The Political Economy of Strategic Environmental Policy When Waste Products Are Tradeable

by
James Cassing* and Thomas Kuhn**

Abstract

A particularly contentious environmental issue between nations, and between regions within nations, is the policy attitude toward the disposal of waste, such as in landfills, and other potentially harmful industrial by-products like spent nuclear fuel. An international and interregional policy issue arises because many of these unwanted products are themselves tradeable commodities. For example, Germany used to export plastic refuse to China until the political resistance of the Chinese population forced a suscession of the trade in 1995 (*Fischer and Petschow*, 2000). More ominously, North Korea has agreed to accept up to 200,000 barrels of nuclear waste from Taiwan, in exchange for tens of millions of dollars (*New York Times*, Feb. 7, 1997).. More generally, the OECD estimated in 1985 that about 350 million tons of hazardous waste are generated worldwide and *Yakowitz* (1987) estimated that ten percent of this might be exported, although proposed shipments far exceed this amount (*Vallette*, 1990). The trade includes at least fifty countries and is worldwide, typically from more developed to less developed countries and trusteeship territories.

In this paper we explore the implications of the possibility of "trade in trash" on optimal environmental policy and on the ramifications of a stronger or weaker environmental lobby across regions or nations. Hence, we have constructed a multiple stage game composed of a market stage and a policy stage. Waste is generated as a by-product of production and, since we assume an international market for waste products to exist, might be exported to some less developed countries to get rid of any damages linked to waste treatment and disposal. Waste markets are imperfect, the assumption made is that waste exporters - usually big industries like the chemical and nuclear industry or central processors for plastics wastes and such kind- do have power in the waste market while importers -small firms in less developed countries- are pure price takers. On the policy level countries are large to be able to affect the terms of trade for waste products. Thus, naturally, governments get involved into Nash tax competition where politicians are taken to maximise a political support function reflecting lobbying activities of environmentalists as well as industrialists. In general, we find that environmentalists do not necessarily succeed in pushing stricter environmental policies nor do industrialists in pushing weaker due to the fact that lobbying may be offset by the terms of trade effect.

JEL: F1, H2, L1, Q2

***James H. Cassing**, Department of Economics, University of Pittsburgh, Pittsburgh PA 15260, USA, e-mail: jcassing+@pitt.edu

****Thomas Kuhn**, Department of Economics and Business Administration, Chemnitz University of Technology, 09107 Chemnitz, FRG, e-mail: t.kuhn@wirtschaft.tu-chemnitz.de, ph +49-371-531-4942, fax +49-371-531-4343 (corresponding author)

1. Introduction

A particularly contentious environmental issue between nations, and between regions within nations, is the policy attitude toward the disposal of waste, such as in landfills, and other potentially harmful industrial by-products like spent nuclear fuel. An international and interregional policy issue arises because many of these unwanted products are themselves tradeable commodities.

For example, Germany used to export plastic refuse to China until the political resistance of the Chinese population forced a suscession of the trade in 1995 (*Fischer and Petschow*, 2000). More ominously, North Korea has agreed to accept up to 200,000 barrels of nuclear waste from Taiwan, in exchange for tens of millions of dollars (*New York Times*, Feb. 7, 1997). Similarly, South Africa continually imports toxic material for recycling and argues forcefully that this is to the benefit of the exporting countries who otherwise would have to deal with illegal dumping of toxic waste by unscrupulous concerns (*Mail&Guardian*, Sept. 19, 1996). More generally, the OECD estimated in 1985 that about 350 million tons of hazardous waste are generated worldwide and *Yakowitz* (1987) estimated that ten percent of this might be exported, although proposed shipments far exceed this amount (*Vallette*, 1990). The trade includes at least fifty countries and is worldwide, typically from more developed to less developed countries and trusteeship territories. (An exception is Britain, which has become a major waste importer recently.) As far as regional trade in waste products is concerned, US interstate solid waste shipments serves as an example *(Ley/Macauley/Salant,*1998), as does the regional allocation of hazardous waste disposal (*Alberini/Bartholomew,* 1998). Several U.S. Indian tribes are also importing wastes onto their quasi-sovereign reservations from nearby urban areas. Associated with the growing trade in waste materials is a series of treaties and understandings, such as the Basel Convention, which purport to control the trade in globally optimal ways. Of course, once waste is tradeable, optimal global policies depend on individual countries' environmental policies as well as on the market structure associated with the trade.

While economists might naturally think of waste as just another traded good, two complications arise in the market for this good. First, the waste commonly embodies a negative externality which means that optimal environmental policy now gets entangled with international (interregional) trade. (We view this tradeable externality as a novel feature of the model presented below.) Second, the issue is a politically charged one and policy-makers cannot ignore the forceful influence of "environmentalists" on one side and "industrialists" on the other. Thus, policy is bound to be driven by pressure group politics irrespective of true marginal social damages.

In this paper we explore the implications of the possibility of "trade in trash" on optimal environmental policy and on the ramifications of a stronger or weaker environmental lobby across regions or nations. Hence, we have constructed a multiple stage game composed of a market stage and a policy stage. Waste is generated as a by-product of production and, since we assume an international market for waste products to exist, might be exported to some less developed countries to get rid of any damages linked to waste treatment and disposal. Waste markets are imperfect, the assumption made is that waste exporters -- usually big industries like the chemical and nuclear industry or central processors for plastics wastes and such -- do have power in the waste market while importers -- small firms in less developed countries -- are pure price takers. On the policy level, countries are large enough to be able to affect the terms of trade for waste products. Thus, naturally, governments get involved in Nash tax competition where polititians are taken to maximise a political support function reflecting lobbying activities of environmentalists as well as industrialists.

Moreover, since strategic behavior on the market as well as the policy level induces efficiency losses from a global welfare point of view, we derive conditions for globally optimal policies as a benchmark for international environmental agreements. However, when it comes to the implementation of second best policies on the national level the policy makers are faced with difficulties originating from gains and losses linked to such a kind of environmental agreements, especially when those do not work in favor of influential national pressure groups. Not least, this might explain the commonly heard complaint that developed countries are environmentally more concerned than less developed countries.

The paper is organized as follows. In section 2 we present a model of trade in waste aimed to capture the salient features of the actual market in such products. In particular, the model allows the possibility of market power on the side of the waste exporting industries and, of course, all governments. The basic model goes back to *Cassing/Kuhn (1999)*, which, however, does not include any political economy aspects. Section 3 is focussed on the computation of the market equilibrium incorporating comparative statics results for the environmental policies which the counties involved impose on domestic firms. In section 4 we try to establish some results for optimal environmental policies when countries are involved in strategic eco-tax competition. In particular, the impact of lobbying on the optimal tax rates is explored. Section 5 is dedicated to the discussion of optimal policies from a global welfare welfare point of view to be taken as a benchmark. Finally, in section 6, we discuss efficiency losses linked to distortions existing in the economy in light of environmental externalities and market power. In particular, inefficiencies driven by pressure groups are considered.

2. The Model

While there is a fairly big market for trade in environmentally sensitive products, that market is a bit idiosyncratic. (For a nice collection of papers on the subject, see *Caldwell and Bartlett*, 1997.) On the "supply of waste" side, the initial suppliers are sometimes fairly competitive in taking the price of waste treatment as given, as is the case with plastic and paper waste in most countries, and sometimes nearly monopolistic, as in the case of nuclear waste from Taiwan. Typically, however, exporters are in fact contracted brokers that behave as price searchers looking for the best deals among the potential buying nations and negotiating contracts (*Hiltz*, 1992; *Hiltz and Ehrenfeld*, 1991; *Roelants du Vivier*, 1988)**.** Also, even when waste is supplied fairly competitively initially, governments often create central processors who have the mandate to dispose of the waste -- including on international markets -- and so there is an opportunity to exploit market power by this central agent. For example, in Germany there is a "green point" industry engaged in the collection of trash and all kinds of packaging material and then charged with the disposal of this waste. The green point industry is itself organized as a monopoly and so when it goes to dispose of the trash, it is the sole supplier for all of Germany. A substantial share of the waste is indeed exported to developing countries such as North Korea, China, Indonesia, and several poor countries in Africa.

On the "demand for waste" side of the market, there is typically considerably more competition, as there are many firms and many countries -- especially developing countries -- which vie for the waste disposal contracts. Indeed, several developing countries have voiced the opinion that they are in a sense exploited by the market power of the waste exporters and have called for some coordinated action by third world countries. More generally, there is some sense in both developed and developing nations that trade in waste, especially hazardous waste such as spent nuclear fuel, carries with it some potentially serious externalities that may call for international conventions on what is appropriate market behavior.

In order to capture some of the essential elements of this market, we aim to construct a model where there is an environmentally harmful by-product of industry in a developed country market. This by-product may be tolerated at some level -- possibly being subjected to a Pigouvian tax -- , abated by the producing industry, or exported out of the country. We will typically assume that there is some market power in the world market for waste. We will characterize the waste importing countries as developing countries with less market power, but who cannot eliminate the external costs of the waste on their own citizens simply by disposing of the waste. Thus, they may want to restrict imports of waste materials.

Specifically, we will suppose that there are $m+1$ countries consisting of a home country, H, and m foreign countries F_j , $j = 1, ... , m$. Home country variables will be distinguished by the absence of a superscript j and aggregate variables, when appropriate, will be denoted with capital letters. In country H, there is an industry comprised of n identical firms each of which produces a quantity of output, y, for sale on world markets at fixed price p_y . The production of y is assumed to create a by-product in the amount z, "waste", which imposes an external cost on society measured by a convex damage function $D(.)$. Conventionally, we suppose that the amount of waste produced depends positively on the output level and negatively on the amount of investment in waste abatement technology, a. Thus, we write $z(y,a)$ and production costs as $c(y,a)$. We take $c(.)$ to be increasing and convex in both arguments and, for convenience, $z(.)$ to be linear and separable with respect to both y and a. Less conventionally, we assume that there is an international market for waste material and that any quantity, e, of the waste may be exported by the home firms at a price. Exported waste does not harm the domestic environment, we suppose, and so the environmental damage in H is given by $D(Z - E)$, where by symmetry of the firms $Z = nz$ and $E = ne$. The home government is assumed to have an environmental policy tool in the form of a tax, t, which can be applied per unit of unexported waste.

In each foreign country F_j , we suppose that there is a competitive waste disposal industry which charges a price p per unit to treat imported waste at a cost $c^j(e^j)$. We assume that marginal treatment costs are increasing and convex. Also, we assume that imported waste, or perhaps the treatment process itself, creates a negative externality in the importing country measured by a damage function $D^j(e^j)$. Finally, each importing country is assumed to have an environmental policy captured by a tax, t^j, applied per unit to imported waste material.

The model is designed as a multiple stage game where there is imperfect competition both on the market level and in the policy space. In the first stage, governments strategically set their tax rates to maximise a Peltzman-Stigler political support function as their objective function. Countries are large in the sense of being able to improve the terms of trade in the waste market. As already mentioned, and following the earlier literature, the environmental tax is taken as a country's sole policy measure to serve as a means not only to internalise externalities, but at the same time to extract rents in the waste market. With regard to the solution concept, we consider Nash strategies with simultaneous moves. In the second stage -- the market level -- firms maximize profits conditioned on the tax rates imposed. The market structure is characterized by a symmetric oligopoly where there is Cournot-Nash competition on the side of the exporting firms and perfect competition on the waste demand side. Following the usual concept of a backwards solution, we turn to the market equilibrium first.

3. The Market Solution

Given the environmental tax policies of governments, the market equilibrium level of the endogenous variables emerges from the profit maximizing conditions for the firms along with the market clearing condition that the total country *H* supply of waste, *E*, equals the sum of the other countries F_j demands for waste, $\Sigma j e^j$. Thus, the equilibrium will be sensitive to the market structure and particular solution concepts which we impose. We begin with optimization by the foreign waste importing industry.

In country F_j, assuming price taking behavior and with the tax-inclusive price of waste treatment being taken as *p*, profits of the representative firm are given by

(3.1)
$$\max_{e^j} \ \pi^j(e^j;t^j) = pe^j - c^j(e^j) - t^j e^j$$

Differentiating with respect to e^j gives the first and second order conditions

(3.2)
$$\frac{\delta\pi^j}{\delta e^j} = p - c^j_{e^j} - t^j = 0 \qquad (FOC\ \pi^j)$$

(3.3)
$$\frac{\delta^2\pi^j}{\delta e^{j^2}} = -c^j_{e^je^j} < 0 \qquad (SOC\ \pi^j)$$

These first order conditions then yield the demand for waste in each country, $e^j = e^j(p, t^j)$ according to the tax inclusive marginal disposal costs and so market demand is just $E(p,t') = \Sigma_j e^j(p,t^j)$. The inverse demand schedule can be written $p(E;t')$ where $t'=(t^1,...,t^m)$ and, from equation (3.3), is upward sloping in *E* and convex. Since $\partial p/\partial t^j > 0$, the whole schedule shifts up or down as t^j increases or decreases for any *j*.

In the home country *H*, profits for the typical (identical) firm are given by

(3.4)
$$\max_{y,a,e} \ \pi(y,a,e;t) = p_y y - c(y,a) - t(z(y,a) - e) - p(E,t')e$$

where $p(E;t')$ is the (endogenous) inverse demand curve confronting the home firms and is less than infinitely elastic in the case of oligopoly or monopoly in the waste market.

The first order profit maximizing conditions are given by

(3.5) $$\frac{\delta\pi}{\delta y} = p_y - c_y - tz_y = 0 \qquad (FOC\ \pi)$$

(3.6) $$\frac{\delta\pi}{\delta a} = -c_a - tz_a = 0$$

(3.7) $$\frac{\delta\pi}{\delta e} = t - p - p_E e = 0$$

Intuitively,first order conditions are straight forward. In the absence of international trade in waste, equations (3.5) and (3.6) determine the optimal levels of output and abatement technology, recognizing that external waste will be subject to a per unit tax of t. When there is an international market for waste, equation (3.7) becomes relevant and helps in determining the level of exports according to marginal revenue equals marginal cost. The marginal cost of exporting is just the price paid to foreigners for waste treatment, p, in addition to any market power effect that may exist, $p_E e$. The marginal revenue of exporting the waste is represented by t, the per unit tax savings from shipping the waste out of the country. Naturally, if the externality is ignored in H -- $t=0$ -- equation (3.7) yields the corner solution of no exports, $e=0$. More generally, if $t>0$ and $p(0^+)$ is close enough to zero, we would expect some exports of waste. Since $p_E>0$, exports will rise in equilibrium as t rises up to the limit of z where all waste is exported. In the case of perfect competition, wherein p is taken as given at the market equilibrium and p_E is viewed as zero by the firms, all waste will be exported or not as $t>p$ or $t<p$.

The equilibrium on the waste market derived from the first order conditions for profit maximisation by home and foreign firms as stated above can be shown to exist and to be unique. (See appendix.) In the case of imperfect competition, and recalling symmetry of the exporting industry so that $E=ne$, the market equilibrium may be characterized as follows:

(3.8) $$\frac{t-p}{p} = \frac{1}{\epsilon_{E,p}(t')n}$$

This equation simply means that the degree of exploitation of market power by the waste exporting industry, measured in terms of the relative tax-price gap, is reciprocal to the degree of oligopolistic competition in the market, n, and to the the elasticity of demand which in turn depends on all foreign taxes. As a result, the ability to depress price leads to too little waste exporting compared to the amount a competitive industry would want to achieve. That is, the shadow price of exporting the waste as percieved by a domestic oligopolist is higher than the competitive price, driving exports down.

Thus, we get the standard result of inefficient trade in waste. A social planner trying to assure the first best solution would alter trade in waste to a level where marginal social costs of the externality would be equalized worldwide. Moreover, it is easy to see that one way to achieve the social optimum is the creation of a perfectly competitive waste market along with a perfectly internalising Pigouvian tax scheme, wherein taxes in each country are set equal to marginal damages. However, with anything less than perfect competition in the international waste market, these Pigouvian taxes are not typically first-best, and, if governments act strategically, the Pigouvian taxes are not typically credible as policy. Waste is traded at a level where marginal social costs in the home country still exceed marginal social costs in any foreign country, so there is too little trade in waste from a global welfare point of view. (See section 5 for a full discussion of efficiency)

Comparative Statics Properties of the Equilibrium:

So far, we have treated the policy variables of the model, t and each t^j, as parameters. In the analysis to follow, we will use the comparative statics properties of the equilibrium and so we state these results here as a lemma, where due to symmetry we write total production $Y=ny$ and total abatement $A=na$.

Lemma 1: *Comparative Statics Properties of the Market Equilibrium*

For all t, t^j, j=1,...,m

i. $dY/dt < 0$

ii. $dY/dt^j = 0$

iii. $dA/dt > 0$

iv. $dA/dt^j = 0$

v. $dE/dt > 0$

vi. $dE/dt^j < 0$

vii. $dp/dt > 0$

viii. $dp/dt^j > 0$

Proof: see Appendix

These results may be interpreted as follows. An increase in the rate t increases taxes on waste directly and on output indirectly by taxing the by-product more. Consequently, output Y falls and investment in abatement technology A increases. Also, the tax can be escaped by exporting more of the waste and so E increases. Since the costs of treatment abroad are increasing in E, the price p must increase. An increase in an environmental tax in a foreign country raises the price of exporting any given quantity and so makes it less attractive to export.

However, since the domestic tax t has not changed and was, through equation (3.7), already equal to marginal export costs, equilibrium is restored by simply shifting some of the exports back to the home market and paying the domestic tax. There is no effect on home production Y or level of abatement effort A from changes in foreign environmental policy since the marginal cost of additional waste is still t and has not changed. There is a kind of interesting asymmetry here in taxes at home and abroad. An increase in t affects production because waste is more expensive to dispose of both at home due to the increased tax and abroad due to increasing marginal costs of waste disposal. However, an increase in t^j leads to fewer exports but does not affect production because as previous exports are now kept at home, the marginal cost of the waste -- t -- does not increase. Finally, we find a decrease in t leads to a fall in p and an increase in any foreign tax causes p to rise.

4. Strategic Environmental Policy and Political Influence Motives

In this section we analyse different regimes according to the strategies the home government and the foreign governments can play and subject to the relative strength of the environmental and industrial lobbies. For reference, we first consider a scenario where all countries act nonstrategically and governments ignore political influence motives, focussing on the environmental impact of the tax on pollution solely. Thus, the taxing authorities are assumed to ignore any effects their tax rates might have on the terms of trade or political support, as well as ignoring any strategic behavior of the other country.

4.1 The Policy Level and the Political Support Function

Generally, the welfare problem of any country is taken to be the maximization of social welfare composed of producer rents, consumer rents, and tax revenues net of damages. Since consumer surplus depends only on the output price which is unaffected by environmental policy for a small open economy, we assume that the good is not consumed domestically so that this term will not appear in the welfare expression. The assumption being made by any government in the first stage of the game is that each local firm is maximising profits for any possible tax schedule. However, in order to parameterize the relative political influence of environmentalists and industrialists, we introduce an "environmental weight" Θ on the environmental component of the welfare expression. Thus, when Θ = *1*, the welfare expression is the usual sum of surpluses and revenues. And, the environmental lobby receives more or less weight as Θ exceeds or falls short of unity. (We give tariff revenue the same weight as industry profits in order to focus on the political influence effect of environmentalists. For a discussion of "revenue motives" in policy formation see *Bhagwati et al., 1998, ch. 34)*

Hence,the home country's decision is given by

$$(4.1) \qquad \max_t \; w(t;t') = n\pi(t;t') + t(Z-E(t;t')) - \theta\, D(Z-E(t;t'))$$

$$s.t. \; (FOC \;\; \pi)$$

In particular, political support in the home country is given by the profits earned on the goods market by the waste generating industry, plus tax revenues net of weighted damages to home residents due to domestic waste retained locally. Note again that when $\Theta = 1$, this is just the usual welfare expression.

The first order condition is

(4.2)

$$n[\frac{dy}{dt}(p_y - c_y - \Theta z_y D_{Z-E}) + \frac{da}{dt}(-c_a - \Theta z_a D_{Z-E}) + \frac{de}{dt}(\Theta D_{Z-E} - p(E) - ep_E)] - \frac{(n-1)}{n} E p_E \frac{dE}{dt} = 0$$

Similarly, the jth foreign government´s welfare maximisation problem is given by:

(4.3)

$$\max_{t^j} \; w^j(t^j;t,t^{-j}) = \pi^j(t^j;t,t^{-j}) + t^j e^j(t^j;t,t^{-j}) - \Theta^j \; D^j(e^j(t^j;t,t^{-j}))$$

$$s.t. \;\; (FOC \;\; \pi^j)$$

where $t^{-j} := (t^1,...,t^{j-1},t^{j+1},...,t^m)$, $j = 1,...,m$ and profits are defined by (3.1). The weight Θ^j again captures the relative strength of the environmental lobby in the foreign country j. When this parameter is unity, the political support function is just the usual welfare expression. More generally, political support is given by the aggregate profits earned on the waste-processing market, plus environmental taxes collected minus the weighted damages that the disposal of waste imposes on domestic residents.

The first order condition is then given by:

(4.4)

$$\frac{de^j}{dt^j}(p - c_{e^j} - \Theta^j D^j_{e^j}) + \frac{dp}{dt^j}(e^j) = 0$$

Any equilibrium in tax policies resulting from the first order conditions of welfare maximisation is conditioned on the particular strategic solution concept which is applied. Although the basic model structure will remain the same, we begin with a discussion of "pure environmental policies."

4.2 Pure Environmental Policy and the Role of Political Influence

First, we consider a regime where all of the Θ parameters are unity, so that the political support function is just the usual welfare expression, and countries are behaving nonstrategically, implying that they do not take into account any impact which their tax rates might have on the market price of waste. Thus, ignoring any terms of trade effects, in turn, implies that the equilibrium price (and the respective equilibrium quantity) on the waste market is considered to be independent from the tax rates.

With regard to country *H,* since the last term in equation (4.2), a measure of the terms of trade effect of the home tax, is viewed to be zero, the home government sets taxes at the closed economy Pigouvian optimal level, $t = D_{Z-E}$. The same conclusion holds for the foreign countries: Ignoring the last term in equation (4.4) they set tax rates equal to marginal damages, $t^j = D^j_{e^j}$. Therefore, the quantity imported assures that the marginal revenues arising from waste imports just balance marginal costs of waste disposal and marginal damages. This solution thus might be considered as the "naive" environmentally optimal import level.

Taken together, the assumed behavior by the governments implies that the"naive" environmentally optimal taxes are in fact the Pigouvian taxes.

Proposition 1: Pure Environmental Policies

If all governments behave non-strategically, and if the political influence weights are neutral ($\Theta = \Theta^j = 1$), then they set the environmentally optimal taxes at the Pigouvian tax levels where the marginal tax rates equal the marginal environmental damages,

$$t = D_{Z-E}\ ,\ t^j = D^j_{e^j},\ j = 1,...,m$$

Proof: First order conditions (4.2) and (4.4) hold under Pigouvian tax rates and pure environmental strategies.

We now turn to the strategic possibilities when governments realize they may have power on world markets and where environmentalists and industrialists influence policy..

4.3 Nash Equilibrium in Tax Policies

As we just saw, even in the absence of political motivations, the usual Pigouvian taxes cannot assure a welfare maximum in either country, since each government might improve welfare by exploiting its market power on the waste market, knowing that they can credibly commit to a tax policy focusing on the waste market price. As we alluded to with the green point industry in Germany, this market power is real and could, in fact, be considerable. Furthermore, the presence of influential political constituencies is also going to influence the environmental taxes depending on which groups are more heavily weighted in the political process. In this section we explore the properties of the equilibrium when the political Θ parameters are all unity and then investigate how a weighting more in favor of environmentalists or industrialists will alter this equilibrium.

In our model, strategic behavior might appeal especially to the foreign governments, whose firms are not able to earn any rents on the waste market at all since they cannot depart from marginal cost pricing. However, any foreign government can do so by raising its environmental tax, causing the "demand for trash" to fall and thus inducing a rise in the price for trash processing services. The home government may gain by acting strategically as well, except in the case of a single trash supplying firm, in which case all rents generated in the waste market are already extracted totally by the domestic industry. In general, these rents depend on the demand, and thus on the taxes in the foreign countries. Thus, to the extent that the home firms have not extracted all of the rents, the home government will have an incentive to adjust its environmental taxes. These incentives give rise to the strategic interactions of the governments.

The Nash solution with simultaneous moves of all governments is derived from the first order conditions of the countries maximization problems, assuming that each government takes the tax rates in all other countries as given.

In the typical country F^j, the neglected terms in equation (4.4) are positive with any market power at all. Thus, the first order condition evaluated at the Pigouvian optimal tax is positive. That is

$$\text{(4.5)} \qquad \frac{\delta w^j}{\delta t^j}(t^j = D^j_{e^j}) = \frac{dp}{dt^j} e^j > 0$$

Since w^j is concave in t^j, this implies that optimally $t^j > D^j_{e^j}$. The environmental tax should be increased in order to exploit any oligopoly power on world markets, even though this means that residents are "over-protected" from the imported pollution.

Similarly, in *H*, the last term in the first order condition for welfare maximization, equation (4.2), which the home country government ignores, is negative. This means that home welfare evaluated at the Pigouvian optimal tax is negative. That is

$$\text{(4.6)} \qquad \frac{\delta w}{\delta t}(t = D_{Z-E}) = -\frac{n-1}{n} E p_E \frac{dE}{dt} < 0$$

Again, since *w* is concave in *t*, this implies that optimally $t < D_{Z-E}$. The environmental tax needs to be lower in order to encourage domestic firms not to export so much waste and thus exploit monopoly power on world markets.

Proposition 2: Nash Equilibrium Tax Policies

If, both governments act strategically in a simultaneous move game with each government playing a Nash strategy,

Then,

$$t<D_{Z-E} \text{ and } t^j>D^j_{e^j},\ j=1,..,m.$$

Proof: Existence and uniqueness of the Nash equilibrium: See Appendix.

The Nash equilibrium and the respective reaction curves on the home and foreign countries are illustrated in Figure 1. In particular, note that the home reaction curve in t-t^j space is downward sloping and that of the foreign countries is upward sloping. While this is proved formally in Appendix 3, the intuition is straight forward. For the home country, a rise in a foreign environmental tax increases the cost of exporting waste and so the home government responds with a lower tax on waste not exported. In the foreign countries, an increase in the home country tax on waste leads to more exports of waste and so an increase in marginal damages in the foreign countries which elicits an increase in the environmental tax.

Due to the rent capturing features of the environmental tax policies explored above, each country has an incentive to deviate from the Pigouvian taxes. The home country is willing to decrease the tax rate, while all foreign countries find it optimal to increase their tax rates. This result, of course, has a straightforward interpretation. By lowering the tax rate, the home country provides an enhanced incentive to dispose of waste domestically, so that the domestic industry is induced to export less waste, thus depressing the price on the waste market. On the other hand, for the foreign countries, rising the environmental tax reduces the demand for waste and so leads to a higher tax inclusive price with decreased waste disposal costs and reduced damages, all of which more than compensate for the reduced volume of waste imports in the usual "optimal tariff" manner.

There are two exceptions to this incentive for governments to adjust environmental taxes in order to exploit a country´s market power. The first is when countries truly are price takers on world markets. Then, of course, there is only one margin that effectively matters and the environmental tax is the first-best tool to address that margin. The second exception is when one of the countries is truly a pure monopolist. For example, suppose in *H* that there is only one firm producing and potentially exporting waste to the world. Then, with $E = e$, the firm´s first order conditions for profit maximization are in fact the same as a social planner´s with respect to exploiting market power. Thus, the optimal environmental tax will be the usual Pigouvian one, and it can be left to the monopolistic firm to set the export of trash at a level that extracts rents from the foreign firms optimally. This result is due to the fact that the distortion of the home country's tax depends upon the number of firms involved in the waste generating industry and thus on the degree of competition taking place. The fewer firms that are involved, the smaller the distortion of the domestic tax rate. Nonetheless, in the foreign countries the optimal environmental tax will still exceed marginal damages.

4.4. Political Pressure Groups and Environmental Policy

In fact, environmental policy is a contentious political issue and environmentalists are typically heatedly at odds with representatives of industry. In our model, the parameters Θ capture the relative strength of the respective groups in the various nations. Using $\Theta = 1$ as a benchmark, we now differentiate the political support function in the vicinity of $\Theta = 1$ in order to ascertain the effect of a stronger or weaker environmental lobby on the Nash equilibrium. As it happens, stronger environmental sentiment in all nations need not lead to increased protection of the environment.

Equations (4.2) and (4.4) define the home and foreign reaction functions respectively. Differentiating equation (4.2) with respect to Θ and using the comparative statics results of section 3. yield

(4.7)
$$\frac{\delta w}{\delta t \delta \Theta} = n[(-\frac{dy}{dt}z_y - \frac{da}{dt}z_a + \frac{de}{dt})D_{Z-E}] > 0$$

Now, since the political support function w is concave in t, it follows that the politically optimal environmental tax in the home country is now higher or lower, for any given level of foreign taxes t^j, as Θ increases or decreases. Thus, in Figure 1, the reaction curve of the home country apparently shifts rightward or leftward as environmental political influence rises or falls. This makes sense, of course, since if the environmental lobby is, say, more powerful than before, the policy-maker will be inclined to rise the tax on waste. That enables foreign countries to rise their tax rates as well. More formally:

Proposition 3: The Effects of Home Political Influence on Environmental Taxes

In the Nash equilibrium where governments maximize political support, $dt/d\Theta \geq 0$ and $dt^j/d\Theta \geq 0$.

Some of the consequences of the change in the environmentalists' political power are straight forward and some are not. Suppose that Θ increases so that the political support function is more favorably disposed toward taxing marginal environmental damages. As illustrated in Figure 2, the rightward shift in the home reaction curve leads to a new equilibrium wherein t is higher. From the comparative statics results of Section 3, this leads to less output and more abatement in the home country. But, it also adds an incentive to export more waste and so has an effect in the foreign country.

In the new Nash equilibrium, the foreign countries apparently optimally rise their environmental taxes as well. This is because the home tax increase leads to more exports of waste in order to escape the tax and so an increase in the marginal damages to the waste-importing countries, who respond by raising their environmental taxes. Additionally, the rise in the demand for waste disposal services enhances the market power of the foreign countries enabling them to increase the tax on waste imports. More generally, the foreign countries mimic the home country's environmental policy changes. Thus, the international market for waste has created a link between the environmental policies of one country with those of other countries.

In contrast, although the international linkages still exist, when a foreign government j becomes more or less environmentally sensitive – Θ^j changes – the new equilibrium is somewhat different. Differentiating the foreign reaction functions with respect to Θ^j yields

(4.8)
$$\frac{\delta w^j}{\delta t^j \delta \Theta^j} = -\frac{de^j}{dt^j} D^j > 0$$

Noting as before that the political support function is concave in t^j, this means that the politically optimal tax in the foreign country is higher for any given t so that the foreign reaction curve in Figure 1 apparently shifts upward as in Figure 3. The new equilibrium is driven by this upward shift in the foreign reaction curve and so results in a higher environmental tax in the foreign country, but a *lower* environmental tax in the home country. In general:

Proposition 4: The Effect of Foreign Political Influence on Environmental Taxes

In the Nash equilibrium when environmental political support changes in a foreign country, environmental taxes change according to $dt^j/d\Theta^j \geq 0$ and $dt/d\Theta^j \leq 0$.

Thus, unlike the case where the foreign country mimics the home country's environmental policy, the home country reacts exactly in the opposite direction when a foreign country alters environmental policy. Intuitively, suppose for example that a foreign country increased the political weight on the environmental interests. This leads to an increase in the environmental tax on waste imports. However, the home country waste exporters must pay this tax and so the home government optimally lowers the home tax on waste in order to discourage exports somewhat.

4.5. Worldwide Changes in Environmental Sentiment

In this section, we investigate the impact on environmental taxes when the political environment shifts simutaneously in countries around the world. Two cases are of interest. First, we will suppose that the environmental lobby becomes more influential worldwide. In our model, all Θ parameters increase for all countries. Second, we will consider the case often alleged in developed countries wherein the developed (home) country becomes more environmentally sensitive and the developing (foreign) countries less so. That is Θ increases and Θ^j decreases.

In the case where all countries become more environmentally sensitive, each Θ increases which, as we saw above, leads to a rightward shift in the home reaction curve and an upward shift in the foreign reaction curve. Thus, as in Figure 4, the foreign environmental tax t^j rises in the new equilibrium, but the home tax t may actually decrease, depending on the magnitudes involved. The reason why the home tax does not increase necessarily as one would expect is simply that the environmentalists impact on policy is not strong enough to offset the terms of trade effect inducing the tax rate to fall as alluded above. But, as the political power effect becomes stronger politicians in the home country are forced to rise the tax even at the expense of producer rents usually extracted from the waste market. In this case the concern for the environment dominating policies in the participating countries calls for an overall eco-tax increase.

The second scenario to be considered is the one where the home country is viewed to be more concerned environmentally than the foreign countries. As shown in Figure 5, the home country's tax rate is rising while the tax rate in any foreign country may increase or decrease according to the political influence exploited by the industrialists in those countries. If industrialists are sufficiently powerful any foreign country's tax rate may well fall below the rate set in the unbiased Nash equilibrium since a low rate triggers trade in waste and thus producer rents. However, this goes along with a detoriation of the environment and a loss in tax revenues. Moreover, lobbying involves a welfare loss since the government is induced to set the tax rate at a lower level than it would do otherwise. The departure from the optimal tariff enables foreign firms to import more waste and to further increase profits though at the cost of weakening the terms of trade. Although the tax inclusive price is falling, the producer price may still rise just opposite to the optimal tariff regime described above. On the other hand, despite of industrialists' lobbying activities importing countries might be able to increase their tax rates, whenever the positive impact of a higher supply in the market for waste products on the terms of trade (driven by a strict environmental policy pursued in the home country) is dominating.

From the home country's view, however, the best strategy in any case is to increase the tax rate when industrialists are influential in the foreign countries, because their activities implicitly work in favor of the exporting countries. The reason for this result to hold is the following: Since the foreign firms are willing to take more of the waste at the same price, the home country is thus enabled to increase the tax on domestically disposed waste without bearing the load of weakening the terms of trade as much. In this respect, please recall that this result does not necessarily hold if a foreign country's policy likewise is biased towards the environment. In this case, as we have argued above, the possible erosion of the terms of trade may keep the home country from rising the tax and encouraging more trade in waste despite of the environmentalists' political pressure.

5. Globally Optimal Environmental Policy and Welfare

Much of the discussion concerning trade and the environment revolves around what an optimal world policy might be and on how to pursue it through coordinated national policies or international agreements. In this spirit, we explore here some of the possible world welfare scenarios in the context of our model of international trade in waste products. We take global welfare to be the sum of every country´s welfare and investigate the possibility of actually implementing globally optimal policies. The optimum policy and implementation will in turn depend upon the structure of the international waste market and, since we will take this as given, our welfare conclusions are usually of a second-best nature. As far as political policy issues are concerned the assumption made here is that lobbying does not play a role when we look at the second- best policy which should be considered as a benchmark anyway.

Generally, noting that *p, y, a, E,* and e^j are all determined endogenously and depend only on *t* and t^j once the market structure has been specified, the global planner´s problem can be written

(5.1) $$\max_{t,t^1,\dots,t^m} W = w(t,t') + \sum_j w^j(t,t')$$

s. t. 1) FOCs in H and F^j***.***

2) $ne = \sum_j e^j$

The welfare expressions are the same as in the discussion in Section 4 and reflect consumer surplus, revenues, costs, and damages in the home and foreign countries respectively. But, note that global welfare does not incorporate the political power parameters reflected in the welfare functions of the respective countries, since it is not at all clear how lobbying on the national level translates into a political support function for global welfare. However, while the global planner is assumed capable of adjusting environmental taxes, we assume that he cannot change the market structure. Thus, the constrained optimal global welfare first order condition will reflect the firms behavioral constraints owing to market structure.

The ability of the global planner to achieve the first-best outcome would appear to be disrupted by the presence of less than perfect competition, but this turns out not to be the case. We next turn to this result.

Proposition 5: Globally Optimal Environmental Policy

If, the home firms behave oligopolistically on the world waste processing market, and if, there are waste exports in equilibrium, i.e., $E > 0$,

Then, the globally optimal taxes satisfy $t = D_{Z-E}$ and $t^j < D^j_{e^j}$.

Proof: Unrestricted maximisation of global welfare over y, a, e^j, and *e* (taking account of the market clearing condition) yields the following first order conditions

(5.2) $$p_y - c_y - D_{Z-E} z_y = 0$$

(5.3) $$-c_a - D_{Z-E} z_a = 0$$

(5.4) $$c^j_{e^j} + D^j_{e^j} = D_{Z-E}$$

For t, compare equations (5.2) - (5.3) with the first order conditions (3.5) - (3.6) of Section 3 for profit maximisation by an oligopolist, hence $t = D_{Z-E}$. For t^j, combining the first order condition for firms in F^j with the first order condition (3.7) using $t = D_{Z-E}$ yields: $t^j = D^j_{e^j} - p_E E/n$. Hence $t^j < D^j_{e^j}$.

Intuitively, there are three distortions to address -- environmental damage in H and F^j, and an oligopoly that exports too little waste. Setting t equal to marginal damages in H addresses one distortion and preserves optimality in production and waste abatement in H. But still there is too little exported. So, instead of setting t^j equal to marginal damages in each F^j, t^j is set lower in order to encourage the H oligopolist to export more. This reflects that the only way that the social planner can increase H waste exports, which would be welfare improving, is to lower the costs of exporting relative to the costs of processing the waste in the home market. While t being set higher would also encourage the home firms to export more, this is not optimal. This would disrupt the other optimality conditions in H.

This globally optimal policy does have some interesting properties. First of all the social planner is able to restore the first best solution, by departing from the Pigouvian taxes in the foreign countries, since then condition (5.4) governing the allocation of waste in the first best way is met. Of course, the usual implementation of the first best solution (5.4) would have been Pigouvian taxes had there been perfect competition, an option which however is not available to the social planner as mentioned. The reason why the first best solution can be restored even with imperfect competition is simply that only the overall allocation of waste matters, and rents and tax revenues have only distributional impacts from a global perspective and do not appear in the global welfare function. Therefore the social planner can encourage more waste exports to the foreign countries by lowering environmental taxes there, although this involves an implicit income transfer from the foreign countries to the home country. And, if the oligopoly is a fact of life, then the optimal policy entails "eco-dumping" in the sense that each F^j is allowing environmental damage in excess of what waste processing firms are required to pay at the margin.

The logic of the oligopoly case carries over substantially to the case of monopoly since too little waste is exported, even less than with oligopoly. Thus , the distortion of any foreign tax rate has to be even bigger.

If we compare the global optimum with the Nash solution for the various political economy scenarios we find that on the one hand environmentalists in the home country drive the eco-tax rate towards the the first best solution by weakening rent seeking activities which is at the heart of eco-dumping. This lobbying activity leads to more exports of waste enhancing global efficiency by discouraging domestic disposal and by making use of comparative advantage in waste treatment abroad instead. However, this does not mean that lobbying does not incur any inefficiencies since it does not assure at all that the Pigouvian rate is met. On the contrary, it may lead to a rate still below or even one above the Pigouvian rate depending on how influential are environmentalists. Nevertheless, efficiency losses are diminished in any case. On the other hand, industrialists political influence in the home country forces the tax rate to fall and thus drives the Nash equilibrium even further away from the first best solution.

In the foreign country lobbying by industrialists goes hand in hand with promoting overall efficiency although the motives for that activity is totally different. Waste importing firms in the foreign country do not have any market power and thus cannot take the option to restrict waste imports to induce a price increase. Thus, industrialists are keen to import more waste at a lower tax. Although the tax inclusive price is falling, the producer price is rising enabling importers to earn higher profits. In the same spirit, the first best solution calls for lower tax rates in the foreign countries and thus entails eco-dumping in some sense. The reason here is simply to offset the market power of the exporters, who try to restrict waste exports in order to keep the price for waste low. Now, since we take market structure as given the only way to offset this effect is to reduce tax rates in the foreign countries. And, this is exactly what industrialists in the foreign country want to achieve. However, again their lobbying activity may reduce global inefficiency but nevertheless this does not mean that the first best solution is met. There is no reason to believe that lobbying would result in the tax rate required to exactly correct for the market power of the waste exporting industry.

6. Conclusions

The implications of our analysis are in a way somewhat discouraging from the standpoint of achieving a globally optimal environmental policy. To the extent that the waste exporting countries can indeed exercise market power, the worldwide optimum requires that importing countries set their environmental taxes below the Pigouvian taxes which would equate marginal damages with marginal benefits (profits). This is because market power, somewhat in contrast to some popular accounts, theoretically leads exporters to export too little waste. The lower environmental tax in the importing countries addresses this distortion. But this puts many developing countries in the position of "under protecting" the environment and, foregoing optimal taxation of oligopoly rents which, as a practical matter, would be a pretty hard sell politically. Furthermore, at the same time, the developed waste exporting countries would need to set their environmental taxes tighter than the developing importing countries, and so institutionalize the commonly heard complaint that richer countries are environmentally more concerned than are poorer countries.

Now, it is interesting to see that this is exactly what implicitly is supported by lobbying activities, namely those of environmentalists in the developed and industrialists in the less developed countries. Or, to put it the other way round, any plea for a strict environmental policy in the developed countries loses a lot of cedibility since it only works hand in hand with ecodumping in the less developed countries. Otherwise, environmentalists influence might not be strong enough to offset the negative impact on the terms of trade leading to a tax rate still below the Pigouvian rate. From the foreign governments' perspective, however, since the globally optimal policy involves an implicit income transfer to the home country, some sort of reverse transfer might be expected as compensation.

Appendix

A1 *Existence and Uniqueness of the Market Equilibrium*

The market solution is implicitly given by the following equation system

$$p_y - c_y - tz_y = 0$$

$$-c_a - tz_a = 0$$

$$t - p(E,t') - p_E e = 0$$

where $E=en$ and $p(E,t')= E(p,t')^{-1}$, $E(p,t')=\sum_j e^j(p,t^j)$. The existence and uniqueness of the equilibrium is assured, since $-c_{yy} <0$, $c_{yy}\, c_{aa} >0$, and recalling $p_E>0$, $p_{EE}>0$ the Jacobian Matrix $|J|$ is negative :

$$|J| = \begin{vmatrix} -c_{yy} & 0 & 0 \\ 0 & -c_{aa} & 0 \\ 0 & 0 & -(n+1)p_E - p_{EE}E \end{vmatrix} < 0$$

A2 *Proof of Lemma 1*: *Comparative Statics of the Market Equilibrium*

Comparative statics solutions are as follows:

i. $$\frac{dy}{dt} = -\frac{(-(n+1)p_E - p_{EE}E)z_y c_{aa}}{|J|} < 0$$

ii. $$\frac{dy}{dt^j} = -\frac{\begin{vmatrix} 0 & 0 & 0 \\ 0 & -c_{aa} & 0 \\ -p_{t^j} & 0 & -(n+1)p_E - p_{EE}E \end{vmatrix}}{|J|} = 0$$

iii. $$\frac{da}{dt} = -\frac{(-(n+1)p_E - p_{EE}E)z_a c_{yy}}{|J|} > 0$$

iv. $$\frac{da}{dt^j} = -\frac{\begin{vmatrix} -c_{yy} & 0 & 0 \\ 0 & 0 & 0 \\ 0 & -p_{t^j} & -(n+1)p_E - p_{EE}E \end{vmatrix}}{|J|} = 0$$

v. $$\frac{de}{dt} = -\frac{c_{yy}c_{aa}}{|J|} > 0$$

vi. $$\frac{de}{dt^j} = -\frac{-c_{yy}c_{aa}p_{t^j}}{|J|} < 0$$

vii. $$\frac{dp}{dt} = p_E \frac{dE}{dt} > 0$$

viii. $$\frac{dp}{dt^j} = p_E \frac{dE}{dt} + p_{t^j} > 0$$

Note further that due to symmetry *dY/dt=n dy/dt,* and similarly for *A* and *E* and all derivatives with respect to the foreign tax rates.

A3 *Proof of Proposition 2: Existence and Uniqueness of the Nash Equilibrium Policies:*

see *Cassing/Kuhn (1999),* Appendix

References

Alberini, Anna, and John Bartholomew. (1998). "The Determinants of Hazardous Waste Diosposal Choice, *processed*, University of Colorado, Boulder.

Althammer, Wilhelm, and Wolfgang Buchholz. (1996). "Distorting Environmental Taxes: The Role of the Market Structure," *processed*, European-University Viadrina, Germany.

Barrett, Scott. (1994). "Strategic Environmental Policy and International Trade," *Journal of Public Economics* 54, 325 - 38.

Bhagwati, Jagdish N. et al. (1998), *Lectures on International Trade*, Cambridge.

Caldwell, Lynton K. and Robert V. Bartlett, eds. (1997). *Environmental Policy: Transnational Issues and National Trends*, London, Quorum Books.

Cassing, James and Thomas Kuhn (1999), Trade in Trash - Strategic Environmental Policies for World Markets in Waste Products, *mimeo*, Pittsburgh-Chemnitz.

Copeland Brian R. (1989). "International Trade in Waste Products in the Presence of Illegal Disposal," *Journal of Environmental Economics and Management* 20, 143 - 62.

Fischer, Lilo and Ulrich Petschow (2000), Municipal Waste Management in Germany, in: Buclet, N., O. Godart, eds., *Municipal Waste Mangement in Europe*, Dordrecht, 5-62

Hiltz, Christoph. (1992). *The International Toxic Waste Trade*, New York, Van Nostrand Reinhold.

Hiltz, Christoph, and John R. Ehrenfeld. (1991). "Transboundary Movements of Hazardous Wastes," *International Environmental Affairs* 3(1), 26 - 8.

Kennedy, Peter W. (1993). "Equilibrium Pollution Taxes in Open Economies with Imperfect Competition," *Journal of Environmental Economics and Management* 27, 49 - 63.

Krutilla, K. (1991). "Environmental Regulation in an Open Economy", *Journal of Environmental Economics and Management* 20, 127-42

Ley, Eduardo, Molly M. Macauley, and Stephen W. Salant. (1998). Spatially and Intertemporally Efficient Waste Mangement: The Costs of Interstate Flow Control, *discussion paper.*

Mail&Guardian. (Sept. 19, 1996). "MPs Face Grilling on Toxic Waste."

Markusen, James R., E. R. Morey, and N. Olewiler. (1993). "Environmental Policy when Market Structure and Plant Locations are Endogenous", *Journal of Environmental Economics and Management* 24, 341-56.

New York Times. (Feb. 7, 1997). "North Korea, Desperate for Cash, Will Take Taiwan's Atomic Waste."

Roelants du Vivier, Francois. (1988). "The South Mustn't Be the Rubbish Tip of the North," *The Courier* (ACP-EEC) 113, 2 - 5.

Simpson, R. David. (1995). "Optimal Pollution Taxation in a Cournot Duopoly," *Environmental and Resource Economics* 6, 359 - 69.

Strohm, Laura A., and Roy W. Shin. (1997). Policy Regimes for International Waste Trade," in *Environmental Policy: Transnational Issues and NationalTrends*, L. K. Caldwell and R. V. Bartlett, eds., London, Quorum Books.

Yakowitz, Harvey. (1987). "Waste Management Activities in Selected Industrialized Countries", Environment Directorate, Paris, *OECD.*

Valette, Jim. (1990). “The International Trade in Toxic Wastes: A Greenpeace Inventory”, 5. ed., Washington, D C: *Greenpeace*.

Figures

Figure 1: Nash-Equilibrium (NE)

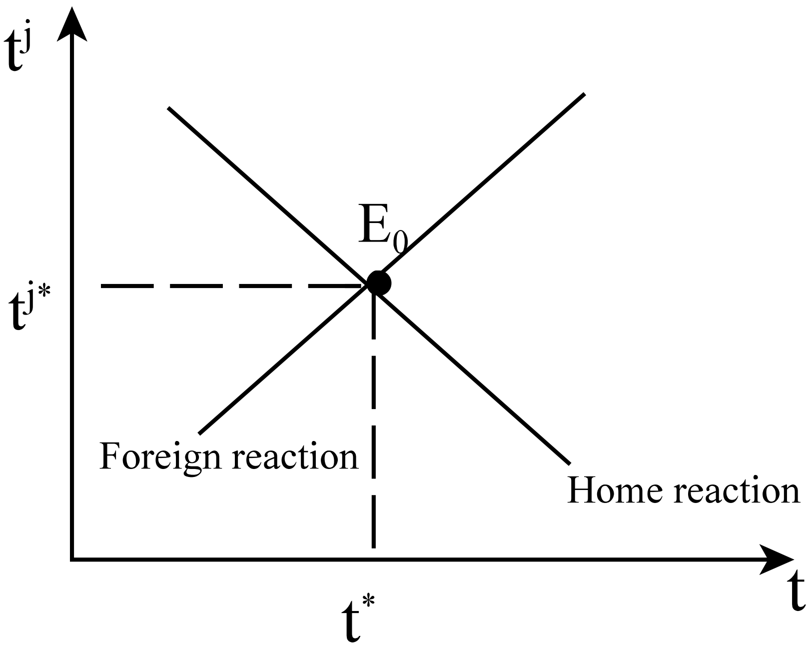

Figure 2: NE, ⊖ > 1

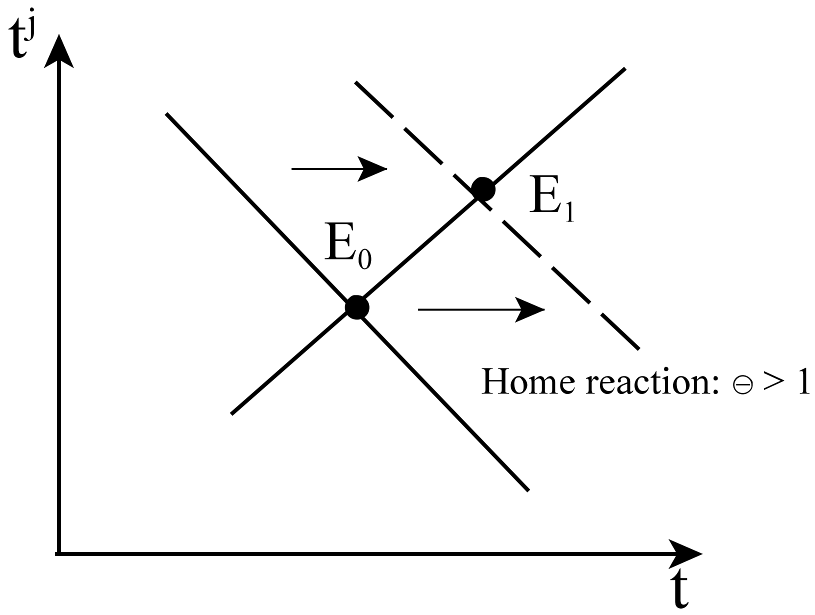

Figure 3: NE, $\ominus^{j} > 1$

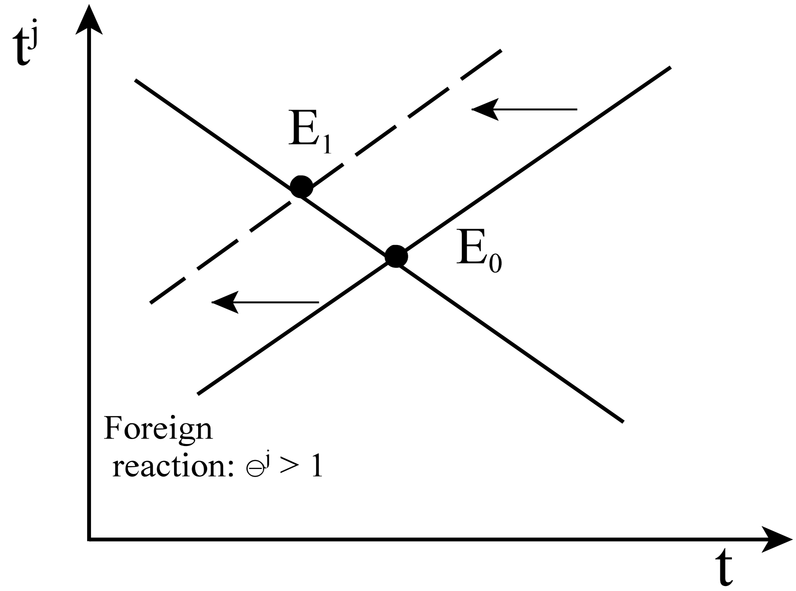

Figure 4: NE, $\ominus > 1, \ominus^{j} > 1$

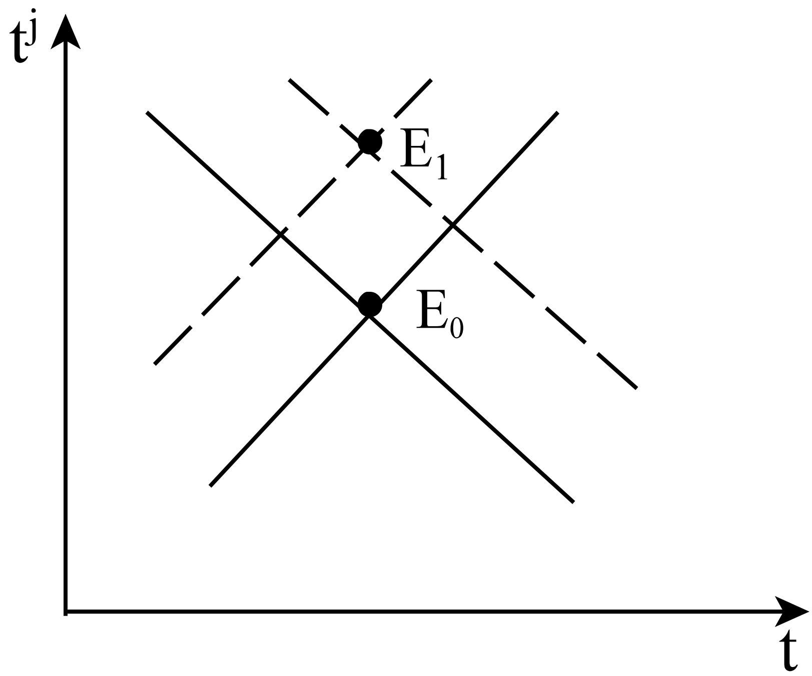

Figure 5: NE, $\ominus > 1$, $\ominus^{j} < 1$