Environmental policy in the presence of bias and uncertainty

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EU climate policy

Climate policy in the European Union:

- EU ETS: Covers ∼40% of total emissions
  - Large industrial installations, thermal electricity generation, intra-EU aviation
  - Cap-and-trade system with emissions permits allocated by country based on historical emissions
  - Climate goals determined jointly; delegated to the European Commission (with periodic adjustments)
- EU ETS 2: for home heating, transport fuels
  - Trading starts only in 2027
- Other actions at the member state level
  - Domestic carbon taxes for transport fuels
  - Support for improving energy efficiency
  - Feed-in tariffs for renewable electricity

EU climate policymaking—and politics

EU climate policy is:

- Implemented by / delegated to the European Commission...
- ...but with goals determined at the EU level...
- ...involving the European Council = member state governments...
- ...who are happy to blame Brussels when climate policy becomes "too hot to touch" at home...
- ...or plead for special treatment because of unique national circumstances...
- ...yet, at other times, undertake efforts additional to EU regulations.

This paper

We want to model a process in which:

- Countries get together to set climate policy goals, trying to control a common externality using a cap-and-trade system;
- Policymakers can face different degrees of political pressure at home to loosen/tighten climate policy; or different shocks (income or taste)
- The pressures/shocks are only known about ex post
  $\Rightarrow$ a need for flexibility
- But there is always an incentive to free-ride:"bias" towards consumption $\Rightarrow$ a need for commitment
- .....so there is a *trade-off between commitment and flexibility*
- Emissions are capped—but local governments can undertake complementary investments, e.g. into energy efficiency or supporting renewable electricity generation

Research question

- Are there cases in which the centralised/EU climate policy is less ambitious that the decentralised/country level policy?
- Is there a need to regulate "complementary" climate actions by member states? Do we need common rules ?
- In other words, could it ever be the case that unilateral "green" actions have adverse welfare effects on other countries?

Commitment vs. flexibility

We borrow the commitment vs. flexibility framework of Halac & Yared (2018), and adapt it to a different setting.

- A mechanism design approach;
- Governments are ex post tempted to be “lax” on policy;
  - bias towards consumption today: excessive debt raising
  - There is a need to commit: an ex ante rule to bind governments’ hands;
- Governments are also exposed to taste/income shocks that affect the MU of current spending and are private information (only available to ex-post goverments)
  - There is a need for some flexibility, so that policies can be adapted to economic/political conditions;
- Optimal mechanism: fiscal debt rule (ceiling)

Our framework

We adapt the model of Halac & Yared (2018) on fiscal rules, with subtle differences:

- Governments interact on a market:
  - H&Y18: debt market
  - This paper: permit market
- The presence of externalities:
  - H&Y18: no externalities
  - This paper: environmental externality
- Inter-jurisdictional transfers:
  - H&Y18: no transfers
  - This paper: transfers implicit because of permit trading

The model

There is a continuum of countries/governments and each country observes a shock to its economy, $\phi > 0$ which is private information.

- types $\phi \in [\underline{\phi}, \overline{\phi}]$, distributed with atomless, twice differentiable c.d.f. $F(\phi)$.
- The types reflect the environmental preference (relative to consumption) of different countries and are privately observed
- Continuum: all countries are "small".
- Symmetry: unit mass of ex-ante identical countries differentiated only by their ex-post type.

2 policy variables :

- emissions
- climate investments

Total emissions are capped at E.

- The emission permits are allocated symmetrically to all countries: permit endowment $w_i = w = E$.

Firm's Problem: emissions

- A representative firm chooses emissions e to maximise profits given the permit price p:

$$\max_e \pi(e; g, p, w) = B(e+g) + p(w-e),$$

where $y = e + g$ is total energy and g is climate investment.

- $B_e \geq 0, B_{ee} < 0$
- Investment cost $c(g), c' \geq 0, c'' > 0$
- optimal emissions $e^* = e^*(g, p)$.

Country's Welfare

Welfare is given by

$$\phi \underbrace{\left[\pi(e^*; g, p, w) - c(g)\right]}_{\text{Consumption utility}} - (\underbrace{d(e^*(g,p)) + D(E)}_{\substack{\text{Local and global} \\ \text{pollution damage}}}).$$

- ϕ is the "weight" given to consumption/income relative to environmental damages
- $e^* = e^*(g,p)$, and price p adjusts to clear the permit market :

$$\int_{\underline{\phi}}^{\overline{\phi}} e^*(g,p) f(\phi) d\phi = E.$$

Ex-post government: Policy making stage-investment level

After the realisation of its type ϕ, a country when choosing investment g, is tempted to underweight environmental damages by the term $\beta \in (0, 1]$:

$$\phi\left[\pi(e^*; g, p, w) - c(g)\right] - \beta(d(e^*(g, p)) + D(E)).$$

- present bias: its welfare ex-post overweighs the importance of income compared to its welfare ex-ante
- countries are small and so take the permit price p as given (as well as their effect on E)
- ex-post optimal investment level $g^* = g^*(\phi, p)$.

Ex-ante government: Planning stage-investment rule

- The ex ante government faces no temptation and has the following objective function

$$\mathbb{E}_{\phi}\left[\phi\left[\pi(e^*; g, p, w) - c(g)\right] - \left(d(e^*(g, p)) + D(E)\right)\right]$$

- two frictions
  - for $\beta < 1$, the ex-post and ex-ante governments have different objectives
  - the realisation of ϕ is privately observed and is not verifiable ex-post: no type contingent investment rule
- with full flexibility (no investment rule), the ex-post government would underinvest
- with full commitment, the ex-post government cannot adjust to its type
- investment rule (floor) that optimises this trade-off

Ex-ante government: Planning stage-investment rule

- $\phi^* \in [0, \overline{\phi}]$ solves

$$\max_{\phi^*} \int_{\underline{\phi}}^{\phi^*} [\phi\,[\pi(e^*; g^*(\phi, p)) - c(g_i^*(\phi, p))] - (d(e^*) + D(E))]f(\phi)d\phi$$
$$+ \int_{\phi^*}^{\overline{\phi}} [\phi\,[\pi(e^*; g^*(\phi^*), p) - c(g^*(\phi^*, p))] - (d(e^*) + D(E))f(\phi)d\phi \tag{1}$$

- a cutoff $\phi^* \in [0, \overline{\phi}]$ (and the corresponding investment floor) such that
  - all types $\phi \leq \phi^*$ can make their full flexibility ex-post optimal choices within the limit, $g^*(\phi, p)$
  - all types $\phi > \phi^*$ are constrained and thus invest at the investment floor, $g^*(\phi^*, p)$

Ex-ante government: Planning stage-investment rule

- the FOC wrt ϕ^* yields

$$\int_{\phi^*}^{\overline{\phi}} \left[(\phi(p(\phi^*, E) - c'(g^*(\phi^*, p)) + d'(e^*(\phi^*, p)) \right] g_\phi^*(\phi) d\phi = 0 \quad (2)$$

  this condition implies that ϕ^* is set so that the average distortion above ϕ_u^* is 0: there exists $\hat{\phi} > \phi_u^*$ such that for $\phi \in [\phi_u^*, \hat{\phi}]$

$$\phi c'(g^*(\phi_u^*, p) < \phi p + d'(e^*(\phi_u^*, p))$$

  and hence the government underinvests (overemmits) relative to its ex-ante optimum while for $\phi \in (\hat{\phi}, \overline{\phi}]$

$$\phi c'(g^*(\phi_u^*, p) > \phi p + d'(e^*(\phi_u^*, p))$$

  and a government overinvests relative to its ex-ante optimum.

- ϕ_u^* defines an optimal trade-off between more discretion for the types that underinvest and more flexibility for the types that overinvest.

Ex-ante government: Planning stage-investment rule

- solving the FOC for ϕ_u^*

$$\frac{\mathbb{E}[\phi|\phi \geq \phi_u^*]}{\phi_u^*} = \frac{1}{\beta} \tag{3}$$

- depends only on the bias β: as β increases (lower present bias), the cut-off value increases (under some mild conditions on the c.d.f.)
- for $\beta = 1$, no present bias and $\phi_u^* = \overline{\phi}$: no reason to restrict any types
- for $\beta \leq \underline{\phi}$, very strong present bias and $\phi_u^* \leq \underline{\phi}$: no flexibility, all types are constrained
- for $\beta \in (\underline{\phi}, 1)$, ϕ_u^* balances the trade-offs between commitment and flexibility

Ex-ante Coordinated Rule-Exogenous E

- the rule is chosen by a central authority (EU) and takes into account all countries AND the impact of the rules on the price in the permits market, $p(\phi^*)$
- choose ϕ^* that solves

$$\int_{\underline{\phi}}^{\phi^*} [\phi(B(y^*(\phi, p^*(\phi^*))) + p^*(\phi^*)(\omega - e^*(\phi, p^*(\phi^*)))$$
$$-c(g^*(\phi, p^*(\phi^*)))) - (d(e^*(\phi, p^*(\phi^*)))) + D(E))] \, f(\phi) d\phi$$
$$+ \int_{\phi^*}^{\overline{\phi}} [\phi(B(y^*(\phi^*, p^*(\phi^*))) + p(\omega - e^*(\phi^*, p^*(\phi^*)))$$
$$- c(g^*(\phi^*, p^*(\phi^*)) - (d(e^*(\phi^*, p^*(\phi^*))) + D(E))] \, f(\phi) d\phi$$

subject to

$$\int_{\underline{\phi}}^{\overline{\phi}} e^*(\phi^*, p) f(\phi) d\phi = E.$$

Ex-ante Coordinated Rule-Exogenous E

- the FOC yields

$$
\begin{aligned}
& p_\phi^* \left[\int_{\underline{\phi}}^{\phi^*} \phi(\omega - e^*) f(\phi) d\phi + \int_{\phi^*}^{\overline{\phi}} \phi(\omega - e^*) f(\phi) d\phi \right] + \\
& p_\phi^* \left[\int_{\underline{\phi}}^{\phi^*} d'(e^*)((1-\beta) g_p^* - e_p^*) f(\phi) d\phi + \int_{\phi^*}^{\overline{\phi}} d'(e^*)(1 - \beta \frac{\phi}{\phi^*}) g_p^* - e_p^*) f(\phi) d\phi \right] \\
& + \int_{\phi^*}^{\overline{\phi}} \left(1 - \beta \frac{\phi}{\phi^*} \right) g_\phi^* d'(e^*) f(\phi) d\phi = 0
\end{aligned}
$$

- 1st row: direct price effects going through the permit market and the implicit transfers to countries
- 2nd row: indirect price effects going through the optimal investment and emissions choices
- 3rd row: direct effects of the cut-off rule as in uncoordinated actions case

Ex-ante Coordinated Rule-Exogenous E

- solving for ϕ^*, we get the coordinated cut-off value ϕ_c^*

$$\frac{\mathbb{E}[\phi|\phi \geq \phi_c^*]}{\phi_c^*} = \frac{1}{\beta} + \underbrace{\frac{p_\phi^*}{\beta d'(e^*(\phi_c^*, p^*(\phi_c^*)))g_\phi^*(1 - F(\phi_c^*))}}_{<0} \Bigg[\rho(\phi_c^*) + \lambda(\phi_c^*, \beta)$$

$$\underbrace{- \left(\int_{\underline{\phi}}^{\phi_c^*} d'(e^*(\phi, p^*(\phi_c^*)))e_p^* f(\phi) d\phi + \int_{\phi^* c}^{\overline{\phi}} d'(e^*(\phi_c^*, p^*(\phi_c^*)))e_p^* f(\phi) d\phi \right) \Bigg]}_{\text{price effect on damages}>0} \quad (4)$$

where

$$\rho(\phi_c^*) = \underbrace{\left[\int_{\underline{\phi}}^{\phi_c^*} \phi(\omega - e^*(\phi, p^*(\phi_c^*)))f(\phi)d\phi + \int_{\phi_c^*}^{\overline{\phi}} \phi(\omega - e^*(\phi_c^*, p^*(\phi_c^*)))f(\phi)d\phi \right]}_{\textit{redistributive effect}} \leq 0$$

$$\lambda(\phi_c^*, \beta) = \underbrace{\left[\int_{\underline{\phi}}^{\phi_c^*} d'(e^*(\phi))(1 - \beta)g_p^* f(\phi)d\phi + \int_{\phi_c^*}^{\overline{\phi}} d'(e^*(\phi_c^*))(1 - \beta\frac{\phi}{\phi_c^*})g_p^* f(\phi)d\phi \right]}_{\textit{discipline effect}} \lesseqgtr 0$$

Ex-ante Coordinated Rule-Exogenous E

- three different channels for the welfare effects of ϕ^* ($\frac{\mathbb{E}[\phi|\phi\geq\phi^*]}{\phi^*}$ is decreasing in ϕ^*)
  - redistributive effect $\phi^* \downarrow$: as a result of less flexibility, emissions $\downarrow$, permit price $\downarrow$ which is beneficial for high types who have to emit more and buy more permits
  - discipline effect for $g_p > 0$, $\phi^* \uparrow$: as a result of more flexibility, permit price $\uparrow$, green investment $\uparrow$ which improves the discipline of unconstrained low types who underinvest
  - damages term $\phi^* \downarrow$: with less flexibility, emissions $\downarrow$ and marginal damages $\downarrow$

Ex-ante Coordinated Rule-Exogenous E

- whether ϕ_c^* is higher or lower than ϕ_u^* will depend on the relative magnitude of these effects and the degree of present bias
    - for high present bias, $\beta \leq \underline{\phi}$: the uncoordinated rule dictates zero flexibility i.e , $\phi_u^* = \underline{\phi}$. Then, $\phi_c^* > \phi_u^*$ and the coordinated rule is more lax (more flexibility)
        - constrained types, $\phi \geq \phi_u^*$: discipline effect is zero, the redistributive effect $\rightarrow 0$ because all types emit up to their allowance and the damage related term< 0 so that $\phi^* \uparrow$
        - unconstrained types, $\phi < \phi_u^*$: as $\beta \rightarrow \underline{\phi}$, their mass $\rightarrow 0$ so the redistributive effect $\rightarrow 0$, the discipline effect< 0,the damage related term< 0 so that $\phi^* \uparrow$
    - for low present bias, $\beta = 1$: no reason to restrict types i.e., $\phi_u^* = \overline{\phi}$. Not clear whether the coordinated rule is more or less lax
        - discipline effect$= 0$, redistributive effect> 0, damage related term< 0: permit price $\downarrow$ (as as result of a tighter rule) would be socially beneficial through the standard redistributive channel but green investment $\downarrow$, emissions $\uparrow$ and local marginal damages $\uparrow$

Ex-ante Coordinated Rule-Endogenous E

- taking into account global damages and the effect of E on p, the FOC wrt E gives us

$$\frac{\mathbb{E}[\phi|\phi \geq \phi_c^*]}{\phi_c^*} = \frac{1}{\beta} + \frac{D'(E^*)}{\beta d'(e^*(\phi_c^*, p^*(\phi_c^*, E^*))} - \frac{\int_{\underline{\phi}}^{\overline{\phi}} \phi B'(y^*) f(\phi)\phi}{\beta d'(e^*(\phi_c^*, p^*(\phi_c^*, E^*))} \quad (5)$$

- which combined with the FOC for ϕ^* gives us

$$\mathbb{E}\left[\phi\right] p = D'(E^*) - \frac{1}{\int_{\underline{\phi}}^{\overline{\phi}} e_p^* f(\phi)\phi} \Bigg(\rho(\phi_c^*)$$

$$+ \lambda(\phi_c^*, \beta) - \int_{\underline{\phi}}^{\phi_c^*} d'(e^*(\phi, p^*(\phi_c^*, E^*))) e_p^* f(\phi) d\phi - \int_{\phi_c^*}^{\overline{\phi}} d'(e^*(\phi_c^*, p^*(\phi_c^*, E^*))) e_p^* f(\phi) d\phi \Bigg)$$

- the price of carbon takes into account global and local marginal damages and the redistributive and discipline effects

Questions-Next Steps

- Next Steps
  - compare the coordinated choice of the total emissions cap E with the constrained efficient level: a central planner who is constrained to use a permit market but can make type contingent investment plans
    - How much loss in efficiency?
  - How do coordinated and uncoordinated policies interact?
  - Ex-ante heterogeneous countries?Infinite horizon ?
  - Functional forms