IMPLICIT CARBON PRICES: Making do with the taxes we have

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This Paper

- THIS PAPER: studies the correspondence between *explicit* and *implicit* carbon pricing of a Ramsey-optimal fiscal policy in a neoclassical growth model of climate change.

- We distinguish between two policy tools:

1. CLIMATE POLICY: targets carbon emissions *explicitly* through carbon prices (carbon tax or ETS).

2. FISCAL POLICY: prices carbon *implicitly* through fuel, energy, consumption, income taxes and renewables subsidies.

Central Result

- An EQUIVALENCE RESULT: any arbitrary sequence of explicit carbon prices can be achieved implicitly through a blend of conventional taxes (consumption, energy, and income taxes)

  - The result holds in a optimal setting with lump-sum taxes and no other distortions

  - Also in extensions (in the paper):

1. Ramsey setting with fiscal needs and distortionary taxes.

2. Net-zero climate target with carbon capture.

3. Cap on cumulative emissions constraint.

Contribution to the Literature

- Contributes to the literature that studies the interplay between fiscal policy and climate policy.

- Barrage (REStud 2018) is the closest paper. Climate policy is a carbon tax; interacts with traditional taxes that raise revenue.

  - Fiscal policy is the climate policy tool in this paper. No carbon taxes.

- We set up an Integrated Assessment Model of the global economy Nordhaus and Boyer (2003). A feature of the model is that the optimal policy replicates the optimal tax in Golosov et al. (ECTA 2014).

- Traditional Public Finance, Ramsey taxation literature: Lucas and Stokey (1983), Chari and Kehoe (1999), Jones et al. (JET1997).

Motivation and Policy Debate

- Carbon prices in the world cover only 21,5% of global carbon emissions.
- Fossil fuel users also confront price signals via implicit pricing measures, with fuel taxes dominating these signals.
- There are policy-initiatives to quantify these signals: OECD, Effective Carbon Rates 2021 and World Bank, Measuring Total Carbon Pricing, 2023
- We speak to these initiatives from a macro general equilibrium perspective.

The Model

- Infinite horizon, global economy, single consumption good produced using

(1) $$\tilde{F}(N_{0t}, K_{0t}, E_{0t})$$

where E_{0t} is an energy composite.

- Three energy sources:

1. Oil (exhaustible): $E_{1t} = R_t - R_{t+1}$; R_0 given
2. Coal (exhaustible; abundant): $E_{2t} = A_{2t}N_{2t}$
3. Renewable energy (clean): $E_{3t} = A_{3t}N_{3t}$

- The energy composite is:

$$E_{0t} = [\kappa_1 E_{1t}^{\rho} + \kappa_2 E_{2t}^{\rho} + \kappa_3 E_{3t}^{\rho}]^{1/\rho}$$

where $\sum_{i=1}^{\infty} \kappa_i = 1$, ρ is the elasticity of substitution between the energy sources; κ is relative energy efficiency of the sources.

The Climate Externality

- Oil and coal use increases carbon in the atmosphere S_t

(2) $$S_{t+1} = (1 - \gamma)S_t + E_{1t} + \phi E_{2t}$$

where $\gamma \in (0,1)$ is the natural rate of carbon reabsorption; ϕ: coal carbon intensity.

- Carbon in the atmosphere generates a climate externality

$$Y_t = F_0(S_t, N_{0t}, K_{0t}, E_{0t}) = [1 - x(S_t)]F_0(N_{0t}, K_{0t}, E_{0t})$$

The damage function x is increasing and convex; N_{0t} given.

- Individuals consume, work, and invest in capital.
- Over time, individuals care about the value:

$$\sum_{t=0}^{\infty} \beta^t [u(C_t) - v(N_t)] \tag{3}$$

- Capital depreciates fully within one period; K_0 given.
- Given $\{G_t\}_{t=0}^{\infty}$, aggregate feasibility ∀t is:

$$C_t + K_{t+1} + G_t = Y_t \quad ; \quad N_t = \sum_{i=0}^{3} N_{it} \quad ; \quad K_t = \sum_{i=0}^{3} K_{it} \tag{4}$$

Market Economy

- As a solution concept, we consider a competitive equilibrium in a market economy with taxes

$$\{\tau_t, \tau_t^e, \tau_t^r, \tau_t^c, \tau_t^k, \tau_t^n, T_t\}$$

(Full set of instruments; some are redundant)

Final Good

- There are 4 productive sectors indexed by $j = 0,1,2,3$

- The final good producer chooses $\{K_{0t}, N_{0t}, E_{1t}, E_{2t}, E_{3t}\}_{t=0}^{\infty}$ to maximize profits

$$\pi_0 = \sum_{t=0}^{\infty} q_t^0 [F_0(S_t, N_{0t}, K_{0t}, E_{0t}) - r_t K_{0t} - w_t N_{0t} - \sum_{i=1}^{3} p_{jt} E_{jt} - \tau_t^e E_{0t}]$$

ENERGY TAX

- p_{jt}: energy price $j = 1,2,3$; q_t: Arrow-Debreu price

- τ_t^e: energy tax on the energy composite.

OIL PRODUCER

- A representative firm owns the oil reserves, and chooses $\{R_t\}_{t=0}^{\infty}$ to maximize

$$\pi_1 = \sum_{t=0}^{\infty} q_t^0 (p_{1t} - \tau_t)(R_t - R_{t+1})$$

CARBON TAX

COAL PRODUCER

- A representative firm chooses $\{N_{2t}\}_{t=0}^{\infty}$ to maximize

$$\pi_{2t} = (p_{2t} - \tau_t) F_2(A_{2t}, N_{2t}) - w_t N_{2t}$$

Renewable energy Producer

- A representative firm in the renewables sector chooses $\{N_{3t}\}_{t=0}^{\infty}$ to maximize

$$\pi_{3t} = (p_{3t} - \tau_t^r)F_3(A_{3t}, N_{3t}) - w_t N_{3t}$$

RENEWABLE TAX

Consumers

- Consumers invest in capital and work subject to the following budget constraint

$$\sum_{t=0}^{\infty} q_t^0[(1+\tau_t^c)C_t + K_{t+1}] \leq \sum_{t=0}^{\infty} q_t^0[(1-\tau_t^k)r_t K_t + w_t(1-\tau_t^n)N_t + T_t] + \Pi$$

CONSUMPTION TAX

CAPITAL INCOME TAX

LABOR INCOME TAX

Competitive Equilibrium

A competitive equilibrium with taxes$\{\tau_t, \tau_t^e, \tau_t^c, \tau_t^r, \tau_t^k, \tau_t^n\}_{t=0}^{\infty}$ is a sequence of quantities $\{S_t, K_t, C_t, E_{jt}, N_{jt}\}_{t=0}^{\infty}$ and prices $\{q_t^0, r_t, w_t, p_{jt}\}_{t=0}^{\infty}$ such that:

(i) Consumers maximize welfare subject to their budget constraint;

(ii) Firms maximize profits;

(iii) Atmospheric carbon follows the carbon cycle;

(iv) Markets clear.

Main Result

PROPOSITION 1 (EQUIVALENCE RESULT)

Let $\Omega \equiv \{C_t, N_{it}, E_{it}, K_{it}, S_{jt}\}_{t=0,i=0,1,2,3}^{\infty}$ be a competitive equilibrium with an arbitrary fiscal policy $\{\tau_t, T_t\}_{t=0}^{\infty}$ with $\tau_t = \tau_t^\star$ $\forall t$. Then Ω is also a competitive equilibrium with a fiscal policy given by

$$\tau_t^{e,Pigou} = \tau_t^\star \frac{\phi}{\alpha_{2t}} \quad ; \quad \tau_t^{r,Pigou} = -\tau_t^e \alpha_{3t}$$

$$\tau_t^{c,Pigou} = \frac{\tau_t^\star}{F_{E1,t} - \tau_t^\star}\left(1 - \phi\frac{\alpha_{1t}}{\alpha_{2t}}\right) \; ; \; \tau_{t+1}^{k,Pigou} = \frac{\tau_t^c - \tau_{t+1}^c}{1 + \tau_t^c} \quad ; \quad \tau_t^{n,Pigou} = -\tau_t^c$$

$\forall t$ where $\alpha_{it} = \partial E_{0t} / \partial E_{it}$, $\tau_t = 0$, and any surplus rebated lump-sum through T_t.

Final Remarks

- Explicit carbon taxes effectively regulate emissions from oil and coal (no need of other taxes).
- The equivalence result shows that fiscal policy can fully replicate the policy impact of carbon tax, even without directly targeting the emissions margin.
- The Principle of Targeting applies: it is best to regulate economic activities through tools that directly affect the intended targets.
- Doing implicit carbon pricing is effective but requires tracking the undesired distortions, and fix them! (through additional taxes).

Rest of the paper

- PROPOSITION 2 (OPTIMAL CLIMATE POLICY). A competitive equilibrium Ω is socially optimal if $\tau_t^\star = \mu_t \ \forall t$
- PROPOSITION 4 AND 5. Equivalence result with a Ramsey government that raises revenue with distortionary taxes.
- PROPOSITION 6. Equivalence result in economy with carbon capture technologies.
- COROLLARY 1. Equivalence result in economy with a cap on cumulative emissions.
- Numerical example.