# "Carbon Taxes and Border Tax Adjustments: Might Industrial Organization Matter?"

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**Guadalajara, Mexico**

**February 16, 2012**

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# Trade and Climate Policy

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

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

**Carbon taxes with import tariffs (export subsidies) on traded goods solution to free-riding (Hoel, 1996)**

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

**Downstream BTAs may be allowed for upstream taxes**

# Competitiveness

**Competitiveness and carbon leakage typically linked in policy debate, but former 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 application of environmental policy (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; Monjon and Quirion, 2010)**

**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

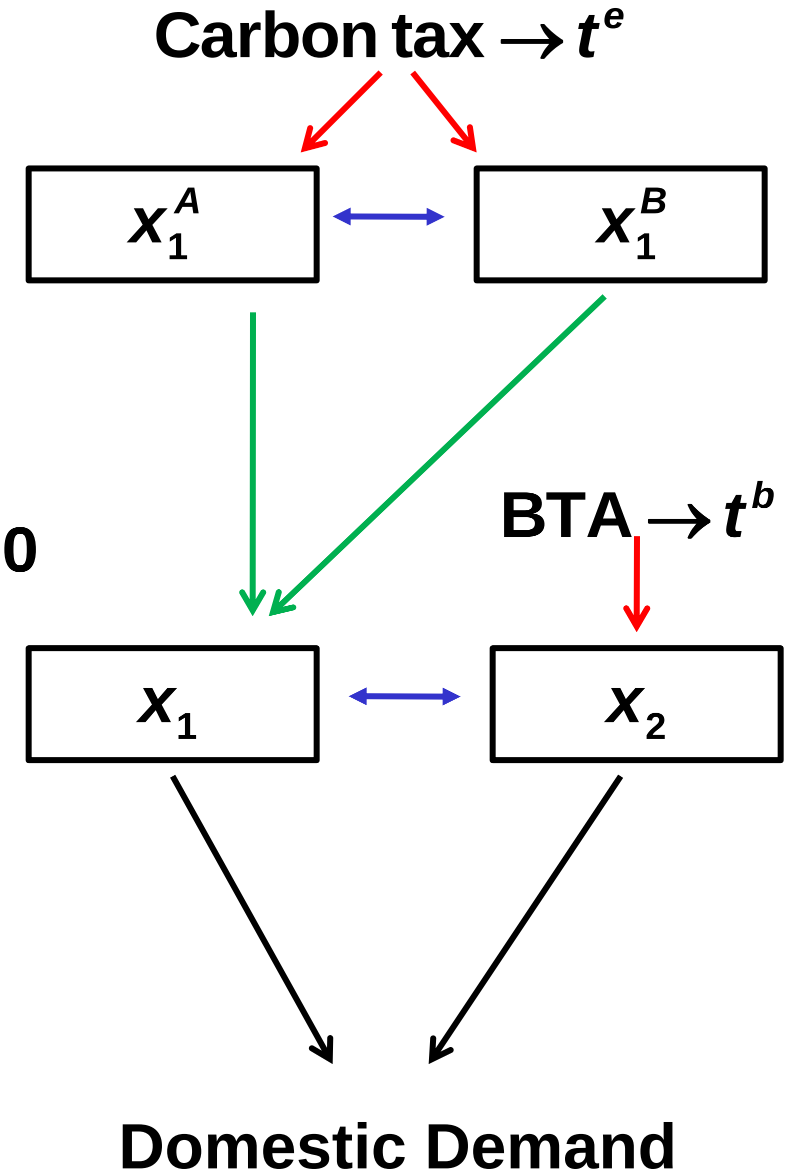
<u>**Stage**</u>

**Domestic Upstream:**

**Technology:**

$$\begin{cases} x_1 = \phi x_1^u \\ x_1^u = x_1^A + x_1^B \\ e_1 = g(x_1^u),\ g'(x_1^u) > 0 \end{cases}$$

**Domestic Downstream:**



# 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:**

$$R_1(x_1, x_2) \qquad (1)$$

$$R_2(x_1, x_2) \qquad (2)$$

- **Downstream profit functions:**

$$\pi_1 = R_1(x_1, x_2) - c_1 x_1 \qquad (3)$$

$$\pi_2 = R_2(x_1, x_2) - c_2 x_2 \qquad (4)$$

# Downstream Equilibrium

- **First-order conditions are:**

$$R_{1,1} = c_1 \qquad (5)$$

$$R_{2,2} = c_2 \qquad (6)$$

- **Nash equilibrium downstream:**

$$\begin{bmatrix} R_{1,11} & R_{1,12} \\ R_{2,21} & R_{2,22} \end{bmatrix} \begin{bmatrix} dx_1 \\ dx_2 \end{bmatrix} = \begin{bmatrix} dc_1 \\ dc_2 \end{bmatrix} \qquad (7)$$

- **Slopes of reaction functions:**

$$dx_1 / dx_2 = r_1 = -(R_{1,12} / R_{1,11}) \qquad (8)$$

$$dx_2 / dx_1 = r_2 = -(R_{2,21} / R_{2,22}) \qquad (9)$$

**where for *strategic substitutes* (*complements*)**

$$R_{i,ij} < 0 (> 0), \; r_i < 0 (> 0)$$

# Downstream Equilibrium

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

$$\begin{bmatrix} dx_1 \\ dx_2 \end{bmatrix} = \Delta^{-1} \begin{bmatrix} a_2 & -b_1 \\ -b_2 & a_1 \end{bmatrix} \begin{bmatrix} dc_1 \\ dc_2 \end{bmatrix} \qquad (10)$$

**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** $\Delta = (a_1 a_2 - b_1 b_2) > 0$

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

$$\begin{bmatrix} dx_1 \\ dx_2 \end{bmatrix} = \Delta^{-1} \begin{bmatrix} a_2 & a_1 r_1 \\ a_2 r_2 & a_1 \end{bmatrix} \begin{bmatrix} dc_1 \\ dc_2 \end{bmatrix} \qquad (11)$$

# 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:

$$\begin{bmatrix} dx_j^A \\ dx_j^B \end{bmatrix} = (\Delta_j^U)^{-1} \begin{bmatrix} a_j^B & a_j^A r_j^A \\ a_j^B r_j^B & a_j^A \end{bmatrix} \begin{bmatrix} dc_j^A \\ dc_j^B \end{bmatrix} \qquad (12)$$

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:

$$I = \frac{de_2}{-de_1} \equiv \left[ \frac{g'(x_2^U)}{g'(x_1^U)} \cdot \frac{dx_2^U}{-dx_1^U} \right] \qquad (13)$$

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

$$I = \frac{de_2}{-de_1} \equiv \left[ \frac{g'(x_2^U)}{g'(x_1^U)} \cdot \frac{\Delta^{-1} a_2 r_2 dc_1}{-(\Delta^{-1} a_2 dc_1)} \right] \qquad (14)$$

Using (11), $\Delta^{-1} a_2 dc_1 < 0$, *direction* of carbon leakage determined by $r_2$, e.g., suppose $g'(x_2^U) = g'(x_1^U)$, then $I > 0$ ($I < 0$) if $r_2 < 0$ ($r_2 > 0$)

# Neutral BTAs

**Neutrality of BTAs not defined explicitly by WTO - two possible rules:**

- ***Import-volume* neutrality**

**- change in foreign firm's costs $c_2$ through BTA that keeps import volume, $x_2$, constant given carbon tax $t^e$**

**- size of BTA depends on *incidence* of upstream carbon tax $t^e$ on downstream firm's costs, $c_1$**

**- profits fall (rise) for domestic (foreign) firm, and carbon leakage is zero**

- **Appropriate BTA defined as:**

$$\textit{neutral BTA} = \frac{(dx_2 / dc_1)\ t^e}{-(dx_2 / dc_2)} \qquad (15)$$

**Already know $dx_2/dc_1$ depends on sign of $r_2$**

**Using (11), effect of BTA is:**

$$dx_2 = \Delta^{-1} a_1 dc_2 \qquad (16)$$

**Since $\Delta^{-1} > 0$ and $a_1 < 0$, then $dx_2 / \mathrm{d}c_2 < 0$**

**Under imperfect competition, if $BTA = t^e$, there will be non-neutral outcome**

- **Using (11) and (15), and after some manipulation:**

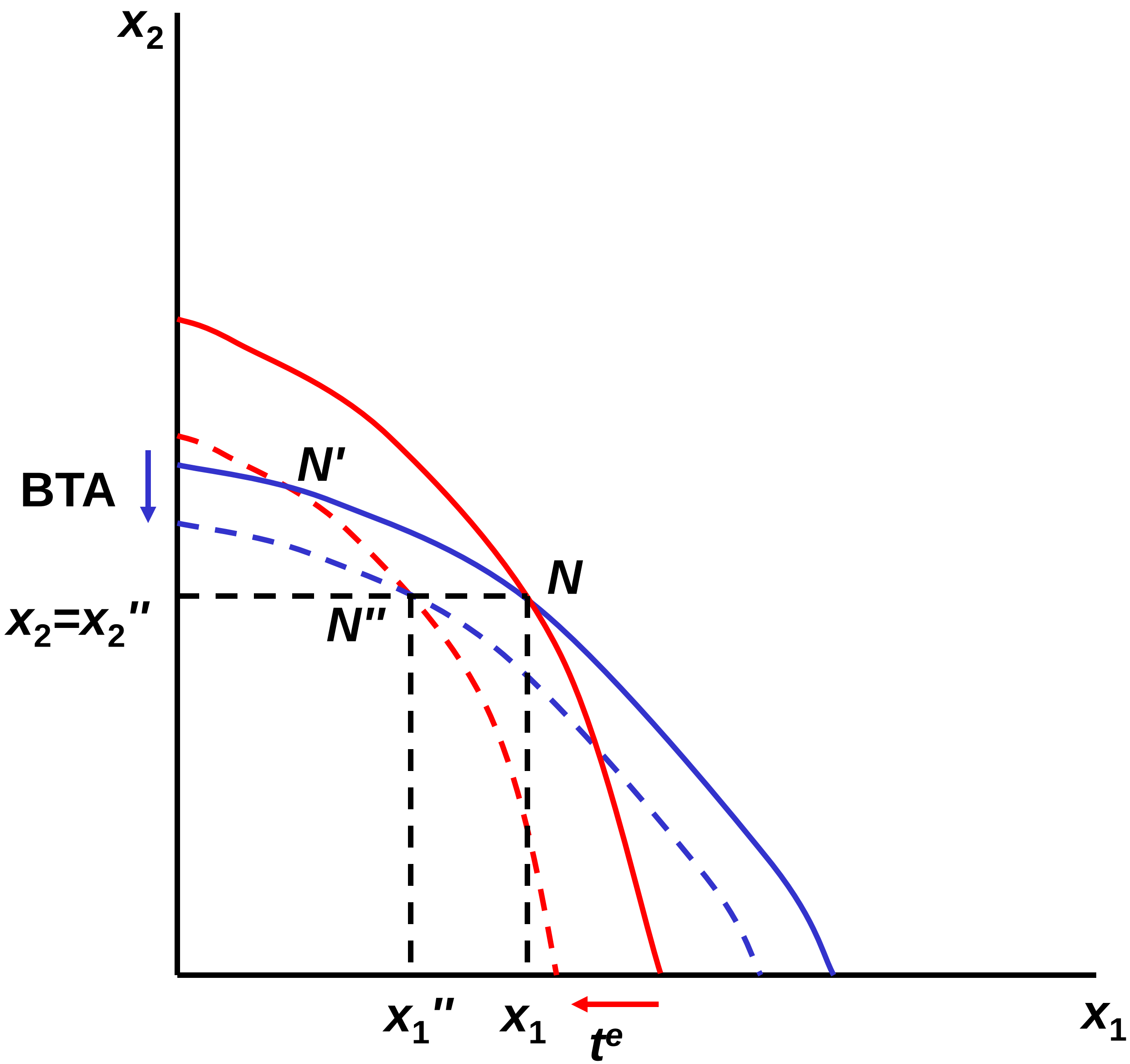
$$neutral\ BTA = -r_2\{p_{1,1}^U D\}t^e = -r_2 dc_1 \qquad (17)$$

**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 BTA depend on** $r_2$ **and extent of pass-through of** $t^e$ **respectively:**

- **BTA is an import tax (subsidy) if** $r_2 < 0$ ($r_2 > 0$)
- **BTA <** $t^e$ **due to under-shifting of emissions tax**

# Figure 1: Import Volume Neutrality



# Neutral BTAs

- ***Import-share*** **neutrality**

  **- change in foreign firm's costs $c_2$ through BTA that keeps its import share $x_2/(x_1+x_2)$ constant given carbon tax $t^e$**

  **- profits of both domestic and foreign firm increase, and there is negative carbon leakage**

  **- while objective is to set border taxes so as not to be unwittingly protectionist, there are profit effects that affect way firms will lobby for policy**

**Appropriate BTA defined as one where net effect of $t^e$ on $x_1$ and $x_2$ must equal the net effect of BTA on $x_1$ and $x_2$ is:**

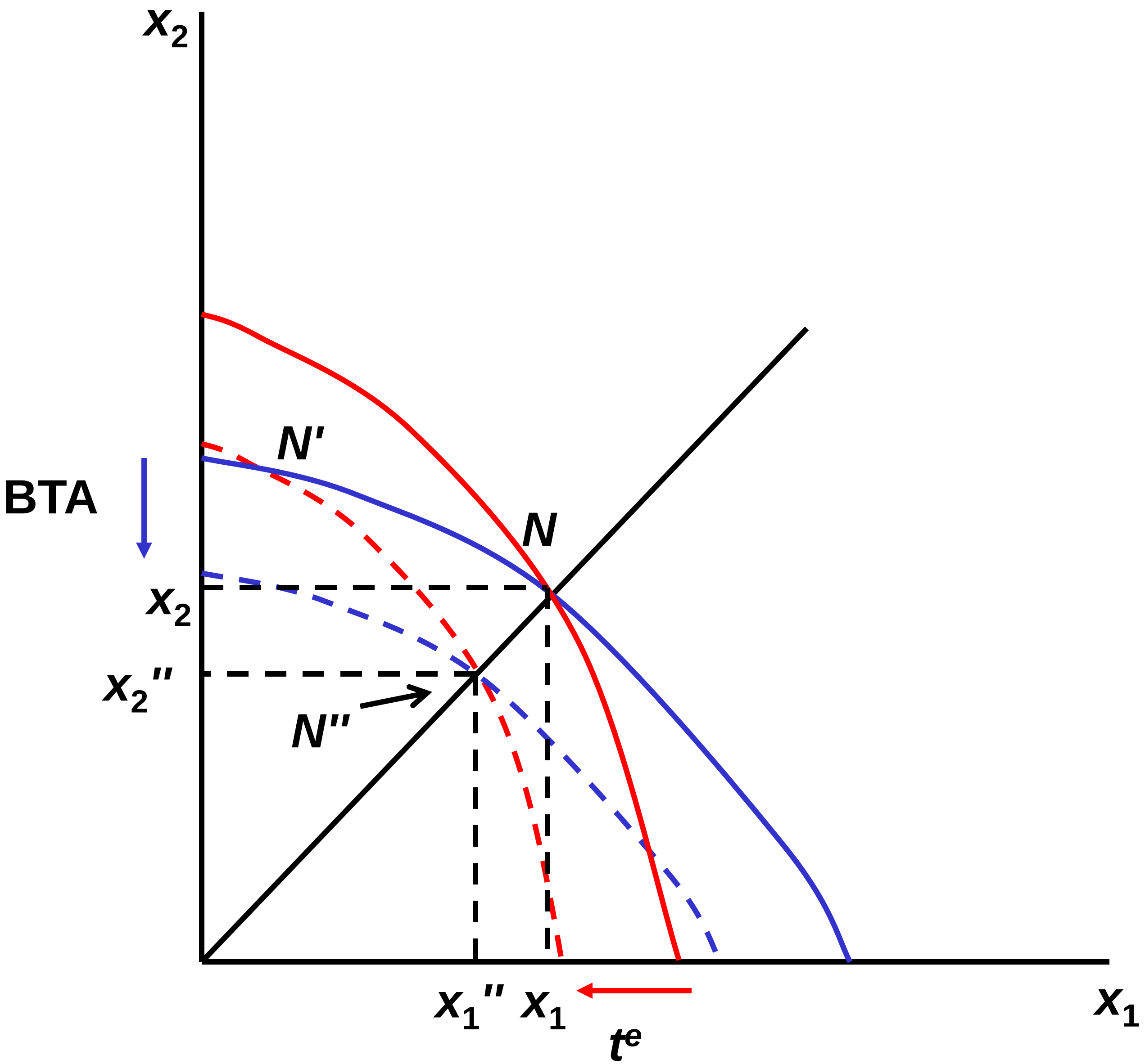
$$\text{neutral BTA} = \frac{t^e[(dx_2/dc_1) + (dx_1/dc_1)]}{[(dx_1/dc_2) + (dx_2/dc_2)]} \qquad (17)$$

**Substituting in from (11), neutral BTA is:**

$$\text{neutral BTA} = \frac{(r_2+1)\,t^e}{(r_1+1)} = \frac{(r_2+1)\,dc_1}{(r_1+1)} \qquad (18)$$

**With $r_i < 0$, and given, $|r_1| > |r_2|$, neutral BTA is an import tax, and BTA for import-share neutrality > BTA for import-volume neutrality**

# Figure 2: Import Share Neutrality



# Conclusions

**Climate policies present additional layer(s) of complexity when vertically-related markets can be characterized as successive oligopoly**

**Carbon leakage can be prevented, but competitiveness concerns not necessarily resolved**

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

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