$

$$\lambda_{t-1}(1 + \rho) = \lambda_t (1 + r_t - \delta),$$

$$(I_T - \delta K^s_T)\lambda_T = 0.$$
Intertemporal optimization: Resource exporter

\[\begin{align*}
\max_{R_t} & \sum_{t=0}^{T} \frac{p_t R_t}{\prod_{s=0}^{t} (1 + r_s)} \\
\text{subject to} & \sum_{t} R_t \leq S_0 \\
\text{where} R_t &= S_t - S_{t+1}, \text{and} S_0 \text{is given.}
\end{align*}\]

Lagrangian:

\[\mathcal{L}_{t}^{RO} = \sum_{t=0}^{T} \left[ \frac{p_t R_t}{\prod_{s=0}^{t} (1 + r_s)} + \lambda_t^R (-S_{t+1} + S_t - R_t) \right]\]

FOCs and TC:

\[\lambda_t^R = p_t,\]
\[\lambda_t^R = \lambda_{t-1}^R (1 + r_t - \delta),\]
\[\lambda_{T-1}^R S_T = 0.\]
Intertemporal optimization: Government

\[
\max_{\tau R, t, \tau K, t} W = \sum_{t=0}^{T} \frac{U(C_t)}{(1 + \rho)^t}
\]

subject to

\[
I_t^G + Tax_t^{\text{transfer}} = r_t \tau K, t K_t^d + \tau R, t R_t^d,
\]

\[
G_{t+1} = G_t + I_t^G - \delta G_t
\]

and

- the international market clearing conditions,
- the maximization problems of households, firms, and the resource exporter,
- their respective FOCs and TCs
RESULTS
Macroeconomic data – non-cooperation

National savings, $Y = C + I + I^G + pR$

![Bar chart showing national savings components](chart.png)

- **Consumption**: Government uses only $\tau_K$.
- **Private investment**: Government uses only $\tau_R$.
- **Infrastructure investment**: Low value.
- **Resources**: High value for government using both $\tau_K$ and $\tau_R$. Other components have lower values.

Net present value [tril. US$]

- Consumption: 1200 tril. US$.
- Infrastructure investment: 100 tril. US$.
- Resources: 1300 tril. US$.
Mixed portfolio of $\tau_K$ and $\tau_R$ – non-cooperation
Elasticity of substitution – non-cooperation

![Graph showing the NPV of consumption in tril. US$ vs. elasticity of substitution between capital and infrastructure. The graph compares scenarios where governments use only $\tau_K$ or only $\tau_R$.](image)
Without cooperation:
No green paradox, but viable green policy
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Carbon tax postpones extraction, because

\[ r_t > \frac{\tau_{R,t}}{\tau_{R,t}} \quad \forall t \]

See also Edenhofer and Kalkuhl (2011)
With cooperation:
Carbon tax speeds up extraction

![Graph showing resource extraction over time with and without cooperation](image)
With cooperation:
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![Graph showing resource extraction over time with and without cooperation]

Only $\tau_R$ used, non-cooperation

Cooperation
With cooperation:
Carbon tax speeds up extraction

Non-cooperation: carbon tax postpones extraction, because
\[ r_t > \frac{\dot{\tau}_{R,t}}{\tau_{R,t}} \quad \forall t \]

Cooperation: carbon tax speeds up extraction, because
\[ r_t < \frac{\dot{\tau}_{R,t}}{\tau_{R,t}} \quad \forall t < 10 \]

See also Edenhofer and Kalkuhl (2011)
Rent capturing, with and without cooperation

![Graph showing resource exporters' profits with and without cooperation over time.](image)
Rent capturing, with and without cooperation

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![Graph showing resource exporters' profits over time with and without cooperation]
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![Graph showing the comparison of resource exporters' profits with and without cooperation over time. The graph plots the profits against time, with two curves representing cooperation and non-cooperation scenarios, labeled $\tau_K$ and $\tau_R$ respectively. The graph illustrates the impact of cooperation on profit over time.](image-url)
Trade-off between fiscal and environmental benefits

**Non-cooperation**
- Carbon tax delays extraction
- Resource rent partially captured
- Infrastructure only 2nd best

**Cooperation**
- Carbon tax speeds up extraction, relative to non-cooperation
- Entire rent is captured
- Infrastructure at 1st best level
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The finance ministers’ blessing is the environmental ministers’ curse!
Summary of results

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Discussion: impact of extraction costs / climate externality

**Extraction costs** imply additional volume effects of carbon taxes.
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impact of extraction costs / climate externality

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Climate externality
  • Then, two motives for taxation
    1. fiscal (infrastructure)
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  2. *pigouvian* (abatement)
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  • in the long run: environmental motive
Conclusion

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3. Fiscal motive to introduce the carbon tax
   - may in the long run facilitate environmental policy based on pigouvian motive,
   - could be a game changer and facilitate global agreement on climate policy.
Appendix
Future research

- Endogenous carbon budget as policy instrument (rent creation via artificial scarcity)
- Dynamics of fiscal and environmental taxation motive (include damage function)
- Intertemporal borrowing and lending
Model setup - solution algorithm

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

<table>
<thead>
<tr>
<th>Description</th>
<th>symbol</th>
<th>value</th>
<th>range</th>
<th>sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intertemporal elasticity of substitution</td>
<td>$\eta$</td>
<td>1.1</td>
<td></td>
<td>Edenhofer et. al. (2005)</td>
</tr>
<tr>
<td>Pure rate of time preference</td>
<td>$\rho$</td>
<td>0.03</td>
<td></td>
<td>Hogan and Manne (1979)</td>
</tr>
<tr>
<td>Annual depreciation rate of capital</td>
<td>$\delta$</td>
<td>0.03</td>
<td></td>
<td>Kemfert and Welsch (2000)</td>
</tr>
<tr>
<td>Share parameter of fossil resource</td>
<td>$\alpha_1$</td>
<td>0.11</td>
<td>0.25 – 0.92</td>
<td>Burniaux et. al. (1992)</td>
</tr>
<tr>
<td>Elasticity of substitution btw. $Z$ and $R$</td>
<td>$\sigma_1$</td>
<td>0.5</td>
<td>0.25 – 0.92</td>
<td>Markandya et. al. (2007)</td>
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<tr>
<td>Share parameter of private capital</td>
<td>$\alpha_2$</td>
<td>0.7</td>
<td></td>
<td>Baier and Glomm (2001)</td>
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<td>Elasticity of substitution btw. $K$ and $G$</td>
<td>$\sigma_2$</td>
<td>1.1</td>
<td>0.5 – 4</td>
<td>Coenen et. al. (2012)</td>
</tr>
<tr>
<td>Total factor productivity</td>
<td>$A$</td>
<td>0.8</td>
<td></td>
<td>Otto and Voss (1998)</td>
</tr>
<tr>
<td>Initial world capital [tril. US$]</td>
<td>$K_0$</td>
<td>165</td>
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<td>Initial world infrastructure [tril. US$]</td>
<td>$G_0$</td>
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<td>Initial world resource stock [GtC]</td>
<td>$S_0$</td>
<td>4000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time horizon [years]</td>
<td>$T$</td>
<td>75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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