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Optimal Policy Instruments and Environmental Federalism

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1 Introduction

The optimality of various environmental policy instruments has provoked a great deal of debate. It is well known that, if a fixed number of identical firms are being regulated in a world with no uncertainty, then the different types of policy instruments (price-control or quantity-control; revenue-raising or non-revenue-raising) are identical in their effects: all give rise to the same resource allocation and social welfare level. A great number of papers have investigated the situations in which the equivalence between policy instruments fails to hold; including heterogeneous firms (Baumol and Oates 1988, chap.4), free entry and exit of firms (Spulber 1985), and the presence of uncertainty (Weitzman 1974). Some argue that the revenue-raising policy instruments are more efficient than the non-revenue-raising instruments, because the former can exploit the revenue-recycling effect. Others focus on political aspect.[1] These papers, however, do not pay attention to the institutions of policymaking. More specifically, they do not explicitly take the types of policymaking— centralized or decentralized— into consideration.

The reason that they do not consider the institutions of policymaking could be partly attributed to, as shown below, that the relative efficiency of policy instruments is invariant with the institutions. Such an institution-invariance property, however, no longer sustains, provided that the policymaking is plagued with the influence of special interest groups. That is, the relative efficiency of environmental policy instruments is contingent on the types of policymaking, or the optimal policy instruments may vary with the degree of environmental federalism. The purpose of this paper is to highlight the interdependence between the optimal policy instruments and the types of policymaking, in the presence of political distortion due to special interest groups. Since the influence of special interest groups seems inevitable, this paper may fill some gap in this field.

To elaborate this idea, we construct a model close to Oates and Schwab (1988), in which there are several identical jurisdictions. The production in each jurisdiction

[1] Several papers compare the efficiency of price-control instruments and quantity-control instruments in the presence of uncertainty. See, e.g., @references. Since we do not consider the issue of uncertainty, we do not discuss these papers further.

needs capital, labor, and waste emissions, which are treated as an input. We extend the model of Oates and Schwab (1988) to incorporate the special interest groups — the capitalists' group and the labors' group. Unlike in Oates and Schwab (1988), the policymakers are not only concerned with their own jurisdictional welfare, but also care about the political contributions provided by the interest groups. Moreover, this present paper considers a continuous types of policy instruments, which is different from Oates and Schwab (1988), which deal with only one type of policy instrument, and most existing literature, which deal with discrete types of policy instruments.

Many researchers have addressed the problem of instrument selection. Few attention has been paid to the relationship between the extent of decentralized policymaking and the instrument selection. These two issues are treated independently. Different instruments are associated with different income distribution. In the framework in which the policymaker is benevolent, different income distributions do not give rise to any real effect, regardless of the extent of DP(decentralized policymaking); i.e., institutions are neutral. This may explain why few attention has been paid to this issue.

However, if the PM(policymaking) is subject to the influence of special interest groups, then different degrees of DP cause different income impacts of the policy, which in turn alter interest groups' lobbying effort and thus the equilibrium policy. Thus, the property of institutional-neutrality no longer exists in this situation. Different policy instruments will have different environmental and welfare consequences. As a result, the problem of policy instrument selection deserves more extensive investigation.

By considering the mobility of firms, Wellisch (1995), and Kunch and Shogren (2002, 2005) point that the NRR instruments are generally less efficient than the pure RR instruments. The intuition behind this result is that under the NRR instruments, the pollution damage is totally born by the immobile residents, whereas some or all rents due to environmental regulation accrue to the mobile firms. Thus, the benevolent local policymaker has too strong an incentive to protect the environment. By contrast, under the pure RR instruments, although the residents suffer the pollution damage, they also receive the rents due to environmental regulation, so the local policymaker will choose a socially efficient pollution level. They consider only the decentralized policymaking, without compare the relative efficiency under the alternative institutions. They also do not consider the political aspect.

Finkelshtain and Kislev (1997) consider the political aspect, but ignore the institutional aspect. Fullerton and others focus on the revenue-recycling effect, without considering both the political aspect and the institutional aspect.

2 The model

Now consider that an economy consists of a number (say m) of identical jurisdictions. These jurisdictions could be either countries or states in a country. There is a competitive industry in each jurisdiction. The product of the industry, which is denoted by Q, is sold in a perfectly competitive world (or national) market. Without loss the generality, we normalized the prices of good Q as unity. The firms in the industry are identical, so we can normalize the number of firms as unity.

Production requires capital, K, an fixed input, L, and polluting waste emissions, E. We treat E as a non-purchased input. To fix idea, we treat the fixed input as labor. Production in each jurisdiction is characterized by the following concave function with constant returns to scale:

$$Q = F(K, L, E) \tag{1}$$

To control pollution, the government levies a pollution tax on waste emissions at rate t. The objective function of the representative firm is given by

$$\pi = F(K, L, E) - rK - tE + R \tag{2}$$

where r the rate of return to capital, and R is the rebated pollution tax revenues, which is treated as a parameter by the firm in this stage. As it will be clear later, different types of policy instruments can be characterized by different R.

The total capital stock in the economy is fixed, but capital is perfectly mobile across jurisdictions. The owners of capital seek to maximize the net rate of return to capital. Capital mobility ensures that r will be the same across jurisdictions. The rate of return to capital is determined by the capital market equilibrium, which is achieved when the demand for capital by all firms is equal to the fixed capital stock; i.e,

$$\sum_{i=1}^{m} K^i = \sum_{i=1}^{m} \bar{K}^i, \tag{3}$$

where $\bar{K}^i$ is the capital endowment of jurisdiction i.

The first-order conditions of the firm's optimization are

$$F_K = r \tag{4}$$

$$F_E = t \tag{5}$$

Totally differentiating the two first-order conditions and rearranging gives

$$\begin{bmatrix} F_{KK} & F_{KE} \\ F_{EK} & F_{EE} \end{bmatrix} \begin{bmatrix} dK \\ dE \end{bmatrix} = \begin{bmatrix} dr \\ dt \end{bmatrix} \tag{6}$$

From (6), we solve that the effect of a change in r on the demand for capital as follows

$$dK/dr = F_{EE}/\Delta < 0 \tag{7}$$

where $\Delta = F_{KK}F_{EE} - F_{KE}^2$. The second-order condition of the firm's optimization requires Δ to be positive. The above equation reveals that the firm's demand for capital decreases with r. We are also concerned with the effect of a change in t on the waste emissions, which is given by

$$dE/dt = F_{KK}/\Delta < 0. \tag{8}$$

As we expect, the above equation shows that the waste emissions decrease with t.

The effect of a change in the pollution tax rate on the demand for capital is more complicated, because a change in t may alter r, which in turn affects the demand for capital. The effect of a change in the pollution tax rate on the rate of return to capital can be derived by totally differentiated (3), the equilibrium condition of the capital market, with respect to t^i, which is given by

$$\left.\frac{\partial K^i}{\partial t^i}\right|_{\bar{r}} + \sum_{j=1}^{m} \frac{dK^j}{dr}\frac{dr}{dt^i} = 0 \tag{9}$$

The first term on the left-hand side of (9) is the effect of t^i on K^i, holding r constant. From (6), we obtain

$$\left.\frac{\partial K^i}{\partial t^i}\right|_{\bar{r}} = -\frac{F_{KE}}{\Delta} \tag{10}$$

We assume that capital and waste emissions are complements, so F_{KE} is positive. By substituting (10) into (9) and applying the property of symmetry, we obtain the effect of a unilateral change in t^i on the rate of return to capital as follows:

$$\frac{dr}{dt^i} = \frac{F_{KE}}{mF_{EE}} = s\frac{F_{KE}}{F_{EE}} < 0. \tag{11}$$

where $s = 1/m$ denotes the market share of an individual jurisdiction. The parameter $s \in [0, 1]$ can measure the degree of decentralized policymaking.

Each jurisdiction contains n residents, which are divided into three types of residents: capital owners (capitalists), owners of the fixed input (labors), and pensioners. All residents are internationally immobile, and residents of the same type are identical. There are n^k capitalists in each jurisdiction. The utility function of a representative capitalist is given by

$$u^I = r\bar{k} + z^I - d(E) \tag{12}$$

where $\bar{k}$ is the capital endowment, z is a lump-sum transfer, which is financed by the pollution tax revenues. The variable $d(\cdot)$ denotes the disutility resulting from pollution emissions, with the property that $d' > 0$ and $d'' > 0$. We note that this setting allows different types of residents to receive different amounts of transfer. It will prove convenient in what follows to define the aggregate welfare of each type of residents. The aggregate welfare of the capitalists is given by

$$W^k = n^k u^k = r\bar{K} + n^k z^k - n^k d \tag{13}$$

where $\bar{K} = n^k\bar{k}$.

Each jurisdiction has n^l labors. Each worker is endowed with one unit of labor time. They inelastically supply their labor to firms as an input and receive the wage w in response. Since the labor supply is equal to its endowment, we have $L = n^l$. A representative worker's preferences are described by

$$u^l = w + z^l - d(E)\,. \tag{14}$$

The wage rate, w, is equal to

$$w = [Q - rK - tE + R]/L \tag{15}$$

The aggregate welfare of labor is equal to

$$W^l = n^l u^l \tag{16}$$

Finally, there are n^p pensioners in each jurisdiction. A representative pensioner's preferences are given by

$$u^p = y + z^p - d(E) \tag{17}$$

where y is the pensioner's earned income, which is assumed to be independent of all policy variables. Thus, the aggregate welfare of the pensioners is given by

$$W^p = n^p u^p = n^p y + n^p z^p - n^p d. \tag{18}$$

3 The equilibrium policy

We assume that the capital owners and labors organize themselves into lobby groups that coordinate their lobbying activities. Since the earned income of the pensioners is independent of the policy variable, they are assumed not being engaged in the lobbying activity.

The timing of events is as follows. First, each lobbying group offers the policymaker a political contribution schedule, $C^j(t)$, $j \in \{k, l\}$, which is contingent upon the policy chosen by the policymaker. Then the policymaker determines the pollution tax rate and collects the political contributions. Finally, given the pollution tax rate, the firms determine their output.

We note that, following the literature, the choice of the environmental policy instruments is not subject to the influence of the interest groups.[2]

Following Grossman and Helpman (1994), the policymaker is assumed to maximize a weighted average of the political contributions and social welfare, which is dented by W. Specifically, the objective function of the policymaker is given by:

$$\theta^k C^I(t) + \theta^l C^l(t) + W(t) \tag{19}$$

where θ^j can be interpreted as either the weight the policymaker attaches to the contributions he or she gets from group j, or the lobbying efficiency of group j. The weight θ^j is subject to certain exogenously determined factors, such as political skills.[3] If $\theta^k = \theta^l = 0$, then the policymaker seeks to maximize the social welfare. The social welfare function, W, is defined as the sum of the aggregate welfare of all residents,

[2] A similar approach is taken by, e.g., Rodrik (1986), Grossman and Helpman (1994), and Finkelshtain and Kislev (1997).

[3] Similar setting can be found in Bernheim and Whinston (1986) and Rama and Tabellim (1998).

which equals:

$$
\begin{aligned}
W &= n^I u^I + n^l u^l + n^p u^p \\
&= r\bar{K} + wL + [n^k z^k + n^l z^l + n^p z^p] - D(E)
\end{aligned} \tag{20}
$$

where we recall that $\bar{K}$ is the total capital endowment in this jurisdiction. The aggregate disutility from pollution emissions is denoted by $D(\cdot)$, which equals $nd(\cdot)$.

The distribution of the pollution tax revenues is important in determining of the equilibrium tax rate, so we discuss it in more details here. The pollution tax revenues can be either rebated to the firm, which accrue to the labor as noted previously, or distributed to all residents. The fraction of the pollution tax revenues that are rebated to the firm is denoted by $\lambda \in [0, 1]$. By using this notation, the rebated tax revenues (R) is equal to λtE. The remaining tax revenues, $(1-\lambda)tE$, are distributed to all residents. We let $n^j z^j = \alpha^j(1-\lambda)tE$, $j \in \{k, l\}$, and thus $n^p z^p = (1 - \alpha^k - \alpha^l)(1 - \lambda)tE$.

Before discussing the equilibrium pollution tax rate, we derive the tax rate that maximizes the social welfare, which is denoted by t^*, to serve a benchmark. This can be done by differentiating (20) with respect to t:

$$
\frac{dW}{dt} = (F_E - D')\,\frac{dE}{dt} \tag{21}
$$

Equation (21) shows that t^* should equate the marginal product of the dirty input with the (aggregate) marginal damage of pollution. The marginal product of the dirty input is the marginal benefit of lowering t, whereas the marginal damage of pollution is the marginal cost of it. The most efficient tax rate should balance the marginal benefit and marginal cost.

Then we turn to the determination of the equilibrium tax rate, which is denoted by t°. The policymaker chooses t to maximize his or her objective function, (19). For ese of exposition, most literature assumes that the lobbying groups' political contribution schedules are globally truthful;[4] that is, the contribution schedule of group j everywhere reflects its true welfare.[5] Under this assumption, the equilibrium pollution tax rate (t°)

[4] The global-truthfulness assumption, which simplifies our exposition, is not essential to the following analysis. The main results remain the same without this assumption.

[5] Bernheim and Whinston (1986) show that a truthful function is always a best response to any strategy of the opponent. Thus, they argue that truthful Nash equilibria may be focal among the set of Nash equilibria. This can justify the assumption of global-truthfulness.

is chosen by the policymaker to maximize the following equation:

$$G(t) = \theta^k W^k(t) + \theta^l W^l(t) + W(t)\,. \tag{22}$$

In what follows we consider only the interior equilibrium tax rate. The first-order condition of the policymaker's optimization is given by

$$\frac{dG}{dt} = \theta^k \frac{dW^k}{dt} + \theta^l \frac{dW^l}{dt} + \frac{dW}{dt} = 0. \tag{23}$$

In the first-order condition, the term dW^j/dt measures groups j's marginal willingness to pay (MWTP) toward lobbying t. The capitalists' MWTP can be obtained by differentiating (13) with respect to t, which equals

$$\frac{dW^k}{dt} = s\bar{K}\frac{F_{KE}}{F_{EE}} + \alpha^k(1-\lambda)(1-\eta)E - \beta^k D' \frac{dE}{dt} \tag{24}$$

where $\eta = -(dE/dt)\cdot(t/E) > 0$ is the demand elasticity of the dirty input with respect to the pollution tax rate, and $\beta^k = n^k/n$ denotes the proportion of the capitalists to the total population.

Since the lobbying groups' MWTPs are essential to their lobbying attitude, we need to examine their MWTPs in details. The capitalists' MWTP consists of three parts. The first part is the effect of t on the capital income ($r\bar{K}$). We refer to this effect as the factor-income effect. The rate of return to capital decreases with the pollution tax rate, provided that s is greater than zero. Thus, the negative capital income effect will lead the capitalists to lobby for a lower t. More importantly, the factor-income effect (in absolute terms) increases with s; in other words, the more decentralized policymaking (the smaller s), the smaller the factor-income effect will be, indicating that the capitalists have weaker incentive to lower the tax rate. If s equals zero, then the factor-income effect vanishes.

The second term measures the effect of t on the lump-sum transfers received by the capitalists, which is referred to as the transfer effect. The sign of this term depends on η. Since the empirical evidence shows that η is usually less than unity, meaning an inelastic demand for the dirty input, we focus on the case where $\eta < 1$ what follows. With $\eta < 1$, the transfer effect is positive, which induces the capitalists to lobby for a higher pollution tax rate. We note that the magnitude of the transfer effect is reversely related to λ. The smaller λ, the greater proportion of the pollution tax revenues are distributed to the general public, providing the capitalists with a stronger incentive to lobby for a higher pollution tax rate.

The last term reflects the effect of t on the pollution damage, which is referred to as the pollution-damage effect. The pollution-damage effect is positive, meaning that the capitalists will raise t to reduce pollution damage.

The net effect of the three effects are generally ambiguous. If s is sufficiently small and $\eta < 1$, then the capitalists' MWTP may be positive, indicating that the capitalist will lobby for a higher tax rate.

Similarly, the labors' MWTP toward lobbying t is given by

$$\frac{dW^l}{dt} = F_E \frac{dE}{dt} - sK \frac{F_{KE}}{F_{EE}} - (1-\alpha^l)(1-\lambda)(1-\eta)E - \beta^l D' \frac{dE}{dt} \tag{25}$$

where $\beta^l = n^l/n$ is the proportion of the labors to the total population. The labors' MWTP also contains three parts. The first two terms on the right-hand side denote the the labor's factor-income effect, which measures the effect of t on the labor income. The factor-income effect is negative, provided that s is small. Without loss the generality, we assume that the labor-income effect is negative for all s. Unlike the capitalists' factor-income effect, the labors' factor-income effect (in the absolute terms) is positively related to s; in other words, the more decentralized policymaking in the pollution tax, the labors have a stronger incentive to lower the tax rate.

The third term is the transfer effect, which is negative when η is less than unity. We also note that the magnitude of the transfer effect increases with λ. This indicates that a greater λ will provide the labors with a stronger incentive to raise t (when $\eta < 1$), or to lower t (when $\eta > 1$).

The last term is the pollution-damage effect, which is positive. Again, like the capitalists' MWTP, the labors' MWTP can be either greater or less than zero.

By substituting (21), (24), and (25) into (23), we can rewrite the first-order condition of the policymaker's optimization as follows:

$$\begin{aligned}\frac{dG}{dt} =& \theta^l F_E \frac{dE}{dt} + \left(\theta^k - \theta^l\right) sK \frac{F_{KE}}{F_{EE}} + \left[\alpha^k\theta^k - (1-\alpha^l)\theta^l\right](1-\lambda)(1-\eta)E \\ & - \left(\theta^k\beta^k + \theta^l\beta^l\right) D' \frac{dE}{dt} + \left(F_E - D'\right)\frac{dE}{dt} = 0\end{aligned} \tag{26}$$

This condition characterizes the equilibrium pollution tax rate. We note that if the political influence of the interest groups vanishes, meaning that $\theta^k = \theta^l = 0$, then (26) reduces to $(F_E - D') \cdot dE/dt = 0$, which implies that the equilibrium tax rate will be equal to t^*. Moreover, this result implies that all types of policy instruments give rise to the same effect under all regimes of policymaking. However, such an institution-invariance property may not hold, as long as the political influence of the interest groups emerges.

We are of interest to know the effects of s and λ on the equilibrium pollution tax rate. The comparative-static result shows that the effect of a change in s on t° as $\partial t^\circ/\partial s = -(\partial^2 G/\partial t \partial s)/(\partial^2 G/\partial t^2)$. The second-order condition of the policymaker's optimization requires $\partial^2 G/\partial t^2$ to be less than zero, so that $\partial t^\circ/\partial s$ has the same sign with $\partial^2 G/\partial t \partial s$. Partially differentiating (26) with respect to s gives rise to

$$\frac{\partial^2 G}{\partial t \partial s} = \left(\theta^k - \theta^l\right) \bar{K} \frac{F_{KE}}{F_{EE}} \tag{27}$$

The above equation shows that the effect of s on t° is ambiguous, depends on the relative magnitudes of θ^k and θ^l. If the capitalists are more efficient in lobbying than the labors, i.e., $\theta^k > \theta^l$, then t° decreases with s. In other words, a more decentralized policymaking will give rise to a higher pollution tax rate in this case. On the other hand, if $\theta^k < \theta^l$, then the opposite occurs.

The following lemma summarizes the above results.

Proposition 1. *If θ^k is greater than θ^l, the a more decentralized (centralized) policymaking will result in a higher (lower) pollution tax rate. If θ^k is less than θ^l, then the opposite will occur.*

The other effect is a change in λ on t°. Similarly, the comparative-static exercise reveals that $\partial t^\circ/\partial \lambda$ has the same sign with $\partial^2 G/\partial t \partial \lambda$. By partially differentiating (26) with respect to λ we obtain

$$\frac{\partial^2 G}{\partial t \partial \lambda} = -\left[\alpha^k \theta^k - (1 - \alpha^l)\theta^l\right](1 - \eta) \tag{28}$$

The above equation shows that the sign of $\partial t^c irc/\partial \lambda$ is also ambiguous. If $\alpha^k \theta^k$ is greater than $(1 - \alpha^l)\theta^l$, then t° decreases with λ. If $\alpha^k \theta^k$ is less than $(1 - \alpha^l)\theta^l$, then the result will be reversed.

We summarize the above findings in the following lemma.

Proposition 2. *If $\alpha^k\theta^k$ is greater than $(1-\alpha^l)\theta^l$, then the equilibrium pollution tax rate decreases with λ. If $\alpha^k\theta^k$ is less than $(1-\alpha^l)\theta^l$, then the equilibrium pollution tax rate increases with λ.*

The above proposition shows that the pollution tax depends on the types of policy instruments. As a result, the federal government can deliberately choose the policy instrument to remedy the policy distortion due to the interest groups.

References

Finkelshtain, I., Kislev, Y., 1997, Prices versus quantities: the political perspective. Journal of Political Economy 105, 83–100.

Fredriksson, P.G. (1997). The political economy of pollution taxes in a small open economy. Journal of Environmental Economics and Management, 33, 44–58.

Fullerton, D. & Metcalf, G. (2001). Environmental controls, scarcity rents, and pre-existing distortions. Journal of Public Economics, 80, 249–67.

Grossman, G.M. & Helpman, E. (1994). Protection for sale. American Economic Review, 84, 833–850.

Rodrik, D., 1986, Tariffs, subsidies, and welfare with endogenous policy. Journal of International Economics 21, 285–99.