Track and Trade:
A liability approach to climate policy

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Significant obstacles:

- Agreement on a global tax rate:
  - Heterogeneity in beliefs about future damage
  - Heterogeneity in discount factors
- Political acceptability
  - Asks emitters to pay today for damage that may or may not happen to future generations

Where carbon is taxed (World Bank 2014)

Country /Jurisdiction	Tax rate (rough USD equivalent)
Australia	$20 per tCO2e (revoked)
British Columbia	$24 per tCO2e (2014)
Costa Rica	3.5% tax on fossil fuels
Denmark	$31 per tCO2e (2014)
Finland	$39 per tCO2e (2013)
France	$8 per tCO2e (2014)
Iceland	$10 per tCO2e (2014)
Ireland	$23 per tCO2e (2013)
Japan	$2 per tCO2e (2014)
Mexico	<$4 per tCO2e (2014)
Norway	$4-69 per tCO2 (2014)
South Africa	$10 per tCO2e (2016*)
Sweden	$168 per tCO2e (2014)
Switzerland	$68 per tCO2e (2014)
UK	$15.75 per tCO2e (2014)

Willingness to pay

Willingness to pay in the US population (Jenkins, 2014):

- \$2-\$8 per tCO_2

Social cost of carbon (US Government, 2013):

- \$37 per tCO_2e and growing over time (in 2007 dollars)

Cap-and-trade programs suffer from the same drawbacks, if not more. (Hsu, 2011)

Classical Pigovian taxation

Two-period illustration with single decision-maker:

- Utility $u(e)$ from emitting e units of CO2 in Period 1;
- Emissions lead to $d \times e$ damage in Period 2;
- Discount factor β.

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Carbon tax asks emitter to pay (βd) per unit of emissions. DM's objective is to maximize Period-1 payoff:

$$\max u(e) - (\beta d)\, e.$$

First-best emissions pattern is achieved:

$$u'(e^*) = \beta d.$$

The Pigovian logic revisited

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Main intuition

Pigovian taxation need not exact full payment upon emitting.

Potential application: carbon liabilities

Converting CO_2 emissions into national (financial) debt

- Emitting CO_2 would be accompanied by the issuance of a *carbon liability;*
- Countries would be made liable to pay over time as climate damage occurs;
- Debt would be owed to an international climate fund;
- Liabilities would not expire but would decay at the rate of atmospheric CO_2.

X: quantity of liabilities sold by DM
p: liability market price
C: convex cost of holding climate debt

DM maximizes the objective:

$$\max_{e,X} u(e) - \beta d\left(e - X\right) - pX - C\left[p\left(e - X\right)\right]$$

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Optimizing in e and X yields:

$$\begin{aligned} e: \quad u'(e) &= \beta d + pC'\,[p\,(e - X)] \\ X: \quad p &= \beta d + pC'\,[p\,(e - X)] \end{aligned}$$

Related literature

- Green accounting and stakeholder value (Weitzman, 1976; Hartwick, 1990; Cairns, 2004; Cairns and Lasserre, 2006; Magill et al., 2013)
- Alternative to carbon tax involving a climate fund (Gersbach and Winkler, 2012)
- Liabilities as a means to cooperation (Gampfer, 2014; Gampfer, Gsottbauer and Delas, 2014)
- Cost-sharing literature: policy should mimic the cost structure (e.g., Moulin, 2002)

- Regulation (taxation) is costly even in the absence of damage, whereas liabilities only kick in when harm actually occurs. (Calabresi, 1970; Shavell, 2011)
- On the other hand, a liability approach is typically more informationally demanding because it requires establishing tort (Kolstad et al, 1990; Shavell, 2011).

Hence, a liability approach is likely to be more appropriate in situations where damage is highly uncertain but where its source can be easily established.

This is precisely the case of climate change:

- The magnitude of future damage is typically unknown;
- but the responsibility of countries towards CO_2 concentration can be readily established.

- $\{X_t^i\}_{t=0}^{+\infty}$: emission flow of country i;
- Stock of CO2 due to country i's emissions, accounting for decay:

$$Z_t^i = \sum_{s=0}^{t} \gamma^s X_s^i :$$

- $Z_t = \sum_i Z_t^i$: total stock of CO2 in the atmosphere at date t;
- Flow of (stochastic) damage borne by all countries:

$$\{D_t(Z_t)\}_{t=0}^{+\infty} = \left\{ \sum_i D_t^i(Z_t) \right\}_{t=0}^{+\infty}$$

Principle: Each period, countries are required to contribute $\mu_t Z_t^j$ to an international climate fund, where $\mu_t = \frac{\partial D_t}{\partial Z_t}$, the current marginal damage.

Efficiency of a carbon debt scheme

Proposition 1

Such a carbon debt scheme yields first-best emission patterns.

Proof. Country i evaluates its present expected net benefit as:

$$PENB_i = \mathbb{E}_{t=0}\left[\sum_{t=0}^{+\infty} \beta^t \left\{B_t^i\left(X_t^i\right) - \mu_t Z_t^i\right\}\right]$$

where $B_t^i\left(X_t^i\right)$ is the per-period benefit of country i resulting from its emissions in the current period. Country i then chooses an emissions stream such that:

$$\frac{\partial B_t^i}{\partial X_t^i} = \mathbb{E}_t\left[\sum_{s=t}^{+\infty} \beta^{s-t} \mu_s \frac{\partial Z_s^i}{\partial X_t^i}\right] = \mathbb{E}_t\left[\sum_{s=t}^{+\infty} (\beta\gamma)^{s-t} \frac{\partial D_s}{\partial Z_s}\right] \equiv \tau_t.$$

- Only information required, on top of emission history of countries, is:

$$\mu_t = \frac{\partial D_t}{\partial Z_t}.$$

- While no trivial task, it is far less daunting to be working with observed data than with predictions over many decades.
- By comparison, the information required to implement an efficient carbon tax, is the *expected*, *discounted* sum of the marginal impacts of current emissions on future climate damage:

$$\tau_t \equiv \mathbb{E}_t \left[\sum_{s=t}^{+\infty} (\beta\gamma)^{s-t} \frac{\partial D_s}{\partial Z_s} \right].$$

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- This is actually a good thing as it allows for greater decentralization (i.e., greater disagreement) rather than having to reach consensus on such difficult issues;
- Decentralization can only be taken so far however: individuals and firms are too short lived;
- Nations are a much better scale: they are both long-lived and required to pay their debts.

In practice, countries may very well have different discount factors, and diverging forecasts, so that FOCs become:

$$\frac{\partial B_t^i}{\partial X_t^i} = \mathbb{E}_t^i \left[\sum_{s=t}^{+\infty} \left(\beta^i \gamma\right)^{s-t} \frac{\partial D_s}{\partial Z_s} \right].$$

Heterogeneity yields trade opportunities:

- A market for debt leaves it to countries to determine how much debt they wish to hold based on their predictions of future climate change damage.
- Should opinions differ, we show that a single carbon price is obtained through trade.

Proposition 3

With convex costs of holding debt, the tradable carbon liabilities scheme where the liability rule is $\mu_t Z_t^i \mathbb{I}_t$ yields a unique carbon price.

Sketch of proof. Given a competitive market price,

- Countries with low expected discounted damage will choose to buy carbon liability (and be paid to do so);
- Countries with high expected damage will sell their liabilities (and pay the buyer);
- Possible corner solution where some countries with highest expected damage sell all their liabilities and choose to emit according to their own (strict) view of climate damage rather than the market price.

Interpretation

- Carbon liabilities act as tradeable Arrow-Debreu-type securities that make markets complete, thus yielding allocative efficiency through decentralization.
- Moreover, the mechanism is immune to strategic manipulation both in the discount factor and in the expectations because the final allocation of debt is a competitive market outcome.

- One drawback of the liability scheme is that countries face an increasing temptation to default on their accumulated carbon debt.
- On the other hand, a drawback of the carbon tax is that its adoption is costly up front. This is because it requires payments immediately for climate damage that may take decades or more to materialize.

- We show that the temptation to default on may be less severe than the current temptation to delay the tax indefinitely

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- allows for country heterogeneity in discount factors and beliefs about climate change.

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Highlights a tradeoff between participation and commitment.

Future directions

Operational feasibility:

- Problem of attribution (information extraction)

Normative reflection:

- Responsibility for risk or outcomes?
- Spatial redistribution (SJE 2011)

Political feasibility:

- Short-term policymakers
- Imperfectly competitive markets

Comparing defaulting costs

Proposition 4

Defaulting on liability payments is more tempting than putting an end to a carbon tax:

$$\Delta_{liability,T} - \Delta_{tax,T} = -\left(\gamma Z^{i}_{T-1}\right)\tau_T < 0,$$

where $\Delta_{liability,T}$ and $\Delta_{tax,T}$ are the net costs of putting an end to each scheme.

Note: This comparison is an underestimate, as it does not account for the reputational costs of defaulting on debt.

Comparing delay costs

Proposition 5

A carbon liability scheme is less costly to adopt than a carbon tax. Comparing their net benefits over the first L periods yields:

$$\Delta_{liability-tax,L} = \beta^L \mathbb{E}_0 \left[\tau_L Z_L^i\right] > 0.$$

Note: Despite the β^L term, the difference is not necessarily small, even if L is large:

- If damage is a convex function of total stock, and if stock increases over time, the tax rate τ_L increases with L.
- Therefore, the size of the difference can even increase with L if $\tau_{L+1}/\tau_L > 1/\beta$. With discount factors close to one, this is a distinct possibility.

- Suppose $D(Z_t) = \bar{D}(Z_t) + \varepsilon_t$ where all the uncertainty is contained in ε.
- Accordingly, $\mu_t = \frac{\partial \bar{D}_t}{\partial Z_t}$, debt does not depend on realized harm.

Modify liability payments to be

$$\mu_t Z_t^i \mathbb{I}_t,$$

where

$$\mathbb{I}_t = \frac{D(Z_t)}{\bar{D}(Z_t)}.$$

Efficiency of a carbon liability scheme

Proposition 2

The liability rule $\mu_t Z_t^i \mathbb{I}_t$ is first-best efficient and yields payments proportional to realized damage.

Proof. By definition, $\mathbb{E}_t [\mathbb{I}_t] = 1$ for all $s \geq t$. Expected payments are unchanged and Prop 1 applies.
Also,

$$\mu_t Z_t^i \mathbb{I}_t = \frac{d\bar{D}_t}{dZ_t} Z_t^i \frac{D(Z_t)}{\bar{D}(Z_t)}$$
$$= \frac{\frac{d\bar{D}_t}{dZ_t}}{\bar{D}_t(Z_t)/Z_t} \times \frac{Z_t^i}{Z_t} \times D_t(Z_t).$$