Price versus quantity debate: the role of business cycles

Anna Grodecka † Karlygash Kuralbayeva*

†Bonn Graduate School of Economics

*Grantham Research Institute (LSE), OxCarre and CFM (LSE)

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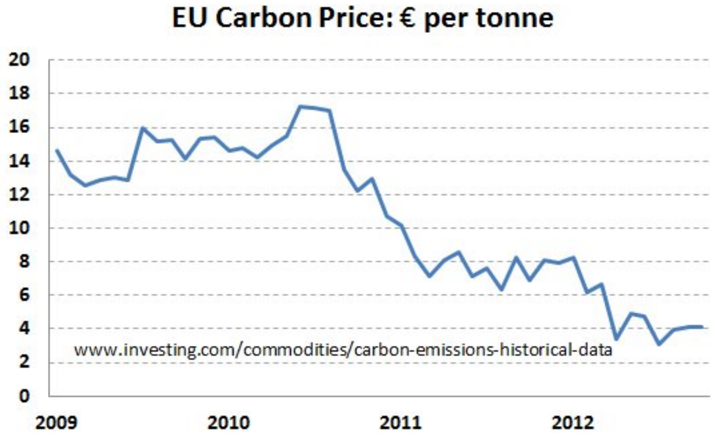

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- Two classic alternatives to regulate pollution: a cap and trade or a tax
- EU ETS: fixed quantity, but price fluctuates
- Our question: how much does price fluctuate in response to the business cycle shocks?

Related literature

- Price vs quantity debate (e.g., Weitzman (1974), Pizer (1999), Hoel and Karp (2002), Newel and Pizer (2003))
- On the analysis of environmental policies and business cycles (e.g., Fischer and Springborn (2011),Fischer and Springborn (2011),Heutel (2012), Lintunen and Vilmi (2013))
- On optimal design of fiscal policy over the business cycle (e.g., Chamley (1986), Zhu (1992), Chari et al. (1994))

What the paper does

- Build RBC economy subject to productivity shocks (based on Heutel (2012))
- Extensions: labor & fiscal policy (public consumption, investment and bonds)
- Characterize dynamics under an optimal (baseline) and alternative (fixed) tax on emissions policy
- Quantify costs of fixed tax on emissions policy in terms of welfare
- Perform sensitivity analysis

Main results

- Tax rates on both labor and emissions are essentially constant
- Optimal emissions policy result in large variation of emissions
- Composition of public expenditure matters: the model with public investment features higher pollution stock over the medium term
- Welfare costs of fixed tax on emissions policy is small in per capita terms

Cyclical properties

Symboll	Variable	Standard deviation (%)
	Instrument: tax	
e	emissions	2.24
τ_E	tax on emissions	0.016
τ_L	labor tax	0.019
	Alternative policy: tax on emissions is fixed	
e	emissions	2.31
τ_L	labor tax	0.015
	Instrument: quantity ("permits")	
e	emissions	2.24
τ_L	labor tax	0.015

Notes: time period is a quarter;

Welfare analysis

	Welfare costs (% of ss consump)
Baseline model	0.28
Model with public capital	0.49
Business cycle (Lucas (1987))	0.008

Table: Welfare effects

- 0.28% of the steady state consumption in 2013 amounts to 32.19 bn USD, or 102 USD/capita annually

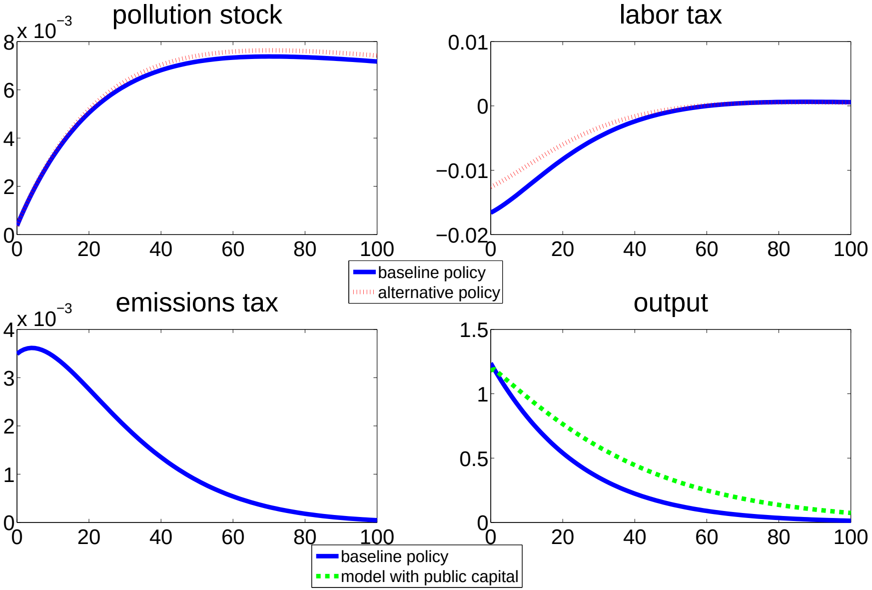

Figure: Impulse response functions to 1% productivity shock

Conclusion

- Investigates optimal level of tax on emissions over the business cycle
- More likely optimal to employ a price instrument, adjusting quantity period-by-period
- Our results reinforce arguments of Stern (2006) among others, who argue in favor of a price control
- Critique of previous RBC/env policy papers that refer to procyclicality of tax on emissions

Additional slides

Model

Households

Maximize:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t, g_t), s.t. \quad (1)$$

$$c_t + i_t + \rho_{Bt} b_{t+1} = w_t l_t + r_t k_{t-1} + b_t + \pi_t \quad (2)$$

$$k_t = (1 - \delta) k_{t-1} + i_t \quad (3)$$

Utility function:

$$u(c_t, l_t, g_t) = \frac{c_t^{1-\kappa} - 1}{1 - \kappa} + \theta \frac{g_t^{1-\kappa} - 1}{1 - \kappa} - \frac{l_t^{1+\psi}}{1 + \psi} \quad (4)$$

Model

Firms

Maximize profits:

$$\pi_t = y_t - w_t(1 + \tau_{Lt})l_t - \tau_{Et}e_t - r_t k_{t-1} - z_t \tag{5}$$

$$y_t = (1 - d(x_t))a_t k_{t-1}^{\alpha} l_t^{1-\alpha} k_{Gt-1}^{\gamma} \tag{6}$$

$$\ln a_t = \rho \ln a_{t-1} + \epsilon_t \tag{7}$$

- x_t - pollution stock emerging from emissions e_t
  $d(x) = d_2 x^2 + d_1 x + d_0$
  $x_t = \eta x_{t-1} + e_t + e_t^{row}$, $e_t = (1 - \mu_t)h(y_t)$, $h(y_t) = y^{1-\nu}$
- z_t - abatement spending

$$\frac{z_t}{y_t} = m(\mu_t) \tag{8}$$

$m(\mu) = \theta_1 \mu^{\theta_2}$

Model

Government

Budget constraint:

$$g_t + i_{Gt} + b_t = w_t \tau_L l_t + \tau_{Et} e_t + \rho_{Bt} b_{t+1} \tag{9}$$

Public capital accumulation:

$$k_{Gt} = (1 - \delta_G) k_{Gt-1} + i_{Gt} \tag{10}$$

Calibration: climate module parameters

Parameter	Value	Definition
η	0.9979	pollution decay
d_2	5.2096e-10	damage function parameter
d_1	-1.2583e-06	damage function parameter
d_0	1.3950e-3	damage function parameter
θ_1	0.2528	abatement cost equation parameter
θ_2	2.8	abatement cost equation parameter
$1-\nu$	0.696	elasticity of emissions with respect to output

Table: Baseline parameter values

Calibration: other parameters

Parameter	Value	Definition
α	0.36	private capital share in the production function
ρ	0.95	persistence of the TFP shock
σ_ε	0.007	standard deviation of the TFP shock
δ	0.025	private capital depreciation rate (quarterly)
δ_g	0.03	public capital depreciation rate (quarterly)
β	0.98	subjective discount factor (quarterly)
κ	1.5	coefficient of relative risk aversion
θ	0.08615	weight of public consumption in utility
$1/\psi$	2.25	Frisch elasticity of labor supply

Table: Baseline parameter values

Data sources

- GDP - from the NIPA Table 1.5.5. Gross Domestic Product, Expanded Detail, line 1.
- Personal consumption expenditure - from the NIPA Table 1.5.5. Gross Domestic Product, Expanded Detail, line 2.
- Government consumption expenditure - from the NIPA Table 1.5.5. Gross Domestic Product, Expanded Detail, line 55+line 58+line 61.
- Government gross investment - from the NIPA Table 1.5.5. Gross Domestic Product, Expanded Detail, line 56+line 59+line 62.
- Gross private domestic investment - from the NIPA Table 1.5.5. Gross Domestic Product, Expanded Detail, line 26.
- Emissions per unit of total GDP - for 2012 for the US from the United States Environmental Protection Agency (2013), p.ES-24, Table ES-9.

Data sources

- Fraction of emissions abated: derived from author's calculations with original data from Creyts et al. (2007), who provide estimates of potential abatement projections for greenhouse gases in the US. They estimate that the US would potentially abate cumulative 3GtCO2 of emissions for the period 2005-2030. Assuming the same amount of emissions abated every year during 25 years time period, from 2005 to 2030, and given that total greenhouse gas emissions amounted to 6.5GtCO2 by the US in 2012 (EPA(2013)), we obtain 1.85%, an estimate of the fraction of emissions abated in 2012.
- Abatement Spending - from the U.S.Census Bureau (2008), Table 1 (Pollution Abatement Operating Costs) and Table 2 (Pollution Abatement Capital Expenditures).
- Labor tax - from the OECD data on labor tax wedge for the US in 2012.