The Impact of Environmental Policy on Welfare and Growth

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Nationally collected global carbon tax

- Current climate negotiations employ a quantity-based Kyoto-type approach. It has however been recently noted that this may be unsuited to achieve an ambitious international climate change agreement (Dion, 2012; Cramton, 2013), due to a problem of incentives (Weitzman, 2014, 2015).
- Proposed alternative (Dion, 2012; Cramton, 2013; Weitzman, 2014, 2015): an internationally harmonized, nationally collected carbon tax.
- Since equity is one of the major challenges in global climate change negotiations (Ringius, 2002), it is important to understand the distribution of economic burdens of this proposal.

Will developing countries bear a greater burden?

- Environmental policy may harm growth (Cooper, 2008).
- Developing countries: high fraction of population close to subsistence consumption of energy (Khandker, 2010; Xiaoping, 2014).
- Literature on growth with subsistence consumption:
    - Single sector: impact of subsistence consumption on savings (Steger, 2000).
    - Multi sector: decline of agriculture and rise of services (Echevarria, 1997, 2000; Herrendorf, 2013).
    - Missing: study of the effects of climate and energy policy in an endogenous growth model with subsistence consumption of energy.

Contributions

- Analytical extension of (Steger, 2000) with explicit representation of the carbon-intensive (energy) sector. Non-homothetic preferences may exhibit subsistence consumption of energy.
- Study the impacts of an internationally harmonized, nationally collected carbon tax on growth and welfare across countries.
- Findings:
  - Developing countries do not necessarily bear greater burdens compared to developed countries.
  - However, the effective redistribution of tax revenue is central in order to avoid excessively negative impacts for economies close to subsistence.

Model overview

- Representative household problem:

$$max_{\{c(t),e(t)\}} \int_0^\infty \frac{(c(t)^\alpha (e(t)-\bar{e})^{1-\alpha})^{1-\theta}-1}{1-\theta} e^{-(\rho-n)t} dt \quad (1)$$

$$s.t. \quad \dot{a}(t) = (r-n)a(t) - c(t) - (1+\tau)p_e e(t) + T(t) \quad (2)$$

$$a(0) \equiv a_0, \quad e(t) \geq \bar{e} \geq 0 \quad c(t) \geq 0 \quad (3)$$

$$lim_{t\to\infty}\left(a(t) \cdot exp(-\int_0^t (r-n)ds)\right) \geq 0 \quad (4)$$

$$T(t) \equiv \tau p_e e(t) \quad (5)$$

- Production technologies:

$$y_c = Ak_c \quad \text{and} \quad y_e = Bk_e \quad (6)$$

- Market clearing:

$$y_c(t) - c(t) - \dot{k}(t) - k(t)\delta - k(t)n = 0 \quad (7)$$

$$y_e(t) - e(t) = 0 \quad (8)$$

$$k_c(t) + k_e(t) = k(t) \quad (9)$$

$$k(t) = a(t) \quad (10)$$

Analytical solution

$$c(t) = c_0 e^{\frac{(A-\delta-\rho)}{\theta}t} \tag{11}$$

$$e(t) = \bar{e} + (e_0 - \bar{e})e^{\frac{(A-\delta-\rho)}{\theta}t} \tag{12}$$

$$k(t) = \bar{k} + (k_0 - \bar{k})e^{\frac{(A-\delta-\rho)}{\theta}t} \tag{13}$$

where

$$\bar{k} = \frac{1}{(A-\delta-n)}\frac{A}{B}\bar{e} \tag{14}$$

$$c_0 = \frac{\alpha}{\theta}\frac{1+\tau}{1+\tau\alpha}(\rho+\delta-A+\theta(A-\delta-n))(k_0 - \frac{1}{(A-\delta-n)}\frac{A}{B}\bar{e}) \tag{15}$$

$$e_0 = \bar{e} + \frac{(1-\alpha)B}{\alpha(1+\tau)A}c_0 \tag{16}$$

Saving rate and relative equivalent variation

- Saving rate (net investment / net output):

$$s = \frac{(A - \delta - n)k(t) - c(t) - (1 + \tau)p_e e(t) + T}{(A - \delta - n)k(t)} \tag{17}$$

- Equivalent Variation relative to initial capital stock (REV) of an increase $\Delta\tau > 0$ of the energy tax:

$$REV := \frac{\Delta k_0}{k_0} \equiv \frac{1}{k_0} \frac{\partial_\tau \mathcal{W}}{\partial_{k_0} \mathcal{W}} \Delta\tau \leq 0 \tag{18}$$

  - Welfare at market equilibrium: $\mathcal{W} := \mathcal{U}(c(t), e(t))$.
  - Welfare change: $\Delta\mathcal{W} = \partial_\tau \mathcal{W} \cdot \Delta\tau$
  - $\Delta k_0 = \Delta\mathcal{W} / \partial_{k_0} \mathcal{W}$ causes the same welfare change $\Delta\mathcal{W}$.

The effect of the climate policy on growth and welfare

Proposition (1)

The tax rate τ does not affect the saving rate: $\frac{ds}{d\tau} = 0$.

Proposition (2)

Subsistence consumption has a positive effect on welfare: $\frac{dREV}{dS_0} > 0$, where $S_0 := \frac{p_e \bar{e}}{k_0}$.

Model extension: losses in the redistribution of tax revenue: $T \Rightarrow \phi T$, $0 \leq \phi \leq 1$

Proposition (3)

Assume $\phi = 0$. *For homothetic preferences* ($S_0 = 0$): $\frac{ds}{d\tau} = 0$.
In the presence of subsistence consumption ($S_0 > 0$): $\frac{ds}{d\tau} < 0$.

Proposition (4)

The effect of subsistence consumption on welfare depends on the intensity of losses: $\exists\ \phi^\star$ *s.t.* $\left.\frac{dREV}{dS_0}\right|_{\phi > \phi^\star} > 0 \quad \& \quad \left.\frac{dREV}{dS_0}\right|_{\phi < \phi^\star} < 0.$

Concluding remarks

- Analytically solve endogenous growth model with subsistence consumption of energy.
- Main message:
  - An internationally harmonized, nationally collected carbon tax will not necessarily burden developing countries more than developed countries.
  - However, the effective redistribution of tax revenue is central in order to avoid excessively negative impacts for economies close to subsistence.
- Directions for future research:
  - For simplicity and analytical tractability, many important features are not represented in this simple model (e.g. international trade, technological progress and non-linear production technologies).
  - Next step: verify that the results still hold for production with decreasing returns to scale.

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