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Ecological Modernisation and the Creation of Lead Markets

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Summary and Introduction

The paper will discuss the potential role of lead markets in the global process of ecological modernisation, here conceived as innovation and diffusion of environmental friendly technologies, including the innovation and diffusion of supporting national policies. This includes the question whether and how national pioneer roles in environmental policy can be played in times of economic globalisation.

Global Environmental Change in the direction of sustainability strongly depends on international markets for environmental friendly technologies. Such markets need national "lead markets" as a starting point. A lead market is the country that adopts an innovation that subsequently adopted worldwide (Beise 2001). Lead markets are empirically characterised by high per-capita income, demanding and innovative buyers, high quality standards, political pressure for change and flexible, innovation-friendly framework conditions for producers and users. Unlike lead markets for normal technical innovations, *environment-friendly* technologies are specific insofar as they are problem-oriented and depend strongly on political influences. The problem dimension constitutes a potential global demand in terms of global environmental needs. It is mainly the role of pioneer countries to stimulate both, environmental innovation and their global diffusion, often in co-operation with international institutions and organisations. The interplay of innovation and diffusion of technology and policy takes place in different forms (from technology forcing to technology-based policies).

It is the high income countries which are able to afford the necessary investments in R&D for the development of new technologies. Many of them have also the demand conditions that enable environmental lead markets. These markets have to deal with the teething troubles of innovations, and they have to provide the pay back of R&D investments. They demonstrate the feasibility of technologies on a large scale application. Lead markets are not only related to potential first mover advantages, they also can attract foreign investors for environmental friendly technologies.

The paper is explorative in nature, as there is a lack of research on the mechanism and conditions for the successful making of global markets for environmental innovations. It should be understood as an overview and systematisation of aspects of global ecological modernisation with special regard to lead markets for environmental innovations.

1 Ecological Modernisation

By "ecological modernisation" we understand the innovation and diffusion of marketable environmentally (more) applied technologies, including the innovation and diffusion of supporting policies. The concept describes the wide spectrum of possible environmental improvements that can be achieved through innovations beyond the purely end-of-pipe approaches. "Ecological modernisation" is not only the headline of the environmental policy of the present red-green government of Germany. It is a concept that at present rapidly diffuses, especially in the field of social sciences. We use it in its narrower technical-economic sense. Other authors - such as Hajer (1995) or Mol (2001) - tend to use a broad definition which includes institutional, structural and cultural changes of all kind. The main reason for our choice is that policies based on technologies and innovations not only represent a large potential of environmental improvements within the market system but are also easier to introduce and implement than those policies requiring intervention in the established production, consumption, transport, or lifestyle structures. We need a special term to denote these types of marketable solutions. If the concept of ecological modernisation is restricted in this sense it may also be easier to take the limits of the "technological" strategy into account, which cannot be ignored.

Figure 1: Model and examples of environmental policy approaches (Jänicke 1985)

Curative approaches			Preventive approaches	
Repair: Reduction / compensation of damage		*End-of-pipe treatment*: Clean-up technology	*Ecological modernization*: Clean(er) technology / Eco-efficiency	*Structural change*: Decrease of "dirty" industries / activities
Examples	Payments for noise damage	Passive noise protection	Less noisy motors	Alternative traffic modes, less traffic
	Ex-post measures against forest damage	Desulphurisation of coal power stations	More efficient power production and consumption; CHP; cleaner primary energy	Less power-intensive modes of production and consumption
	Measures against damage caused by industrial waste	Waste incineration	Recycling	Reduction of waste-intensive sectors

Ecological modernization starts beyond end-of-the pipe approaches (clean-up technology) and way beyond merely reparative measures (see Figure 1). The scope of environmental friendly technologies varies from incremental improvements to radical innovation, where innovation means the initial market introduction of a new technology. The latter may improve some or all of the phases of a product's life cycle and thereby maybe labelled as "clean" or "cleaner" technology. Incremental improvement affects different dimensions such as material intensity (efficient use of resources), energy intensity (efficient use of energy), land use intensity (efficient use of space), transport intensity (efficient logistics), or risk intensity (regarding plants, substances, products). This involves also waste intensity, i.e. waste materials and harmful emissions (Jänicke 1985).

Modernisation in its economic core is a process of continuous improvement of procedures and products. It is a compulsory necessity in capitalistic industrial societies driven by the forces of competition which generates innovative or efficient technologies. Typically, technological progress is a market based process. It is however possible, and for ecological modernisation a prerequisite, to influence the *direction* of modernisation. The spread of environmental concern can be an important motor for economic modernization (Brickwedde 1997). Recently, also public agencies adopted this view, as for example the Swedish Ministry of the environment (1996: 5) argues that "environmental policy is contributing towards the modernisation Swedish enterprise" or the European Commission: "...high environmental standards are an engine for innovation and business opportunities" (European Commission 2001: 3). This argument is extended to competitiveness: "How an industry responds to environmental problems may, in fact, be a leading indicator of its overall competitiveness ... Successful environmentalists, regulatory agencies, and companies will ... build on the underlying economic logic that links the environment, resources productivity, innovation, and competitiveness" (Porter/van der Linde 1995; cf. Wallace 1995). This argument, however, has also been disputed and certainly needs more empirical evidence and more differentiation.

Unlike the interpretation of N. Ashford (2001) - ecological modernisation conceived as the transformation of the 'problem industries' into 'green' industries - our view on ecological modernisation, focuses on innovative technologies. The technologies which are put on the markets to substitute the environmental harmful technologies are not necessarily produced by the same firm or the same industry. For instance firms producing technologies for renewable energies constituting a new - booming - industry. Our view on ecological modernisation is concerned with technologies which are marketable. For certain environmental problems there is, indeed, the necessity of a structural change, e.g. the phasing out of nuclear energy or lignite coal, which cannot be effected via market mechanism. But the difficulty of this political task is so different that we should use a different term: The dichotomy between ecological modernisation on the one hand and structural change of the phasing-out type on the other hand may be helpful here. Ecological modernisation – using the logic of modernisation and markets - is the easier policy. It is at best a continuous process leading to win-win situations. However a decrease of an industry in its core technologies creating losers and e.g. regional employment problems requires huge political endeavour and is therefore possible only exceptionally.

As we will show later ecological modernisation, too, needs government policy overcoming market failures. And the policy may include the “big stick” as a final resort against laggards in the diffusion process (see below). But this is, at least from the point of view of policy sciences, a quite different task compared to structural solutions.

The political dimension of environmental innovations

What are the driving forces of this process and how can they be reinforced? As a starting point for the analysis, the approaches of innovation economics for the explanation of innovations may be utilised. However, in addition, the special characteristics of environmental innovations must be considered. Traditional R&D policies do focus on the provision of infrastructure needed for the generation, transfer, and application of knowledge by the state and on the amount of subventions for R&D activities. Financial aids and research institutions are considered as the adjusting screws to explain success or failure of National Innovation Systems (NIS) (OECD 1999).

For environmental innovations additional aspects have to be taken into account, too. It is not only the supply of technologies which is supported by public R&D policy, but also environmental regulations, frequently having a strong influence on the demand side that is of special importance. Environmental technologies which become obligatory as e.g. BAT standards (see Hitchens et al., this volume) do have a well protected market. But there are many other means to support and increase the demand for environmental innovations beyond command and control measures such as e.g. tax exemptions or reductions (as for unleaded gasoline), labelling schemes (e.g. Blauer Engel), public procurement, or EMAS (demand of enterprises).

Innovations both in environmental technology and in environmental policy can nowadays count on a broad spectrum of transfer mechanisms beyond the market which - from the OECD, by way of the World Bank, right through to Greenpeace - help their diffusion on the world market. Pioneering measures taken by states and the international orientation along "best practice" lines (benchmarking) serve to further reinforce these mechanisms.

To conclude, political strategies, aiming at a creation of markets for environmental innovations, can be build on three different approaches: 1) The improvement of the infrastructure for the supply with environmental innovations; 2) the safeguarding of demand by means of environmental policy and 3) the utilisation of transfer mechanism to speed up the diffusion of policy innovations into other countries.

There are, however, less favourable conditions for environmental innovations. First, there is a short-term and most often even static perspective on the technological possibilities of enterprises both by regulators as well as managers. Technologies, products and preferences are taken as granted and possible changes are perceived as provoking additional costs. Thereby, environmental policy is oriented on the state of the art rather than on the potentials of technologies. Second, there are many persistent reasons for an end-of-pipe orientation of environmental technologies. These technologies are more easy to control, they usually do not require a change in central processes, there are standardised solutions at hand. Furthermore, if substantial investments in EOP technologies have been done, sunk costs have to be depreciated before considering more innovative technologies. Third, due to the externalities of innovations and especially environmental innovations, there is an undersupply of R&D activities. For innovation in general, there is an incentive for free riding and to obtain second mover advantages. Klaus Rennings (2000) has pointed out, that there is a second externality of environmental innovation: There is an incentive for free riding on the environmental benefits of environmental innovations because these benefits are a public good. Environmental policy therefore has been promoting the diffusion of existing technologies rather than the stimulation of innovations (s.a. Hübner/Nill 2001: 97 f.).

Considering these peculiarities of environmental innovations it is a task of considerable difficulty for politics to implement a policy which is likely to foster environmental innovations. Whereas with "normal" innovations state and politics form only one factor among many influencing the framing conditions of the potential innovator, environmental innovations benefit from socio-political actors (state, also NGOs). It is important to note, that environmental innovators often orientate their decisions on the early phases of public problem definitions and the early phases of policy formulation rather than wait until a suitable policy has been passed and enacted (Jacob/Jänicke 1998). Innovations cannot be explained by a single governmental instrument, but many

other factors have been taken into account such is the policy style, the actors configuration and the instrumentation (Jänicke et al. 2000).

A political strategy should strengthen the ecological motivation of potential innovators, improve their situation regarding the available information, and above all cut their investment risk by providing calculable perspectives. A strategy of ecological modernization will begin with clear target data but with "soft" instruments and regard regulations and official directives as the very last resort (Wallace 1995; Jacob/Jänicke 1998). The guiding axiom is: The more credibly the government threatens specifications and sanctions right from the outset, the more effective the "softer" instruments will work. This rather management-oriented approach is likely to be effective particularly if *targeted* environmental innovations are at stake, for which potential innovators and target groups can be addressed directly. For a broad stimulation of unspecific environmental innovations it is necessary to address a wider spectrum of potential innovators less specifically and directly. For the latter type of innovation oriented environmental policy more traditional means of regulation and stimulation seem more appropriate.

Recently, with a broadly effective set of instruments applied as part of innovation-oriented environmental policy, it has been above all environmental levies and energy taxes that have gained in significance. Of course state provision of the necessary infrastructure for research, development, and knowledge transfer - as innovation research has always stressed - is also critically important. State-run "green" R&D programs play an important and more specific role in innovation-oriented pioneer countries (e.g. the Netherlands, Denmark, and Sweden).

Another important aspect is cooperative environmental planning as defined by "Agenda 21". This encompasses elements of classical regulation and control and of public management systems. The use of strategic targets in environmental plans and strategies reduces the insecurities involved in suitable innovation processes and offers innovators more reliably calculable investment conditions. If, for example, a hazardous substance has to be withdrawn from the market before a specified deadline, the potential supplier of a substitute substance has greater certainty with respect to the profitability of his research and investment planning. Moreover, sustained environmental planning can create motives for innovation and marketable solutions insofar as it is linked to a broad target-oriented debate on specific problem situations. Strategic environmental planning is usually associated with the formation of networks, among other things favouring the exchange of information so important for innovations.

For a comprehensive explanation of environmental innovations, it is not sufficient to look for the political management of single innovations only. The overall capacity of nation states, or even regions for innovations as well as market demands have to be reflected, too. This capacity has been conceptualised as "national innovation systems" where innovative firms are part of a network which encompasses actors from other firms, research institutes, universities, etc. (e.g. Freeman 1987; Lundvall 1992; OECD 1999). The concept of a national innovation system is, however, not a consistent theory, but it tries to combine a wide range of influencing factors which possibly explain national and regional differences in innovation activities.

So far, we have dealt with policy factors supporting innovation. But ecological modernisation is both innovation and - hopefully - rapid and complete diffusion of available and marketable solutions. Therefore, we discuss in the following the conditions for their diffusion.

2 Globalisation and National Environmental Policy Capacity

The greening of international markets strongly depends on national pioneers in environmental policy. But is pioneer behaviour of nations possible in the context of globalisation? Before we turn to the global diffusion of environmental innovations we should clear this important point.

Figure 2:
The Pioneer Countries in Environmental Policy: Policy Innovation or Early Adoption 1970-2000(x)

Country:		1970- 1985	1985 - 2000
Sweden	(11)	7	4
USA	(10)	8	2
Japan	(9)	8	1
Denmark	(9)	5	4
Finland	(8)	4	4
France	(7)	5	2
Germany	(7)	5	2
The Netherlands	(7)	3	4
UK	(6)	4	2
Canada	(6)	2	4
		51	29

(x) Introduction of 20 new environmental policy institutions, laws or instruments: innovation plus first 3 adoptions. Preliminary data

Source: Busch/Jörgens (FFU) 2001

According to a broad review of literature conducted by Thomas Bernauer (2000), there are three distinct understandings of globalisation. From a constructivist/sociological perspective globalisation encompasses political, economic, cultural phenomena of diminishing importance of national borders (e.g. Giddens 1990). Political scientists which also stress the diminishing importance of boarders between nation states and using the term of denationalisation (e.g. Zürn 1998). A neo-marxist perspective stresses the globalising of capital, the dominance of transnational firms, or the unleashed world market (e.g. Altvater/Mahnkopf 1996). Finally, from the point of view of economists, globalisation refers to the extension of international markets both in terms of trade and investment activities. This is accompanied by an easier mobility of factors movements, especially the international movement of capital. For this paper we are interested in the possibilities and obstacles for the establishment of international markets for environmental innovations. Since *environmental* innovation/ diffusion as a rule need to be stimulated by policies it is crucial to understand not only the economic, but also the political dimensions of globalisation and its implications for policy making as well.

There is an ongoing debate about the implications of globalisation for national policy making. Regarding social policy, economic policy, but also environmental policy it has been argued that a free movement of production factors limits the possibilities for national regulations which lead to rising costs for firms and to a competitive disadvantage. Globalisation therefore leads to a "*race to the bottom*" or to de-regulation to attract foreign investments. This phenomena of deregulation became known as the Delaware effect of globalisation (Vogel 1995). It was in Delaware where competition on deregulation of corporate chartering began. In the US charters are granted by individual states, but all states are required to recognize each other's charter. In the course of this competition, a race to the bottom was won by Delaware by lowering the level of protection for employees, shareholders, and customers.

According to David Vogel (1995; 1997; 2001) economic integration and strict regulation is not as antagonistic as it can be expected. High standards in important markets may force foreign producers to adapt to these standards by which foreign governments react by raising their own standards. Furthermore, due to scale effects in production but also to obtain the image of an innovative firm, it may be sensible for firms to adapt to the higher standards for other markets as well on a voluntary basis. A promi-

nent example of this *race to the top* are environmental standards set by California which lead to a world wide adaptation by car manufactures which became known as the California effect.

Figure 3: General Characteristics of the Present Pioneer Countries in Environmental Policy (PCEP)

Definition: PCEPs are innovators or early adopters of new environmental policy measures that diffuse into other countries (thereby contributing to the development of global environmental policy).	
Characteristic (Indicator/Measurement):	**General Hypothesis:**
Environmental policy innovations (Policy monitoring, FFU data)	Pioneering environmental policy is possible
Strict environmental regulation (e.g. Environmental Regulatory Regime)	Strict environmental policy is possible (s.a. Porter)
Innovation or early adoption of environmental technologies (Monitoring of environmental technology diffusion)	PCEPs having the capabilities for technology based environmental strategies and are by this candidates for becoming lead markets
High economic income (GNP/cap.)	High income means both, high (perceived) pressure **and** high capacity for environmental policy
High competitiveness (e.g. Competitiveness Report)	Environmental issue is important for the competition on innovation
Open economy (x) (export/import ratio of GNP)	Economic globalisation is no impediment for active environmental policy
Strong role of government (x)	No general "withering away" of governments in times of globalisation
(x) *Mainly true for the present PCEPs (forerunners within the EU, and Canada)*	

It is a question open to empirical investigation if this example of a successful convergence of environmental standards on a high level of protection may be generalised. It has been argued that this mechanism may apply to product regulation only (Vogel 1997; Scharpf 1999). The distinction between products and processes is not selective since all process technologies are products as well (e.g. wind mills). Empirical evidence is given for a spread of industrial pollution standards to developing countries (Hettige et al. 1996).

Regarding the expected decline in competitiveness by environmental policy the race-to-the-bottom hypothesis suffers from several highly questionable assumptions: It assumes that environmental regulations impose costs for producers that affect location, regardless of differences in labour productivity. It also assumes that governments react exclusively to the preferences of the international capital, ignoring the preferences of voters or interest groups (Drezner 2001). Last but not least, the race-to-the-bottom hypothesis not only overestimates the importance of environmental costs and the differences in regulatory costs but also the general role of prices, thereby ignoring the role of innovation in the global competition. The rising importance of the environmental issue in the competition on innovations may be the most interesting counter argument.

The Porter Hypotheses on Environmental Regulation and Competitiveness

The Porter hypothesis argues that a strict environmental policy can improve competitiveness of firms and sectors (Porter 1990; Porter/van der Linde 1995; s.a. Ashford 1979) may be split into two distinct parts

(s.a. Taistra 2001): First, a competitive advantage might be achieved in case of a strict environmental policy which, at a later stage, diffuses internationally. If there has been a development of technologies in response to strict environmental standards, industries (not necessarily the polluting industry itself), might be able to export their technologies. Their competitive advantage may be based on learning effects or patent protection of their innovation.

Second, strict environmental policy might lead to innovation in the polluting industry itself which is able to compensate or even overcompensate for the costs of adaptation. This part of the Porter hypotheses has been labelled the "free-lunch" or even "paid lunch" hypotheses.

This second case refers to inefficient patterns of production. The existence of considerable inefficiencies is not expected by conventional economic theory. Possible explanations for the broad empirical evidence supporting this part of the hypotheses, might be seen in the fact that both regulators and enterprises most often have a static view when evaluating the expected costs of environmental regulation. Strategies for environmental protection are usually are developed on the basis of given technologies, products and preferences. Policies are most often formulated in a short term perspective only. All this leads to a policy which is based on the state of the art, instead of being oriented on the technical potentials.

According to Porter, environmental policy should choose instruments stimulating innovations which are able to take advantage of the potentials of technologies rather than stimulating the diffusion of existing technologies. Furthermore, national environmental standards should be a slight precursor for other countries. However, a wide gap between the different national standards should be avoided in order to beware of idiosyncratic solutions.

The "Porter hypothesis" has been supported by policy science research on environmental pioneer countries (Wallace 1995; Jänicke/Weidner 1997; Anderson/Liefferink 1997). There have been always national pioneer countries in environmental policy. In the context of globalisation these countries have gained additional importance - just in opposite to the "race to the bottom" hypotheses. They are - possibly more than international institutions - the paramount protagonists of the development of international environmental policy. While environmental policy is mainly based on technologies, they are at the same time supporters of a global ecological modernisation. It is mainly a few highly developed OECD pioneering national states which pushes technology based measures for environmental protection. For these countries the competition on quality which is based on innovation - rather than competition on costs - seems to be the primary push.

Governments do not have an exit option but must react to functional imperatives of their countries. In the global competition the nation state is coming under pressure in areas such as employment, financial policy, social security, infrastructure, R&D policy, and last but not least environmental policy. Here the (recently renewed) *Cameron hypothesis* in political science may be remembered stating that open OECD economies tend to a higher share of public expenditure (Cameron 1978). The underlying causalities for this phenomena may be disputed. We expect, however, that open economies need more government activities, both to enable international competition (e. g. by providing the infrastructure or an effective innovation system) and to counteract its problems (e. g. by compensating its losers). This pressure for action operates contrary to a diminishing importance of national boarders. For policy researchers it is no surprise that well

developed OECD countries which are highly integrated into the world market are also more active in environmental policy (see Bernauer 2000). The nation state also remains the most competent and best organised actor (alongside multinational enterprises) in the global arena. Empirical evidence for this interlinkage is given by the research of Eliste and Fredriksson (1998). According to these authors countries with an open trade regime do have more stringent environmental regulation.

While there has been a (most often voluntary) transfer of sovereignty to international institutions, nation states gained partially additional opportunities by concerting globally their actions (e.g. nature conservation, Basel convention, Rio process, but also the consolidation of national budgets). Therefore, the decline of national sovereignty should not be confused with a decline of capacity to solve national problems.

There is an ongoing debate in economic research about the question of whether a pioneering role in environmental policy influences the competitiveness of firms, sectors or nations. A number of empirical studies on technologies, sectors, firms and countries have been published which in general support the expectations of the Porter hypotheses (for an overview: Taistra 2001; furthermore Jaffe et al. 1995; Hübner/Nill 2001; Sturm et al. 2000; Esty/Porter 2000).

All of these investigations are not able to model the *causal* relationship between economic and environmental performance. At least, the correlations giving further evidence for the thesis that an ambitious environmental policy doesn't harm competitiveness. Furthermore, they giving evidence once again, that a well developed economy is a prerequisite for the development of a successful environmental policy. It is the highly developed countries which are characterised both by high environmental pressure (both objective and subjective, induced by high education and income) and high capacity (encompassing the institutional basis, administrative competence, economic/fiscal resources, knowledge, and the strength of NGOs) to react on it.

A key mechanism for an integrated approach which utilises the economic forces of globalisation, might be the establishment of *lead markets* for environmental innovations.

3 Diffusion of Policy Innovations and the Globalisation of Environmental Policy

As mentioned above, the international diffusion of clean(er) technologies strongly depends on the diffusion of their supporting policies. Therefore, the role of environmental policy diffusion is relevant in our context. Recent comparative research on the spread of environmental policy among countries reveals an astonishing international convergence in the development of national policy patterns (Kern 2000; Jörgens 1996; Kern/Jörgens/Jänicke 1999). It is possible, by way of policy monitoring, to treat innovations in environmental policy as indicators and evaluate these accordingly (from the establishment of an environment ministry right through to the introduction of a CO2 tax). It is also possible in the same way to assess the significance of pioneer countries and the role of certain strategic countries without which rapid diffusion would not succeed. This procedure also allows us to deduce, from the diffusion rate, the level of difficulty involved in solving a problem. Monitoring individual policy measures in this way (as policy output) is of course not a proper policy outcome evaluation; but the method of empirically describing national and global policy developments with the aid of policy indicators can still be considered a step forward in environmental policy research.

The result shows, for example, that the globalisation of environmental policy, insofar as this is reflected at state level, can indeed be described using the analytic concept of innovation diffusion: Standard solutions in certain pioneer countries are diffused worldwide, thus causing a substantial measure of convergence in policy formulation at national state level - irrespective of extremely different capacities for action. Unlike in the 1970s, when for example the USA or Japan had a major innovative function in global environmental policy, nowadays innovations in environmental policy emerge strikingly often in small EU countries tightly integrated in the global market (Jänicke 1998).

The - reformed - institutional fabric of the EU seems comparatively favourable both for innovations and for their diffusion (Héritier et al. 1994). The EU must firstly, at least in principle, accept a "high level of protection" in member states; it must secondly seek to harmonize innovations in environmental policy implemented at national state level. Pioneer countries, for their part, often have an interest in anchoring their policy innovations within the EU framework in order to thus minimize their subsequent need to adapt to European policy. It is also often a matter of "Europeanizing" certain national pioneer measures favouring the particular country's domestic industry. Policy diffusion within the EU, however, takes place not only by way of EU harmonization but also from country to country. In the latter case the policy innovation in question will often need first to be introduced by one of the more influential EU countries before it achieves the necessary widespread impact. For example, the CO2/energy tax was already introduced in the Netherlands and the Scandinavian countries in the early 1990s - but it seems that the decisive push towards European diffusion has been the adoption of a green tax by the red-green coalition government in Germany in 1998. The CO2 tax is an example of "horizontal" diffusion. It has yet to be established as a European measure.

The diffusion of innovations in environmental policy thus takes place both directly from one country to another, i.e. by way of imitative policy learning or "lesson drawing" (Rose 1993) and by way of international institutions (e.g. OECD, UNEP, World Bank), organizations (e.g. Greenpeace), or expert-networks (e.g. the International Network of Green Planners). It is striking how rapidly many innovations in environmental policy are diffused. Environment ministries have, in a period of just under 30 years, clearly asserted their position in the industrialized countries. Environmental plans, as defined under "Agenda 21", just ten years after the Rio Conference (1992), are going to be more or less in place worldwide - though in extremely disparate quality. However, in other cases (e.g. soil protection legislation) the diffusion rate is clearly curbed by the difficulty of solving the problems involved.

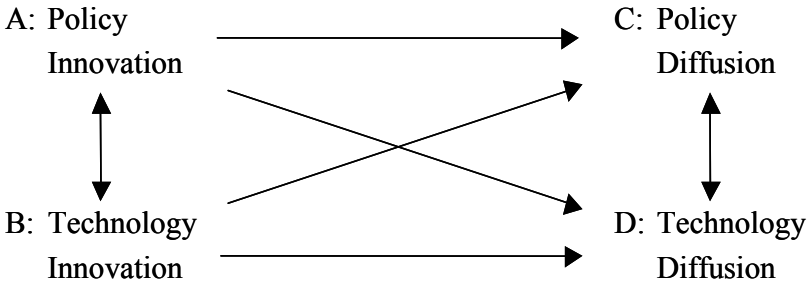
It can be expected that a high capacity *for environmental policy* is needed both for policy innovation and the adoption of innovations. The OECD defines it broadly as "a society's ability to identify and solve environmental problems" (OECD 1994: 8). While the term capacity and capacity building was used previously by numerous institutions such as UNEP, FAO, World Bank, OECD, and others in connection with less developed countries only, it has been fruitfully extended to industrialised countries as well (Jänicke/Weidner 1997; Weidner/Jänicke 2002). It refers to the structural preconditions for successful environmental policy and encompasses the collective actors (esp. environmental institutions and organisations). The structural preconditions include (a) the institutional set-up (e. g. open and effectively integrated political institutions, administrative competence), (b) the system of creation, transfer and application of knowledge and (c) the economic-technical basis.

4 The Interplay between the Diffusion of Environmental Policy Innovations and Environmental Technology

There is a highly symbiotic fabric of interwoven interests between innovators in technology and policy makers. Suppliers of environmental technology seek the support of politicians and politicians are always looking out for technological options, because precisely these are much easier to implement than any sort of structural intervention.

However, the interplay between environmental policy and environmental technology in the case of innovation diffusion is characterized by a wide variety of possible constellations. Theoretically it is possible to distinguish between the following diffusion scenarios, depending on the factors leading to the political and technological innovations:

Figure 4: Diffusion patterns of Environmental Innovation



Policy induced Diffusion

- Technology Forcing $A \Rightarrow B \Rightarrow C \Rightarrow D$
  e.g. US-Car Emission Standards (1970)
- Political Initiative $A \Rightarrow B \Rightarrow D \Rightarrow C$
  e.g. Cadmium substitutes
- Political Dominance $A \Rightarrow C \Rightarrow B \Rightarrow D$
  no example yet ?

Technology induced Diffusion

- Technological Initiative $B \Rightarrow A \Rightarrow C \Rightarrow D$
  e.g. wind energy
- Technological Dominance $B \Rightarrow A \Rightarrow D \Rightarrow C$
  e.g. CHP technologies
- Autonomous Diffusion $B \Rightarrow D$
  e.g. Incremental improvements of energy efficiency

Technology forcing (A⇒B⇒C⇒D): A national environmental policy innovation in one country forces a technological innovation which diffuses if also the policy innovation is diffused (e.g.: catalytic converter technology in cars).

Technological initiative (B⇒A⇒C⇒D): A new but already existing environmental technology induces a political innovation whose diffusion in turn encourages the diffusion of the technology (e.g.: wind mills).

Political initiative (A⇒B⇒D⇒C): A national environmental policy leads to technological innovations whose diffusion in turn encourages diffusion of the policy innovation (e.g.: cadmium substitute [1]).

Technological dominance (B⇒A⇒D⇒C): An innovation in environmental technology is successfully diffused and as a result receives political support both nationally and internationally (e.g.: combined heat and power in industry [2]).

Political dominance (A⇒C⇒B⇒D): The innovation in environmental policy is successfully diffused before a corresponding technology is available (this scenario is, symptomatically, very rare in ecological modernization).

Autonomous technological development (B⇒D): An innovation in environmental technology is successfully diffused without political influence; this case, beyond incrementally increasing energy efficiency in companies, seems to be rather rare.

1 The use of cadmium was regulated in Sweden in the early 1980s with their standards for substitutes being adopted by European industry. Not until the early 1990s, however, were these standards made binding by the European Commission (Bätcher/Böhm/Tötsch 1992).

2 Combined heat and power (CHP) in industry spread largely autonomously, even though regulatory measures were intended to encourage its use in public power stations.

Technological innovations do provide additional options for policy makers. For other cases, policy factors have been the major driving forces in the stimulation of environment-friendly technical innovations. The case of technology forcing has, however, been exceptional for environmental innovation (cf. Conrad 1998; Jacob 1999). So far, environmental policy has its merits in the promotion of the diffusion of technologies. It can be observed, however, that policies promoting the diffusion do support incremental innovations.

There is considerable plausibility for the assumption that autonomous emergence and diffusion of innovations in environmental technology is the exception rather than the rule and that such developments usually remain limited to incremental increases in efficiency in companies. The reverse border-line case is innovation in environmental policy where policy clearly exceeds the given technological possibilities.

The limits of ecological modernization (in the "technocratic" sense) are thus defined by the limits of technology. However, these limits are dynamic. They can be extended by research (and by backing for research). For example, research into the development of procedures for reducing CO2 emissions, if successful, could substantially widen our room for manoeuvre in climate politics - even if only in the sense of end-of-pipe measures. The rapid diffusion of suitable policy innovations will then be as similarly predictable as the difficulty and slowness of a structural climate policy which de facto places restrictions on established energy markets (coal, oil).

The variants of this interplay between policy and technology in any case are a central theme in research on the diffusion of environmental innovations, especially when it comes to selectively optimising such innovations.

To summarise our main assumptions:

- Ecological modernisation can be conceived and has its strength as a market compatible strategy of technical environmental innovations and their policy based diffusion. It is the nation state, which is playing a crucial role in this context.
- The necessary pioneer role is a possible option for highly developed countries, many of them being especially open economies - there is no race to the bottom in times of globalisation.
- There is no general contradiction between competitiveness and demanding environmental policy, on the contrary, highly developed countries tend to integrate the environmental issue into the competition on quality.
- Global diffusion of best practice in environmental policy takes place and is a major driving force for the diffusion of marketable, technical solutions for environmental problems, that typically exist on a global scale

If we are right, the creation of lead markets for environmental technologies would be a feasible global environmental strategy.

5 Lead Markets for Environmental Technologies

Lead markets are the geographical starting point of global diffusion processes. We understand lead-markets for environmental technologies as regional or national markets, which were stimulated by higher preferences for environmental goods in a given country, specific supporting measures, or policy interventions, which are able to influence the markets in other regions effectively, trigger reactions of adjustment and finally lead to an international diffusion of the new technologies. By this, we take again into account, that *environmental* innovations have to be largely ascribed to governmental (or NGO) activities.

Figure 5: Lead Markets for Environmental Technologies

An environmental lead market is the core of the world market for a product or process where:

- national policy or non-governmental influences successfully have created an incentive structure for users to adopt an innovation relating to a (manifest or latent) global environmental problem and
- the global dimension of the problem creates a potential demand also in other geographic markets.
- As a rule environmental lead markets are created by national policy innovations (e.g. standards) which potentially diffuse into other countries. There is a close interrelationship between policy innovation/diffusion and technical innovation/diffusion.
- The diffusion of environmental policy innovations is supported both by horizontal imitation ("benchmarking", "lesson-drawing") and by international organizations

For a targeted ecological modernization of international markets the potential of nation states for a framing of national markets might gain considerable importance. The history of environmental protection is rich in examples for lead-markets: it encompasses the legally enforced introduction of catalytic converters for automobiles in the USA, desulphurisation technologies in Japan, the Danish support for wind energy or the CFC free refrigerator in Germany. Another impressive example is the global diffusion of chlorine-free paper, from the political activities by Greenpeace and the EPA in the USA, by way of the introduction of chlorine-free paper whitener in Scandinavian countries and various Greenpeace campaigns in Germany and Austria, right through to effective political market intervention in south-east Asian countries like Thailand (Mol/Sonnenfeld 2000).

By setting up increasingly demanding environmental standards, pioneer countries in environmental policy may send out a two-fold signal beyond the boundaries of their national market:

1. A national market for environmentally-friendly technology acting as a basis for subsequent expansion to bigger markets. The pioneer country demonstrates the feasibility of its standards, regulations. Subsequently the innovative regulation is adopted by other countries. For example, the German tax preference for fuel-saving cars (1997) has supported suppliers in that country (Volkswagen, Mercedes). The diffusion of this instrument, e.g. throughout the EU, can bring appropriate market expansion. Frequently, the international diffusion is supported by the national producers, if they were able to adopt successfully to the new standards (examples in Jacob 1999). A diffusion of regulations will be more likely if a country has attained the image of being a pioneer. It is only a few countries nowadays, mostly member states of the EU, which serve as the benchmark for the development of environmental policy.
2. The pioneer market with its demanding environmental regulations can, however, also send out signals to the supply side outside the domestic market. For example, California, with its stricter emission rules compared with the rest of the USA, was able to exert a general influence on the car industry word-wide (Vogel 1995). Similarly, Denmark, in 1994, with its targeted promotion of energy-efficient refrigerators, was able to prompt European suppliers to offer such devices there. In cases like these, competitive companies can advertise their ability to supply such demanding market areas as a sign of their technological competence. It can be cost efficient to orient the production on the highest standards, if there are scale effects.

An ongoing research project carried out for the German Ministry for Research and Education BMBF on "ecological lead markets" (conducted by the DIW, FFU, IÖW, and ZEW) aims at identifying both framework conditions and policy measures for the establishment of lead markets on a more systematic empirical basis. Lead markets generally are "geographic markets which have the characteristic that product or process innovations, which are designed to fit local demand preferences and local...conditions, can subsequently be introduced successfully in other geographic markets as well and commercialized world-wide without many modifications. In the model of international diffusion of innovations a lead market is the core of the world market where the local users are early adopters of an innovation on an international scale" (Beise, 1999: 4). The U.S. as lead market for the internet, Japan as lead market for fax, or Finland as lead market for mobile phones are well-known examples. Empirically lead markets are characterized as follows:

General characteristics of lead markets (see also F. Meyer-Krahmer 1997):

- High per-capita income, low price elasticity
- Demanding, innovative buyers, high quality standards
- Problems, pressure for change and innovation
- Flexible regulation, innovation-friendly framework conditions for producers and users
- Product standards are acknowledged also in other countries.

Lead markets for environmental technologies, however, are characterised by additional factors. They typically are not only stimulated by higher environmental preferences of consumers in that country, but also by special promotion measures, or by political market intervention.

They provide marketable solutions for global environmental needs, offering at least improvements for environmental problems which are mostly encountered worldwide or at least in a great many countries. Thus technological solutions to environmental problems enjoy, right from the outset and by their very nature, potentially larger markets. Lead markets affect competition in other market regions, trigger appropriate responses and adaptations, and thereby lead to the international diffusion of the new technology. The creation of lead markets for an environmental technology takes place in two stages, the first being the most important:

1. Struggling for success on the national market: This includes the establishment of a national market (not only a niche market), successful incremental improvements of the product and its production. Government instruments may be standards, subsidies, charges, labels, public procurement, network management, or EMAS (demand of firms).
2. Government support for technology transfer by activities within international organizations (e. g. diffusion of the supporting policy pattern), bilateral actions with strategic countries (e. g. the environmental co-operation between Germany and China), special international conferences, use of the international media, cooperation with international NGOs. More important may be - on the demand situation - the diffusion motor of benchmarking and search for best practices which in many countries is an institutionalised mechanism, today. In addition, the cooperation with multinational companies may be a relevant transfer mechanism.

Figure 6: Possible Functions of Environmental Lead-Markets

Global Functions:

- Problem solving function regarding global environmental needs
- Return function for R & D and learning costs (possible in high-income countries)
- Technological demonstration function (benchmarking)
- Political demonstration function (lesson-drawing).

National Functions:

- Competitive function, potential first-mover-advantages
- Potential attractiveness for foreign direct investments
- Increased market value of environmental and technological reputation
- Political legitimation function (for environmental policy, national policy actors as global players)

If successfully established, such markets may fulfil a range of functions: From a *global* perspective they provide marketable solutions for typical environmental problems. Lead Markets in high-income countries are able to raise the necessary funds for refinancing the costs for development and "learning". This is true for environmental innovations in particular since there is a need to survive the teething troubles of new technologies. They are demonstrating both the technical and the political feasibility and thereby giving a stimulus for other countries and enterprises to adopt to their pioneering standards. From a national perspective ambitious standards or support mechanisms might safeguard the first mover advantage for the own industries. Furthermore, ambitious policy measures can attract foreign investors which are interested in the development and marketing of environmental innovations. (It is not by chance that there have been recently some prominent investments for the production of solar cells or for fuel cells in Germany.) Finally, a demanding policy which holds economic advantages additionally legitimates the national policy makers, sometimes providing them also with attractive roles in the global arena.

6 The Limits to Ecological Modernization

We use this "technocratic" concept of ecological modernization, in its narrower sense, to describe the spectrum of technical, system-compliant solutions for environmental problems. Ecological modernisation in this sense, however, comes up against its limits where potentially marketable technological standard solutions are not available. The so far unsolved environmental "persistent problems" - urban sprawl, loss of bio-diversity, soil erosion, groundwater pollution, final storage for nuclear waste, or the deterioration of global climate - all, so far, show up these limits. The modernization approach is also no viable option where the risk is acute and immediate defensive action is needed.

If incremental increases in ecological efficiency are not a causal, sustained solution, the environmental relief might be compensated by subsequent growth processes. In this case, the effects of ecological modernisation are compensated by growth A reduction in pollution tends to be followed by a resurgence. These facts were recognized as early as the late 1970s as the "dilemma of the N curve" (Jänicke 1979: 111). This di-

lemma applies not only to clean-up environmental protection (end-of-pipe treatment) but even to efficiency improvements. For example, Japanese industries, between 1973 and 1985, succeeded in saving energy and raw materials in a remarkable way but the high industrial growth in those days simply devaluated this effect (Jänicke/Binder/Mönch 1997). The overall growth rate must thus always be accompanied by equivalent progress in (compensatory) technology providing environmental relief. This "*hare and tortoise-dilemma*" of ecological modernization is even tightened if there are losers of modernisation: If it is not the polluting industry itself which finds new opportunities in environmental friendly products, the sector often seeks for new sales opportunities for the old product. For example, the successful campaigns of environmentalists against using chlorine in applications free to the environment leading to a considerable reduction in production and consumption have since been compensated by the expansion of chlorine uses in other areas (Jacob 2001).

What is needed in the long term therefore is, firstly, a transition from incremental to radical innovations in which ecologically problematic procedures and products are substituted by unproblematic ones (Kemp 1997: 9). An example is the transition from efficiency improvement in coal-fired power plants to variants of solar energy. In between lie the border-line cases, a variety of incremental improvements which together represent a radically new quality (e.g. the zero-energy house).

What is also needed are structural solutions, i.e. solutions of a non-technical nature, changes in the structure of demand and of industry, and, based on these, an ecological industrial policy. Finally for the areas that are difficult to control, namely lifestyle, the level of personal mobility, and residential and housing structures, etc. have to be tackled by other means than technical approaches. Unlike the economic-technical variant of ecological modernization there are no marketable technical solutions to problems of that type.

The much higher degree of political difficulty for an even cautious ecological industrial policy aiming at a restructuring away from the environmentally intensive "chimney industries" is indicated by the fact that there are hardly any examples for such a far reaching policy. Examples so far, namely the running down of coal mining in the Netherlands or of crude steel works in Luxembourg, were hardly suitable for or capable of diffusion and are unlikely to find imitators. Often, environmental objectives haven't been the driving force in these cases, although there has been a considerable environmental relief (Binder/Petschow/Jänicke 2001).

Finally, an innovation oriented environmental policy is limited to those sectors where the target group has sufficient capacities to fulfil the expectations of environmental policy. A strategy based on innovation is more likely to be successful if the target group is small but encompasses potent actors.

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