“Carbon Taxes and Border Tax Adjustments: Might Industrial Organization Matter?”

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Trade and Climate Policy

Non-universal application of climate policies creates potential for *carbon leakage*

With no international carbon price, climate policy may also affect *competitiveness* of domestic firms

Provisions for border tax adjustments (BTAs) on energy-intensive imports in US and EU climate legislation

Border tax adjustments (BTAs) for domestic taxes legal under WTO/GATT rules, as long as they have *neutral* impact on trade
Competitiveness

Carbon leakage and competitiveness typically linked in policy debate, but latter is harder to define.

Typically thought of in terms of market share and/or firms’ profits – a function of market structure, technology and behavior of firms (WTO/UNEP, 2009)

Appropriate to analyze climate policy and BTAs in context of strategic trade theory and environmental policy (Ulph, 1992; Conrad, 1993; Barrett, 1994)

If firms earn above normal profits, climate policy may shift rents between domestic and foreign firms.
Which Industries?

Steel, aluminum, chemicals, paper and cement (Houser et al., 2009; Messerlin, 2012)

Appropriate to assume upstream and downstream sectors are imperfectly competitive:

Electricity generation now typically modeled as oligopolistic, e.g., Fowlie (2009)

Carbon leakage also modeled in oligopolistic setting, e.g., steel (Ritz, 2009)

Apply McCorriston and Sheldon’s (2005) model of successive oligopoly to BTAs and climate policy
Vertical Market Structure

Stage

Domestic Upstream:

Technology:

\[ x_1 = \phi x_1^u \]

\[ x_1^u = x_1^A + x_1^B \]

\[ e_1 = g(x_1^u), \quad g'(x_1^u) > 0 \]

Domestic Downstream:

Carbon tax \( \rightarrow t^e \)

BTA \( \rightarrow t^b \)

Domestic Demand
Successive Oligopoly Model

- Three-stage game:
  (1) Domestic government commits to $t^e$ and $t^b$
  (2)/(3) Nash equilibria upstream and downstream

- Downstream revenue functions:
  
  \[ R_1(x_1, x_2) \]  
  \[ R_2(x_1, x_2) \]

- Downstream profit functions:
  
  \[ \pi_1 = R_1(x_1, x_2) - c_1 x_1 \]  
  \[ \pi_2 = R_2(x_1, x_2) - c_2 x_2 \]
Downstream Equilibrium

- First-order conditions are:
  \[ R_{1,1} = c_1 \] \hspace{1cm} (5)
  \[ R_{2,2} = c_2 \] \hspace{1cm} (6)

- Nash equilibrium downstream:
  \[
  \begin{bmatrix}
  R_{1,11} & R_{1,12} \\
  R_{2,21} & R_{2,22}
  \end{bmatrix}
  \begin{bmatrix}
  dx_1 \\
  dx_2
  \end{bmatrix}
  =
  \begin{bmatrix}
  dc_1 \\
  dc_2
  \end{bmatrix}
  \] \hspace{1cm} (7)

- Slopes of reaction functions:
  \[
  \frac{dx_1}{dx_2} = r_1 = -\left( \frac{R_{1,12}}{R_{1,11}} \right) \] \hspace{1cm} (8)
  \[
  \frac{dx_2}{dx_1} = r_2 = -\left( \frac{R_{2,21}}{R_{2,22}} \right) \] \hspace{1cm} (9)

where for strategic substitutes (complements)
\[ R_{i,ij} < 0(> 0), \hspace{0.5cm} r_i < 0(> 0) \]
Downstream Equilibrium

- Solution found by re-arranging and inverting (7), and simplifying notation:

\[
\begin{bmatrix}
    dx_1 \\
    dx_2
\end{bmatrix}
= \Delta^{-1}
\begin{bmatrix}
    a_2 & -b_1 \\
    -b_2 & a_1
\end{bmatrix}
\begin{bmatrix}
    dc_1 \\
    dc_2
\end{bmatrix}
\]

where:
\[
a_1 = R_{1,11}, \quad a_2 = R_{2,22}, \\
b_1 = R_{1,12}, \quad b_2 = R_{2,21},
\]

and for stability, \( a_i < 0 \), and \( \Delta = (a_1a_2 - b_1b_2) > 0 \)

- From (8) and (9), substitute \( r_i = -(b_i) / a_i \) into (10):

\[
\begin{bmatrix}
    dx_1 \\
    dx_2
\end{bmatrix}
= \Delta^{-1}
\begin{bmatrix}
    a_2 & a_1r_1 \\
    a_2r_2 & a_1
\end{bmatrix}
\begin{bmatrix}
    dc_1 \\
    dc_2
\end{bmatrix}
\]

(11)
Upstream Equilibrium

- In each country, two upstream firms A and B whose combined output is $x_j^A + x_j^B = x_j^U$

- Upstream equilibrium derived in similar fashion to that downstream:

\[
\begin{bmatrix}
    dx_j^A \\
    dx_j^B
\end{bmatrix} = (\Delta_j^U)^{-1}
\begin{bmatrix}
    a_j^B & a_j^A r_j^A \\
    a_j^B r_j^B & a_j^A
\end{bmatrix}
\begin{bmatrix}
    dc_j^A \\
    dc_j^B
\end{bmatrix}
\]

where $a_j^A, a_j^B < 0$, and $(\Delta_j^U) > 0$

- $t^e$ raises domestic upstream costs $c_1^A$ and $c_1^B$, raising price of electricity, $dc_1 = dp_1^U = p_{1,1}^U(dx_1^A + dx_1^B)$, and thereby affecting imports of final good, $dx_2 / dc_1$
Carbon Leakage

Following Karp (2010), carbon leakage defined as:

\[ l = \frac{de_2}{-de_1} \equiv \left[ \frac{g'(x_2^U)}{g'(x_1^U)} \cdot \frac{dx_2^U}{-dx_1^U} \right] \]  

(13)

Given technology and (11), (13) re-written as:

\[ l = \frac{de_2}{-de_1} \equiv \left[ \frac{g'(x_2^U)}{g'(x_1^U)} \cdot \frac{\Delta^{-1} a_2 r_2}{-(\Delta^{-1} a_2 c_1)} \right] \]  

(14)

Using (11), \( \Delta^{-1} a_2 c_1 < 0 \), direction of carbon leakage determined by \( r_2 \), e.g., suppose \( g'(x_2^U) = g'(x_1^U) \), then \( l > 0 \) (\( l < 0 \)) if \( r_2 < 0 \) (\( r_2 > 0 \))
Neutral BTAs

- Assume $t^b$, can be targeted at imports – affects $dc_2$ which feeds back into foreign electricity production, and, hence carbon leakage by (13):
  $$dx_2^U / dc_2 = d(x_2^A + x_2^B) / dc_2$$

- WTO/GATT rules not specific on neutrality of BTAs - consider two cases:
  (i) Change in $c_2$ that keeps volume of imports constant given $t^e$
  (ii) Change in $c_2$ that keeps market share of imports constant given $t^e$
(i) Appropriate BTA defined as:

\[
t^b = \frac{(dx_2 / dc_1) t^e}{-(dx_2 / dc_2)}
\]  

(15)

Already know \( dx_2 / dc_1 \) depends on sign of \( r_2 \)

Using (11), effect of \( t^b \) is:

\[
dx_2 = \Delta^{-1} a_1 dc_2
\]

(16)

Since \( \Delta^{-1} > 0 \) and \( a_1 < 0 \), then \( dx_2 / dc_2 < 0 \)

Under imperfect competition, if \( t^b = t^e \), there will be non-neutral outcome, *pass-through* of \( t^e \) matters
Using (11) and (15), and after some manipulation:

\[ t^b = -r_2 \{ p_{1,1}^U D \} t^e = -r_2 dc_1 \quad (17) \]

where \( p_{1,1}^U < 0, \ D = (\Delta^U)^{-1} [a_1^B (1 + r_1^B) + a_1^A (1 + r_1^A)] < 0 \), and for reasonable characterizations of demand, \{.\} < 1

Form and size of \( t^b \) depend on \( r_2 \) and extent of pass-through of \( t^e \) respectively:

- \( t^b \) is an import tax (subsidy) if \( r_2 < 0 \) (\( r_2 > 0 \))

- \( t^b < t^e \) due to under-shifting of carbon tax by domestic electricity producers
Figure 1: Import Volume Neutrality
(ii) Appropriate BTA defined as:

\[ t^b = \frac{t^e \left[ \left( \frac{dx_2}{dc_1} \right) + \left( \frac{dx_1}{dc_1} \right) \right]}{\left[ \left( \frac{dx_1}{dc_2} \right) + \left( \frac{dx_2}{dc_2} \right) \right]} \]  \tag{18}

Substituting in from (11), neutral \( t^b \) is:

\[ t^b = \frac{(r_2 + 1) t^e}{(r_1 + 1)} = \frac{(r_2 + 1) dc_1}{(r_1 + 1)} \]  \tag{19}

- with \( r_i < 0 \), and given, \( |r_1| > |r_2| \), neutral \( t^b \) is an import tax, and \( t^b \) for import-share neutrality > \( t^b \) for import-volume neutrality
Figure 2: Import Share Neutrality

\[ \frac{dN}{dc_2} \]

\[ x_2 \]

\[ x_1 \]

\[ dc_1 \]
Conclusions

Analysis of BTAs more complex with vertically-related markets and successive oligopoly

Carbon leakage can be prevented through use of BTAs, but competitiveness concerns not necessarily resolved

Deadweight losses to domestic consumers an issue in presence of carbon tax and BTA

Classic second-best problem: three market failures and only two policy instruments