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DISCUSSION PAPER

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Abstract

In this paper we set up a model to consider how individual voter characteristics determine their policy preferences over the level of a tax on fossil energy. We introduce the possibility for voters to invest to change their reliance on fossil versus clean energy. The effect of this on preferred tax rates are, in general, ambiguous. If a tax would be high enough to make fossil energy more expensive than clean, then this would induce investment with the direct effect of increasing support for higher tax rates. When taking the full general equilibrium effects into account, the effects are again ambiguous but we derive sufficient conditions under which the preferred tax increases for all voters.

1 Introduction

In this paper we set up a model to analyze the political feasibility of carbon taxes. More precisely, we set up a model with voters who are heterogeneous in several dimensions to see what tax level would get political support from these voters. The dimensions of heterogeneity are general energy reliance, reliance on fossil versus clean energy, the valuation of public goods financed by the tax revenues and perceived damages form emissions of carbon dioxide. this models is then used to find how the support for a given policy depends on these individual characteristics and how the fossil-fuel tax with the highest support is found. We also consider how introducing the possibility to change the reliance on fossil versus clean energy changes these preferences. Finally, we discuss the consequences of allowing for targeted government spending of the tax revenues.

Our analysis builds on a large literature from political economics, climate economics and environmental economics more generally. Below we describe some of that literature.

The fossil-fuel tax in our model works by increasing the relative price of the polluting energy leading to reduced use. This works the same way as a classical Pigouvian tax going back to Pigou (2017). In climate economics, this is a recurring theme in papers such as Brock et al. (2013) and Golosov et al. (2014).

Besley and Persson (2023) set up a dynamic model where the support for environmental policy changes over time due to both directed technical change and changing values related to the environment. Similar to them, our model features changed behavior in response to climate policy that in turn affect policy preferences, but we model the investment directly rather than as through technical change and while we can interpret our perceived cost of emissions as reflecting values rather than direct climate impacts, we do not model the process through which the attitudes towards emissions are formed.

There is also a significant literature investigating empirically how attitudes towards climate policy is affected by individual characteristics and policy design. See, for example, Beiser-McGrath and Bernauer (2019), Bergquist et al. (2022) and Nowlin et al. (2020).

We now describe the model and derived results, followed by a discussion.

2 Model description and analysis

There is a continuum $\mathbb{I}$ of voters. The model features two different types of energy, fossil-fuel-based energy (or fossil energy for short) with endogenously determined total use E_F. The fossil energy is based on oil sold at the exogenously given price p_O. Use of this type of energy is subject to a per-unit tax τ. The consumer price of fossil energy is thus $p_F = p_O + \tau$. There is also a green energy source with total use E_G that does not cause any environmental externalities. This can be bought at the exogneously given price p_G. The tax revenues are used to finance a public good T. Voters benefit differently from different types of public goods.

2.1 Voters' preferences and behavior given taxes

Voter $i \in \mathbb{I}$ derives utility from energy services E_i and public goods T_i (where the index refers to the public goods that voter i benefits from), and disutility from the external effects associated with total fossil-energy use E_F. Their total utility is

$$\tilde{V}_i = u_i(E_i) - p_{E,i}E_i + b_i(T_i) - c_i(E_F), \tag{1}$$

where u_i the the utility voter i derives from energy services, $p_{E,i}$ is the voter-specific price of energy services, b_i is the benefit from public goods and c_i is the subjective cost of emissions. The energy services used by voter i are given by a Cobb-Douglas combination of use of fossil and green energy:

$$E_i = E_{F,i}^{\alpha_i} E_{G,i}^{1-\alpha_i}, \tag{2}$$

where α_i is voter i's fossil-energy reliance.

We define voter i's price of energy services as the cost-minimizing per-unit cost of energy services:[1]

$$p_{E,i} \equiv \frac{1}{E_i}\left[\min_{E_{F,i},E_{G,i}} p_F E_F + p_G E_{G,i} \text{ subject to } E_{F,i}^{\alpha_i} E_{G,i}^{1-\alpha_i} \geq E_i\right].$$

Solving this cost-minimization problem gives

$$p_{E,i} = \left(\frac{p_F}{\alpha_i}\right)^{\alpha_i}\left(\frac{p_G}{1-\alpha_i}\right)^{1-\alpha_i} \tag{3}$$

and the cost-minimizing uses of the energy sources are

$$E_{F,i} = \alpha_i \frac{p_{E,i}}{p_F} E_i \text{ and } E_{G,i} = (1-\alpha_i)\frac{p_{E,i}}{p_G} E_i \tag{4}$$

respectively. We furthermore assume that voter i's utility of energy services is logarithmic:

$$u_i(E_i) = \mu_i \ln(E_i), \tag{5}$$

where μ_i is a measure of voter i's energy reliance.

Given the voter-specific energy price $p_{E,i}$, voter i maximizes net benefits from energy use:

$$\max_{E_{F,i},E_{G,i}} \mu_i \ln(E_i) - p_{E,i}E_i. \tag{6}$$

Solving this maximization problem gives

$$E_i = \frac{\mu_i}{p_{E,i}}. \tag{7}$$

[1] Given that the production function in (2) has constant returns to scale, this will be constant as long as the energy prices are constant.

Substituting this in (4) gives energy uses

$$E_{F,i} = \frac{\alpha_i \mu_i}{p_F} \text{ and } E_{G,i} = \frac{(1-\alpha_i)\mu_i}{p_G}. \tag{8}$$

This gives net private benefit from energy use

$$\mu_i \ln(E_i) - p_{E,i}E_i = \{(7)\} = \mu_i \left[\ln \mu_i - \ln\left(p_{E,i}\right) - 1\right]. \tag{9}$$

Substituting for the energy price from (3) and rewriting gives

$$\mu_i \ln(E_i) - p_{E,i}E_i = \xi_i - \mu_i \left(\alpha_i \ln(p_F) + (1-\alpha_i)\ln(p_G)\right), \tag{10}$$

where

$$\xi_i \equiv \mu_i \left(\ln \mu_i + \alpha_i \ln \alpha_i + (1-\alpha_i)\ln(1-\alpha_i) - 1\right), \tag{11}$$

which is independent of the tax.

2.2 Aggregation and tax preferences

In Equation (8) we derived the decisions made for a given tax rate. We can use this to compute total fossil-energy use and tax revenues.

This can be used to compute aggregate fossil-energy use:

$$E_F = \int_{i \in \mathbb{I}} E_{F,i} \mathrm{d}i = \frac{1}{p_F} \int_{i \in \mathbb{I}} \alpha_i \mu_i \mathrm{d}i. \tag{12}$$

Defining

$$\theta \equiv \int_{i \in \mathbb{I}} \alpha_i \mu_i \mathrm{d}i \tag{13}$$

we get

$$E_F = \frac{\theta}{p_F}. \tag{14}$$

Total tax revenues are

$$R = \frac{\tau\theta}{p_F}. \tag{15}$$

Let the share of spending on public goods that benefit voter i be σ_i. Then the public goods benefiting voter i is

$$T_i = \sigma_i R = \sigma_i \frac{\tau\theta}{p_F}. \tag{16}$$

Taking the endogneous responses to the tax into account, the benefit to voter i of the tax τ is

$$V_i(\tau) = \xi_i - \mu_i \left(\alpha_i \ln(p_F) + (1-\alpha_i)\ln(p_G)\right) + b_i(T_i) - c_i(E_F). \tag{17}$$

The derivative with respect to τ is

$$\begin{aligned} V_i'(\tau) &= -\mu_i\alpha_i\frac{1}{p_F} + b_i'(T_i)T_i\left(\frac{1}{\tau}-\frac{1}{p_F}\right) + c_i'(E_F)\frac{E_F}{p_F} \\ &= \left(b_i'(T_i)T_i\frac{p_O}{\tau} + c_i'(E_F)E_F - \mu_i\alpha_i\right)\frac{1}{p_F} \end{aligned}$$

We now use the following functional forms:

$$b_i(T) = \beta_i \ln(T) \text{ and } c_i(E_F) = \gamma_i E_F. \tag{18}$$

With these and (14), the derivative becomes

$$V_i'(\tau) = \left(\beta_i\frac{p_O}{\tau} + \gamma_i\frac{\theta}{p_F} - \mu_i\alpha_i\right)\frac{1}{p_F} \tag{19}$$

The parenthesis is strictly decreasing in τ and it goes from infinity to $-\mu_i\alpha_i$ as τ goes from zero to infinity. This leads to the following proposition:

Proposition 1. *Each voter $i \in \mathbb{I}$ has single-peaked preferences over the tax rate and their unique preferred tax rate $\tau_i^* \in (0,1)$ is implicitly defined by*

$$\beta_i\frac{p_O}{\tau_i^*} + \gamma_i\frac{\theta}{p_O+\tau_i^*} = \mu_i\alpha_i. \tag{20}$$

2.3 Endogenizing α

We here assume that α can take two values: $\check{\alpha} \in (0, \frac{1}{2})$ or $\hat{\alpha} = 1 - \check{\alpha} \in (\frac{1}{2}, 1)$. The voters can change their α between these values at a cost η and such an investment leaves all other parameters unchanged.

The symmetry of the α values mean that ξ_i, defined in (11), is unchanged. Starting from (17), we can see that voter i, who has $\alpha_{i,0} = \check{\alpha}$ will invest to change to $\hat{\alpha}$ if

$$\mu_i\left(\hat{\alpha}-\check{\alpha}\right)\ln\frac{p_G}{p_F} > \eta. \tag{21}$$

Similarly, if voter i initially have $\alpha_{i,0} = \hat{\alpha}$ they will chose to invest to change α to $\check{\alpha}$ if

$$\mu_i\left(\hat{\alpha}-\check{\alpha}\right)\ln\frac{p_F}{p_G} > \eta. \tag{22}$$

Hence a low tax, so that $p_F < p_G$ will tend to induce investments to increase fossil dependency. This will decrease the tax preferred by the voters. Similarly, a high tax, such that $p_F > p_G$ will tend to induce investments to decrease fossil energy dependence and increase the tax desired by the voters. Hence, this mechanism will tend to move the equilibrium away from the tax that would give the same price of both types of energy. this is summarized in the following proposition.

Proposition 2. *The possibility to invest to change the reliance on clean versus fossil energy induces investments such that each voter's own investment makes them prefer a lower tax if the current tax is such that $p_F < p_G$ and a higher tax if the current tax is such that $p_G < p_F$.*

In addition to this direct effect, there is a also an effect on the tax revenues and aggregate emissions as voters invest to change their fossil-energy dependence and this complicates the picture.

In equlibrium, θ defined in (13) is an important determinant of both tax revenues and emissions. With the binary set of α values, θ becomes

$$\theta_0 = \check{\alpha} \int_0^\infty \mu \check{f}(\mu) \mathrm{d}\mu + \hat{\alpha} \int_0^\infty \mu \hat{f}(\mu) \mathrm{d}\mu, \tag{23}$$

where $\check{f}$ and $\hat{f}$ are the distributions of energy reliance μ among the voters that initially have $\alpha = \check{\alpha}$ and $\alpha = \hat{\alpha}$ respectively.

For a given tax τ, we can define the cutoff in terms of energy intensity between investing and not investing in changing α. If $\tau < p_G - p_F$ we define

$$\bar{\mu} \equiv \frac{\eta}{(\hat{\alpha} - \check{\alpha}) \ln \frac{p_G}{p_F}}. \tag{24}$$

Through p_F this is an increasing function of τ. Voter i with $\alpha_{i,0} = \check{\alpha}$ will change to $\hat{\alpha}$ if $\mu_i > \bar{\mu}$. The resulting θ is

$$\theta(\tau) = \check{\alpha} \int_0^{\bar{\mu}} \mu \check{f}(\mu) \mathrm{d}\mu + \hat{\alpha} \left[\int_0^\infty \mu \hat{f}(\mu) \mathrm{d}\mu + \int_{\bar{\mu}}^\infty \mu \check{f}(\mu) \mathrm{d}\mu \right]. \tag{25}$$

Differentiating this with respect to τ gives

$$\theta'(\tau) = -\left(\hat{\alpha} - \check{\alpha}\right) \bar{\mu} \check{f}(\bar{\mu}) \frac{\mathrm{d}\bar{\mu}}{\mathrm{d}\tau} < 0. \tag{26}$$

If, instead, $\tau > p_G - p_F$ we define

$$\bar{\mu} \equiv \frac{\eta}{(\hat{\alpha} - \check{\alpha}) \ln \frac{p_F}{p_G}}. \tag{27}$$

Through p_F this is a decreasing function of τ. Voter i with $\alpha_{i,0} = \hat{\alpha}$ will change to $\check{\alpha}$ if $\mu_i > \bar{\mu}$. The resulting θ is

$$\theta(\tau) = \check{\alpha} \left[\int_0^\infty \mu \check{f}(\mu) \mathrm{d}\mu + \int_{\bar{\mu}}^\infty \mu \hat{f}(\mu) \mathrm{d}\mu \right] + \hat{\alpha} \int_0^{\bar{\mu}} \mu \hat{f}(\mu) \mathrm{d}\mu. \tag{28}$$

Differentiating this with respect to τ gives

$$\theta'(\tau) = \left(\hat{\alpha} - \check{\alpha}\right) \bar{\mu} \hat{f}(\bar{\mu}) \frac{\mathrm{d}\bar{\mu}}{\mathrm{d}\tau} < 0. \tag{29}$$

When finding each voter's preferred tax rate, we need to take this dependency into account. Whether or not the possibility to invest to change α will increase or decrease the equilibrium tax is difficult to say. We have three different effects. Firstly, some voters will change their α with a direct effect on their own tax preferences. Secondly, the fact that some other voters will change their α will have an effect on tax revenues given by (15). Both directly but also by changing the tax base through the change in θ. Thirdly, it will also affect emissions given in (14) by changing θ.

Computing the full derivative of the value to voter i from equation (17), using the functional forms from Equation (18) and rewriting we now get

$$V_i'(\tau) = \left[\beta_i \frac{p_O}{\tau} + \gamma_i \frac{\theta}{p_F} - \left(\gamma_i - \beta_i \frac{p_F}{\theta} \right) \underbrace{\frac{\mathrm{d}\theta}{\mathrm{d}\tau}}_{<0} - \mu_i \alpha_i \right] \frac{1}{p_F}. \tag{30}$$

We now focus on the case where the preferred taxes defined in Proposition 1 are such that $\tau_i^* > p_G - p_O$ so that $p_F > p_G$. This means that any investments to change α will be to change from $\hat{\alpha}$ to $\check{\alpha}$. In this case, $\mu_i \alpha_i$ is weakly smaller with the possibility to invest. Consider now a tax rate that gives the same total emissions as τ_i^*. Since θ is now lower, this will correspond to a lower τ. For this lower τ, $\beta_i \frac{p_O}{\tau}$ will be higher. All these factors would make the voter prefer a tax rate that corresponds to less emissions than without the possibility to change α. Remains to consider the parenthesis in (30). If this is positive, then voter i will now prefer a tax corresponding to lower total emissions. A sufficient condition for this is that β_i is sufficiently small compared to γ_i. This can be summarized in the following proposition:

Proposition 3. *Assume that without the possibility to change α, the taxes τ_i^* implicitly given in Proposition 1 are such that $\tau_i^* > p_G - p_O$. Then the possibility to change alpha will make all voters prefer a tax corresponding to lower total emissions as long as the costs of emissions (represented by γ_i) are sufficiently important as determinant of the preferred tax compared to generated tax revenues (represented by β_i).*

Note that the conditions in this proposition are sufficient but not necessary for the result to hold.

3 Discussion

In this short paper we have analyzed how voter preferences and reliance on energy in general and fossil energy in particular shapes voters preferences over a tax on fossil fuels. We found that without the possibility to invest to change your reliance on fossil fuels, all voters have single peaked preferences over the tax level. The preferred tax level is increasing in valuation of public goods financed by the tax revenues and in the subjective cost of climate change. It is decreasing in the reliance on energy and specifically fossil energy.

If we introduce the possibility to invest to change the relative reliance on fossil and clean energy, the direct effect will be that if a potential tax would result in clean energy still being more expensive than fossil energy, this would induce investments to increase overall fossil-energy dependency lowering the support for the tax. If, instead, a potential tax would make clean energy cheaper than fossil energy, then this would induce investments to reduce fossil-energy dependency and increase the support for a higher tax.

When allowing for these types of investments, the investments made by others will affect each voter's tax preferences through effects on tax revenues and emissions. Given this complication, the full effect of introducing the possibility to invest on the resulting implementable tax is complicated to derive. It does, however, seem plausible that if the resulting tax without the possibility to invest is such that fossil energy is more expensive than clean energy, then introducing the possibility to decreases the equilibrium emissions.

The model that we set up here can also be used to consider the effects of targeting government spending towards specific groups to gain support for the policy. That would have two different effects, it could increase support for a stringent tax by compensating those hit hard by the tax. This would, however, also risk reducing the incentives to invest to reduce fossil-energy dependence leading to a lower support for a stringent tax. The total effect in terms of whether the policy package that would have the strongest voter support would increase or decrease overall emissions would then depend on the distribution of characteristics in the population.

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