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Peter Michaelis, Thomas Ziesemer

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by

PETER MICHAELIS and THOMAS ZIESEMER

We incorporate the process of policy diffusion (i.e. the uncoordinated dissemination of policies among countries) into a probabilistic two-country-model of strategic environmental policy. Contrary to the usual setting with simultaneous decision making we consider the impact of sequential decision making: In the first step the domestic government introduces an emission tax, in the second step policy diffusion occurs with a certain probability and in the third step the firms decide on output quantities. Within this framework we analyze how the prospect of policy diffusion, motivated by a higher damage parameter in the domestic country, influences the optimal domestic emission tax. We show that if the damage parameter in the foreign country is sufficiently high policy diffusion will occur which leads to higher tax rates and higher welfare compared to the equilibrium resulting from simultaneous decision making. Moreover, we show that an increase in the domestic tax rate also increases the probability that the foreign country adopts the tax policy.

Keywords: strategic environmental policy, emission tax, policy diffusion, sequential decision-making.
JEL: F18, Q55, Q58

1 Introduction

Non-cooperative behavior is a recurring theme whenever the internalization of negative environmental externalities is analyzed in a setting with more than one country. For instance, strategic environmental policy games show that the resulting Nash-equilibrium usually is characterized by a trade-off between the firms' rent-seeking motive and the reduction in environmental harm which regularly leads to ecological dumping (RAUSCHER 2005). The latter implies a downward adjustment of the instruments' strength, e.g. the rate of an emission tax, until the according reaction functions intersect. That is, the governments' decisions regarding the instruments' respective strength are strategic substitutes. This result, in turn, is the consequence of the inherent disincentive of the governments to precommit to their regulatory decision in a game of simultaneous decision-making.

In principle, the interdependency underlying strategic environmental policy models captures the reaction of one government upon the policy decision of its counterpart. These multi-stage games, which basically are a modification of the classic strategic trade models (SPENCER & BRANDER 1983, BRANDER & SPENCER 1985), consider the above described non-cooperative decisions about the respective strength of environmental policies in different setups. The latter comprise analyses of the interdependencies of emission taxes and subsidies (CONRAD 1993), varying configurations of competition and market structure (BARRETT 1994), the impact of emission-reducing R&D expenditures (SIMPSON & BRADFORD 1996, ULPH & ULPH 1996) or the inclusion of an environmental service sector (FEESS & MUEHLHEUSSER 2002). However, Bárcena-Ruiz (2006) shows that simultaneous decision making is not the only possible setup: countries may move sequentially due to the impact of transboundary pollution. If pollution spillovers are sufficiently low emission taxes are strategic complements due to the pollution shifting effect known from Kennedy (1994), that is a country has an incentive to shift production to another country to avoid environmental damage. Consequently, emission taxes and social welfare are higher compared the standard simultaneous decision making setting. In case of high emission spillovers, this incentive diminishes and emission taxes may become strategic substitutes.

Our model follows this idea but leaves aside the pollution shifting effect to find another rationale that explains the possibility of a gradual spread of policies among countries and how this spread influences the governments' regulation schedules and their attitude towards acting as a leader. A swift glance at the real world of environmental policy making shows that policies employed elsewhere may indeed be adopted by second-movers. One example is the gradual spread of CO2/energy-taxes as can be seen from table 1.[1]

Country	*Year of introduction*	*Country*	*Year of introduction*
Finland	1990	Boulder, Colorado (USA)	2006
Norway	1991	Alberta (Canada)	2007
Sweden	1991	Quebec (Canada)	2007
Denmark	1992	British Columbia (Canada)	2008
Netherlands	1992	San Francisco Bay Area (USA)	2008
Belgium	1993	Switzerland	2008
Austria	1996	Ireland	2010
Slovenia	1997	Montgomery County, Maryland (USA)	2010
Costa Rica	1997	India	2010
Italy	1998	South Africa	2010
Germany	1999	Australia	2012
United Kingdom	2001	Taiwan (under debate)	

Table 1: The international spread of CO_2 and energy taxes

Hence, we ask, if policy adoption is a systemic determinant of policy making, whether this issue can be implemented into the context of strategic environmental policy. To begin with, a review of the literature on the topic of policy convergence ultimately provides three explanations for the spread of policies (ELKINS & SIMMONS 2005): (1) policy makers respond similar-

[1] The first carbon/energy tax was implemented in Finland in 1990. Since then further countries have introduced similar regulatory measures. This process was neither the result of harmonization nor of imposition but an outcome of policy diffusion (OECD 2001, BUSCH & JÖRGENS 2005). Note that we only listed those taxes that explicitly aim at curtailing CO_2-emissions, that is, many more countries have implemented taxes, mainly out of fiscal motives, on e.g. electricity or fuels.

ly to similar conditions in an independent and uncoordinated way; (2) the propagation of policies ensues from an interdependent and coordinated process which may involve either harmonization or imposition; (3) policy makers decide uncoordinatedly but in doing so they consider their counterparts' choices. The third explanation, which has also been dubbed "uncoordinated interdependence" (ELKINS & SIMMONS 2005, p. 35), refers to the diffusion of policies. According to the majority of scholars we view policy diffusion as the process by which a political innovation – like the introduction of a novel emission tax – disseminates over time among countries (ROGERS 2003). This implies that at least one country has to act as a first-mover in terms of policy making. The choice of the first-mover is then expected to alter the probability of further policy adoptions (STRANG 1991). These notions can be readily translated into a non-cooperative Cournot-game in which a government sets an emission tax under consideration of the other player's decision.

We show that the crucial parameter governing the decision of a country to play leader in terms of setting a higher tax rate is the damage parameter. The motivation for playing leader therefore is a higher damage parameter which may result from (1) a higher vulnerability of the environment, (2) a higher aggregated demand for a sound environment or (3) a politico-economic constellation that is favorable for installing green policies. Accordingly, we can analyze how the prospect of policy diffusion affects the decisions of a government concerning the setting of an optimal emission tax. The higher the domestic government sets its emission tax rate the higher the probability is that the foreign government adopts this policy. Nonetheless, our simple model is not meant to give a detailed account on the determinants of policy diffusion. By focusing on the damage parameter we rather aim at investigating one motivation that may explain its emergence.

The remainder of the paper is organized as follows. In section 2 we introduce the model and in section 3 we analyze the equilibrium domestic tax rate in the case of an exogenously given probability of policy diffusion. In section 4 we then compare the results of our Stackelberg-setting with the conventional simultaneous non-cooperative game. In section 5 we discuss the determinants of policy diffusion and analyze the resulting impact on the optimal domestic tax rate. Finally, in section 6 we summarize the main conclusions of our model.

2 The Model

Consider a simple model with one domestic firm indexed by *d* and one foreign firm indexed by *f*. Both firms produce a homogenous good which they sell on a third country's market. The latter assumption, which allows for omitting consumer surplus in calculating welfare levels, is standard in models of strategic environmental policy that focus on rent-seeking aspects (e.g. CONRAD 1993 and SIMPSON & BRADFORD 1996). Inverse market demand is linear and downward sloping, i.e. $p=a-(y_d+y_f)$ where y_j $(j=d,f)$ denotes the output of firm *j* which results from Cournot quantity competition. For simplicity, production costs are neglected, but it is assumed that each unit of output leads to one unit of a pollutant which is harmful to the environment of the respective country. Environmental damages are given by a quadratic damage function $D_j = \gamma_j e_j^2$ with emissions e_j equal to output y_j. In order to motivate the domestic government's role as a first-mover in environmental policy we assume that the domestic damage parameter is higher than its foreign counterpart $(\gamma_d > \gamma_f)$. This difference between the damage parameters can either be due to a higher domestic preference for environmental quality or to a more vulnerable domestic environment.

The game under consideration consists of three stages. In the first stage the domestic government introduces an emission tax t_d which may initiate a process of policy diffusion. In the second stage policy diffusion occurs with a probability of $\bar{\sigma} \in [0,1]$ which prompts the foreign government to introduce an emission tax t_f. Without policy diffusion − i.e. with a probability $(1-\bar{\sigma})$ − no foreign emission tax emerges. In the third stage the firms choose their output level given the governments' decisions from the first and the second stage.

In order to avoid confusion, it should carefully be noted that $\bar{\sigma}$ has to be interpreted within the context of our model as a *subjective probability* resulting from the judgment of the domestic government about how likely policy diffusion is to occur. To begin with we treat $\bar{\sigma}$ as exogenous. However, in section 5 we will discuss the determinants of $\bar{\sigma}$ from the viewpoint of the domestic government and analyze the resulting impacts.

As usual in models of strategic environmental policy, both governments aim at maximizing national welfare which is given by the firms' profits plus tax revenues net of environmental damages. However, in contrast to the simultaneous decision making approach usually employed in such models (e.g. SIMPSON & BRADFORD 1996), the sequence of decisions described above focuses on the process of policy diffusion and therefore establishes a Stackelberg-relationship between the two governments: Provided that policy diffusion occurs the optimal foreign tax rate t_f depends on the domestic tax rate t_d. Hence, we can derive a reaction function $t_f(t_d)$ which has to be accounted for by the domestic government in stage one of the game.

Before we proceed to analyze the equilibrium it should be noted that the above Stackelberg-framework requires that the domestic government is able to commit to its initial decision on the tax rate. At least in the short- and medium-term, however, such a commitment is already guaranteed by the nature of the political process because changing an already established emission tax requires a time-consuming legislative process. Moreover, unpredictable changes in environmental policy are not desirable in terms of providing planning reliability for the affected firms.

3 Equilibrium and Comparative Statics

Due to the sequence described above, the model can be solved by backwards induction. In the third stage, profit maximization by the firms leads to the output levels $y_d^P(t_d,t_f)=[a+t_f-2t_d]/3$ and $y_f^P(t_d,t_f)=[a+t_d-2t_f]/3$ in the case *with* policy diffusion (see Appendix A.1).[2] Analogously, we obtain for the case without policy diffusion $y_d^N(t_d)=[a-2t_d]/3$ and $y_f^N(t_d)=[a+t_d]/3$. Re-inserting these results into the firms' objective functions $\pi_j^i(t_d,t_f)=(p-t_j)y_j^i(t_d,t_f)$ yields the according profit levels of the firms $\pi_j^i(t_d,t_f)=y_j^i(t_d,t_f)^2$ for *j=d,f* and *i=P,N.*

In the second stage, the foreign welfare function for the case with policy diffusion is given by $w_f(t_d,t_f)=\pi_f^P(t_d,t_f)+t_f y_f^P(t_d,t_f)-\gamma_f y_f^P(t_d,t_f)^2$. Maximizing this expression with respect to t_f leads to the following reaction function:

(1) $$t_f(t_d)=\frac{(a+t_d)(4\gamma_f-1)}{4(1+2\gamma_f)}.$$

As shown by (1), a positive foreign tax rate requires $\gamma_f>1/4$. The explanation for this result is straightforward since there are two opposite incentives for the government: On the one hand, granting a subsidy per unit of output or emissions will increase welfare by increasing the foreign firm's profits for an amount that is higher than the subsidy itself; on the other hand, charging a tax per unit of output or emissions will increase welfare by decreasing environmental damages. Consequently, to arrive at a positive tax rate on balance, the latter incentive has to outweigh the former one. This, in turn, requires that the damage parameter γ is sufficiently large. Of course, this rationale also applies for the domestic government. In the fol-

[2] We use the superscripts "P" and "N" to indicate the case with and the case without policy diffusion. All calculations have been done using Mathematica version 5.2. The program file is available from the authors on request.

lowing we will assume that both damage parameters satisfy the condition for a positive tax rate, i.e. $\gamma_j > 1/4$ for $j=d,f$. Under this assumption, we obtain $\partial t_f / \partial t_d > 0$ from (1), i.e. the two tax rates are strategic complements.

By inserting the reaction function (1) into the above results for $y_j^P(t_d, t_f)$ we can express the output levels in the case with policy diffusion solely in terms of the domestic tax rate t_d, where the according profit levels are again given by $\pi_j^P(t_d) = y_j^P(t_d)^2$:

(2) $$y_d^P(t_d) = \frac{a(1+4\gamma_f) - t_d(3+4\gamma_f)}{4(1+2\gamma_f)},$$

(3) $$y_f^P(t_d) = \frac{a+t_d}{2(1+2\gamma_f)}.$$

Now we turn to the first stage where the domestic government introduces the tax rate t_d which may trigger the process of policy diffusion. For simplicity, we assume that the domestic government behaves risk neutral and aims at maximizing expected welfare which is given by $\tilde{w}_d(t_d) = \bar{\sigma} \cdot w_d^P(t_d) + (1-\bar{\sigma}) \cdot w_d^N(t_d)$ with $w_d^i(t_d) \equiv y_d^i(t_d)^2 + t_d y_d^i(t_d) - \gamma_d y_d^i(t_d)^2$ for $i=P,N$. Accounting for the above results concerning output and profit levels, maximization of expected welfare leads to the following domestic tax rate:

(4) $$t_d^* = \frac{8a(4\gamma_d - 1)(1+2\gamma_f)^2 + \bar{\sigma}a(4\gamma_f - 1)[1+5\gamma_d + 8\gamma_f + 4\gamma_d\gamma_f]}{32(1+2\gamma_d)(1+2\gamma_f)^2 - \bar{\sigma}(4\gamma_f - 1)[17\gamma_d - 4\gamma_f + 28\gamma_d\gamma_f - 5]}.$$

In interpreting t_d^* we start with the extreme case of $\bar{\sigma} = 0$. Under this condition (4) reduces to $t_d^*|_{\bar{\sigma}=0} = a(4\gamma_d - 1)/(4+8\gamma_d)$. This expression represents the optimal solution in the case of a pure national emission tax that is unbiased by any prospect of policy diffusion. Due to $\gamma_d > 1/4$ we obtain $t_d^*|_{\bar{\sigma}=0} > 0$. Hence, the positive welfare effects of reduced emissions always outweigh the negative effects of reduced output such that the introduction of t_d^* pays even if there is no chance for policy diffusion.

For the general case with $0 \le \overline{\sigma} \le 1$ we obtain $\partial t_d^* / \partial \overline{\sigma} > 0$ as shown in Appendix A.2.[3] Consequently, other things equal the optimal domestic tax rate is the higher the higher the probability of policy diffusion σ is. This result is not surprising since an increase in the probability of policy diffusion decreases the expected loss in profits caused by taxing emissions. Moreover, since the domestic and the foreign tax rates are strategic complements, we can conclude that any effect that leads to a higher domestic tax rate t_d^* will also increase the foreign tax rate t_f^* to be introduced in the case of policy diffusion. The latter can be calculated from inserting t_d^* into reaction function (1).

Next, we analyze how variations in the probability of policy diffusion will affect domestic welfare in equilibrium. In doing so, we have to distinguish between an ex ante and an ex post perspective. In the ex ante perspective it is not clear whether policy diffusion will occur in the end such that the relevant magnitude is *expected* welfare $\tilde{w}_d(t_d^*)$; in the ex post perspective policy diffusion has occurred or has not occurred, such that the resulting welfare level $w_d^P(t_d^*)$ or $w_d^N(t_d^*)$ has to be considered. Obviously, ex post an increase in $\overline{\sigma}$ will lead to an increase in welfare if policy diffusion occurs and to a decrease in welfare if policy diffusion does not occur, i.e. $\partial w_d^P(t_d^*)/\partial \overline{\sigma} > 0$ and $\partial w_d^N(t_d^*)/\partial \overline{\sigma} < 0$. The reason for this is straightforward: If policy diffusion finally does not occur, the difference between the tax rate actually chosen and the ex post optimal tax rate $t_d^*\big|_{\overline{\sigma}=0}$, will, other things equal, be the higher the higher $\overline{\sigma}$ is. However, if policy diffusion finally does occur, the difference between the tax rate actually

[3] Note that $t_d^*\big|_{\overline{\sigma}=0} > 0$ and $\partial t_d^* / \partial \overline{\sigma} > 0$ implies that t_d^* is always strictly positive for $\gamma_j > 1/4$ and $\overline{\sigma} \in [0,1]$.

chosen and the ex post optimal tax rate $t_d^*\big|_{\bar{\sigma}=1}$ will, other things equal, be the smaller the higher $\bar{\sigma}$ is.

In the ex ante perspective an increase in $\bar{\sigma}$ has two opposite effects on expected welfare: On the one hand, $\bar{\sigma}w_d^P(t_d^*)$ increases, on the other hand, $(1-\bar{\sigma})w_d^N(t_d^*)$ decreases. However, as shown in Appendix A.2, on balance an increase in the probability of policy diffusion will always lead to an increase in expected welfare in equilibrium.

4 First-Mover Behavior vs. Simultaneous Decision Making

In order to explore the implications of first-mover behavior by the domestic government, it is also instructive to compare the above results with the results of a standard model of strategic environmental policy where both governments fix their emission taxes simultaneously. For reasons of consistency, we restrict the analysis to the case with probability $\bar{\sigma}=1$ and omit the second stage of the game described above. In order to distinguish the according outcome from the results derived in the last section, we use upper case letters for the case of simultaneous decision making. In the second stage of the now modified game, the tax rates T_d and T_f are already given and the firms simultaneously choose their output levels. This leads to output levels $Y_d(T_d,T_f)=[a+T_f-2T_d]/3$ and $Y_f(T_d,T_f)=[a+T_d-2T_f]/3$ with the according profit levels $\Pi_j(T_d,T_f)=Y_j(T_d,T_f)^2$ for $j=d,f$. In the first stage of the game, both governments simultaneously maximize the welfare function $W_j(T_d,T_f)=\Pi_j(T_d,T_f)+T_jY_j(T_d,T_f)-\gamma_jY_j(T_d,T_f)^2$ for $j=d,f$. The resulting reaction functions can be solved for the following tax rates:

(5) $$T_d^*=\frac{a(4\gamma_d-1)(1+4\gamma_f)}{5+12\gamma_f+4\gamma_d(3+4\gamma_f)}, \quad T_f^*=\frac{a(4\gamma_f-1)(1+4\gamma_d)}{5+12\gamma_f+4\gamma_d(3+4\gamma_f)}.$$

In contrast, in the Stackelberg setup, following from (3), first-mover behavior by the domestic government implies for the case of $\bar{\sigma}=1$:

(6) $$t_d^* = \frac{a(1+4\gamma_f)[\gamma_d(3+4\gamma_f)-1]}{(3+4\gamma_f)[1+3\gamma_d+4\gamma_f(1+\gamma_d)]}$$

By inserting this into the reaction function (1) we obtain for the according foreign tax rate:

(7) $$t_f^* = \frac{a(4\gamma_f-1)[1+4\gamma_f+\gamma_d(6+8\gamma_f)]}{2(3+4\gamma_f)[1+3\gamma_d+4\gamma_f(1+\gamma_d)]}.$$

Comparing (5) with (6) and (7) respectively, it is easy to show that first mover behavior by the domestic government implies higher tax rates compared to the Nash-equilibrium resulting from simultaneous decision making for both countries, i.e. $t_d^* > T_d^*$ and $t_f^* > T_f^*$ (see Appendix A.3). Hence, the domestic government exploits its first mover advantage in order to fix a higher tax rate. Moreover, both countries attain a higher level of welfare compared to the case of simultaneous decision making. Consequently, first mover behavior that is accompanied by policy diffusion leads to a Pareto-improvement (see Appendix A.3) and accordingly prevents a tax race to the bottom.

In the next section we turn back to our original model where policy diffusion occurs with probability $\bar{\sigma}$. But now we will discuss the determinants of $\bar{\sigma}$ from the viewpoint of the domestic government and analyze the resulting impacts on the optimal domestic tax rate.

5 *Determinants of Policy Diffusion*

Since adopting the domestic tax rate leads to a higher foreign welfare level the domestic government could assume a probability of 1. Hence, the commitment of the domestic government signals its foreign counterpart that taxing emissions will not harm foreign industry profits as long as γ_f >1/4. However, different impediments towards adoption like the lack of foreign institutional capabilities may arise. Overcoming such impediments is more probable the higher the gains from establishing an emission tax are. Hence, from the viewpoint of the domestic government it seems to be rational to assume that the probability of policy diffusion is other things equal the higher, the larger the foreign difference in welfare between the cases with and without policy diffusion is. For the case without policy diffusion the foreign welfare level as a function of t_d is given by $w_f^N(t_d) = (1-\gamma_f)y_f^N(t_d)^2$. Inserting $y_f^N(t_d)$ as calculated in Section 3 yields:

(8) $$w_f^N(t_d) = \frac{(a+t_d)^2(1-\gamma_f)}{9}.$$

For the case with policy diffusion the foreign welfare level as a function of t_d is given by $w_f^P(t_d) = (1-\gamma_f)y_f^P(t_d)^2 + t_f(t_d)y_f^P(t_d)$. Inserting $t_f(t_d)$ according to (1) and $y_f^P(t_d)$ according to (3) yields:

(9) $$w_f^P(t_d) = \frac{(a+t_d)^2}{8(1+2\gamma_f)}.$$

Finally, calculating the difference between both welfare levels we arrive at:

(10) $$\hat{w}_f(t_d) \equiv w_f^P(t_d) - w_f^N(t_d) = \frac{(a+t_d)^2(4\gamma_f - 1)^2}{72(1+2\gamma_f)}.$$

As indicated by (10), the difference in foreign welfare is, other things equal, the higher, the higher the domestic tax rate t_d is. Consequently, increasing t_d leads to an increase in the probability of policy diffusion. Moreover, foreign welfare also increases in the foreign damage parameter if γ_f >1/4. So again, environmental damage in the foreign country must be sufficiently high to make policy diffusion plausible.

Although our model is too complex to allow for an explicit backwards solution with an endogenous probability of policy diffusion, the above result yields some interesting insights concerning the relationship between optimal first-mover behavior and policy diffusion. First, the merits of models with simultaneous decision making notwithstanding actual patterns of the spread of environmental policies show that the introduction of regulatory instruments usually happens sequentially. Hence, our model provides a starting point for the analysis of an empirical phenomenon. Second, it is shown that playing first-mover does not trigger a non-cooperative reaction as long as the foreign government has an incentive to reduce emissions. This, in turn, is ensured by a sufficiently high damage parameter. Thus, if an environmental problem is substantial a country considering acting as a first mover in terms of setting an emission tax does not necessarily need to fear ecological dumping. Third, the more ambitious the domestic government acts in terms of fixing the tax rate the higher the probability of policy diffusion becomes. Thus, although a non-cooperative setting has been utilized the early commitment of the domestic government leads to an equilibrium which is Pareto-superior to non-cooperative simultaneous decision-making. Acting as a first mover is therefore a strong signal for more reluctant governments to overcome their doubt and reevaluate their approach to implementing an environmental policy.

6 Summary and Conclusions

Policy diffusion describes the process by which a political innovation – like the introduction of a novel emission tax – disseminates over time among countries. This implies that at least one country has to act as a first-mover in terms of policy making. The choice of the first-mover is then expected to alter the probability of further policy adoptions. In order to analyze this issue from an economic point of view we have developed a simple two-country-model in which emissions are taxed in the presence of (possible) policy diffusion. Contrary to the usual approach of simultaneous decisions on tax rates we consider a Stackelberg game: In the first step the domestic government introduces an emission tax t_d thus acting as Stackelberg-leader, in the second step the foreign government decides whether or not to introduce an emission tax t_f and in the third step the firms decide on their output quantities to be sold on a third country's market. For the case of an exogenous probability of policy diffusion we show that the optimal domestic tax rate is, other things equal, the higher the higher the probability of adoption is. Next, we demonstrate that this probability is determined by the increase in foreign welfare that follows from taxing emissions. Due to the domestic government's commitment to the introduction of an emission tax the foreign government can only gain by adopting the regulatory policy (as long as the foreign damage parameter is sufficiently high). Moreover, we show that first-mover behaviour by the domestic government leads to a higher tax rate compared to the Nash solution with simultaneous decisions on tax rates.

To be sure, our analysis of policy diffusion in a strategic trade setting is not meant to be an exhaustive treatment of this issue. Rather, its objective is to introduce an empirically relevant topic into an established theoretical framework of environmental policy making. Obviously, modelling the foreign government's policy choice as a reaction to the decision of its domestic counterpart obviates the standard assumptions about the actors' optimising behaviour in a typical strategic environmental policy game. At first glance, our setup involves a rather servile foreign government which may be a disquieting proposition in an analysis of welfare-maximising behaviour. However, the simple decision rule of the foreign government is a proxy for more complex considerations that may also serve as starting points for future research: First, the simple decision rule may reflect economizing on scarce political and administrative resources in the sense that imitating an existing policy is the consequence from costminimising behaviour. Second, the rule may stand for the existence of substantial costs of learning about the policy innovation. This implies ex ante imperfect information about possible policy innovations which allows for the emergence of a first-mover. Third, the rule may capture the issue of heterogeneous stocks of experience and knowledge about policy making which also allows for first-mover behaviour. Finally, future research can also analyze a multi-period setup in which the domestic government is able to revaluate its initial decision after the foreign government adopted the tax or not. Thus, these examples represent other determinants of policy diffusion and their analysis may further improve our understanding of the implications of policy diffusion.

Appendix

A.1 Determination of quantities in equilibrium

Profit maximization by the domestic firm implies:

(A1) $$Max!\ \pi_d = [a - y_d - y_f]y_d - t_d y_d \quad \rightarrow \quad y_d = 0.5[a - y_f - t_d].$$

Analogously, profit maximization by the foreign firm implies:

(A2) $$Max\ !\ \pi_f = [a - y_d - y_f]y_f - \varphi t_f y_f \quad \rightarrow \quad y_f = 0.5[a - y_d - \varphi t_f],$$

where φ is a dummy variable associated with the foreign tax rate, i.e., we use $\varphi=1$ for the case with policy diffusion and $\varphi=0$ for the case without policy diffusion, respectively. Solving (A1) and (A2) for the equilibrium yields:

(A3) $$y_d = (1/3)[a + \varphi t_f - 2t_d],$$

(A4) $$y_f = (1/3)[a + t_d - 2\varphi t_f].$$

A.2 Proof for $\partial t_d^* / \partial \bar{\sigma} > 0$ *and* $\partial \tilde{w}_d (t_d^*) / \partial \bar{\sigma} > 0$

Differentiating t_d^* with respect to $\bar{\sigma}$ and rearranging terms yields:

$$\text{(A5)} \qquad \frac{\partial t_d^*}{\partial \bar{\sigma}} = \frac{72a}{\omega}[(1+2\gamma_f)^2(4\gamma_f - 1)(1+(4\gamma_f + \gamma_d(4\gamma_f - 1 + 4\gamma_d(3+4\gamma_f))))]$$

with $\omega \equiv [\bar{\sigma}(4\gamma_f - 1)(28\gamma_d\gamma_f + 17\gamma_d - 4\gamma_f - 5) - 32(1+2\gamma_d)(1+2\gamma_f)^2]^2 > 0$. Due to $\gamma_f > 1/4$ we obtain $\partial t_d^* / \partial \bar{\sigma} > 0$ from (A5). Moreover, to see that an increase in $\bar{\sigma}$ always leads to an increase in expected welfare in equilibrium, note that the latter can be written as $\tilde{w}_d^*(t_d^*(\bar{\sigma}), \bar{\sigma})$. Hence, we obtain:

$$\text{(A6)} \qquad \frac{\partial \tilde{w}_d^*(t_d^*(\bar{\sigma}), \bar{\sigma})}{\partial \bar{\sigma}} = \frac{\partial \tilde{w}_d^*}{\partial \bar{\sigma}} + \frac{\partial \tilde{w}_d^*}{\partial t_d^*}\frac{\partial t_d^*}{\partial \bar{\sigma}}.$$

Due to the first order condition $\partial \tilde{w}_d^* / \partial t_d^* = 0$, equation (A6) reduces to the direct effect $\partial \tilde{w}_d^* / \partial \bar{\sigma}$ which is always positive.

A.3 Proof for $t_j^* > T_j^*$ *and Pareto-improvement*

Calculating the difference $\Delta t_d = t_d^* - T_d^*$ and $\Delta t_f = t_f^* - T_f^*$ from (5), (6) and (7) yields the following expressions which are always positive due to $\gamma_j > 1/4$:

$$\text{(A7)} \qquad \Delta t_d = \frac{2a(1+2\gamma_f)(4\gamma_f - 1)(1+4\gamma_f)}{(3+4\gamma_f)[1+3\gamma_d + 4\gamma_f(1+\gamma_d)][5+12\gamma_f + 4\gamma_d(3+4\gamma_f)]} > 0$$

$$\text{(A8)} \qquad \Delta t_f = \frac{a(1-4\gamma_f)^2(1+4\gamma_f)}{2(3+4\gamma_f)[1+3\gamma_d + 4\gamma_f(1+\gamma_d)][5+12\gamma_f + 4\gamma_d(3+4\gamma_f)]} > 0$$

Moreover, the resulting welfare levels for the case of first-mover behavior by the domestic government (w_j^*) as well as for the case of simultaneous decision making (W_j^*) can be calculated as:

(A9) $$w_d^* = \frac{a(1+4\gamma_f)^2}{4(3+4\gamma_f)[1+3\gamma_d+4\gamma_f(1+4\gamma_d)]},$$

(A10) $$w_f^* = \frac{a^2(1+2\gamma_f)[1+4\gamma_f+\gamma_d(6+8\gamma_f)]^2}{2(3+4\gamma_f)^2[1+3\gamma_d+4\gamma_f(1+\gamma_d)]^2},$$

(A11) $$W_j^* = \frac{2(1+2\gamma_j)(a+4\gamma_i)^2}{[5+12\gamma_i+4\gamma_j(3+4\gamma_i)]^2} \quad \textit{for} \;\; i=d,f \;\; j=d,f \;\; \textit{and} \;\; i \neq j .$$

Calculating the differences $\Delta w_d = w_d^* - W_d^*$ and $\Delta w_f = w_f^* - W_f^*$ and accounting for γ_f>1/4 shows that first-mover behavior leads to a Pareto improvement compared to the Nash equilibrium with simultaneous decision making:

(A12) $$\Delta w_d = \frac{a^2(1-16\gamma_f^2)^2}{4(3+4\gamma_f)[1+3\gamma_d+4\gamma_f(1+\gamma_d)][5+12\gamma_f+4\gamma_d(3+4\gamma_f)]^2} > 0 ,$$

(A13)

$$\Delta w_f = \frac{a^2(16\gamma_f^2-1)[16\gamma_d^2(3+4\gamma_f)^2+4\gamma_d(3+4\gamma_f)(7+20\gamma_f)+(1+4\gamma_f)(11+20\gamma_f)]}{(3+4\gamma_f)^2[1+3\gamma_d+4\gamma_f(1+\gamma_d)]^2[5+12\gamma_f+4\gamma_d(3+4\gamma_f)]^2} > 0$$

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