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Optimal carbon abatement policy - taxes should be high now!

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Outline

- Background
- Our plan
- Model
- Scenarios
- Preliminary results
- Future research

Background

- Induced Technological Change (ITC)
  - climate policy affect the incentives to conduct research within energy technologies
    - taxing carbon based energy will decrease demand for these types of energy and increase the demand for less carbon intensive energy types
    - as the demand for those energy types rises it is plausible to assume that more intensive research will be conducted within these area

Background

- Former research
  - the effect of ITC on the optimal carbon abatement policy – taxation and reduction path
  - Nordhaus, 2002, Popp, 2004, Gerlagh and Lise, 2005, Zwaan ea., 2002, and Goulder and Mathai, 2000
  - assumptions/analyses
    - exogenous vs. endogenous/induced technological change – either or?
  - findings
    - lower taxation path
    - postpone reduction?

Our plan

- What we intend to do…
  - Set up a theoretical model
    - inspired by Romer, 1990
  - analyse how the optimal taxation path is affected under different assumptions of
    - endogenous/induced technological change
  - compared to
    - exogenous technological change

Model

- Energy sector
- Carbon abatement technology producer
- R&D sector
- Energy demand
- Social planner

Model

- Energy sector
  - one representative energy producer
  - faces a CO_2 emission tax
  - BAU CO_2 emissions proportional to energy production
  - reduces CO_2 emission by buying abatement technology
  - decreasing returns to each type of abatement technology

Model

- Abatement technology producer
  - N different abatement technology producers
  - close substitutes, monopolistic competition
  - pays a fee to the R&D sector for renting the ideas

Model

- R&D sector
  - abatement technology inventor
  - costs of inventing increasing in the number of ideas within each period
  - costs of inventing decreasing in the total number of ideas in the economy
  - sets a fee equal the net present value of profits from the technology

Model

- Energy demand
  - linear demand function
- Concentration
  - change in concentration given by the emissions minus a constant decay rate

Model

- Energy producer
  - Emissions $e_t = q_t - \sum_{i=1}^{N_t} (u_t^i)^\rho, \rho < 1$
  - Energy production costs

$$c_t(q_t, u_1^i, \ldots, u_t^n) = c_0 q_t + \tau_t \left(q_t - \sum_{i=1}^{N_t} (u_t^i)^\rho\right) + \sum_{i=1}^{N_t} p_t^i u_i^t$$

  - Abatement equipment demand $u_t^i = \left(\frac{\tau\rho}{p_t^i}\right)^{\frac{1}{1-\rho}}$

Model

- Abatement equipment
  - profit maximisation

$$\max_{\tau} \pi_t^i = p_t^i u_t^i - b^i u_t^i - f^i$$

  - supply

$$u_i^i(\tau) = \left(\frac{\tau \rho^2}{b^i} \right)^{\frac{1}{1-\rho}}$$

Model

- R&D sector
  - technology development costs

    $$a(n_t, N_t) = \alpha_1 e^{-\alpha_2 N_t} (n_t)^2$$

  - the fee equals the total expected profit

    $$f^i = \int_0^\infty \pi_t e^{-rt} dt$$

  - determines

    $$n_t = \eta e^{\alpha_2 N_t} \int_0^\infty \left[\tau^{\frac{1}{1-\rho}} \right] e^{-rt} dt$$

Model

- Solving the model
  - the social planner maximises Total Surplus
    - wrt. the carbon tax
    - given a CO_2 concentration target
  - Total Surplus is given by
    - consumer surplus
    - energy producer surplus
    - emission tax income
- The model is solved numerically using the program GAMS

Scenarios

- Endogenous technological change
  - solving for the optimal taxation path
  - deriving the development in the technological change:

Period	1	2	…	T
τ_t	τ_1	τ_2	…	τ_T
$n_t(\tau_t)$	$n_1(\tau_1)$	$n_2(\tau_2)$	…	$n_T(\tau_T)$
$N_t(\tau_t)$	$N_1(\tau_1)= n_1(\tau_1)$	$N_2(\tau_2)= N_1(\tau_1)+n_2(\tau_2)$	…	$N_T(\tau_T)= N_{T-1}(\tau_{T-1})+n_T(\tau_T)$

- Exogenous technological change
  - implementing the development in the technological change as exogenous and solving for the optimal taxation path

Preliminary results

- Only ITC:
  - taxes should be high in the beginning
- Compared to exogenous technological changen
  - taxes should be higher in the beginning under ITC compared to exogenous technological change
- Intuition behind the results:
  - Goulder and Mathai
    - exogenous technological growth
    - affects the future development of ITC
  - We have future external effects of R&D today

Future research

- Knowledgde accumulation
  - Fishing out rather than standing on shoulders
- Subsidies
  - three possible sectors to subsidies
  - combined with taxes