ZEW Economic Studies

Klaus Jacob et al.

Vol. 27

Lead Markets for Environmental Innovations

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Zentrum für Europäische Wirtschaftsforschung GmbH
Centre for European Economic Research

Physica-Verlag
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Publication Series of the Centre for European Economic Research (ZEW), Mannheim, Germany

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With 52 Figures
and 20 Tables

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Cataloging-in-Publication Data
Library of Congress Control Number: 2005922602

ISBN 3-7908-0164-X Physica-Verlag Heidelberg New York

Physica-Verlag is a part of Springer Science+Business Media

springeronline.com

Printed in Germany

Cover design: Erich Dichiser, ZEW, Mannheim

SPIN 10981283 43/3153-5 4 3 2 1 0 – Printed on acid-free paper

Preface

Some countries are earlier than others in the development and introduction of environmental innovations. If other countries follow their examples and adopt their innovation design as well, these countries can be analysed as lead markets. In this book, contributions from innovation economics, environmental economics, and policy sciences are reviewed to explain the leadership of such countries. In case studies on environmental innovations such as photovoltaic cells, fuel cells, chlorine-free paper bleaching, diesel particulate filters, social responsible investments and others the lead markets are identified and factors that determine their advance are analysed. Often, the leadership in technological development is accompanied by a leadership in environmental policy. There is a parallel diffusion of environmental technologies and policies. Based on the theoretical considerations and the case studies, policy recommendations for R&D policies, environmental and industrial policies are derived to support the development of lead markets for environmental innovations.

This book is the result of a joint research project under the title "Policy Framework for the Development of International Markets for Innovations of a Sustainable Economy – from Pilot Markets to Lead Markets (LEAD)". The authors are grateful for the funding provided by the German Federal Ministry of Research and Education (grant number 07RIW1A).

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1 Introduction

1.1 The Notion of Lead Markets

There are considerable differences in the rate of adaptation of environmental innovations among the different countries. Some countries are earlier in adopting innovation, and the penetration of markets is more encompassing than in others. If these innovations are adopted subsequently without great changes in other countries, the countries where the first market introduction took place, can be viewed as *lead markets*. The concept of lead markets has been developed and fruitfully applied for any type of technological innovations. Examples for lead markets for non-environmental innovations are the mobile phones that were introduced in Finland, the fax in Japan or the internet in the USA (Beise, 2001). The lead market is not necessarily the country where the technology was actually invented. These markets have the characteristic that product or process innovations that are designed to meet local demand preferences and conditions can be introduced in other geographic markets as well and successfully commercialised without many modifications. A lead market is the core of the world market where local users are early adopters of an innovation on international scale (Beise, 1999). This definition focuses on two characteristics of lead markets. Firstly, they are pioneering countries in the development and – more important – the marketing of innovations. Secondly, innovations that arise in these markets subsequently diffuse worldwide. Both phenomena call for analysis and explanation.

At first glance, lead markets are countries with the following features (Meyer-Krahmer, 1999):

- High per capita income,
- Demanding, innovative buyers and high quality standards,
- Problems creating pressure for change and innovation,
- Flexible regulation and innovation-friendly basic conditions for producers and users,
- Product standards acknowledged in other countries.

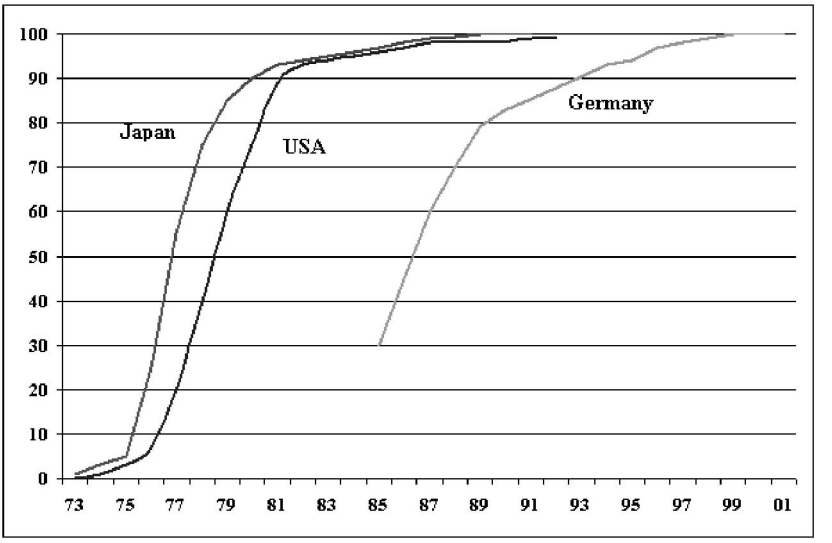
These factors hint to the fact that there are many different economic and policy factors that contribute to the emergence of such markets. Our study systematises the different factors that can be found in different streams of literature. Our approach is largely explorative, since no encompassing explanation has been developed for the emergence of lead markets for environmental innovations so far. Based on this study we develop recommendations for policy strategies that are able to stimulate the emergence of lead markets.

Our studies are dealing with lead markets for environmental innovations. It can be expected that the above mentioned factors are characteristic of lead markets for *environmental* technologies as well, but that there are also additional factors at work here, arising from the particular context in which environmental innovations are developed, both at the national and international level.

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 United States, desulphurization 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 United States, 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 Southeast Asian countries like Thailand (Mol and Sonnenfeld, 2000, see chapter 4.4 for a more detailed analysis). The latter case shows that political action that stimulates internationally successful innovations is not limited to governmental agencies only, but that this function at least regarding the process of setting environmental objectives may also be taken over by environmentalists.

Lead markets can be represented by the rate of market penetration in the different countries. The diffusion starts earlier and the market penetration is typically more complete than in other countries. An example is the catalytic converter for cars (see for more detailed discussion: chapter 4.5):

Fig. 1. Share of passenger cars equipped with catalytic converter in %



California became the pacesetter for air quality and automobile emission standards from the 1960s on. U.S. congress took over these far-reaching standards in

1970 that were not to be met with existing technologies. That was for the first time a purposeful technology forcing. However, the short period of time to meet the standards did not allow the development of a new engine design. Therefore, the catalytic converter became the dominant technical strategy to reduce emissions. The U.S. regulations were adopted by several countries with automobile industry. In particular Japan adopted early the US regulations, in order to adapt its own car industry to global markets and to enhance its competitiveness.

While the U.S. standards were postponed and lowered due to successful lobbying of the U.S. car industry, the Japanese government maintained the earlier objectives. In Europe, the regulations favouring a catalytic converter had been adopted in 1985, and among the European countries Germany took over the leading role, mainly due to its export oriented automobile industry.

What are the determinants that cause the differences in the introduction of innovations? What are the characteristics of the leading countries? Is there room for manoeuvre for a purposeful establishment of lead markets for environmental innovations?

From our case studies as well as previous studies we can infer that technical *environmental* innovations have to be largely ascribed to governmental (or NGO) activities. Environmental innovations are not only stimulated by the higher environmental standards of consumers in a country as compared with those in other countries, but also by special promotional measures, or by political intervention in the market (Klemmer et al., 1999; Jänicke et al., 2000). If the technologies cause additional costs without improving the benefits for the users as for the case of end of pipe measures, regulatory interventions are even indispensable for innovation and diffusion. But also in cases of integrated technologies, with additional advantages in efficiency, policy measures are often necessary to stimulate innovations and to support their diffusion. The underinvestment in environmental innovation can be explained by the double externality of R&D efforts made in environmental technologies: Alongside the spillover effects that can be observed for any R&D activities, efforts in *environmental* technologies do result in improvements of the environment which again is a public good. Therefore an underinvestment in environmental innovations can be expected (Rennings, 2000).

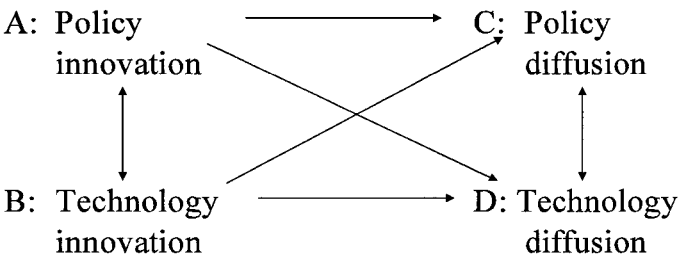
Environmental innovations do have another characteristic that is in favour of their international diffusion: They provide marketable solutions to environmental problems that are usually encountered worldwide, or at least in many countries. Thus, technological solutions to environmental problems inherently lend themselves to adoption in international or global markets.

The regional differences in adoption and diffusion of innovations cannot be explained with the specifics of environmental innovations. For this purpose, the framework conditions and political strategies in the leading countries have to be analysed. The dependence of environmental technologies on regulatory measures leads to the question to what extent national environmental policies to stimulate lead markets remain possible and effective in the context of globalisation. Our theoretical and empirical investigations, however, reveal that there is considerable room for manoeuvre for national actors. Typically, policy innovations arise in a national framework rather than being imposed by an international regime. Innova-

tive policies do diffuse very much like technological innovations. The process of diffusion is determined by the capacities of the innovating countries to develop environmental policies, by the type of innovation and the underlying problem, and by activities of international actors that often look for best practices on the national level and stimulate their diffusion (Tews et al., 2003, see chapter 2.2 for a more detailed discussion).

There is a close inter-linkage in the innovation and diffusion of environmental policies on the one hand and the innovation and diffusion of technologies on the other hand. The interplay between the diffusion of environmental policy measures and environmental technology can take a wide variety of possible sequences as depicted in the following graph.

Fig. 2. Stage model of the diffusion of environmental innovation



Policy induced diffusion

Technology forcing

(A⇒B⇒C⇒D): e.g. US-car emission standards (1970)

Political initiative (A⇒B⇒D⇒C): e.g. Cadmium substitutes

Political dominance

(A⇒C⇒B⇒D): no example yet?

Technology induced diffusion

Technological initiative

(B⇒A⇒C⇒D): e.g. wind energy

Technological dominance

(B⇒A⇒D⇒C): e.g. CHP technologies

Autonomous diffusion (B⇒D): e.g. Incremental improvements of energy efficiency

Source: Jänicke (2000).

Theoretically, it is possible to distinguish between the following diffusion scenarios, depending on the factors leading to the political and technological innovations:

- *Technology forcing* (A⇒B⇒C⇒D): A national environmental policy innovation in one country forces a technological innovation which diffuses if the policy innovation also diffuses (e.g.: catalytic converter technology in cars).
- *Technological initiative* (B⇒A⇒C⇒D): An existing environmental technology induces a political innovation the diffusion of which in turn encourages the diffusion of the technology (e.g.: wind energy in Denmark).
- *Political initiative* (A⇒B⇒D⇒C): A national environmental policy leads to technological innovations the diffusion of which in turn encourages diffusion of the policy innovation (e.g.: cadmium substitute).

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

The different patterns of innovation and diffusion can be distinguished regarding the degree of difficulty of the underlying political strategies. On the one hand, a policy measure will meet resistance of the target groups in particular in those cases where a technology that is able to fulfil the required standards has yet not been developed and an international example for comparable policy measures is missing (technology forcing). On the other hand, policy measures that primarily aim at a support for the diffusion of developed technologies may still meet the resistance of the affected industries if they prefer to use their previous technologies for a longer period of time. However, these policies are easier to be enforced if the related technologies have proved their technological and their economic feasibility. This is particularly true if there are international examples for such policy measures. These examples are often used to legitimise planned policies. In this way, technological innovations provide additional options for policymakers.

By this logic of different degrees of difficulty of policy interventions, a technology forcing can be observed only rarely (e.g. Californian exhaust gas standards, to a lesser degree also the European standards for automobiles). Environmental policy up to now, has had its merits in the support of the diffusion of developed innovations (Conrad, 1998; Jacob, 1999).

For the choice of policy instruments it can be concluded, that in those cases where no innovator exists yet, distributive measures e.g. R&D funding are easier to be implemented. For policies that aim at a diffusion of existing technologies regulative measures are likely to be more efficient and effective. The opposite extreme of technology forcing – the autonomous emergence and diffusion of innovations in environmental technology – is the exception rather than the rule and such developments usually yield only limited incremental increases in efficiency.

The mechanism of international diffusion of policy innovations is favourable for the creation of lead markets for environmental innovations. On the one hand, the convergence of standards and regulations implies – in the case of technology-based policies – a widening of the market for technologies. On the other hand, the availability of technical solutions makes the diffusion of the corresponding policy innovation more likely.

Technologies with advantages beyond environmental relief (e.g. cost reductions or users' higher willingness to pay) are more likely than end-of-pipe (EOP) technologies to be successful abroad, even in the absence of policy diffusion. There is evidence, however, that EOP technologies, in combination with supporting regulation, diffuse in a very similar manner. Often technologies address environmental

problems of an international nature, i.e. problems that are on the international agenda or at least occur in various regions of the world.

However, the emergence of lead markets is not a matter of the introduction of a single policy instrument and the successful stimulation of innovations cannot be explained by focusing on policy instruments only, but the political will and favourable framework conditions are decisive. In addition to an innovation oriented environmental policy it is favourable for the emergence of lead markets if the countries have attained the image of a pioneer in environmental policy making. Furthermore, lead markets emerge more often in countries that have accumulated a high level of technological competences in their industries.

We expect these mechanisms to have a considerable potential for an encompassing ecological modernisation. Ideally, lead markets affect competition in other market regions, trigger appropriate responses and adaptations, and thereby promote the international diffusion of the new technology. Thus, lead markets may fulfil a range of functions. From an *international* perspective, they provide marketable solutions to global environmental problems. Lead markets in high-income countries are able to raise the necessary funds for the development of innovations. This may help new technologies through their teething troubles. In demonstrating both technical and political feasibility, they stimulate other countries and enterprises to adopt their pioneering standards.

From a *national* perspective, ambitious standards or support mechanisms may create a first-mover advantage for domestic industries. Furthermore, ambitious policy measures can attract internationally mobile capital for the development and marketing of environmental innovations. Finally, economic advantages legitimate the national policymakers, and a demanding policy provides them with an attractive role in the global arena.

1.2 Studying Lead Markets

There is no single disciplinary approach that is able to analyse and to explain the emergence of lead markets. For our analysis we draw on several approaches that contribute to the understanding of the phenomenon. In chapter 2 the core ideas and methods of the disciplines that contribute to our analysis are depicted. The concept of lead market has been developed by innovation economics. The core question of innovation economics is how innovations are selected and what are the determinants of their success and failure. We are focusing on the country specific determinants that contribute to success and failure of a certain innovation and on the question how these factors influence the selection of innovations that are adopted in other countries as well. Many of these factors are influenced by policies, and in the case of environmental innovations political measures are often even indispensable for their success. Therefore, policy analysis constitutes the second pillar of our theoretical framework. We are particularly concerned with the question why and how the diffusion of policies takes place from one country to another, because this mechanism creates market opportunities in other countries. Environmental

economics contributes to the question to what extent countries may gain economic advantages in setting stricter environmental standards than others. Recent game theoretical approaches shed some light on a consistent explanation for this phenomenon for which many empirical examples have been shown. Finally, management science contributes to the analysis by explaining the behaviour of firms. We analyse what characteristics of a firm must be taken into account, in particular if there are only few companies that compete in a certain market segment in order to explain, why some step ahead and why certain markets are chosen for the introduction of their innovations.

All of the distinct theoretical approaches, defined by their methodologies and their respective subjects of research as described above, contribute to the analysis of this phenomenon. In section 2 the contributions of the various theoretical approaches are described in more detail. We conclude the first part of this study with the development of an integrated model for the analysis of lead markets that is based on the above mentioned approaches.

Within this framework for analysis, we study historical cases of innovation and diffusion based on an analysis of the literature. In total 12 innovations are analysed in this part of the study. Our studies comprise energy technologies (biomass CHPs, wind energy), innovations for automobiles (technologies for fuel efficient cars, catalytic converters for cars), substitutes for hazardous chemicals (CFCs in refrigerators, cadmium in paints, phosphates in detergents), innovations in the paper production (chlorine-free/reduced bleaching, black liquor gasification), and organisational/institutional innovations (EMAS, leasing of solvents, return systems for waste). For this study we have selected those cases for which lead markets are well documented in the literature.

The second part of our empirical studies comprises cases of emerging technologies. We apply the lead market model to innovations for which it is not yet decided where the leading countries are. Our examples are photovoltaic, fuel cells for mobile and stationary applications, technologies for the reduction of diesel emissions, technologies for the substitution of paper as well as technologies for the recycling of paper, paints with a reduced content of solvents and as another example for an institutional innovation, social responsible investments. For each of the cases we analyse the regulatory framework and the activities of companies in those countries which are the most likely candidates for becoming a lead market. From these studies we derive policy recommendations for strategies that advance the emergence of lead markets.

Due to the explorative character of the study, we dismiss a narrow selection criterion for the analysis. Instead we aim at covering a broad set of different technologies, from a great variety of sectors in various countries and with different degrees of maturity. While some of the technologies are still in the stage of development, in other cases it is mainly the process of policy diffusion that is of primary concern. Table 1 gives an overview of the characteristics of the innovations studied.

Table 1. Characteristics of the innovations ●: directly/fully applicable; ○: indirectly/partly applicable.

	Fuel cells stationary	Fuel cells mobile	Substitution of paper	Recycling of paper	Low solvent paints	Photovoltaic	Social respon-sible investment	Diesel emission reduction	Biomass CHP	Catalytic con-verter	CFC substitutes	Phosphate substitutes	EMAS	Wind energy	Cadmium in paints	Technologies for fuel efficient cars	Chlorine-free /reduced paper	Black liquor gasification	Leasing of sol-vents	Return systems for waste
Sector																				
Automobiles	○	●						●		●					○	●				
Energy	●	○				●			●					●						
Chemicals	○	○			●						●	●			●				●	
Paper			●	●													●	●		
Fin. services							●													
Waste man.																			○	●
Maturity of Innovation																				
Development	●	●	●			●														
Market intr.								●	●							●				
Policy diff.				●	●		●							●					●	●
Complete										●	●	●			●		●			
Underlying problem																				
Climate ch.	●	●				●			●					●		●		●		
Em. to water												●					●			
Waste reduc-tion/cleaning															●				●	●
Em. to air		●			●			●		●	●									
Regions																				
Europe	○	○	○	●	●	●	●	●	●		●	●		●	●	●	●		●	●
USA	●	●	●		●					●	●	○								
Japan	●	○	●			●				●										

The study concludes with a generalisation of our findings regarding the opportunities for political strategies that are favourable for the creation of lead markets. There is a great variety of starting points in the different sectors of policy making. There is no single "lead market instrument" that is able to foster all the conditions required for the successful stimulation of innovations that are adopted also in other countries. What is required is a comprehensive strategy that encompasses all the stages of the innovation process from invention to diffusion. A coordinated approach of innovation policy, environmental policy and industrial policy is required to successfully stimulate lead markets for environmental innovations.

2 Theoretical Approaches

2.1 Lessons from Innovation Economics

The main question the lead market theory must address is why countries follow a lead market in adopting an innovation, even if these markets have previously favoured different environmental innovation approaches or designs. An innovation design is a technical specification of an innovation idea. An environmental problem can be solved by a variety of innovation designs. Different countries usually prefer different innovation designs for a given problem, as the initial market contexts pose different technical requirements. Not only strong needs and the demand for a particular innovation, but also the ability to transfer specific national innovations or preferences to other countries are prerequisites for a lead market. A variety of lead effects are responsible for this internationalisation of an innovation design. The lead or leverage effect is the mechanism by which a design adopted by the lead market spreads to lag markets, supersedes initially preferred alternative designs in these markets, and becomes the globally dominant design. There are several factors that can explain this internationalisation pattern. Basically, lower prices and the certainty of the benefit of an innovation design can compensate for internationally varying market conditions. Secondly, an international trend that is most advanced in the lead market brings about an internationalisation of needs (or preferences), and thus the adoption of innovations which respond to these needs by more and more countries. Beise (2001) has reviewed these and other explanations of the lead market phenomenon. On the basis of his results, a system of five groups of lead advantages of a country has been derived:

1. Price advantage. National conditions that result either in relative price decreases of a nationally preferred innovation design compared to designs preferred in other countries, or in the anticipation of international factor price changes.
2. Demand advantage. National conditions that result in the anticipation of the benefits of an innovation design emerging at a global level.
3. Transfer advantage. National conditions which increase the perceived benefit of a nationally preferred innovation design for users in other countries, or by which national demand conditions are actively transferred abroad.
4. Export advantage. National conditions that support the inclusion of foreign demand preferences in nationally preferred innovation designs.
5. Market structure advantage. National conditions that increase the level of competition between domestic companies and facilitate low market entry barriers for new ones.

Demand Advantage

National demand advantage results from local conditions which facilitate the anticipation of the benefit of nationally preferred innovation designs in foreign markets. This mechanism allows the internationalisation of innovation designs and is dependent on a global trend in which specific innovations become increasingly beneficial or preferable to most countries. This trend can be, for example, a demographic trend, an environmental trend, or simply an increase in per capita income. A trend can also mean a time lead in building up infrastructure complementary to the innovation. Lead markets are at the forefront of the international trend. Various factors can put users in a country at the forefront of a trend: high income, as in the case of Vernon's (1966) product life cycle; a national context that foreshadows global environmental changes; an advanced accumulation of collateral assets, such as infrastructure. When other countries catch up, they demand the innovation already in use in the country at the forefront of the trend.

Price Advantage

Countries may gain a price advantage if the relative price of the nationally preferred innovation design decreases, so that differences in demand preference to foreign countries can be compensated. This price mechanism is the centrepiece of Levitt's (1983) globalisation hypothesis, in which the consumers in foreign markets "capitulate" to the attraction of lower prices and abandon their initial selection of goods. Price reductions are mainly due to cost reductions based on static and dynamic economies of scale. The two nation-specific factors of economies of scale are market size and market growth. Another price advantage emerges from anticipatory factor prices; the lead market demands innovations induced by factor price changes which later occur worldwide. A factor that is more expensive in the lead market than in other countries, e.g. petrol, induces innovations causing the factor to be used less, e.g. more fuel-efficient cars. When the factor becomes expensive in other countries as well, the same innovations are adopted in these lag countries. In such a case, the lead-market country anticipates a worldwide price trend. The same price advantage results from price changes of goods complementary to the innovation design.

Export Advantage

National conditions that support the inclusion of foreign demand preferences in nationally preferred innovation designs constitute a national export advantage. One can derive three factors of a national export advantage: domestic demand that is sensitive to the problems and needs of foreign countries; long-time export experience of domestic companies; and the similarity of local market conditions to foreign market conditions. Firstly, even if a country is not at the forefront of a global trend in terms of domestic environmental issues, domestic users may be more sensitive to global problems and needs than potential adopters in countries where the problem is more advanced. This sensitivity of demand can provide incentives for domestic companies to adopt a global perspective and increase their ability to meet global problems ahead of companies in other countries. For in-

stance, consumers in a given country may be sensitive to the effects of worldwide climatic change, even if their domestic environment is not as seriously affected as that of other countries.

Secondly, firms in a given country have an advantage over foreign competitors if their innovations can be exported more easily. Innovations can be exported more easily if (1) the environmental and market conditions of foreign countries are similar to the market for which the innovation was designed, and (2) a design includes features that make it suitable for a variety of contexts. The reduction in the variety of nation-specific designs is faster, because it is easier for a country to turn to a foreign design if the loss of benefit is small. Dekimpe et al. (1998) support the hypothesis already proposed by Vernon (1979) that the higher the similarity of cultural, social and economic factors between two countries, the greater the likelihood that an innovation design adopted by one of two countries will be adopted by the other country as well. Companies can gain an export advantage if knowledge of the benefit of innovations to users in foreign countries is applied in the design of their innovations. Knowledge of foreign market conditions enables an innovator to design his innovations to fit the local as well as foreign markets by incorporating additional features. With such "dual-use" or "robust" innovation designs, a company can catch up with foreign firms' innovations in their home markets at an early stage, so as to pre-empt the international competition for nation-specific technologies. A country's context, including its users, suppliers and national institutions, can support or pressure companies to design innovations which can be exported. Small countries' firms are often pressured into developing innovations for both domestic and foreign environments, because the domestic market is too small to justify the necessary R&D investment.

Transfer Advantage

When users in a given country adopt an innovation design, this can increase the perceived benefit of the design among users in further countries, thus influencing their adoption decisions. The perceived benefit increases when information on the usability of the innovation design is made available. Information about the innovation not only raises awareness of the innovation design, but also reduces uncertainty surrounding new products and processes. A country can have a transfer advantage if its market context supports increases in the perceived benefit of a nationally preferred innovation design for users in foreign countries. Diffusion theory suggests that the international diffusion of durable goods depends on the intensity of communication between two countries (Takada and Jain, 1991). The lead market could therefore be the country that has the strongest communication ties with other countries. Lead countries are those that are generally watched by many other countries, for instance countries that are intensively covered by mass media or whose lifestyles are often present in television series and motion pictures. In the international innovation diffusion context, the "demonstration effect" (Mansfield, 1968) becomes an international "lead effect" (Kalish et al., 1995). Potential adopters in a second country observe the success of the innovation in the first market earlier than the success of innovations adopted in other, not so keenly watched countries. The reputation and sophistication of a user can be a signal for

the quality of an innovation design. As Porter (1990a) pointed out, it is not only the quantity, but also the *quality* of the home demand that determines the international competitive advantage of a nation. Therefore, even a small country with a small market size can achieve a competitive advantage in certain segments. The quality of home demand can be interpreted as information on the specification of an innovation, based on the users' competence, know-how and prior experience with related products or processes.

International network externalities constitute a further transfer advantage. The Internet has gained international appeal because it connects all countries in a standardised transmission protocol. The preference for a design can likewise be actively transferred abroad. A country transfers demand for innovation design abroad through multinational companies, using the innovation in their foreign subsidiaries.

Market Structure Advantage

Innovations may be adopted internationally simply because, among all alternatives, they are the most beneficial to most countries. The reason users in one country adopt an innovation before users in other countries is sometimes that the market pushes local companies to innovate, making the innovation available earlier in that country. Faster development and more market-oriented innovations can be supported by competition. From Posner (1961) to Dosi et al. (1990), the degree of competition and entrepreneurial effort in the domestic market has been described as one of the main determinants of international patterns of innovations. Even in the case of Japan, Sakakibara and Porter (2001) found that the higher the domestic competition, the bigger the country's export success. Firstly, buyers tend to be more demanding when the producers face competition than when they are tightly regulated or hold a monopoly (Porter, 1990a). Secondly, competing companies are more strongly pressured to follow those who have already adopted a new technology (Mansfield, 1968: 144). Thirdly, and perhaps most importantly, more innovation designs are tested in a competitive market than in a monopolised market. As a result, a competitive market is more appropriate for finding a design that is not only the best within the domestic environment, but in all national environments. Fierce domestic competition facilitates the tapping of an internationally homogeneous latent consumer demand for innovations.

2.2 Lessons from Policy Analysis

The research project LEAD focuses on regional differences regarding the diffusion of environmental innovations. As a rule, both the innovation as well as the diffusion of such innovations is stimulated and supported by policy measures. On this background the conditions for national pioneering policies have to be analysed. Under which circumstances are countries adapting policy measures that exceed the level of regulation of other countries? Furthermore, if the diffusion of technologies depends on the adaptation of policies in other countries, it has to be

analysed secondly, under which circumstances countries do implement policy measures that spread internationally. In the following, the state of the art in policy sciences regarding both questions is compiled.

Conditions for a Pioneering Role of Countries

It is subject of controversial debate, which influence the internationalisation of markets and the worldwide mobility of goods, humans and capital have on the scope for action of modern, democratic states. Some argue that the nation state is under considerable pressure to modify its national systems of taxation and regulation in order to avoid the exodus of capital and the movement of enterprises: This may force nation states to lower environmental standards because they affect the competitiveness of many industries adversely (so called "race to the bottom") (Green and Griffith, 2002; deVries, 2001; Hardt and Negri, 2000; Cerny, 1999; Strange, 1998).

A second argument stresses the limitations of the nation states' autonomy of action that arise both from the norms of international regimes and regional confederations of countries such as the EU or NAFTA as well as the appearance of new actors such as multinational enterprises and nongovernmental organisations and the fact that nation states lack the competence to solve many environmental problems because of their global nature (Koehn and Rosenau, 2002; Nye and Donahue, 2000; Held and et al., 1999; Haas and et al., 1993).

It is widely believed by politicians that unilateral action in the context of economic globalisation becomes less likely not only in case of trans-boundary problems, but also for all environmental problems if they bear additional costs. This implies that there is the danger of a "regulatory chill" (Hoberg, 2001: 213) independent of the real existence of adverse impacts on competitiveness of more far reaching unilateral environmental regulations: If politicians and voters are convinced that regulatory measures affect the competitiveness adversely, this argument can be utilised from the target group of a policy to make credible threats. (Hay and Rosamond, 2002; Hoberg, 2001; World Trade Organisation, 1999: 5). In this case, innovative environmental policy measures will not be adopted.

From this point of view, promising solutions to the problem are mainly dependent on whether the international community of nations will agree on binding law and create the institutional framework for a new governance structure on the international level that is able to enforce these agreements (Young, 2002; Esty, 1999; Keohane and Martin, 1995). A more optimistic view perceives the appearance of new actors such as nongovernmental organisations or scientific networks, the rapid growth of the body of international law and organisations, and the emergence of new forms of regulation such as public-private partnerships, as the rise of a first outline of a governance beyond the nation states (Park, 2002; Knill and Lehmkuhl, 2002; Auer, 2000; Zürn, 1998). Under certain circumstances, norms are even developed in bilateral negotiations between private actors without including governmental actors at all (Jacob and Jörgens, 2001).

A more sceptical position argues that in general, international bargaining processes do generate insufficient results because of the disparate structure of interests

and an unclear hierarchy for decision making (Suranovic, 2002). However, both lines of argument postulate a declining importance of the role of nation states.

The results of comparative empirical research are contradicting the often postulated assumption of an extensive loss of national capacities in environmental policies. Despite of the political and economic globalisation, some countries still carry on with an ambitious environmental policy beyond the regulatory level set by international agreements. Even the global scale of many environmental problems, such as climate change, ozone depletion of the loss of biodiversity that cannot be solved by unilateral action, does not lead to a ceasing of ambitious policies. Likewise the frequently feared general lowering of environmental standards to improve the economic competitiveness cannot be observed empirically yet (Weidner and Jänicke, 2002, Lafferty and Meadowcraft, 2000, Desai, 2002, Wheeler, 2001, Liefferink and Andersen, 1998).

Despite all critical forecasts, nation states seem to keep their central role in the international development of environmental policy, both in the model of horizontal diffusion and country by country learning as well as in the model of furthering international regimes (Volkery and Jacob, 2003, see also SRU, 2002). Looking at the basic environmental policy innovations during the past 30 years reveals processes of innovation and diffusion: Environmental policy innovations of certain countries do spread either voluntarily from one country to another by learning and adaptation or they are taken over and further developed by international agreements (Tews et al., 2003, Binder, 2002; Busch and Jörgens, 2003). The emergence of many international agreements can be traced back to the initiatives of single countries or groups of countries that also influenced their figuration without meeting great resistance by other countries (see Young, 2002, Underdal, 1998).

Although the importance of pioneering behaviour for the further development of international environmental policy is generally acknowledged in the literature, there are partially oppositional assumptions about its prerequisites and the extent to which these prerequisites can be expected to change. Furthermore there is no consensus about the conceptualisation of the phenomena (Volkery and Jacob, 2003, with other references). The empirically oriented research on pioneering countries is based mainly on comparative country case studies (e.g. Jänicke and Weidner, 1997, Weidner and Jänicke, 2002, Anderson and Liefferink, 1997, Lafferty and Meadowcraft, 2000, Desai, 2002). Regarding the international diffusion of single instruments a research project[1] by the Environmental Policy Research Centre has been finished only recently. As part of this project, the spreading curves of 22 laws, instruments and institutions for 45 countries have been ascertained. The results of the project underline once more the importance of pioneers in environmental policy. It remains open, however, which factors are supporting countries in developing and adopting environmental policy innovations. Several distinct approaches of policy sciences, law and economics deliver contributions for single aspects of this question. In the following, the different ap-

[1] "Die Diffusion umweltpolitischer Innovationen als Aspekt der Globalisierung von Umweltpolitik".

proaches will be outlined to what extent they contribute to an explanation of pioneering behaviour in environmental policy.

It can be expected that a high *capacity for environmental policy* is needed, both for policy innovation and the adoption of innovations (see Jänicke and Weidner, 1997; Weidner and Jänicke, 2002, with more references). The OECD defines it broadly as "a society's ability to identify and solve environmental problems" (OECD, 1994: 8). While the terms capacity and capacity building were used previously by numerous institutions such as UNEP, FAO, World Bank, OECD, and others in connection with less developed countries only, they have now been fruitfully extended to industrialised countries as well. They refer to the structural preconditions for successful environmental policies and encompass the collective actors (esp. environmental institutions and organisations). The structural preconditions refer to (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.

Scholars of law and policy science who focus on international regimes deliver contributions regarding the extension and limitation of possibilities for national pioneering strategies. An extension is given for example if the internationally agreed objectives legitimise the enforcement of ambitious but disputed measures on the national level. Likewise, the requirements of international regime may lead to an extension of national institutional capacities which then form the basis for further reaching measures (more comprehensive see: Jacobson-Brown and Weiss, 1998).

Innovative policies are frequently supported by international organisations that were founded in the context of the formation of international regimes. By spreading information about best practice, even weak organisations which are merely provide an international arena rather than being international actors (Underdal, 2001) do have a chance for effective action. For example the OECD is continuously evaluating, comparing and benchmarking national policies and by this successfully supporting a convergence in policymaking without having any formal legitimacy of its own.

Limitations of the national possibilities for action are frequently arising at the interface of environmental law and international trade law (Altemöller, 1998). The world trade regime limits the possibilities for countries to enact product or process standards that lead to restrictions of imports. An immediate limitation is given, however, only regarding product standards. Standards regarding the production processes are affected by trade liberalisation only if production sites may be dislocated, or if a border adjustment is planned for imported goods. The purpose of the international trade law is mainly to secure the enactment of policies avoiding limitations of competition but is not to consider other protection objectives. Thereby, contradictions between the different domains of law can be avoided and national pioneering behaviour remains in principle possible (Kelemen, 2001).

Further limitations for national pioneering behaviour may be caused by the guidelines of regional free trade agreements such as NAFTA, MERCOSUR or ASEAN. A special case in this respect is the EU. For the achievement of the European Single Market the Member States transferred far-reaching competences

to the European level. But the European competition law does not lead to a general pressure on the member stated to lower their environmental standards. Meanwhile, it has been shown that for product standards the opposite is true. Restrictions are given regarding subsidies that are offered because of environmental objectives (instead of several others: Scharpf, 1999, with more references).

On this background an analysis of the national opportunities has to differentiate between the different levels and areas of action, instruments and their impacts (see among others Miles B. et al., 2000, Haas, 2002, Young, 2002, Mitchell, 1994).

The anticipation of economic advantages of pioneering behaviour in environmental policy can be seen as another determinant. Advantages for the competitiveness may arise from an early and strict regulation (see section 2.3 for a more detailed discussion). Quantitative analysis reveal a high statistical correlation between the competitiveness and strictness of environmental regulation (Schwab et al., 2003; Esty and Porter, 2000; Europäische Umweltagentur, 2001) or between eco-efficiency and competitiveness (Sturm et al., 2000). The causal direction between these variables remains ambiguous: Technological innovations may be induced by environmental policies that again improve the competitiveness. However, the opposite direction is possible too: Technical innovations may be a resource for the advancement of environmental policy, and regulators frequently take up the capabilities of technologies in their standard setting, thereby contributing to their diffusion (Jänicke and Jacob, 2002; Jacob, 1999). Furthermore, the empirical analysis of innovation oriented environmental policy reveals that innovation effects cannot be attributed to a single policy instrument, but that policy style and actors configuration are self-contained influencing factors (Jänicke et al., 2000). By this, additional potentials for action arise from the arrangement of policy processes.

Conditions for the Diffusion of Environmental Policy Innovations

Recent comparative research on the spread of environmental policy among countries reveals an international convergence in the development of national policy patterns (Kern et al., 2000; Kern, 2000; Jörgens, 1996; Tews et al., 2003). Standard solutions in pioneer countries diffuse worldwide, thus causing a substantial convergence in policy formulation at national 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 often in small EU countries that are 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 harmonise 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 minimise their subsequent need to adapt to European policy. It is also often a matter of "Europeanising" certain national pioneer measures, favouring the particular country's domestic industry. Policy diffusion within the EU, however,