Emission Trade in International Air Transportation

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Outline

1. Recent Policy Situation of International Aviation and Climate Change
2. Emission Trading Simulation under NCG Theory Framework
3. Welfare Consideration for Bargaining among States
1. Recent Policy Situation of International Aviation and Climate Change
Major Countries’ Positions

**Kyoto Protocol**

- **[Reduction obligation]**
  - CAP & Trade (EU-ETS)
    - 8% EU
    - 6% JAPAN
  - Sector specific / indexed unit base

- **[No Reduction]**
  - 0% Russia (FSU)

**Outside of Kyoto Protocol**

- **[Economic Growth]**
  - 7% US (Bush ad.)
  - 7% US (Obama ad.)
  - Economy-wide Cap & Trade

- **[Balance with NDC]**
  - Details not certain yet

**Common But Differentiated Responsibilities**

- 0% [Economic Growth]

- CHINA, INDIA, BRAZIL, SOUTH AFRICA, … [NDC]

cf; Waxman=Markey Bill (Cap & Trade)
Int’l Aviation and Climate Change

✈ ICAO is the forum designated by Kyoto P. for Int’l aviation. (Domestic is included in KP.)

✈ ICAO set up GIACC (high level group on the issue) and GIACC reached agreement.

✈ EU pursues their own EU-ETS approach.

✈ US is still under policy formation phase.

✈ China & others sticks to CBDR principle.
EU Directive (09/01/13)

✈ Introduce aviation into EU-ETS in 2012

✈ Need each country’s own enactment

✈ All airlines to/from EU must buy some allowance from EU-ETS

✈ Allowance are distributed more than 80% free and the rest by auction from 2012.
Emission Allowance under EU Directive

Past emission

2004~2006 average CO₂ Emission ( = 100)

Limit for 2012

CO₂ Allowance ( = 97)

Based on 2010 level ton-kilo,
Distributed freely ( = 82)

Auction ( = 15)

Limit for 2013~

CO₂ Allowance ( = 95※1)

Based on the level of ton-kilo 2 years before,
Distributed freely ( = 80※1)

Auction ( = 15※2)

※1 : may change
※2 : may change

Source: MLIT
Global Aspirational Goal; 2% annual fuel efficiency improvement from 2012 through 2050

* : Liter/RTK for in-service fleet average of Int’l operation

No agreement on economic measures, like ETS

Future measures include; Drop-in bio-fuel, CO2 standard for new A/C type
2. Emission Trading Simulations under NCG Theory Framework
# Basic Numbers in 90

<table>
<thead>
<tr>
<th>Countries with obligation</th>
<th>Carbon Emission in 90 in Mil. ton</th>
<th>GDP 90 B US$</th>
<th>Carbon Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU 15</td>
<td>915</td>
<td>6,961</td>
<td>0.13</td>
</tr>
<tr>
<td>FSU 22</td>
<td>989</td>
<td>1,535</td>
<td>0.64</td>
</tr>
<tr>
<td>Japan</td>
<td>292</td>
<td>2,970</td>
<td>0.10</td>
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<tr>
<td>US</td>
<td>1,315</td>
<td>5,794</td>
<td>0.23</td>
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<tr>
<td>China Area (incl. HK, Macao)</td>
<td>662</td>
<td>484</td>
<td>1.37</td>
</tr>
<tr>
<td>Korea (x DPRK)</td>
<td>66</td>
<td>264</td>
<td>0.25</td>
</tr>
<tr>
<td>India</td>
<td>186</td>
<td>327</td>
<td>0.57</td>
</tr>
</tbody>
</table>
If Countries with obligation in Kyoto P. were in the Emission Trade System (ETS) in 1990, what seemed to happen under NCG approach to ETS (including aviation emission)?

← Just a simple calculation for the sake of discussion
Literature on the Model

By Emission Trade…

<table>
<thead>
<tr>
<th>Country</th>
<th>Reduction rate</th>
<th>Reduction (Mil.ton)</th>
<th>Initial permits (Mi. ton)</th>
<th>P* (US$)</th>
<th>Equil. Cost (Mil. US$)</th>
</tr>
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<td>EU 15</td>
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<td>575</td>
</tr>
<tr>
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<td>989</td>
<td>9.65</td>
<td>-402</td>
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<tr>
<td>Japan</td>
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<td>18</td>
<td>275</td>
<td>9.65</td>
<td>138</td>
</tr>
<tr>
<td>US</td>
<td>0.07</td>
<td>92</td>
<td>1223</td>
<td>9.65</td>
<td>563</td>
</tr>
</tbody>
</table>
If China, Korea, and India were in Kyoto P. with ETS, what seemed to happen?
## Simulation with 3 countries

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<tr>
<th>Countries</th>
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<td>6.65</td>
<td>-143</td>
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<tr>
<td>Korea (x DPRK)</td>
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<td>0</td>
<td>66</td>
<td>6.65</td>
<td>-8</td>
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<tr>
<td>India</td>
<td>0</td>
<td>0</td>
<td>186</td>
<td>6.65</td>
<td>-35</td>
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Sensitivity Analysis for EA Price

Sensitivity of Reduction Rate for 3 Countries

Reduction Rate $+1\%$

↓

Equilibrium Price $P^* +0.34 \sim +0.32$

↓

$\frac{dp^*}{dRR} = +0.34 \sim +0.32$ US$

↓

$\frac{d^2p^*}{d^2RR} = +0.06$ US$

$P^* \sim 6.65^{+++} + .3356^{+++}$ RR

+++: significant with 0.001 or less p-value

3 countries: China, Korea, India

Emission Allowance Price $P^*$ (US$(90)$)

Reduction Rate (RR) for 3 countries (%)
3. Welfare Consideration for Bargaining among States
Basic Model  (numerical example)

✈ There are only 2 states in the world.
✈ There is a common linearly separable uncertainty, $\varepsilon$.
✈ Each has utility function as follows;

\[
V_1(c_1, X) = -\exp\{-0.2(c_1^{0.8}(10 - X)^{0.2} + \varepsilon)\}(\varepsilon \sim N(\mu, \sigma^2))
\]
\[
V_2(c_2, X) = -\exp\{-0.2(c_2^{0.2}(10 - X)^{0.8} + \varepsilon)\}(\varepsilon \sim N(\mu, \sigma^2))
\]

✈ Initial allocation rule for emission is skewed, namely 92.5% for state 1 and remaining 7.5% for state 2.

\[
\theta_1 = 0.925
\]
\[
\theta_2 = 0.075
\]
Literatures on the Model

Lindahl-Bowen-Samuelson (LBS) condition


Basic Case

V2 = State 2’s Utility (Welfare) level

V1 = State 1’s Utility (Welfare) level

Bargaining Frontier

Nash Product

Limit of Bargaining

Disagreement Point

Pareto Frontier

\[ x^*_1 = x^*_2 \]

parameters:
- \( \mu = 0 \)
- \( \sigma = 1 \)
- \( \eta_1 = 0.2 \)
- \( \eta_2 = 0.2 \)
- \( \theta_1 = 0.925 \)
- \( \theta_2 = 0.075 \)
- \( f = 0.8 \)
Same Utility/ Even Initial Allocation

By bargaining, they can reach social optimum!!

\[ V_1 = \text{State 1's Utility (Welfare) level} \]

\[ V_2 = \text{State 2's Utility (Welfare) level} \]
Uncertainty ($\sigma$) ↑

$V_1(c_1, X) = -\exp\{-0.2(c_1^{0.8}(10 - X)^{0.2} + \varepsilon)\}(\varepsilon \sim N(\mu, \sigma^2))$

$V_2(c_2, X) = -\exp\{-0.2(c_2^{0.2}(10 - X)^{0.8} + \varepsilon)\}(\varepsilon \sim N(\mu, \sigma^2))$

World Shrinks!!
Initial Allocation’s Impact

Under un-even initial allowance allocation, no way to reach the social optimum!!
Conclusion

✈ Simulation analysis about the effects on pricing of carbon emission allowances by including major players such as China and India.

✈ In a 2-country bargaining setting,

⇒ If uncertainty increases, then both Pareto Frontier and Bargaining Frontier shrink and make the negotiation harder.

⇒ Under different utility structure/a non-even initial allocation allowances, reaching the pareto frontier by bargaining could be extremely difficult.
Thank you for your attention!

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