Designing a Global Differentiated Carbon Tax Scheme - Based on the Cost Fairness Principle

Lei ZHU, Lianbiao CUI, Ying FAN
Center for Energy and Environmental Policy Research
Institute of Policy and Management
Chinese Academy of Sciences
Table of Contents

- Introduction
- DCTC Principle
- Simulation
- Conclusions
After Copenhagen Summit (UNFCCC, 2009), the global 2°C target may become a moot point if numerous countries continue to show a lack of concerted actions.

- One of the main concerns is the negative economic impact of mitigating actions, especially the impact of abatement cost on the competitiveness of industries.

Developed Countries

- Unilateral mandatory emissions reduction efforts in recent years have not changed the trend of rapidly rising GHG emissions.
- Domestic industries are facing higher costs than their international peers. This could be a competitive disadvantage.

Developing Countries

- Economic development and poverty alleviation are their main tasks.
- Exportation is a driving factor in economic growth.
- Concerns quantified emission cuts might weaken their product competitiveness in both domestic and international markets.

Some developed countries have considered levying taxes (e.g. carbon tariffs or border carbon adjustment options) on the carbon content of imports from developing countries that do not commit to reduce their emissions.
Can we have a cooperated global emission reduction scheme with the consideration of competiveness and carbon leakage?

In this work, we propose a differentiated carbon tax scheme based on cost fairness principle (DCTC).

- A two country, two goods partial equilibrium model
- GTAP-E model

  - Unilateral Tax in Developed Countries
  - Unilateral Tax + Carbon Tariffs
  - DCTC

The output may add knowledge and provide references to global emission reduction scheme design
Table of Contents

- Introduction
- DCTC Principle
- Simulation
- Conclusions
1. Analysis Framework

- A two country, two goods partial equilibrium model has been adopted in our analysis which refers to that of Fisher and Fox (2012).

Country A (Developed)

Country A produces good $H$ at a per-unit cost $c_H(r_H)$ that rises with reductions $r_H$ from its baseline emission rate $e_H^0$ ($c_H^0 = c_H(0)$).

The consumption of good $H$ in countries A and B are $h$ and $x$ (exports to B), respectively.

Country B (Developing)

Country B produces good $F$ at a per-unit cost $c_F(r_F)$.

It may have incentive to reduce emissions under some specific climate policy, also its baseline emission rate is $e_F^0$ ($c_F^0 = c_F(0)$).

The consumption of good $F$ in countries A and B are $m$ (exports to A) and $f$, respectively.

Global Emissions

Producers are perfectly competitive, and the prices of $H$ and $F$ in turn will equal the (constant) marginal costs of production, inclusive of any taxes or rebates (zero-profit condition is satisfied).

And global emissions are

$$E = (e_H^0 - r_H)H + (e_F^0 - r_F)F$$
2. Differentiated Carbon Tax Scheme Design

After carbon taxes have been introduced in both countries, and the carbon price levels of A and B will be $t_A$ and $t_B$, respectively

**Tax Introduced**

The prices of $H$ and $F$ will change to:

$$p_H = p_X = c_H(r_H) + t_A(e_H^0 - r_H), \quad p_F = p_M = c_F(r_F) + t_B(e_F^0 - r_F)$$

**Equal Cost Burdens**

Based on the cost fairness principle, the emission reduction burden (increased production cost plus emission cost to the original cost) of $H$ and $F$ should be the same, which means the relative prices of $H$ and $F$ should not change after carbon taxation, we have:

$$\frac{c_H(r_H) + t_A(e_H^0 - r_H)}{c_F(r_F) + t_B(e_F^0 - r_F)} = \frac{c_H^0}{c_F^0}$$

Here assuming the production costs and emission intensities remain the same as before carbon taxes, then we have:

$$\frac{c_H^0 + t_Ae_H^0}{c_F^0 + t_B^2e_F^0} = \frac{c_H^0}{c_F^0}$$

Compromised Way to define the tax rates
2. Differentiated Carbon Tax Scheme Design

\[
\left( \frac{e^0_H}{c^0_H} \right)t_A = \left( \frac{e^0_F}{c^0_F} \right)t_B^2
\]

As we assume each country only produces one good, according to expenditure-based GDP accounting, the final output of this sector is the GDP of the country.

Let \( s_A = \left( \frac{e^0_H}{c^0_H} \right) / \left( \frac{c^0_H}{H} \right) \), \( s_B = \left( \frac{e^0_F}{c^0_F} \right) / \left( \frac{c^0_F}{F} \right) \)

\[ s_A t_A = s_B t_B^2 \]

Where \( s_A \) and \( s_B \) can be viewed as the carbon intensities per unit of GDP among countries A and B.

\[
\left( \frac{c_F(r_F) + t_B^2(e^0_F - r_F) - c^0_F}{c^0_F} \right) < \left( \frac{c_H(r_H) + t_A(e^0_H - r_H) - c^0_H}{c^0_H} \right)
\]

If we extend our DCTC to multi-stage design, at each stage, country A and B can adjust their differentiated carbon price level based on their emission intensities in previous stage. With the consideration of emission reduction potential, after several stages adjustments, \( t_B^2 \) will converge to \( t_B^1 \).
Table of Contents

- Introduction
- DCTC Principle
- Simulation
- Conclusions
GTAP-E model (Data based in 2007)
- To simulate the socio-economic and environment impact of the DCTC scheme
- 129 regions into three groups: Annex I countries, major developing countries (MdevCs), and the least developed countries (LDCs)
- 57 sectors into 13 sectors in which, various heavy manufacturing sectors with high energy intensities (sector codes: omn, crp, nmm, i_s, nfm, ele, ome) have been combined into one sector (HeavyMnfc)

Carbon tariffs processing
- Production-based accounting

Figure: The flow chart to calculate carbon tariffs
### Scenarios

#### Table: Policy Scenarios Designing

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Annex I adopts itself $15/ton CO₂ carbon tax</td>
<td>Unilateral emission reduction</td>
</tr>
<tr>
<td>Ctax</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S2</td>
<td>Annex I adopts itself $15/ton CO₂ carbon tax + Annex I imposes $15/ton CO₂ carbon tariffs on imports from MdevCs</td>
<td>Embodied carbon is calculated by production-based accounting</td>
</tr>
<tr>
<td>ImpTax</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S3</td>
<td>Annex I and MdevC both adopt themselves carbon taxes based on DCTC principle and the tax rate is endogenous which satisfy the CO₂ emission change equal to that in S2</td>
<td>Annex I countries and MdevCs satisfy DCTC (cost fairness) principle and with emission target comparable to S2</td>
</tr>
<tr>
<td>DCTC I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S4</td>
<td>Annex I adopts itself $15/ton CO₂ carbon tax + MdevC adopts itself $5.68/ton CO₂ carbon tax</td>
<td>Annex I countries and MdevCs satisfy DCTC (cost fairness) principle</td>
</tr>
<tr>
<td>DCTC II</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# The impact on carbon emissions

<table>
<thead>
<tr>
<th></th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
</tr>
</thead>
<tbody>
<tr>
<td>MdevCs</td>
<td>1.81</td>
<td>1.44</td>
<td>-3.62</td>
<td>-6.91</td>
</tr>
<tr>
<td>LDCs</td>
<td>0.78</td>
<td>0.87</td>
<td>0.63</td>
<td>1.18</td>
</tr>
<tr>
<td>World</td>
<td>-4.30</td>
<td>-4.35</td>
<td>-4.35</td>
<td>-7.97</td>
</tr>
<tr>
<td>Carbon leakage</td>
<td>15.95</td>
<td>13.05</td>
<td>0.25</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Carbon leakage prevented: -15.36, 98.43, 98.37 (Comparing to S1)

* Carbon leakage is defined as the ratio of the increased carbon emissions of countries that do not take any reductive actions to the decreased carbon emissions of countries that do take reductive actions.
The impact on competitiveness - Export

Table: The export change in the three scenarios (%)

<table>
<thead>
<tr>
<th></th>
<th>Annex I</th>
<th>MdevCs</th>
<th>LDCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>-0.39</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>S2</td>
<td>-0.66</td>
<td>-0.48</td>
<td>0.39</td>
</tr>
<tr>
<td>S3</td>
<td>-0.17</td>
<td>0.09</td>
<td>0.16</td>
</tr>
<tr>
<td>S4</td>
<td>-0.33</td>
<td>0.14</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Export Loss Avoided
(S2 compares to S1)  -69.23
Export Loss Avoided
(S3 compares to S1)  56.41
Export Loss Avoided
(S4 compares to S1)  15.38
Export Loss Avoided
(S3 compares to S2)  74.24
Export Loss Avoided
(S4 compares to S2)  50.00
# The impact on competitiveness - Production

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Annex I</th>
<th>MdevCs</th>
<th>LDCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>-0.091</td>
<td>0.004</td>
<td>0.004</td>
</tr>
<tr>
<td>S2</td>
<td>-0.084</td>
<td>-0.042</td>
<td>0.005</td>
</tr>
<tr>
<td>S3</td>
<td>-0.037</td>
<td>-0.015</td>
<td>0.005</td>
</tr>
<tr>
<td>S4</td>
<td>-0.08</td>
<td>-0.038</td>
<td>0.01</td>
</tr>
</tbody>
</table>

GDP Loss Avoided

(S2 compares to S1)

GDP Loss Avoided

(S3 compares to S1)

GDP Loss Avoided

(S4 compares to S1)

GDP Loss Avoided

(S3 compares to S2)

GDP Loss Avoided

(S4 compares to S2)
The impact on energy intensive sectors

- HeavyMnfc
The impact on energy intensive sectors

- Ely
Table of Contents

- Introduction
- DCTC Principle
- Simulation
- Conclusions
# Policy Preference Analysis

Table: The comparative analysis between S2 and S3 for Annex I and MdevCs

<table>
<thead>
<tr>
<th></th>
<th>Annex I</th>
<th>MdevCs</th>
<th></th>
<th>Annex I</th>
<th>MdevCs</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S2</td>
<td>S3</td>
<td></td>
<td>S2</td>
<td>S3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon emission</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon leakage</td>
<td>X</td>
<td>√</td>
<td></td>
<td>X</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>X</td>
<td>√</td>
<td></td>
<td>X</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real GDP</td>
<td>X</td>
<td>√</td>
<td></td>
<td>X</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EV</td>
<td>X</td>
<td>√</td>
<td></td>
<td>X</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td>S4</td>
<td></td>
<td>S2</td>
<td>S4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon emission</td>
<td>X</td>
<td>√</td>
<td></td>
<td>X</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon leakage</td>
<td>X</td>
<td>√</td>
<td></td>
<td>X</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export</td>
<td>X</td>
<td>√</td>
<td></td>
<td>X</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real GDP</td>
<td>X</td>
<td>√</td>
<td></td>
<td>X</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EV</td>
<td>√</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: “√” stands for relatively preferred policy, “X” stands for not relatively preferred policy.
• From the results:

  • The DCTC scheme provides an effective solution to address climate change through international cooperation
    • Less impact on international trade than carbon tariffs
    • Small carbon leakage rate
    • Can be viewed as an extension to the ‘common but differentiated responsibilities’ principle
Thanks a lot!

Lei ZHU

Center for Energy and Environmental Policy Research
Institute of Policy and Management
Chinese Academy of Sciences

lions85509050@gmail.com