Green Asset Pricing

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Abstract

This paper studies the optimal design of a carbon tax when environmental factors (i.e. CO_2), directly affect agents' marginal utility of consumption.

- Our first result is that the optimal tax is determined by the shadow price of CO2 emissions.
- We estimate this implicit price in the data and find that the optimal tax is pro-cyclical.
- The optimal policy not only generates large welfare gains, it also reduces risk premiums and raises the average risk-free real rate.
- The effect of the tax on asset prices and welfare critically depends on the emission abatement technology.

Introduction

- CO2 emissions is a classical example of what economists call "**externality**". Emissions contribute to climate change, a phenomenon which affects everybody's well-being. The problem is that the adverse effects of emissions are not reflected in market prices. Without a price mechanism, markets fail in the sense that they cannot allocate resources efficiently. This "**market failure**" in turn leads to excessive CO2 emissions. Government intervention is thus necessary to correct the resulting inefficiency.
- This work shows how to design a carbon tax that is optimal from a welfare perspective. We firstly use asset pricing theory to derive the implicit market price of CO2 emissions. We then show that the optimal carbon tax is determined by this implicit price. Next, we use our methodology to compute an estimate of the optimal carbon tax over the business cycle.

The model

We consider the Jermann (1998)'s model, an extension of Lucas Jr (1978) with endogenous production function and consumption habits, and include environmental constraints, where our main assumption is **non-separability** between consumption and stock of emissions:

$$u\left(c_t - \phi x_t\right)$$

- $u_x < 0$: **externality** $\rightarrowtail$ disutility increases when emission rises (Stokey (1998), and Acemoglu et al. (2012)).
- $u_{cx} > 0$: **compensation effect** $\rightarrowtail$ consumption rises following a rise in emissions Michel and Rotillon (1995).
- $cu_{cc}/u_c = \sigma c_t/(c_t - \phi x_t)$: **risk aversion increases in stock of emissions** $\rightarrowtail$ more emissions increases precautionary saving.

The other blocks of our model are the following:

1. Environmental block: modeled à la Nordhaus.
2. Household and production à la Jermann (1998).
3. Government that sets the environmental policy.

Solution, Data, and Estimation

- Using US quarterly data on GDP, consumption, investment, and CO_2 emissions, we estimate the structural parameters of the model using **Bayesian methods**. Since the U.S. has not implemented any environmental policy, we propose to estimate the *laissez-faire model*.
- To take into account the effect of risk on asset prices, we employ a tractable likelihood-based method pioneered by Kollmann (2013). In this paper, since we want to accurately measure higher order effects of environmental preferences (e.g. precautionary saving), we consider a **second-order approximation** to the decision rules of our model.

Results

Important Result 1

The first main takeaway is that **the optimal tax is determined by the shadow value of CO2 emissions** and that a small average carbon tax (as shown in Figure 1) is sufficient to restore the first-best allocation. Indeed, under our benchmark scenario, which corresponds to the case $\theta_1 = 0.05607$, it is optimal to impose an average tax of around 2.1 percent.

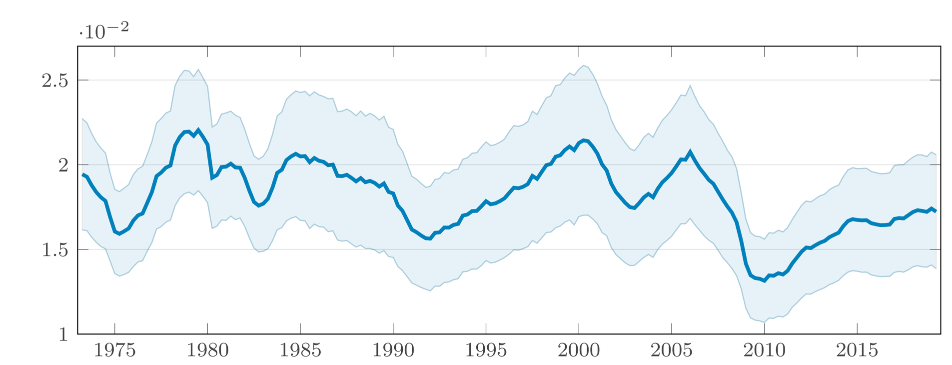

Figure 1: Environmental Tax - Counterfactual Estimation

Important Result 2

Our second main result is that **slow movements in the stock of CO2 can have significant financial market implications**. Of particular relevance to central banks is the finding that environmental externalities affect the natural rate of interest. Climate change reduces the natural rate of interest, thereby increasing the likelihood of hitting the effective lower bound as shown in Table 1 below.

Important Result 3

Next, we show that introducing an **optimal environmental tax reduces risk premia and increases the natural rate of interest**. Under our baseline scenario, the tax reduces the premium on a long-term bond by around half and increases the natural rate by around 2 percent.

	Laissez-faire	Optimal policy		
	Estimation (1972-2019)	$\theta_1 = 0.05607$	$\theta_1 = 0.56797$	$\theta_1 = 6.8844$
	(1)	(2)	(3)	(4)
Business cycle variables				
$E\left(c_t\right)$	0.5484	0.5014	0.5268	0.5398
$E\left(x_t\right)$	932.0311	222.3127	702.9981	860.9645
$E(W_t)$	-18694.3	-515.3	-4306.3	-11739.6
$E(\tau_t)$	0.0000	0.0213	0.0235	0.0253
Asset pricing implications				
$400E\left(r_t^F\right)$	3.6118	5.6544	4.7403	4.0130
$400E\left(r_{t+1}^B - r_t^F\right)$	1.1052	0.4818	0.8813	1.1071
$std(\hat{\lambda}_t)$	2.4673	1.0990	1.7941	2.2308
$E(RRA_t)$	32.1324	10.8755	20.2128	27.5478
$std(\widehat{rra}_t)$	0.5876	0.2617	0.4273	0.5312
Abatement technology				
$E\left(\mu_t\right)$	0.0000	0.7464	0.2162	0.0562
$E\left(f\left(\mu_t\right)\right)$	0.0000	0.0250	0.0079	0.0022
$E(\frac{\tau_t e_t}{y_t})$	0.0000	0.0081	0.0289	0.0374

Notes: The first column is the estimated model under a laissez-faire equilibrium, with no abatement and no environmental tax. Column (2) is the equilibrium under an environmental tax with θ_1 set as in the litterature. Columns (3) and (4) are equilibriums under alternative values of θ_1 that matches a share of abatement $\bar{\mu}$ of 20% and 5%. Note that in columns (3) and (4) $E(\mu_t) \neq \bar{\mu}$ because of the contribution of futur shocks on the asymptotic mean of these variables.

Table 1: Estimation and simulation results

Important Result 4

Estimation key result: **the environmental preference** ϕ.

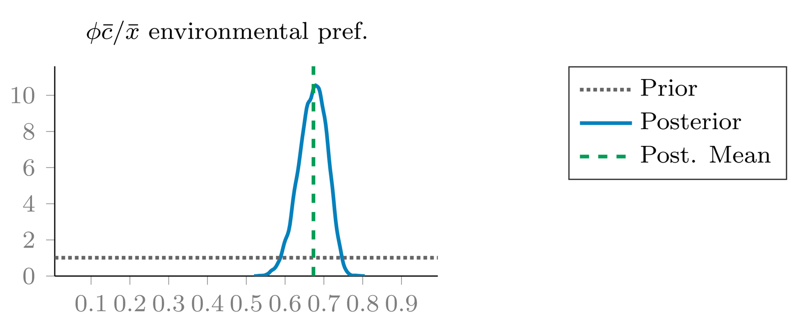

Figure 2: Environmental preference estimation

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Article Link

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