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## Environmental policy and industrial competitiveness: The pollution haven hypothesis reconsidered

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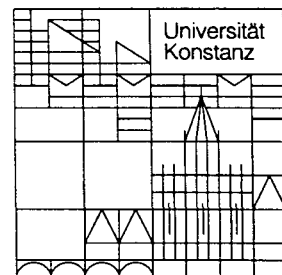
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**Sonderforschungsbereich 178**  
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Diskussionsbeiträge



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**Environmental Policy and**  
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**The Pollution-Haven Hypothesis Reconsidered**

**Rolf Bommer**

Serie II - Nr. 262

Dezember 1995

# **Environmental Policy and Industrial Competitiveness: The Pollution-Haven Hypothesis Reconsidered<sup>#</sup>**

by

**Rolf Bommer\***

**University of Konstanz**

December 1995

## **Abstract**

The Pollution-Haven Hypothesis suggests that tight environmental standards reduce domestic producers' competitiveness and give rise to their relocating to countries with more lenient standards. This paper questions that relocation is always caused by reduced competitiveness at home. By using a signaling approach, I show that relocation can be undertaken for purely strategic reasons. Relocation is the producer's tool to convince the policy maker to refrain from a further tightening of environmental control. I show that trade liberalization increases the probability of strategic relocation. *ehs. with Bommer*

JEL classification: D78; F13; F15.

Key words: environmental policy, trade liberalization, industrial competitiveness, international political economy, signaling

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# 1. Introduction

The unilateral increase of environmental control has been frequently objected on the grounds that domestic firms may lose their competitive edge to foreign competitors not subject to these restrictions. As a consequence, so runs the argument, the domestic firms shift their production, and hence employment, to countries with less restrictive environmental standards. This is the so-called pollution-haven hypothesis. Recent examples include furniture manufacturers who moved from the Los Angeles area to Mexico allegedly due to tighter air emission laws in the U.S. (Hufbauer/ Schott, 1992, 150).<sup>1</sup> Other producers shut down specific product lines or complete plants. The two chemical companies Hoechst and Bayer, for example, have closed production for certain chemicals in Germany because of tight environmental standards (Voss, 1993, 31-32). Should policy makers really be concerned that a tighter environmental policy will bring about a substantial relocation of capital? This paper focuses on this issue. In particular, I show that following an increase of environmental standards, firms may shift part of their production abroad for strategic reasons rather than due to a loss of competitiveness. That is, capital export is used to signal the government an alleged low competitiveness at home, while its real intention is to avoid costly cleaning-up investment in the future. Inasmuch as foreign direct investment is motivated by this signaling intention, politicians should not be concerned; on the contrary, their responsiveness to such „threats“ would tend to increase rather than reduce the export of capital.

This paper differs from the existing body of literature on trade and environment by taking a quite different perspective to the formation of environmental policy. The literature on eco-protectionism shows how environmental policy serves domestic producers to shelter them from foreign competitors (Leidy/Hoekman, 1994); by the same token, low environmental standards may help domestic exporters to gain a competitive advantage over their foreign rivals (eco-dumping, cf. Rauscher, 1994). Barrett (1994) analyzes environmental policy as a tool for strategic trade policy in an imperfect competition setting. In a model of political competition Hillman/Ursprung (1994) demonstrate under which conditions environmentalists find common cause with free trade or protectionist interests, depending on where the externality occurs and whether environmentalists are "supergreens" who also care for the environment abroad. The influence of trade liberalization on environmental policy is studied by Bommer/Schulze (1994) in a model of political optimization. There it is shown, that trade liberalization will be accompanied by a tighter environmental policy in order to compensate losers from free-trade if

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<sup>1</sup>For empirical evidence on the relocation of emission-intensive industries (e.g. asbestos, petrol, copper smelting, PVC) see Gray/ Walter (1983). For a survey on industrial competitiveness and the environment see Jaffe et al. (1995).

the export sector is pollution-intensive. In Oates/Schwab (1988) lower environmental standards are used to attract foreign investment.

While these studies are useful in explaining environmental policy in the international context, they neglect the asymmetry of information between regulator and regulatee. The administration setting environmental standards does not know to which extent the firms are affected by its regulation, especially because firms are heterogeneous in their ability to adapt to higher levels of environmental control. Since a political support-maximizing government balances the interests of the relevant lobbying groups at the margin, regulation will be less stringent, the more severe the companies' losses in terms of output and employment are. Firms can take advantage of that and may relocate production abroad subsequent to an enhancement of environmental standards for strategic reasons only: by signaling low adaptability they may convince the government to refrain from further a increase of environmental control.<sup>2</sup> I will analyze this possibility analytically in a signaling game, and I will demonstrate under which circumstances the firm will be able to deceive the government about its ability to adapt to higher standards. In particular, it turns out that trade liberalization leads to a more frequent use of strategic relocation. This helps the producer to compensate losses from trade liberalization, which occur as competition with foreign rivals is now more intense. *Stephan*

The paper proceeds as follows. Section two presents a simple static setting in which environmental policy is determined. Section three extends the analysis to a dynamic structure to allow for signaling. Section four derives the results, and section five discusses the effects of trade liberalization. Section six concludes.

## 2. The Model

### 2.1 The Framework

A simple model is presented to show the central features of the interaction between a government, which sets an pollution standard and a producer who chooses technology and output. I keep the model as simple as possible to allow for the complexity, which arises by introducing uncertainty and dynamic aspects in the subsequent sections.

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<sup>2</sup>This is closely related to indirect lobbying in trade policy. Opposite to direct lobbying, real changes in production, like layoffs and plant closings are used to lobby for protection. One case is *spurious injury*. Because the injury criterion is a necessary condition to obtain protection under contingent protection rules, import-competing firms may use *spurious injury* to qualify for protection. For a survey on indirect protection see Leidy (1994).

The policy maker sets a pollution standard  $V$ , which is specified as limit to purely domestic environmental pollution, to maximize his political support  $M$  according to following function<sup>3</sup>

$$M = \max_V f[(X(V), U(V))]. \quad (1)$$

There is a trade-off for the policy maker between high support from output interests  $X$  and support from environmentalists  $U$ . Tight pollution regulation of the policy maker (a low  $V$ ) increases support from environmentalists, but reduces support from the consumer interests. These interests can be thought of as consumers, who profit from an abundant supply of goods. In a similar fashion, labor interests, which are not modeled explicitly, profit from high output if one assumes a strong correlation between employment and output. By choosing a political support function to depict the political sector, I follow Stigler's and Peltzman's theory of regulation (Stigler, 1971; Peltzman, 1976), a standard concept in endogenous trade policy analysis (Hillman, 1989).<sup>4</sup> The support function has the standard concavity properties: positive, but diminishing marginal support in the supply of purely domestic pollution. Important to note is the distinction from welfare analysis. The government does not maximize social welfare but its own utility. It provides environmental policy to redistribute utility from consumers and labor to the environmentalists.

The political-support function is specified as follows:

$$M = \max_V \alpha X - V^2, \quad (2)$$

where  $\alpha$  is the weight of the consumers and labor in the political process.

Consider now the production side. There are two available production technologies. First, there is an old-fashioned and "dirty" technology  $H$  ( $H$  for high pollution)

$$X^H = V^{0.9}. \quad (3)$$

For using the  $H$ -technology and generating output  $X^H$ , a given investment  $K^H$  has to be undertaken.

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<sup>3</sup> I abstain from modeling environmental taxes because standards are still the most common instruments for regulating the use of the environment. For a political-economy explanation of the prevalence of standards instead of more efficient environmental taxes see Buchanan/ Tullock (1975).

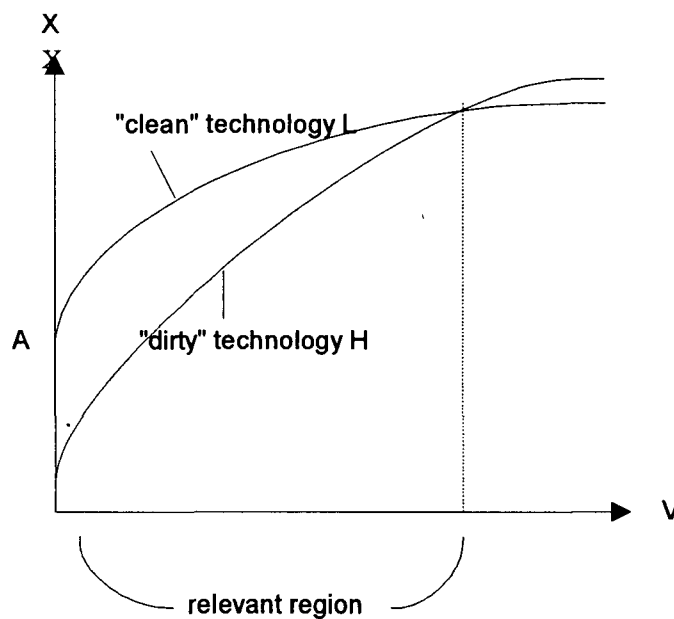
<sup>4</sup>For a micro-foundation see Grossman/ Helpman (1994).

Production needs two inputs, capital  $K$  and pollution  $V$ .<sup>5</sup> In this model, pollution regulation is not specified in detail and can cover a wide range of environmental problems resulting from production. It includes water pollution like sewage released into the river, as well as air pollution from sulphur-dioxide emissions. Pollution regulation specifies a maximum allowance of harmful emissions for the producer. Because pollution serves as an input, pollution regulation (the restriction of on input: pollution) adversely affects output.

The second possible technology  $L$  (  $L$  for low pollution) depends less heavily on polluting the environment.

$$X^L = A + V^{0.7} \quad (4)$$

For using the  $L$ -technology and generating output  $X^L$  a given investment of  $K^L$  has to be undertaken.



**Figure 1**

<sup>5</sup>To model environmental pollution as an input to production is fairly standard in the literature on trade and the environment, see for example Rauscher (1991) and McGuire (1982).



As shown in Figure 1, the "clean" technology L creates less pollution for any given output than the "dirty" technology H in the relevant region. The "clean" technology is more efficient with the use of the environment because it produces a higher output for given pollution.<sup>6</sup> But the "clean" technology is more expensive. For the installation of the production equipment an investment  $K^L$  is necessary which is higher than the required investment for the "dirty" technology  $K^H$ .

A single producer in a small open economy is faced with a given domestic market price  $q = q^* + t$ , where  $t$  is the tariff rate and  $q^*$  the world market price. The producer's profits  $\Pi$  depend on his production technology H or L:

$$\Pi^i = qX^i - rK^i, \text{ with } i = H \text{ and } L. \quad (5)$$

$r$  is the opportunity cost of capital. There are two possible types of producers  $j = H, L$ , who both own the same given capital stock  $\bar{K}$ . Both are able to invest their capital  $\bar{K}$  at home or abroad according to the following two possibilities:

$$\bar{K} = K^H + K^{\text{abroad}} \text{ and} \quad (6)$$

$$\bar{K} = K^L. \quad (7)$$

Equation (6) shows how capital use is split when the "dirty" technology is employed.<sup>7</sup> Using  $K^H$  for the "dirty" technology, the remaining capital  $K^{\text{abroad}}$  is invested abroad and earns a given world market return of  $r$ .<sup>8</sup> According to (7), investment in the "clean" technology needs the complete available capital stock, with the consequence that no investment abroad takes place.

Producer L is the innovative type. He is able to choose between both available technologies. If he uses the "dirty" H-technology, he employs  $K^H$  and invests the remaining capital  $K^{\text{abroad}} = \bar{K} - K^H$  abroad. I assume that parameter A is sufficiently large to make the "clean"

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<sup>6</sup> The technology parameter A is assumed to be sufficiently large to ensure that the output from the "clean" technology is higher than output from employing the "dirty" technology for given pollution. This renders the right-hand region of graph 1 irrelevant.

<sup>7</sup> It is assumed that if capital is not totally used up in the specified production process, the capital is invested abroad because there are no profitable domestic alternatives available. One can imagine, that because the producer is the only domestic firm in this sector of production, sector specificity of capital leaves him only foreign options of investment.

<sup>8</sup>  $\Pi$  represents only the profit from the domestic activity, for total profits the opportunity cost of capital use  $r\bar{K}$  have to be added.

technology superior to the "dirty" technology. As a consequence, the innovative producer prefers employing the "clean" technology because of higher profits. Producer H is inflexible and has to stick to the outdated "dirty" technology H by employing the smaller amount of capital  $K^H$ . He invests his remaining capital  $K^{abroad} = \bar{K} - K^H$  abroad.

## 2.2 Environmental Policy in a Static Setting under Complete Information

This simple static model with complete information helps to motivate the following. The model is a Stackelberg game where the government sets the pollution standard first and the producer follows by deciding about the allocation of his capital. The model is solved by backward induction.

The innovative producer employs the "clean" L-technology because his profits are highest with this technology. His domestic profits are as follows:

$$\Pi^L = q \cdot X^L - rK^L. \quad (8)$$

Adding the output  $X^L$  from the investment decision in the political support function (2), differentiating with respect to  $V^L$ , and solving for  $V^L$  results in

$$V^L = (0,35\alpha)^{\frac{10}{13}},$$

the politically optimal pollution standard. The standard is the lower, the higher  $\alpha$ , which denotes the strength of the consumer and labor interests. The policy maker maximizes his political support by balancing the politically viable interests at the margin. The larger the weight of the consumers and labor in the political process, the more rents they are able to appropriate from the environmentalists and vice versa. The tool of this rent-shifting process is pollution regulation.

Now consider the inflexible H type who has to stick to the old-fashioned technology. His profits are as follows:

$$\Pi^H = q \cdot X^H - rK^H. \quad (9)$$

Adding the output  $X^H$  in the political support function (1), differentiating with respect to  $V^H$  and solving for  $V^H$  results in

$$V^H = (0,45 \cdot \alpha)^{\frac{10}{11}}.$$

Again the politically optimal pollution standard depends positively on the strength of the consumer and labor interests in the political process. Because producer H depends more heavily on polluting the environment, the politically optimal standard  $V^H$  is more lenient than

the standard for the producer with the "clean" technology  $V^L$ .<sup>9</sup> The innovative producer is able to cope with tighter environmental regulation more easily, which enables the government to get support from environmentalists by tight environmental policy without losing much support from labor and consumer interests. If confronting the inflexible producer, the government is less lucky. By providing tight environmental policy to raise support from environmentalists, it is confronted with serious output losses which reduce political support. In this situation, the policy maker will specify a more generous pollution limit.

### 2.3 Environmental Policy in a Static Setting under Incomplete Information

Now consider the case where the government is uncertain about the type of producer it faces and assumes with probability  $p$  that it is confronted with the inflexible type  $H$ , where  $0 < p < 1$ . The probability of facing the innovative type is  $1-p$ . As explained in section 2.2, the policy maker would prefer to set a tight standard if he faces the innovative producer and a low standard in case of being confronted with the inflexible type. Just as under complete information, the game follows the sequential structure in which the government sets environmental policy first and the producer follows by making his input decision. Again the game is solved by backward induction.

Type  $H$  sets the out-dated technology  $K^H$  because he has no other choice. Type  $L$  employs the "clean" technology  $K^L$  because the "clean" technology maximizes his profits. Because of his uncertainty, the risk-neutral policy maker maximizes his expected political support which is a linear combination of facing the  $H$  type with probability  $p$  and of facing the  $L$  type with probability  $1-p$ .

$$M = \max_v p[\alpha \cdot V^{0.9} - V^2] + (1-p)[\alpha(A + V^{0.7}) - V^2]. \quad (10)$$

Differentiating (10) with respect to the pollution standard  $V$  and solving for  $V$ , the result is the politically optimal environmental policy under uncertainty  $V(p)$ .  $V(p)$  is tighter than  $V^H$  when facing type  $H$ , but less stringent than  $V^L$  when facing the innovative producer  $L$ . The policy maker chooses an increasingly high pollution standard, the higher his probability of facing the innovative type.

The innovative producer benefits from a weak environmental policy, which enables him to produce even more and have higher profits. He has an interest in the government's belief that he is the  $H$  type. Therefore he likes to pretend being the  $H$  type to profit from a lower

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<sup>9</sup>This result holds for  $\alpha > 0.6$ , which implies that consumer and labor interests must be of reasonable strength compared to environmental interests.

environmental standard. In the following section, I consider the case how the innovative producer is able to affect the belief of the government to raise his profits.

### 3. Environmental Policy in a Dynamic Setting under Incomplete Information

#### 3.1 Structure of the Game

Now, the model is expanded to allow for the possibility of strategic capital flight of the innovative producer. In a two-period model both types of producers have to decide in both periods on their investment decisions. The policy maker does not know the ability of the producer to cope with environmental regulation. In the first period the innovative producer is able to exploit this deficit of knowledge and may deliberately choose the less capital-demanding old-fashioned technology and invest the remaining capital abroad with the intention to influence the standard-setting of the policy maker. By investing part of his capital abroad, he signals his difficulties to cope with environmental regulation. The relocation may pay off later in a more lenient environmental regulation.

The model structure of section 2.3 prevails, there is an inflexible and an innovative producer type. The risk neutral policy maker has the prior probability  $p$  of being confronted with the inflexible type.<sup>10</sup> But unlike in section 2.3, the policy maker is able to learn over time about the producer type and is able to update his belief. The possibility to invest abroad for strategic reasons arises just because the belief of the policy maker can be influenced by the innovative producer.

The *timing of the two-period game* involves four steps:

1) In the first period, environmental policy in *period one* is given ( $V_1 = \bar{V}$ ), a simplification which is necessary to concentrate on the pivotal effects.<sup>11</sup> In period two new and tighter pollution regulation is considered, a fact that affects the producer's profits adversely. It is a stylized fact in environmental economics that environmental protection rises over time like

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<sup>10</sup>Prior  $p$  is the key to solve the game. According to Harsanyi (1967) is it possible to take a game of incomplete information as if it were a game of imperfect but complete information. The type the government faces is decided through a move by nature at the beginning of the game, about which the government has the prior of  $p$ .

<sup>11</sup>One can assume that a policy maker just moves into office in the first period and is too late to influence policy making. But he is able to observe the first-period investment decision of the producer, which will influence future standard-setting behavior.

under a ratchet effect. Increasing wealth in society may be a cause for rising demand for environmental amenities, as well as scientific progress about dangers of pollution raise demand for environmental regulation. Similarly, an chemical accident or an oil spill may lead to articulate public concern for strengthening environmental protection laws. Articulate environmental interest groups transform individual concern into political effects.

2) The producer decides about his use of capital and technology in period one. The producer knows that about plans to tighten the pollution standard in period two. Proposed tightening of regulation endangers his future profits. The reaction of both types of producers is different. The inflexible type has no other option than to stick to his old-fashioned technology and by investing  $K^H$ . The innovative type has two relevant options. He may invest his complete capital  $K$  by choosing the innovative technology. This strategy maximizes his profits his first-period profits but reveals his identity to the government. The government is able to strengthen standards in the future. His second option is to invest part of his capital  $K^{\text{abroad}}$  abroad and mimic the inflexible type by investing in the old-fashioned technology with the remaining capital  $K^H$ .

3) The structure in *period two* is similar to the Stackelberg-game under incomplete information in section 2.3. The government is uncertain about the type of producer it faces. But contrary to the belief  $p$  of facing the inflexible type in section 2.3, the policy maker is able to update his belief. By observing the capital stock in period one, he learns about the type of producer<sup>12</sup>. He updates his belief and sets the environmental policy  $V_2$  according to his updated, posterior belief.

4) After the policy maker has decided about  $V_2$ , the producer chooses his second-period investment without strategic ambitions and the game ends.

This section provides an extension of the model to a dynamic game between producer and political-support-maximizing policy maker. Both actors maximize their two-period utilities, the producer his two-period profit and the policy maker his two-period political support. The policy maker's strategy involves setting  $V_2$  according to his information about the type of producer, an information which depends on the producer's signal  $K_1$ . The innovative producer's strategy consists of two investment decisions  $K_1$  and  $K_2$  which depend on the belief of the policy maker and therefore on the tight pollution standard  $V_2$ . The result is a Perfect Bayesian

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<sup>12</sup> This paper focuses on the extent of capital relocation because industry flight is central in the public debate. Of course, another possibility of modeling the strategic interaction would be that the policy maker observes the producer's output decision. The size of output instead of the size of capital relocation would become the producer's signal for the policy maker.

Equilibrium if strategies and beliefs are consistent. Each player's strategy has to be the best response to the other player's strategy, given the beliefs.

### 3.2 Equilibria

A Perfect Bayesian Equilibrium is characterized if the innovative type's strategy ( $K_1$ ,  $K_2$ ), the government's strategy  $V_2$ , the beliefs  $p$  (prior) and  $\mu$  (posterior) fulfil the following requirements:

1.  $K_2$  maximizes the profit in period two. The choice of  $K_2$  has no strategic component because the game ends with the setting of  $K_2$ .
2.  $V_2$  maximizes the expected value of the political support in period two which depends on the posterior belief  $\mu$  and on the investment decision in period two  $K_2$ .
3.  $K_1$  maximizes the two-period profit of the innovative producer type, given the second period strategies.
4. The posterior belief  $\mu$  is Bayes-consistent with the prior belief  $p$  and with the firm's first period strategy  $K_1$ .

Three kinds of Perfect Bayesian Equilibria are possible.

1. *Pooling equilibria*: The inflexible type invests  $K^H$  in the "dirty" technology and relocates  $K^{abroad}$  in period one. The innovative type mimics the inflexible type by investing  $K^H$  and relocating  $K^{abroad}$  abroad in period one as well. The policy maker is unable to learn from the signal and can not update its prior  $p$ . The policy maker's posterior belief is for that reason  $\mu = p$ .

2. *Separating equilibria*: The inflexible type invests in the "dirty" technology in period one. Observing the investment in the "dirty" technology, the policy maker is sure to face the H type and updates his belief  $p$  to  $\mu = 1$ . The innovative type invests all his capital in the "clean" technology. Observing "clean" investment, the policy maker is sure to face L and does update  $p$  to  $\mu = 0$ .

3. *Mixed equilibria*: The inflexible type invests in the "dirty" technology in period one. The innovative type randomizes between "dirty" and "clean" technology. Observing the investment  $K^L$  in the "clean" technology, the policy maker is sure to face the innovative type and updates  $p$  to  $\mu = 0$ . If the policy maker observes investment in the "dirty" technology and relocation of capital, he updates  $p$  to  $p < \mu < 1$ . Under these circumstances, the probability of facing the inflexible producer increased from  $p$ , because the innovative producer does sometimes reveal himself.

The final equilibrium depends on the innovative type's costs and benefits of mimicking the inflexible type. The innovative type sacrifices first-period profits if employing the "dirty" technology and relocating capital abroad. But he benefits in the second period from a more lenient pollution regulation by investing in the "dirty" technology and pretending to be the

inflexible type. The innovative type's cost  $C$  of mimicking is the difference in his first-period-profit from employing the "clean" technology and from employing the outdated "dirty" technology.

$$C = \Pi_1[K_1^L] - \Pi_1(K_1^H) = q(A + V^{0.7}) - r \cdot K_1^L - [q \cdot V^{0.9} - r \cdot K_1^H] > 0. \quad (11)$$

The cost of mimicking is positive by definition: The innovative type does give up first-period profits if employing the "dirty" technology and relocating capital in the size of  $K^{\text{abroad}} = K^L - K^H$  abroad.

The innovative type's mimicking pays off in period two by the gain from mimicking  $G(\mu)$ , which is the difference between the innovator's profit in period two if mimicking was undertaken before, and his profit if he had revealed himself in the first period.

$$G(\mu) = \Pi_2[K_2^L(\mu)] - \Pi_2[K_2^L(0)] = \underbrace{q(A + V_2(\mu)^{0.7}) - r \cdot K_2^L}_1 - \underbrace{[q(A + V_2^L)^{0.7}) - r \cdot K_2^L]}_2 \quad (12)$$

Mimicking leads to a comparatively low pollution regulation with high profits in the second period (term 1 of equation 12). On the other hand, revealing himself in the first period by investing in the "clean" technology results in a tight standard with lower profits (term 2 of equation 12).

### 3.3 Existence Conditions

In a *pooling equilibrium* the policy maker does not obtain new information from observing the signal  $K_1$  because both types choose the "dirty" technology. Therefore, he is not updating his prior belief  $p$  and sets environmental policy according to  $\mu = p$ . The necessary condition for a pooling equilibrium is:

$$G(\mu = p) > C \quad (13)$$

A pooling equilibrium is obtained, if the innovative type's profit from mimicking is higher than his investment. The gain is realized according to equation (13) because the innovative type's two-period profits from investing in the "dirty" technology and capital relocation abroad under the policy maker's belief  $\mu = p$  exceed his two-period profits from investing in "clean" technology but suffering from tight pollution regulation (with a belief of  $\mu = 0$ ).

For the existence of a pooling equilibrium, the out-of equilibrium beliefs and actions have to be specified. The innovative type could play his first-period optimal strategy, but has no incentive because his gain from mimicking exceeds his loss. The policy maker could hold the out-of-equilibrium belief  $\mu = 1$ , being sure to be confronted with the inflexible type. But he knows that both types set  $K^H$ . Under his belief  $\mu = 1$  the pollution standard would be to

lenient to maximize his expected political support because there is a change of facing the innovative type. Therefore, holding the prior belief  $p$  is the optimal choice of the policy maker.

In a *separating equilibrium* the innovative type chooses in the first period his favored "clean" technology because the gains from mimicking do not outweigh the cost. In period two, he has to cope with tight environmental regulation because the policy maker is now sure that the producer is innovative and can handle the tight standard ( $\mu=0$ ). Different the inflexible producer, he invests in the "dirty" technology in the first period. Observing the "dirty" technology, the policy maker is sure that the producer is inflexible and sets more lenient environmental regulation ( $\mu=1$ ). Because the policy maker lost all uncertainty about the type of producer, the game in period two is the same as in the static model under complete information in section 2.2. The necessary condition for a separating equilibrium is:

$$G(\mu = 1) < C. \quad (14)$$

This is a separating equilibrium because the gain of the innovative producer does never outweigh the cost of mimicking for any belief of the policy maker. The innovative type reveals his true identity, he will not behave strategically and not invest abroad for putting pressure on future environmental regulation.

What out-of-equilibrium actions and beliefs do we have to consider for the existence of a separating equilibrium? Because pooling is not profitable, the innovative type chooses the "clean" technology in period one. The policy maker could hold the out-of-equilibrium belief of  $\mu = 0$  if observing this technology choice. But because of (14), the innovative type has no incentive to mimic the H type. Only type H employs the "dirty" technology. Therefore, the beliefs  $\mu=0$  if observing the "clean" technology and  $\mu=1$  if observing the "dirty" technology are consistent.

For a last range of values *mixed equilibria* are obtained. The necessary condition is:

$$G(\mu = 1) > C > G(\mu = p). \quad (15)$$

In this case, there are no equilibria in pure strategies. The inflexible type employs the "dirty" technology in the first period, the innovative type is indifferent between his two options "dirty" and "clean", and alternates between both. This result is explained as follows: The cost from mimicking outweigh the benefits for the innovator (right part of equation 15), for this reason pooling is not profitable. The innovative type would prefer separating. Because  $G(\mu = 1) > C$  (left part of equation 15), the policy maker understands that the innovative type has an incentive to deviate from separating, given the policy maker's separating beliefs ( $\mu=1$  if  $K^H$ ,  $\mu=0$  if  $K^L$  in period one). Therefore, these are not consistent. The final equilibrium condition



for mixed strategies states that the innovative type must be indifferent between his both alternatives:

$$G(\mu = \mu_1) = C \quad (16)$$

where  $p < \mu_1 < 1$ .

The innovative type's gains are equal to his investment from mimicking. The policy maker understands that the innovator alternates between his two alternatives. Remember the prior belief  $p$  of facing type H. If the policy maker observes investment in the "clean" technology, he is sure ( $\mu=0$ ) to be confronted with the innovative type. But if he observes investment in the "dirty" technology, he updates  $p$  according to Bayes' rule:

$$\mu_1 = \frac{p}{p + x_1(1 - p)}, \quad (17)$$

where  $0 < x_1 < 1$ .

His posterior belief  $\mu_1$  is higher than  $p$  because the innovator sometimes does not mimic. The probability of facing type H increases if observing the "dirty" technology. In a mixed-strategy equilibrium there is the innovator's probability of mimicking the inflexible producer  $x_1$  which results in a posterior belief  $\mu_1$  that keeps the innovative type indifferent between his two possible actions. The higher  $x_1$ , the closer is the government's posterior belief to his pooling belief. The lower  $x_1$ , the more certain is the policy maker to face the innovative type.<sup>13</sup>

## 4. Results

### 4.1 The Basic Case

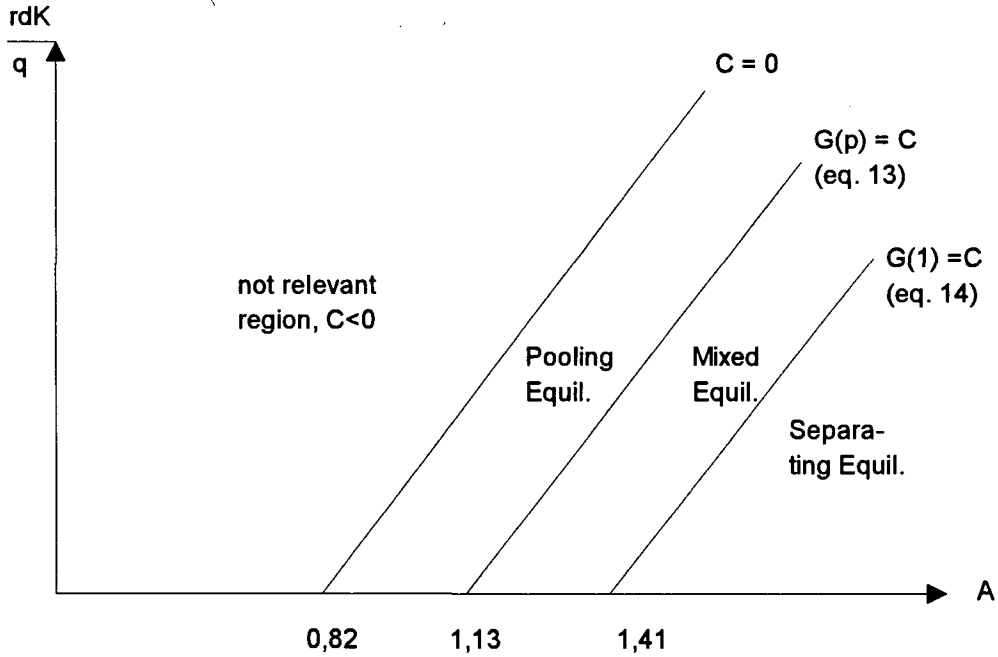
Under which circumstances does the innovative producer behave strategically, shifting part of his capital abroad? To find out, the equilibrium conditions for the pooling equilibrium (13)

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<sup>13</sup>This game is based on the assumption that the policy maker is intelligent: he understands the structure of the game and has complete information, except for the producer's type. The results differ if the policy maker is naive: He always trusts the output signal in period one and keeps his separating beliefs ( $\mu = 1$  if  $\kappa^H$ ,  $\mu = 0$  if  $\kappa^L$ ) even if the innovator has an incentive to mimic the H-type. Because of this naiveté, his realized political support will be not maximal.

A second case, where a policy maker does not maximize his political support, is the case of a green hard-liner government. This government does never believe the producer's signal of being the inflexible one ( $\kappa^H$ ). It always chooses the tight environmental standard. The policy maker loses political support because it neglects the interests of the part of his constituency concerned about output and employment.

and for the separating equilibrium (14) are solved for the given parameters.<sup>14</sup> Figure two presents the results.



**Figure 2**

Imported for the resulting equilibrium is the influence of  $A$ , the parameter indicating the productivity of the innovative technology.  $A$  has to be large enough that the innovative producer still gets higher profits from the "clean" technology than from the "dirty" technology. The case, where the innovator would prefer the "dirty" technology is excluded, it does not fulfil the requirement of positive cost of mimicking from (11). Graphically this is represented by the area called "non-relevant region". The innovative type does prefer the innovative technology to the outdated one in the south-east parts of Figure two.

<sup>14</sup> I assume  $\lambda = 10$  without loss of generality of the argument. The given first-period environmental standard  $\bar{v}$  is chosen to be  $\kappa^H$ , a quite low standard which the government would prefer to choose if facing the inflexible producer. The prior belief is  $p = 0,5$ . Variations for the values of  $p$  and  $\lambda$  are given in the following sub-sections.

A pooling equilibrium is obtained if the productivity parameter  $A$  is small, but large enough to satisfy equation (11). In this case, the "clean" technology's productivity is barely higher than the productivity of the "dirty" technology. The profits of employing the "clean" technology are small, and therefore reduce the cost of sacrificing the "clean" technology with mimicking and investing abroad. The gains from mimicking, low pollution regulation, outweigh the small cost of mimicking easily. On the other hand, if the productivity of the "clean" technology is high, represented through a larger parameter value for  $A$ , the cost of mimicking increase and profits from a low pollution standard do not easily repay the cost of mimicking. The result is a separating equilibrium.

How does mimicking depend on the output price and on the necessary size of capital relocation? Consider Figure three.<sup>15</sup>

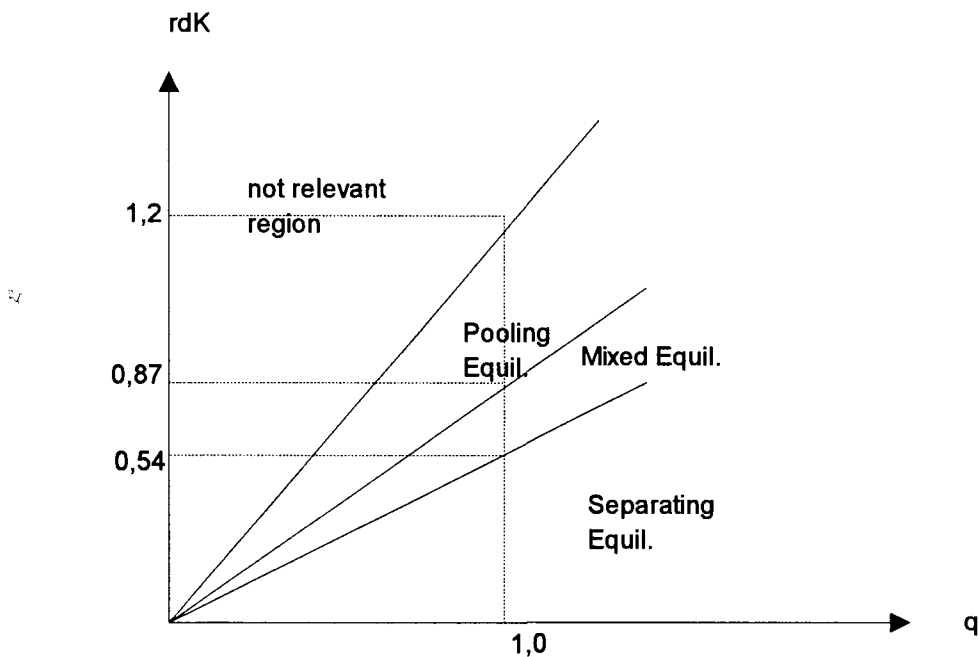


Figure 3

Again, there is a "non-relevant region" which is excluded through equation (11). The "clean" technology does create larger profits for the innovator than the "dirty" technology.

<sup>15</sup>For this exercise the value of  $A$  is fixed ( $A = 2$ ).

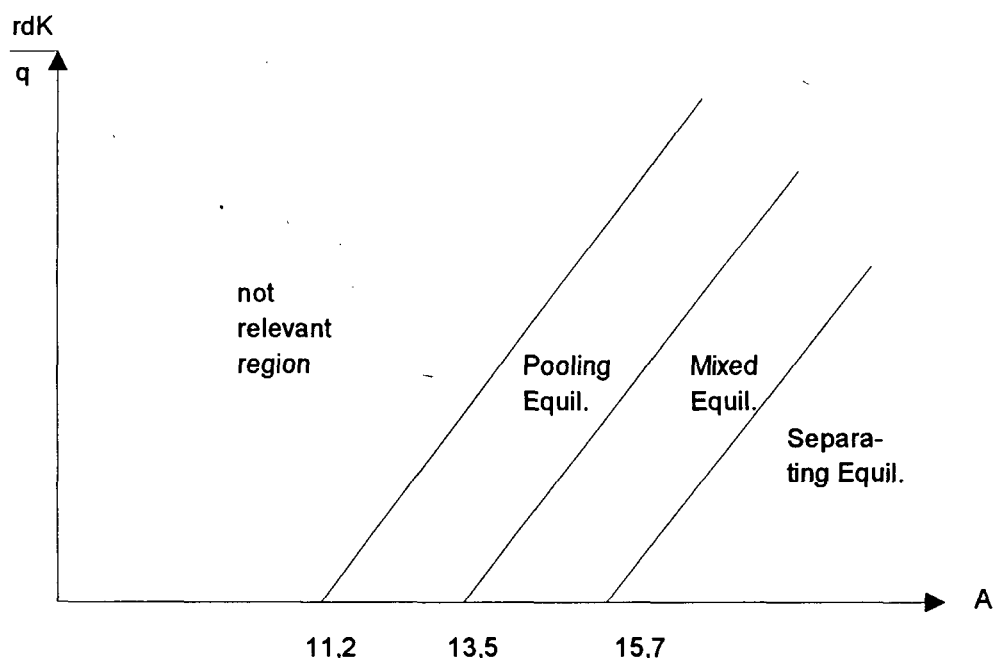
How does the strategic choice of the "dirty" technology and the relocation of capital depend on the necessary size of relocation and the output price? Mimicking is undertaken by the innovator if the cost of mimicking is low. Mimicking helps the innovator to save capital expenditures if using the "dirty" technology. The capital not employed if using the "dirty" technology,  $dK$ , can be profitably invested abroad and earning  $rdK$ , compared to the employment of the "clean" technology, where all the producer's capital  $\bar{K}$  has to be employed. If the saved opportunity cost  $rdK$  are big, the cost of mimicking shrink and make the "clean" technology is less attractive. If, on the other hand, the additional capital expenditures, that the "clean" technology requires, are relatively small, mimicking does not pay off. The innovative producer will reveal himself and abstain from strategic relocation of his capital. Concluding, if the necessary relocation of capital for a credible demonstration of injury from tight environmental regulation is large, such a strategic behavior does barely pay off. Strategic relocation does pay off if the limited relocation is sufficient for the producer's desired injury result.

The relocation decision does also depend on the output price  $q$ . When mimicking, the innovator sacrifices profits through reduced output. With increasing  $q$ , cost of mimicking increase faster than benefits, making separating the profit-maximizing strategy. In between, mixed equilibria are obtained (see section 5 as well).

Concluding, the innovative producer relocates capital for strategic reasons if the "clean" technology is hardly more profitable than the old-fashioned "dirty" technology. This may happen for two reasons. First, the "clean" technology requires considerably more capital than the "dirty" technology. Second, the output price is low, so that the productivity gain from the new technology does not increase profits considerably.

## 4.2. Reduced Political Influence of Environmentalists

How does the pollution standard and the mimicking behavior of the innovative producer type depend on the strength of the environmentalists? The weight of the labor and consumer interests is increased 10-fold to 100, which reduces the influence of the environmentalists. Figure four illustrates the fall of the influence of environmentalists relative to labor and consumer interests.



**Figure 4**

Increasing the power coefficient  $\alpha$ , the politically optimal pollution  $V^L$  and  $V^H$  is increased drastically. The marginal support of output interests is now much higher. Because the policy maker equates political support from the viable interests at the margin, the pollution standard supplied by the policy maker is more lenient. Because the "dirty" technology is more dependent on the use of the environment, it does relatively better with the expanded pollution limit. If parameter  $A$  is high enough to satisfy equation (11), strategic relocation is now more attractive because the losses from employing the "dirty" technology are smaller, meaning the cost of mimicking are smaller as well. With decreasing political power of the environmentalists, the innovator is more likely to strategically employ the "dirty" technology and to relocate the remaining part of his capital. A strong environmentalist movement helps to avoid strategic relocation of the innovative producer by making his "clean" technology too profitable to sacrifice it to his strategic ambitions.

#### **4.3. Variations of the Prior Belief**

What happens if the government is pretty sure of facing the inflexible type? Assume the prior belief of facing the inflexible type changes from the benchmark case of  $p = 0,5$  to a probability of  $p = 0,9$ . Pooling is now more attractive for the innovative type, because the government sets the lower an environmental standard, the higher its probability of being confronted with the inflexible type. This is demonstrated in Figure 5. With increasing prior,

pooling equilibria replace the region of mixed equilibria. At the extreme of  $p = 1$  the government is completely sure that it faces type H. Mixed equilibria cease to exist.

Consider on the other hand, a small prior belief of  $p = 0,1$ . The government is pretty sure that it faces the innovative type and sets a tight pollution policy in the first period. Now, pooling is less attractive for the innovator because mimicking does hardly reduce the environmental standard. Mixed equilibria replace most pooling equilibria (not shown). In the border case of  $p = 0$ , the policy maker is sure to be confronted with the innovator. If the innovator employs the "dirty" technology and relocates capital, he can not avoid that the tough environmental standard is chosen. Therefore, pooling equilibria are not profitable and cease to exist.

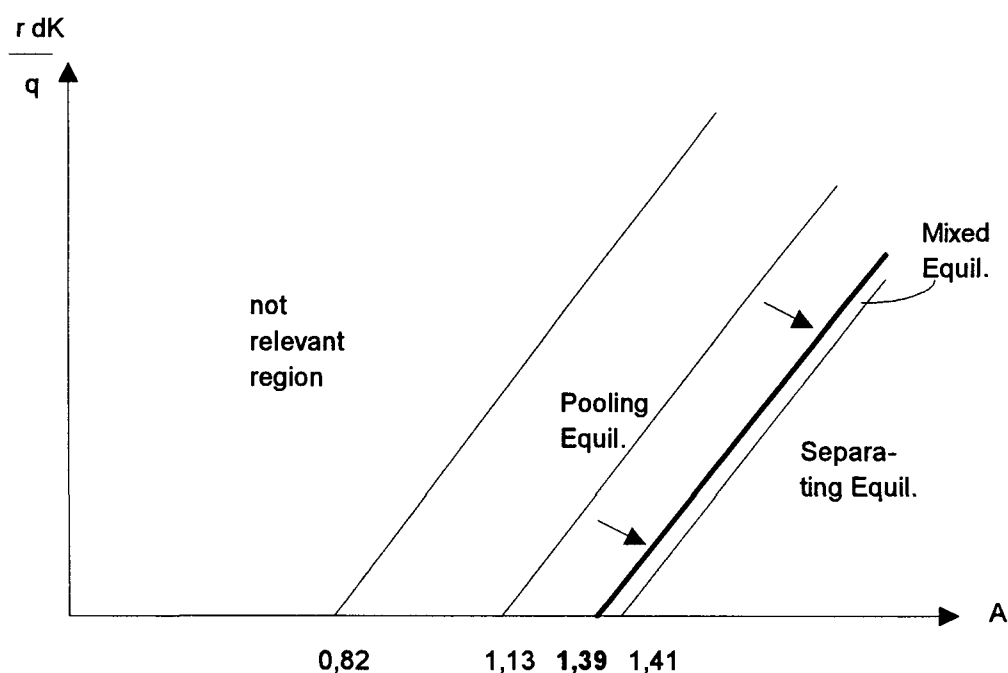


Figure 5

## 5. Trade Liberalization

How does trade liberalization affect environmental regulation and the innovative type's incentive to strategically employ the "dirty" technology and to relocate capital?<sup>16</sup> The

<sup>16</sup>For a two-production-sector analysis of trade liberalization and endogenous environmental policy see Bommer/ Schulze (1994).

innovator operates in a small open economy with a given domestic market price  $q = q^* + t$ , where  $q^*$  is the world market price and  $t$  is the tariff rate. The producer is assumed to compete on the domestic market against foreign rivals. The tariff rate is reduced by trade liberalization, which eases the access of foreign rivals to the home market. Increasing competition drives down the domestic price in the same amount as the tariff rate falls. Trade liberalization lead to a fall of the product price of the import-competing producer.

How does trade liberalization affect the cost and benefits from mimicking? Assume at first that parameter  $A$  is sufficiently large to satisfy condition (11), which guarantees that the cost of mimicking are positive. A lower output price reduces the cost of imitating the inflexible type because now the innovative technology is now less profitable relative to the "dirty" technology.. The profits sacrificed through mimicking are smaller. In the second period, the benefits from a less stringent pollution regulation, obtained by mimicking, decrease as well. Because the cost of mimicking decrease faster than the benefits, mimicking is now more likely. The result is illustrated in Figure 6.

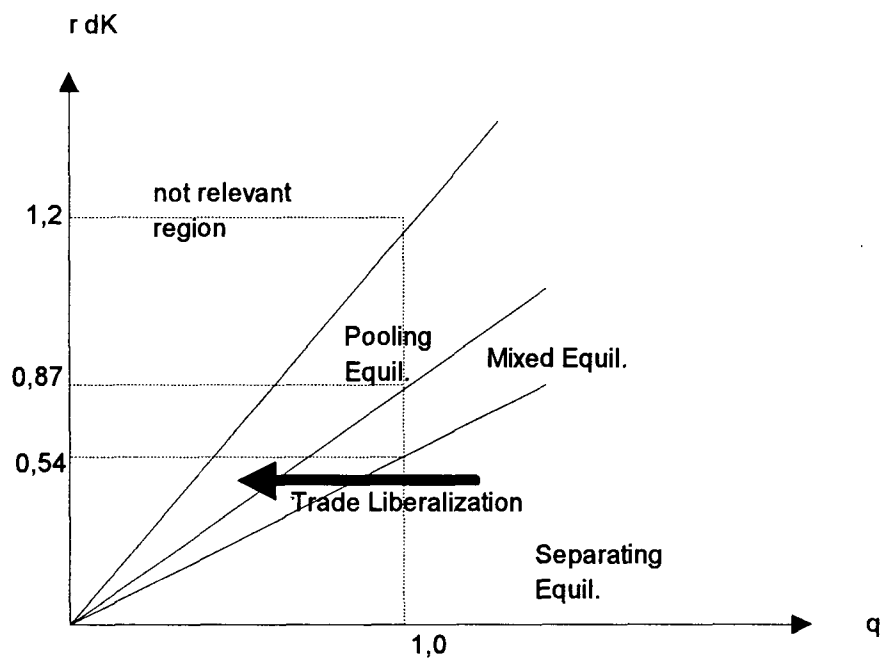


Figure 6

Trade liberalization hurts the import-competing producer through a fall of his market price. Strategic relocation is his tool to recapture part of the losses. Environmental standard setting

serves as the instrument of compensation, which the producer tries to influence by his strategic behavior. The probability of strategic relocation increases under trade liberalization because the producer, adversely affected by a fall of his output price, can now more easily deceive the government in his ability to cope with environmental regulation. By relocating part of his capital abroad, he shows the policy maker his dependence on the "dirty" technology and on lenient environmental regulation.

The results are bleak for the environment, but depend on the assumption of the producer being import-competitive. The results change if the producer is an exporter, who gains from trade liberalization. A lower foreign tariff rate offers him additional opportunities in export markets, which increases his output price. His cost of mimicking rise, at the same time as his gains from mimicking rise as well. Because cost of mimicking increase faster than the benefits, mimicking is less likely if an export-oriented producer is exposed to liberalized trade.

## 6. Conclusion

The paper shows that an entrepreneur may relocate production for strategic reasons rather than due to a real loss of competitiveness if he is expecting a tightening of environmental regulation in the future. Capital flight is intended to signal damage due to increasing environmental control to the policy maker that might or might not occur in reality. Capital flight for strategic reasons is possible because the government is uncertain about the ability of the producer to adapt to environmental regulation.

If strategic capital flight takes place depends on the producer's cost of strategic action. His cost are low if replacing the "clean" technology by the "dirty" technology and by capital investment abroad causes only a small decline of profits. In this case, strategic capital flight has the potential to raise total profits. Sacrificing the "clean" technology is the easier, the less capital the "dirty" technology requires, with the consequence that more capital can be profitably invested abroad. With increasing size of this capital flight, necessary to imitate the inflexible producer, the probability of the capital flight increases as well. On the contrary, strategic relocation can be avoided if the environmental pressure groups are strong. Strong environmentalists increase the level of environmental regulation and make the use of a "clean" technology too attractive, to sacrifice it to strategic ambitions.

A second result shows that trade liberalization affects endogenous environmental policy by increasing the probability of strategic relocation of an import-competing firm. Because trade liberalization makes competition more intense, the firm loses market share to its foreign competitors. Already hit by liberalization, the cost of sacrificing its preferred "clean" technology are lower, making strategic capital flight cheaper. Now, it is more easy for the firm



to deceive the government in his ability to cope with environmental regulation by relocating part of his capital abroad.

Inasmuch as foreign direct investment is motivated by this signaling intention, politicians should not be concerned; on the contrary, if they lower environmental standards in response to such „threats“ they may increase rather than reduce the export of capital. There is considerable scope for further research. For reasons of simplicity, strategic capital-flight was modeled in a very simple fashion. It would be desirable to model the effects of relocation abroad, as well as the foreign actors more explicitly. The domestic decision of raising the environmental standard may well affect the standard-setting process and producer actions abroad.

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## **Workshop 1995**

### **Environmental Policy in Open Economies**

June 5-7, 1995  
Waldhaus Jakob, Eichhornstrasse 84, D-78464 Konstanz

#### **Monday, June 5, 1995**

19.00 - 21.00     Welcome Reception.

#### **Tuesday, June 6, 1995**

*Chairman:* Heinrich Ursprung.

9.00 - 9.45     *Opening Address:* Hans-Jürgen Vosgerau (Speaker of the SFB 178, Konstanz).

*Introduction:*     Bernd Genser (SFB 178, Konstanz).

9.45 - 10.30     Coffee Break.

10.30 - 12.00     James R. Markusen (University of Colorado, Boulder):  
*Costly Pollution Abatement, Competitiveness, and Plant Location Decisions.*

*Discussant:*     Ulrich Landwehr (University of Mannheim).

Gunter Stephan (University of Bern):  
*Laissez-Faire, International Cooperation or National Greenhouse Policy:  
A CGE Study.*

*Discussant:*     Andreas Haufler (University of Konstanz).

12.00 - 14.00     Lunch Break.

14.00 - 15.30     Roger D. Congleton (George Mason University):  
*Return to Rio: On the Political Economy of Environmental Treaties.*

*Discussant:*     Hans Peter Grüner (University of Konstanz).

Rolf Bommer (SFB 178, Konstanz):  
*Endogenous Environmental Policy and Trade Liberalization - A Signaling  
Approach.*

*Discussant:*     Ronald Jones (University of Rochester).

15.30 - 16.00     Coffee Break.

- 16.00 - 17.30 Michael Rauscher (University of Kiel):  
*Protectionists, Environmentalists, and the Formation of Environmental Policy in an Open Economy.*  
 Discussant: John S. Chipman (University of Minnesota).  
 Achim Körber (SFB 178, Konstanz):  
*Raising Rivals' Costs with Environmental Policy - A Lobbying Approach.*  
 Discussant: Hans Gersbach (University of Basel).

### **Wednesday, June 7, 1995**

*Chairman:* Bernd Genser.

- 9.00 - 10.30 Ernst Mohr (University of Kiel, Hochschule St. Gallen):  
*Sustainable Development and International Distribution: Theory and Application to Rainforests as Carbon Sinks.*  
 Discussant: Carsten Schmidt (University of Konstanz).  
 Sebastian Killinger (SFB 178, Konstanz):  
*Decentralized Internalization of International Externalities.*  
 Discussant: Lucas Bretschger (University of Zürich).
- 10.30 - 11.00 Coffee Break.
- 11.00 - 12.30 Ronnie Schöb (University of München):  
*Choosing the Right Instrument: Environmental Policy in the Presence of a Double Dividend.*  
 Discussant: Frank Hettich (SFB 178, Konstanz).  
 Günther Schulze and Rolf Bommer (SFB 178, Konstanz):  
 Economic Integration and Economic Policy. Does NAFTA Increase Pollution?  
 Discussant: Sven Arndt (McKenna College).
- 12.30 - 14.30 Lunch Break.
- 14.30 - 16.00 Albert Schweinberger (SFB 178, Konstanz):  
*Environmental and Commercial Policies in More or Less Populous Open Economies.*  
 Discussant: James R. Markusen (University of Colorado, Boulder).  
 Ruud de Mooij (Ministry of Economic Affairs, The Hague) and  
 Lans A. Bovenberg (University of Tilburg):  
*Environmental Taxation and the Double Dividend: The Role of Factor Substitution and Capital Mobility.*  
 Discussant: Gebhard Kirchgässner (University of St. Gallen).
- 16.00 Closing Address: Heinrich Ursprung (SFB 178, Konstanz).