Price carbon — I will if you will

Peter Cramton, Maryland / EUI / Cologne
with David MacKay, Axel Ockenfels, and Steven Stoft
14 December 2015
Symposium: International Climate Negotiations
Cramton, Ockenfels, Stoft (eds.), Gollier, Stiglitz, Tirole, Weitzman
Economics of Energy & Environmental Policy, 4:2, September 2015

Price Carbon—I Will If You Will
MacKay, Cramton, Ockenfels & Stoft
Nature, 15 October 2015

Global Carbon Pricing—We Will If You Will
Cramton, MacKay, Ockenfels & Stoft
MIT Press, under review, 2016

carbon-price.com
Consensus Aspiration: 2°C goal

How to bridge gulf between goal and intentions?

IPCC, SYR Figure SPM.10
Paris Agreement

Abatement effort

- Until 2020
  - max political power
  - no down-payment
  - no excuses
  - national policy

- Until 2030
  - moderate power
  - no payments first 15 years
  - some excuses
  - national plans

- Until 2100
  - no power or blame
  - many excuses
  - global aspiration

Non-binding jumbo payments
Economics:
Price carbon
Direct
Efficient
Transparent
Promotes international cooperation

Remarkably, “price” never appears in 31 page COP21 Final Agreement
Treaty Design:
Promoting cooperation in international negotiations
Individual commitments (intended nationally determined contributions) cannot promote cooperation.

**APPENDIX I: QUANTIFIED ECONOMY-WIDE EMISSIONS TARGETS FOR 2020**

<table>
<thead>
<tr>
<th>DEVELOPED COUNTRY</th>
<th>Quantified economy-wide emissions targets for 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Emissions reduction in 2020</td>
</tr>
</tbody>
</table>

**APPENDIX II: NATIONALLY APPROPRIATE MITIGATION ACTIONS OF DEVELOPING COUNTRY PARTIES**

<table>
<thead>
<tr>
<th>DEVELOPING COUNTRY</th>
<th>Actions</th>
</tr>
</thead>
</table>
Individual commitments cannot promote cooperation

- 10 players; individual endowment = $10
- Each $ pledged will be doubled and distributed evenly to all players
- Voluntary pledges are enforced
- Result: *Zero* cooperation, all pledge $0

Unique equilibrium

No cooperation
Dynamics of individual commitments: “Upward spiral of ambition”?

- History: Japan, Russia, Canada, and New Zealand left the Kyoto agreement
- Ostrom (2010), based on hundreds of field studies: insufficient reciprocity leads to a “downward cascade”
- Supported by theory and laboratory experiments
Common commitment: “I will if you will”
Trump: “I won’t ‘cause you won’t”
“I will if you will” promotes cooperation

- 10 players; Individual endowment = $10
- Each $ pledged will be doubled and distributed evenly to all players
- *Pledge is commitment to reciprocally match the minimum pledge of others*
- Voluntary pledges are enforced
- Result: *Full* cooperation, all pledge $10
Price is focal common commitment
Direct, efficient, common intensity of effort
Consistent with tax or cap & trade (flexible at country level)
Consensus that price should be uniform reduces dimensionality problem:

\[ P_{\text{Country}} = P_{\text{global}} \]

(No such consensus exists for quantity commitment)
Price commitment reduces risk

- Countries keep carbon revenues
- Eliminates the risk of needing to buy credits
But are quantity commitments equivalent?

China, you will be safe, if you accept a “Business-as-Usual” target for 2008 – 2012.

—Jeffery Frankel, 1998

- Business as Usual means what experts think
- 1999 US Dept. of Energy: 7.5 Gt of CO₂
- Reality in 2008 – 2012: 36.6 Gt of CO₂
Cap targets $P = 30$, but then $P \Rightarrow 45$

- China’s unexpected costs > $1$ trillion
- $817$ B Payments to US, EU, India ??

**Prediction-Error Trading Costs for China, 2008 – 2012**

- $817$ B Unexpected Trading Cost under Cap & Trade
- $225$ B Unexpected abatement cost under Global Cap

---

18
Carbon Pricing: $P = $30$

- China’s unexpected costs = $88 \text{ B}
- Payments clean up China’s pollution
Sharing the burden
- Use Green Fund to maximize abatement
- As before, reduce dimensionality
  - Carbon price = intensity of cooperation
  - “Generosity parameter” = intensity of Green Fund
- Last resort enforcement with trade sanctions
Designing the Green Fund

Payment into Green Fund = \text{Generosity parameter} \times \text{Excess emissions} \times \text{Global carbon price}

- Excess emissions = deviation from world per capital average (+ for US, - for India)
- This addresses “differentiated responsibilities”
  - Rich, high-emission countries pay into fund
  - Poor, low-emission countries receive from fund
Maximizing treaty strength

- If G is high, rich countries will want P* low
- If G is low, poor countries will want P* low
- Some moderate G maximizes the P* that a super-majority will accept
A mechanism for the willing (G20?)

- Countries with little stake in the Green Fund (near average emissions) first determine G
  - G will be determined so that both rich and poor countries benefit from an effective agreement
- Then countries vote for $P^*$; low price wins
  - No country $i$ commits to a $P^* > P_i$, so any country could protect itself by naming a low $P_i$ if G were unacceptable
- Mechanism promotes a strong agreement
Summary

- Keys to a strong climate treaty
  - “I will if you will” (common commitment)
  - Two parameters
    - Carbon price (common intensity of effort)
    - Green fund intensity (addresses asymmetries)

- Further research
  - Equilibrium simulations using standard climate models to identify best “climate club”
  - Develop details of treaty (e.g. voting mechanism)
Price Carbon

I will if you will
Backup
Carbon price vs. cap & trade
Price Carbon Emissions?

- Global Cap-and-Trade
  - Prices International Permits (Kyoto’s AAUs)
  - No requirement to price *emissions*
  - Kyoto mainly caused renewable regulations

- Global Carbon Price Commitment
  - Pricing emissions is what counts
  - For a while renewables get credit—but only for the (carbon they actually save) × (global price)
Pricing of Carbon *Emissions*

### Price Commitment

- **Cap-and-Trade (EU ETS)**
- **Fossil Fuel Taxes**
- **Price-Like Carbon Regulations**
- **Command and Control Regulations**

### Cap-and-Trade

- **Cap-and-Trade Fossil Fuel Taxes**
- **Price-Like Regs.**

---

*“Best avoided when feasible” —Jean Tirole*
Why Global Cap-and-Trade Fails

- Trading risk pushes up individual “targets”
- Free-riding pushes up individual “targets”
- No one can find a common-commitment
- 2°C pushes the global cap down
- It will never add up
Climate games
Two International Games

- **Public-Goods Game:**
  - Each country chooses its abatement, $A_j$

- **Cap-and-trade Game**
  - Each country chooses its target, $T_j$
  - Sells carbon credits for $P \times (A_j - T_j)$
  - $P = \text{marginal cost of each country } j$

- Countries acts in their self interest
Payoff = Net-Benefit

\[ NB_j = b_j A - c_j A_j^2 + P (A_j - T_j) \]

- Climate benefit = \( b_j \times \) (Total abatement)
- Abatement cost = \( c_j \times \) (country abatement)\(^2\)
  - Marginal cost = 2 \( A_j = P \)
- Carbon Trade Revenue = \( P \times (A_j - T_j) \)
  - Only under cap-and-trade
Cap & Trade Can Beat Public Goods

<table>
<thead>
<tr>
<th>Game #1</th>
<th>Public Goods</th>
<th>Cap and Trade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$A_j$</td>
<td>$T_j$</td>
</tr>
<tr>
<td>Country</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.5</td>
<td>$1$</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>$2$</td>
</tr>
<tr>
<td>Total</td>
<td>1.0</td>
<td>1.13</td>
</tr>
</tbody>
</table>

- Country 1: $b_j = 1, c_j = 1$
- Country 2: $b_j = 2, c_j = 2$
### Or Not

<table>
<thead>
<tr>
<th>Game #2</th>
<th>Public Goods</th>
<th>Cap and Trade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A&lt;sub&gt;j&lt;/sub&gt;</td>
<td>P</td>
</tr>
<tr>
<td>Country</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.17</td>
<td>$1</td>
</tr>
<tr>
<td>2</td>
<td>1.00</td>
<td>$2</td>
</tr>
<tr>
<td>Total</td>
<td>1.17</td>
<td></td>
</tr>
</tbody>
</table>

- Country 1: b<sub>j</sub> = 1, c<sub>j</sub> = 3
- Country 2: b<sub>j</sub> = 2, c<sub>j</sub> = 1
- Negative Target ➔ Cap > BAU emissions
THE GLOBAL QUANTITY-TARGET, AND PRICE-TARGET GAMES
Global-Target Games

- $N$ identical countries in the world

**The quantity-target game**
- Each country names a target $Q^T_j$
- $Q^T = \text{maximum (weakest) } Q^T_j$
- National caps = $Q^T / N$

**The price-target game**
- Each country names a target $P^T_j$
- $P^T = \text{minimum (weakest) } P^T_j$
- National carbon prices = $P^T$
- Currency = Global index of major currencies (USD, euro, ...)
Identical Countries $\Rightarrow$ Identical Games

- Every $P^T$ matches some $Q^T$ that would cause global price $P^T$
- Vote for $P^T$ or its matching $Q^T$
- The same holds in each identical country
Optimal Cooperation

- “I will if you will.”
- If you vote for a high $P$ and set price, then $P$ is high for all (and optimal)
- Voting for $Q$ also works optimally
Price handles some asymmetries

- Country 1: Temperate w/ renewable resources
- Country 2: Hot with only coal
- With a P-target, country 2 accepts high price because carbon revenues stay in country 2
- With a Q-target, Country 2 must pay country 1 a lot of money (to buy carbon credits)
- P-target minimizes transfers among countries
But what if countries disagree about price

- Poor countries
  - Have a lower cost/ton of abatement
    ➔ a greater social cost of abatement
  - Have a higher discount rate
    ➔ less benefit from future climate

- Poor countries will vote for a low global $P_T$

- And the lowest price wins
LINK THE GREEN FUND TO PRICE
Green Fund Payment and Reward

- Green Fund Payment Received = \( G \cdot \Delta E_j \cdot P^T \)

- \( \Delta E_j = (\text{World emission}) - (\text{Country emission}) \) on a per-capita basis.

- \( G = \text{the strength of the Green Fund} \)

Green-Fund Game Payoff Function:

\[
NB_j = b_j A - c_j A_j^2 + G \cdot \Delta E_j \cdot P^T
\]
Green-Fund Game

- Example Game with Three Countries
  - “U.S.” = High, “China” = Average, “India” = Low emissions / capita
  - So China neither pays nor is paid Green Funds
  - India wants a low global price
  - As with other games,
    Self interest and no cheating
Green-Fund Game Rules

1. China picks G
2. Then, all three vote for $P^T$
3. All get the Net-Benefit payoff

Strategy

- China will raise India’s vote for $P^T$ by picking $G > 0$, but not too high because the U.S. would vote for a lower $P^T$ than India
## Without the Green Fund

<table>
<thead>
<tr>
<th>Country</th>
<th>pop</th>
<th>$e$</th>
<th>Voted P</th>
<th>$P^*$</th>
<th>$A_j$ %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>billions</td>
<td>ton/cap.</td>
<td>$/ton$</td>
<td>$/ton$</td>
<td>%</td>
</tr>
<tr>
<td>U.S.</td>
<td>0.3</td>
<td>18</td>
<td>$31$</td>
<td>$10$</td>
<td>6.7%</td>
</tr>
<tr>
<td>China</td>
<td>1.2</td>
<td>5</td>
<td>$31$</td>
<td>$10$</td>
<td>6.7%</td>
</tr>
<tr>
<td>India</td>
<td>1.0</td>
<td>1.1</td>
<td>$10$</td>
<td>$10$</td>
<td>9.1%</td>
</tr>
</tbody>
</table>


The Green-Fund Game

<table>
<thead>
<tr>
<th>Country</th>
<th>pop</th>
<th>$/ton</th>
<th>Voted P</th>
<th>$/ton</th>
<th>$/ton</th>
<th>$/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>billions</td>
<td>ton/cap.</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>U.S.</td>
<td>0.3</td>
<td>18</td>
<td>$26</td>
<td>18%</td>
<td>11.5¢</td>
<td>-4¢</td>
</tr>
<tr>
<td>China</td>
<td>1.2</td>
<td>5</td>
<td>$31</td>
<td>18%</td>
<td>3.2¢</td>
<td>0.0¢</td>
</tr>
<tr>
<td>India</td>
<td>1.0</td>
<td>1.1</td>
<td>$26</td>
<td>24%</td>
<td>1.0¢</td>
<td>1.2¢</td>
</tr>
<tr>
<td>World</td>
<td>2.5</td>
<td>5</td>
<td>$26</td>
<td>18%</td>
<td>3.3¢</td>
<td>0.0¢</td>
</tr>
</tbody>
</table>

Poorest countries gain even ignoring climate benefits!
The Green-Fund Game vs. Cap and Trade

<table>
<thead>
<tr>
<th>Game</th>
<th>Global price, $P$</th>
<th>$P$ as a % optimal</th>
<th>$A$ as a % optimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green-Fund Game</td>
<td>$26.40$</td>
<td>93%</td>
<td>93%</td>
</tr>
<tr>
<td>Global Cap and Trade</td>
<td>$9.51$</td>
<td>33%</td>
<td>33%</td>
</tr>
<tr>
<td>Optimal Outcome</td>
<td>$28.52$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Cap-and-trade has individual caps, no Green Fund, and same physical world
Green-Fund Game Mechanisms

- The Green-Fund is also a climate incentive
  - Reduce your E/capita and pay less / get more
  - This works equally on every country
- Let near-average E/capita country vote for G
  - Then pick the median vote for G
- Trading carbon-revenue credits could make compliance more agreeable