Green Taxes: Refunding Rules and Lobbying
Supplementary Material

Appendix A: List of symbols used in the model

Symbol	Explanation
x	Private good
p^*	World market price of x
l	Labor input
$\bar{l}$	Labor supply
r	Raw material input
K	Specific capital input
w	Wage rate
z	Domestic price of raw materials
Π	Profits (net of tax reimbursement)
z^*	World market price of raw materials
G	Environmental damage
t	Green tax on raw materials
υ	Share of the ecotax revenue refunded to polluters
ϕ	Share of that revenue funded to voters used to cut taxes
n_I	The fraction of informed voters
n_U	The fraction of uninformed voters
$\widehat{\tau}$	Pre-reform income tax rate
τ	Post-reform income tax rate
$\widehat{g}$	Pre-reform spending on public goods
g	Post-reform spending on public goods
t^{**}	The equilibrium green tax without lobbying and lump sum recycling
$1/\mu$	The marginal cost of public funds
R	The ecotax revenue
$H(g)$	The benefit of public spending
CS	Consumers' surplus
V	The indirect utility of a voter
β^k	The ex ante bias of voter k
λ	Index of political competition
b	The ex ante popularity of one of the parties
s_I	The share of informed voters voting for party A
s_u	The share of uninformed voters voting for party A
s	The total share of voters voting for party A
C_j	Contribution to party j from the lobby group
θ	The productivity of campaign spending
π	Profits (inclusive tax reimbursement)
$E(\pi, C_A, C_B)$	Expected profits net of campaign contributions
g^*	The efficient supply of public goods
I_j	Indicator function equal to 1 (-1) if $j = A$ $(j = B)$
u	$u = \frac{(1-n_U)\lambda}{\theta n_U}$
j	Index for party with $j = A, B$.
k	Index for voters.
$(t^*, \phi^*, \upsilon^*)$	The tax package that maximize voter welfare
$(t_j^o, \phi_j^o, \upsilon_j^o)$	The equilibrium tax package of party j
ρ_j	The Lagrangian multiplier on the participation constraint for party j
s_I	The share of informed voters voting for party A

Appendix B: Competition between lobby groups

In the main text, we assume that only polluter interests are organized in a lobby group. In reality, the polluter lobby group may face competition from an environmental lobby group. It is natural to suppose that environmentalists are a subset of informed citizen-voters. As such they care about their wage income and provision of public goods in addition to pollution. The objective function of the environmental lobby group, then, is

$$\begin{aligned} E\left(V, C_A, C_B\right) &= sn_I^E V(t_A, \phi_A, \upsilon_A) + (1-s)\, n_I^E V(t_B, \phi_B, \upsilon_B) \\ &\quad -C_A^E(t_A, \phi_A, \upsilon_A) - C_B^E(t_B, \phi_B, \upsilon_B), \end{aligned} \tag{1}$$

where $V(.)$ is defined as

$$\begin{aligned} V(t_j, \phi_j, \upsilon_j) &= w(t_j)(1-\tau\left(t_j, \phi_j, \upsilon_j\right))\bar{l} + CS\left(p^*\right) \\ &\quad +H\left(g\left(t_j, \phi_j, \upsilon_j\right)\right) - G\left(r\left(t_j, w\left(t_j\right)\right)\right). \end{aligned} \tag{2}$$

C_j^E is the contribution from the environmental lobby group to party j and $n_I^E \leq n_I < 1$ is the fraction of environmentalists in the population. Moreover, let $p_j = \left\{t_j, \phi_j, \upsilon_j\right\}$ denote the platform endorsed by party j. We can adopt proposition 6 from Grossman and Helpman [1] to characterize the equilibrium platforms. The proposition says that if all participation constraints bind, then the platform choice of each party satisfies the following necessary conditions for maximization of the weighted sum of the welfare of the two lobby groups and the average welfare of informed voters:

$$s^o \nabla\Pi(p_A^o) + \left(s^o n_I^E + u\right)\nabla V(p_A^o) = 0 \tag{3}$$

$$\left(1-s^o\right)\nabla\Pi(p_B^o) + \left(\left(1-s^o\right)n_I^E + u\right)\nabla V(p_B^o) = 0, \tag{4}$$

where ∇ indicates a derivative. Since the vote shares (s^o) appear in these conditions, the equilibrium platforms are not, as in the case with a single lobby group, uniquely determined, and there may exist multiple equilibria. However, if we assume that $b = 0$, the equilibrium in which the two lobby groups treat the two parties symmetrically and the parliament is split evenly between the two parties ($s^o = \frac{1}{2}$) may be focal. In that case, we can rewrite the first-order conditions as

$$\phi_j^o \;:\; (1-\upsilon_j)\left(u + \frac{n_I^E}{2}\right) R_j\left(.\right)\left[\frac{1}{\mu} - \frac{\partial H}{\partial g}\left(g_j'\right)\right] \begin{cases} < 0 \text{ if } & \phi_j = 0 \\ = 0 \text{ if } & \phi_j \in (0,1) \\ > 0 \text{ if } & \phi_j = 1 \end{cases} \tag{5}$$

$$\upsilon_j^o \;:\; R_j\left(.\right)\left[\frac{1}{2} - \left(u + \frac{n_I^E}{2}\right)\left(\frac{\phi_j}{\mu} + \left(1-\phi_j\right)\frac{\partial H}{\partial g}\left(g_j'\right)\right)\right] \begin{cases} < 0 \text{ if } & \upsilon_j = 0 \\ = 0 \text{ if } & \upsilon_j \in (0,1) \\ > 0 \text{ if } & \upsilon_j = 1 \end{cases} \tag{6}$$

$$\begin{aligned} t_j^o \;:\; & \frac{1}{2}\left\{\frac{d\Pi}{dt_j} + \upsilon_j \frac{dR_j}{dt_j}\right\} + \\ & \left(u + \frac{n_I^E}{2}\right)\left\{\frac{\partial w}{\partial t_j}\bar{l} + (1-\upsilon_j)\left(\frac{\phi_j}{\mu} + \left(1-\phi_j\right)\frac{\partial H}{\partial g}\left(g_j'\right)\right)\frac{dR_j}{dt_j} - \frac{\partial G}{\partial r}\frac{dr}{dt_j}\right\} \\ = \; & 0, \end{aligned} \tag{7}$$

In this symmetric equilibrium, the two parties endorse the same platform. A comparison between these first-order conditions and those governing the choice of platform with just one

lobby group reveals three facts. Firstly, adding the environmental lobby group to the analysis is similar to giving informed voters more weight. Secondly, the condition under which the ecotax revenue is refunded to the polluter lobby group (assuming that $\widehat{g} = g^*$) becomes

$$\frac{u}{\mu} + \frac{n_I^E}{2\mu} < \frac{1}{2} \tag{8}$$

rather than $\frac{u}{\mu} < \frac{1}{2}$. Although condition (8) is harder to satisfy (and so, it is less likely that the revenue is refunded to polluters when they face competition from an environmental lobby group), we see that the basic determinants of the refunding rule (μ and u) are the same as in the case studied in the main text. Thirdly, the green tax is higher than in the case without an environmental lobby group.

Appendix C: The Laffer point

This appendix compares the revenue maximizing green tax with the politically optimal equilibrium tax. The revenue maximizing green tax is $t_L = -r(.)\left(\frac{dr}{dt}\right)^{-1}$. Using equation (18) from the main text and using that $R = tr(.)$, the equilibrium tax can be written as

$$t^o(\phi^o, \upsilon^o) = \frac{-\frac{1}{2}\frac{d\Pi}{dt} + \upsilon^o \frac{dr}{dt} + u\left\{\frac{\partial G}{\partial r}\frac{dr}{dt} - \frac{\partial w}{\partial t} - (1-\upsilon^o)\left(\frac{\phi^o}{\mu} + (1-\phi^o)\frac{\partial H}{\partial g}\right) r(.)\right\}}{\left\{(1-\upsilon^o)\, u\left(\frac{\phi^o}{\mu} + (1-\phi^o)\frac{\partial H}{\partial g}\right) + \upsilon^o\right\}\frac{dr}{dt}}. \tag{9}$$

We can then express the difference between the equilibrium tax $t^o(\phi^o, \upsilon^o)$ and t_L as

$$t^o(\phi^o) - t_L = \frac{-\frac{1}{2}\frac{d\Pi}{dt} + u\left(\frac{\partial G}{\partial r}\frac{dr}{dt} - \frac{\partial w}{\partial t}\bar{l}\right)}{\left\{(1-\upsilon^o)\, u\left(\frac{\phi^o}{\mu} + (1-\phi^o)\frac{\partial H}{\partial g}\right) + \upsilon^o\right\}\frac{dr}{dt}} \tag{10}$$

where we recall that $\frac{dr}{dt} < 0$. The equilibrium tax rate is more likely to be to the left of the Laffer point if the social marginal damage from emission is small, labor and raw materials are substitutes ($\frac{\partial w}{\partial t} > 0$), and/or the effect of the green tax on profit is large in absolute value. On the other hand, if emission does substantial harm at the margin, labor and raw materials are complements ($\frac{\partial w}{\partial t} < 0$) and/or the profit effect is numerically small, the economy might be to the right of the Laffer point.

References

[1] G. M. Grossman, E. Helpman, Electoral competition and special interest politics, Rev. Econ. Stud. 63 (1996) 265-285.