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Abstract.
Strategic environmental policy games are usually based on simultaneous decision making and reach the conclusion that the policy choices are strategic substitutes. Empirical evidence, however, shows that the introduction of a regulatory instrument usually follows a consecutive pattern that is best described as policy diffusion. To introduce policy diffusion into to a strategic environmental policy game we transform the typical model setup into a Stackelberg game in which we analyze the policy decisions of two governments when one can commit to its choice. We find that the well-known trade-off between rent-seeking and the internalisation of negative externalities from pollution is mitigated when policy diffusion takes place.

Keywords: strategic environmental policy, policy diffusion, emission tax

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1. Introduction

Strategic environmental policy games usually investigate simultaneous decision-making in a Cournot setup and predict a suboptimal internalisation of the negative externality (Conrad 1993, Barrett 1994, Simpson & Bradford 1996, Ulph & Ulph 1996). Simultaneous decision-making, however, does not find much empirical support when the introduction of environmental policy instruments is concerned. Rather, the establishment of novel regulatory instruments, such as emission taxes, follows a consecutive pattern (Busch & Jörgens 2005). If this spread of policies happens in an uncoordinated but interdependent manner it is referred to as policy diffusion (Elkins & Simmons 2005). The latter therefore defines a process by which a political innovation disseminates over time among countries (Rogers 2003). Translated into a strategic environmental policy game the diffusion of policies implies that at least one government is able to precommit to its policy decision and thus acts as a first-mover. The conventional setup then turns into a Stackelberg game in which the policy choice of the potential adopter depends on the first-mover's initial decision. If the domestic government actually commits to a tax rate it signals the foreign government that taxing foreign emissions will not create a comparative disadvantage for the foreign firm. Modelling policy diffusion therefore entails the question whether the governments' incentive to make rent-seeking for the firms located under their respective jurisdiction possible will be weakened.

2. The model

We investigate a Cournot game in which two firms that are located in two different countries produce a homogenous consumption good. Producing the good entails the creation of environmentally harmful emissions. Each country also harbours a welfare-maximising governmental agency that aims at internalising the external effect of pollution. To do so it sets a tax rate per unit of emission.

The game comprises three stages. In the third stage the firms choose their equilibrium quantities and take the choice variables of the other stages as given. The output is then sold on a third country's market which allows for the omission of consumer surplus in the welfare functions.[2] In the second stage the foreign government chooses its tax rate which, in turn, depends on the domestic tax rate. The latter is fixed in stage 1 which implies that the domestic government expects its policy choice to diffuse to the foreign government. Hence, the domestic government accounts for policy diffusion when making its decision. This Stackelberg configuration then can be solved via backward induction beginning with stage 3.

Throughout the game subscripts *i,j* refer to domestic (*d*) and foreign (*f*). The firms face a downward-sloping inverse demand function $p(y_d, y_f)$ for the consumption good on the third country market with y_i denoting the output of firm *i* which implies $p'(\cdot) < 0$. The emissions of firm *i* are denoted e_i. Emissions e_i equal output y_i, that is, $\partial e_i / \partial y_i = 1$. Moreover, firms face the cost functions $c_i(t_i, y_i)$ in which t_i stands for the tax rate in country *i*. The cost functions have the standard properties $\partial c_i / \partial y_i > 0; \partial^2 c_i / \partial (y_i)^2 = 0$ and

[2] The third-country market assumption is standard in strategic environmental policy games and allows neglecting the detrimental effects of imperfect competition.

$\partial c_i / \partial t_i > 0; \partial^2 c_i / \partial (t_i)^2 \leq 0$. Furthermore, environmental harm is captured in the convex damage function $D_i(y_i)$ with $\partial D_i / \partial y_i > 0$ and $\partial^2 D_i / \partial (y_i)^2 \geq 0$.

In the third stages of the game the firms choose their optimal quantities which maximise the according profit function:

$$\max_{y_i} \ \pi_i = p(y_i, y_j) \cdot y_i - c_i(t_i, y_i) \tag{1}$$

Maximising (1) will yield optimal quantities as functions of both the domestic and foreign tax rates from stages 2 and 1. Reinserting the optimal quantities from stage 3 into (1) yields the objective function in the second stage:

$$\max_{t_f} \ W_f = \pi_f(t_d, t_f(t_d)) - D_f(y_f(t_d, t_f(t_d))) + t_f(t_d) \cdot y_f(t_d, t_f(t_d)) \tag{2}$$

Maximising (2) yields the equilibrium foreign tax rate which, in turn, depends on the domestic tax rate. Finally, in the first stage the domestic government sets the optimal tax rate by maximising its welfare function:

$$\max_{t_d} \ W_d = \pi_d(t_d, t_f(t_d)) - D_d(y_f(t_d, t_f(t_d))) + t_d \cdot y_d(t_d, t_f(t_d)) \tag{3}$$

3. Optimal Decisions

In stage 3 both firms choose their output quantities. They do so by differentiating (1) with respect to quantities. This yields the following first-order conditions which implicitly define the Nash-Equilibrium in quantities (assuming that an interior solution exists):

$$\frac{\partial \pi_i}{\partial y_i} = p'(\cdot) \cdot y_i + p(\cdot) - \frac{\partial c_i(\cdot)}{\partial y_i} = 0 \tag{4}$$

First-order condition (4) implies the reaction functions $\tilde{y}_i = y_i(y_j)$. Equilibrium quantities can therefore be written as $y_i = y_i(t_i, t_j)$.

In stage 2 the foreign government sets its tax rate which, by definition, depends on the domestic tax rate. Differentiating (2) with respect to the foreign tax rate yields the following first-order condition which implicitly defines the Nash-equilibrium in the foreign tax rate (again, assuming an interior solution):

$$\frac{\partial W_f}{\partial t_f} = \frac{\partial p(\cdot)}{\partial y_d} \cdot \frac{\partial y_d}{\partial t_f} \cdot y_f - \frac{\partial D_f}{\partial y_f} \cdot \frac{\partial y_f}{\partial t_f} + t_f \cdot \frac{\partial y_f}{\partial t_f} = 0 \tag{5}$$

Solving first-order condition (5) for the foreign tax rate yields:

$$t_f = \frac{\partial D_f}{\partial y_f} + \frac{1}{\partial y_f / \partial t_f} \cdot \left(-\frac{\partial p(\cdot)}{\partial y_d} \cdot \frac{\partial y_d}{\partial t_f} \cdot y_f \right) \tag{6}$$

The foreign optimal regulation schedule (6) replicates the standard result that arises in simultaneous Nash-Cournot games, namely the emergence of ecological dumping. The strategic rent-shifting effect in the parenthesis in combination with the negative multiplier on the RHS in (6) is negative which results in a suboptimal internalisation of the negative externality from environmental harm.

In stage 1 the domestic government sets its tax rate in expectation of policy diffusion. To do so it maximises its welfare function with respect to the domestic tax rate:

$$\begin{aligned} \frac{\partial W_d}{\partial t_d} = \frac{\partial p(\cdot)}{\partial y_f} \cdot \frac{\partial y_f}{\partial t_d} \cdot y_d + \frac{\partial p(\cdot)}{\partial y_f} \cdot \frac{\partial y_f}{\partial t_f} \cdot \frac{\partial t_f}{\partial t_d} \cdot y_d - \frac{\partial D_d}{\partial y_d} \cdot \frac{\partial y_d}{\partial t_d} \\ - \frac{\partial D_d}{\partial y_d} \cdot \frac{\partial y_d}{\partial t_f} \cdot \frac{\partial t_f}{\partial t_d} + t_d \cdot \frac{\partial y_d}{\partial t_d} + t_d \cdot \frac{\partial y_d}{\partial t_f} \cdot \frac{\partial t_f}{\partial t_d} = 0 \end{aligned} \tag{7}$$

Solving first-order condition (7) for the domestic tax rate yields:

$$t_d = \frac{\partial D_d}{\partial y_d} + \frac{1}{\left(\frac{\partial y_d}{\partial t_d} + \frac{\partial y_d}{\partial t_f} \cdot \frac{\partial t_f}{\partial t_d} \right)} \cdot \left(-\frac{\partial p(\cdot)}{\partial y_f} \cdot \frac{\partial y_f}{\partial t_d} \cdot y_d - \frac{\partial p(\cdot)}{\partial y_f} \cdot \frac{\partial y_f}{\partial t_f} \cdot \frac{\partial t_f}{\partial t_d} \cdot y_d \right) \tag{8}$$

Whether the common rent-shifting effect is intensified or weakened by the novel second term in the second parenthesis depends on the sign of $\partial t_f / \partial t_d$: for $\partial t_f / \partial t_d < 0$ the tax decisions are strategic substitutes, for $\partial t_f / \partial t_d > 0$ they are strategic complements. In the first case the novel strategic effect is negative and thereby intensifies the downward pressure on the tax rate initiated by the rent-shifting effect. This result seems only plausible when the foreign country can gain more from the transfer of polluting production capacities from the domestic into its territory compared to the reduction in environmental harm which hints at a low foreign damage parameter. Furthermore, the domestic government must base its decision on a substantially higher damage parameter otherwise it would not have committed itself to increasing the tax rate since it accounts for the foreign government’s decision. Hence, the strategic-substitutes-case may only occur if a substantial asymmetry between the damage parameters exists so that pollution is only a marginal issue for the foreign country.
The second case, in turn, describes policy diffusion which necessitates that the tax decisions are strategic complements. Although the internalisation of environmental harm remains suboptimal, the then positive novel strategic effect in the optimal regulation schedule (8) mitigates ecological dumping. The domestic tax rate in the Stackelberg-game with policy diffusion will be higher compared to the domestic tax rate in a Cournot-Nash-game without policy diffusion (which is identical with regulation schedule (6)). Hence, in expectation of policy diffusion the unilateral setting of a tax rate yields a Pareto-improvement compared to the standard Nash-Cournot game due to the smaller extent of ecological dumping.

4. Conclusions

Including policy diffusion into a strategic environmental policy game shows that the standard result of a suboptimal internalization of the negative externality from environmental harm is mitigated when the tax decisions are strategic complements. While simultaneous decision making in an according one-period model inevitably entails the well-known race to the bottom the domestic government's opportunity to commit to its policy choice allows its foreign counterpart to break this downward spiral since the trade-off between rent-seeking and reducing emissions becomes less urgent. Thus, introducing the empirically corroborated theory of policy diffusion weakens the well-established trade-off between environmental regulation and competitiveness as long as the environmental problem is perceived to be substantial in both countries.

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