Carbon Trading, Carbon Taxes and Social Discounting

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Introduction

Climate change is a global externality, within periods but also over time

- *Carbon emissions are an externality and an intergenerational problem*
- *Inefficiency and Equity redistribution as two policy objectives*
- *This paper studies what are the implications for policy design of jointly addressing the externality and the intergenerational climate problem*

Literature Review

- *Stern (2007, AER 2008) : low discount rate ⇒ Intergenerational Equity*
- *Critique: discount rate should be consistent with market returns; otherwise, there is a savings problem*
- *We are discussing appropriate Pareto weights… if there's such a thing*
- *Suppose there is social discounting, what are the implications for the design of carbon policies*
- *Not many papers formally address this*

- *Von Below (2012), Barrage (2016)*
- *A subsidy on capital income is optimal*
- *Decreasing consumption taxes/labor income taxes (Barrage, 2016)*
- *Implications for climate policy? Carbon taxes / subsidies to renewable energy / buy oil and supply-side policies*
- *How do we need to modify the climate policies so that they seek intergenerational equity, besides efficiency.*

Goal of the talk: Revisit some results on climate policies:

1. *Uniform carbon taxation on dirty energy inputs*

2. *Coal, not oil, is the biggest threat to climate change*

Model Economy

- *Single consumption good*

$$\tilde{F}(K, N, \mathbf{E})$$

- *3 energy sectors: oil, coal, green*

- *Oil (exhaustible):*

$$E_{1t} = R_t - R_{t+1}$$

- *Coal (abundant):*

$$E_{2t} = A_2 N_{2t}$$

- *Green Energy:*

$$E_{3t} = A_3 N_{3t}$$

- *There is a carbon externality modeled as an output loss*

$$F(K, N, \mathbf{E}, S) \equiv x(S)\tilde{F}(K, N, \mathbf{E})$$

- ***Carbon Cycle.*** *Oil and coal use increases carbon in the atmosphere*

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

- *Individuals derive utility from consumption*

$$\sum_{t=0}^{\infty} \beta^t u(c_t)$$

- *Individuals consume, work and invest in capital*
- *Capital evolves according to the law of motion*

$$K_{t+1} = (1 - \delta)K_t + I_t$$

Socially Optimal Allocation

The *socially optimal allocation* is the path of consumption, output, energy, capital, carbon sequestration and carbon level, $\{C_t^*, \mathbf{E}_t^*, K_t^*, S_t^*\}_{t=0}^{\infty}$, that maximizes the social welfare function

$$\sum_{t=0}^{\infty} \hat{\beta}^t u(c_t)$$

subject to the carbon cycle, the resource constraints and the initial conditions $\{K_0, R_0, S_0\}$.

- *The SOCIAL COST OF CARBON in this model is given by*

$$\mu_t^* = -\sum_{j=0}^{\infty} [\hat{\beta}(1-\gamma)]^j \frac{u'(c_{t+j})}{u'(c_t)} F_S'(t+j)$$

- *Assuming log utility and an exponential damage function of the form*

$$x(S) = e^{-\varphi S}$$

The social cost of carbon becomes

$$\mu_t^* = Y_t \sum_{j=0}^{\infty} [\hat{\beta}(1-\gamma)]^j \varphi$$

Define:

$$\Lambda_t^* \equiv \frac{\mu_t^*}{u'(c_t^*)}$$

The socially optimal allocation satisfies:

A. Marginal productivity of labor equalized across sectors

B. Hotelling Rule on oil extraction

$$\frac{F'_{E_1}(t+1) - \Lambda^*_{t+1}}{F'_{E_1}(t) - \Lambda^*_t} = \frac{u'(c_t)}{\hat{\beta} u'(c_{t+1})}$$

C. Non - arbitrage condition

$$\frac{F'_{E_1}(t+1) - \Lambda^*_{t+1}}{F'_{E_1}(t) - \Lambda^*_t} = F'_k(t+1)$$

Market Economy

- *There is a per-unit carbon tax on oil and on coal, a carbon subsidy on green energy and a subsidy on capital income*

$$\tau_{1t} \;\; ; \;\; \tau_{2t} \;\; ; \;\; \tau_{3t} \;\; ; \;\; s_t^k$$

- *Final consumption good producers maximize*

$$\Pi_0 = \sum_{t=0}^{\infty} q_t^0 [\tilde{F}(K_t, N_{0t}, \mathbf{E}_t, S_t) - r_t K_t - w_t N_{0t} - \sum_{j=1}^{3} p_j E_{jt}]$$

- *Oil* ***firms*** *maximize discounted profits given by*

$$\Pi_1 = \sum_{t=0}^{\infty} q_t^0 (p_{1t} - \tau_{1t})(R_t - R_{t+1})$$

- *Coal* ***firms*** *maximize discounted profits given by*

$$\Pi_2 = \sum_{t=0}^{\infty} q_t^0 (p_{2t} - \tau_{2t}) A_2 N_{2t}$$

- *Green energy firms maximize*

$$\Pi_3 = \sum_{t=0}^{\infty} q_t^0 (p_{3t} + \tau_{3t}) A_3 N_{3t}$$

- *Individuals consume and save in order to maximize*

$$\sum_{t=0}^{\infty} \beta^t u(c_t)$$

s.t. the budget constraint:

$$\sum_{t=0}^{\infty} q_t^0 (C_t + K_{t+1}) \leq \sum_{t=0}^{\infty} q_t^0 (r_t (1 + s_t^k) K_t + w_t N_t + T_t) + \Pi$$

Note that consumers are paid a subsidy on capital income

PROPOSITION 1: Suppose that $\hat{\beta} = \beta$. The socially optimal allocation can be decentralized with carbon taxes equal to

$$\tau_{1t} = \tau_{2t} = \Lambda_t^*$$

$$\tau_{3t} = s_t^k = 0$$

- There is a **uniform tax** on all carbon energy inputs

PROPOSITION 2: Suppose that $\hat{\beta} > \beta$. The socially optimal allocation can be decentralized with taxes equal to

$$\tau_{1t} = F'_{E_{1t}} - (\frac{\hat{\beta}}{\beta})^t (F'_{E_{1t}} - \Lambda^*_t)$$

$$\tau_{2t} = \Lambda^*_t$$

$$s^k_t = \frac{\hat{\beta}}{\beta} - 1$$

Carbon tax on OIL ≠ Carbon tax on COAL

- *Economy saves too little means here:*

low accumulation of capital + fast depletion of oil

- *Carbon tax on oil must pick up the 2 sources of inefficient use of oil*

    1. *Oil reserves are depleted too fast due to **externality and impatience**. The optimal carbon tax must reflect both.*

- *Coal reserves are so abundant that the "savings problem" becomes irrelevant; the tax just needs to correct the externality*

- *A constant subsidy on capital income is optimal (Farhi&Werning, von Below, Barrage)*

Insight 1: Oil under the crust of the earth is a form of capital accumulation.

Insight 2: Oil use may be more important than what we think.

In terms of the externality: Coal is the biggest threat. It is abundant and dirtier. Welfare losses come from the inefficient use of coal, not oil. (van der Ploeg&Withagen)

In terms of the equality redistribution: Oil is the problem, not coal. Welfare losses come from the inefficient use of oil, not coal.

Whether coal or oil is the biggest threat is a quantitative question.

Supply-side policies

PROPOSITION 3: Suppose that $\hat{\beta} > \beta$. The socially optimal allocation can be decentralized with taxes equal to

$$\tau_{1t} = \tau_{2t} = \Lambda_t^*$$

$$s_{E_1 t} = (\frac{\hat{\beta}}{\beta})[F'_{E_1(t)} - \Lambda_t^*]$$

$$s_t^k = \frac{\hat{\beta}}{\beta} - 1$$

Firms are paid to keep oil under the crust of the earth.

- *If the problem of climate change involves an environmental damage and a concern about intergenerational equity, then we must design policy instruments capable of dealing with both sides of the same problem.*

- *Carbon taxes are not just standard Pigouvian taxes*

- *Carbon taxes on oil and coal are not equal*

- *Subsidy on capital income is optimal*

- *Subsidy on oil reserves may be optimal*