# ARE THERE ANY FIRST AND SECOND MOVER ADVANTAGES FOR ECO-PIONEERS? LEAD MARKET STRATEGIES FOR ENVIRONMENTAL INNOVATION

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#### Abstract

In environmental policy first mover advantages for environmental technologies are often taken for granted. It is a popular view to see the state as a political entrepreneur who introduces a certain environmental policy instrument, e.g. feed-in tariffs for renewable energies, and thus becomes the world market leader or the lead market for the respective technology. Against this background, this paper wants to find out if the idea of first mover advantages can be justified by theories and empirical evidence from the relevant literature on business administration, innovation, environmental and development economics.

A review of theoretical and empirical studies at the firm level shows that first mover advantages are not confirmed by empirical evidence. The successful innovator is not necessarily the first but very often one of the early movers within the competition of different innovation designs. Studies carried out at the national level give however only anecdotical evidence on the existence of lead market patterns. However, with regard to emerging countries, there is as well anecdotical evidence on successful latecomers, i.e. states that follow a strategy of environmental leapfrogging. The question under which conditions a country may switch from a second mover to a first mover strategy can't be answered by the existing literature.

This paper argues that it seems to be more reasonable to complement a lead market strategy by a lead supplier position. The lead supplier strategy corrects for the problem that the domestic industry may not participate sufficiently from the growth of the national market due to the demand advantage. It considers also goals from industrial policy, which play an important role also within latecomer strategies in emerging countries.

#### JEL classification: Q55, L60, O33

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#### 1. Introduction

The term "first mover advantage" is often cited in documents of environmental policy. For example, in the justification of the Renewable Energy Act the German government states that it will realize first mover advantages due to the use of renewable energy with modern technology (Bundesregierung, 2007). Another example from the German Ministry of Environment (2008) is the report "Investments for a climate friendly Germany" which mentions these technology investments will create "first mover advantages" for the domestic industry. At the European level the President of the European Commission, Jose Manuel Barroso (2008), argues that the European energy and climate change package should be seen as an opportunity to Europe in economic terms: "It will encourage innovation and it will increase competitiveness of European industries. The Union should lead the global efforts to tackle climate change. And European industries should continue to be world leaders. At the same time, we will also create new markets and new jobs, and make sure that we have the "first mover advantage" in many sectors."

It seems that in the political arena first mover advantages for environmental technologies are taken for granted. It is a popular view to see the state as a political entrepreneur who introduces a certain environmental policy instrument such as feed-in tariffs for renewable energies, and thus creates a profitable market for the respective technology. However, with regard to lead markets, the question should be allowed if it can be attractive for a country to invest in the development of a market where the majority of goods and services is imported from other countries, such as in the case of photovoltaics in Germany (Frondel et al., 2010). There would also be an alternative strategy for government strategies in environmental technology markets to wait and co catch up quickly later by leapfrogging, being a second mover or a late follower, with likely giants steps in catching up (Hilton, 2001). This is a strategic option especially for emerging countries such as China and India (but

the question of being a 2nd mover seems also be realistic e.g. for many South- or Eastern European countries in the European Union).

Against this background, this paper wants to find out if first mover advantages for pioneering firms are confirmed by theories and empirical evidence from the relevant literature of industrial organization, business management, environmental and development economics. It starts with an analysis of market-oriented innovation strategies of innovating companies. It has however to be asked if such strategies can easily be transferred to eco-innovations and to the level of national policy strategies. In a second step we look at the case of wind energy in China as an example for successful leapfrogging strategies at country level. The second case of the feed-in-tariffs policy in Germany will show that a too narrow defined national lead market policy – only focusing on the demand advantage of the market – may not necessarily lead to advantages of the German photovoltaic industry. Industry policy has to take into account the whole range of all lead market factors of the lead market approach and the supply-side of the industry at the same time. Only if the supply-side is able to develop high lead market potentials for all lead market factors, country's industry may benefit from a governmental lead market strategy.

Therefore the structure of this paper is as follows: While section 2 introduces the concept of lead markets, section 3 reviews the theoretical reasons for first and second mover advantages. Section 4 gives an overview about the empirical literature on econometric analyses and case studies for first and second mover advantages, country lead market strategies and leapfrogging. In section 5 the question of lead markets vs. lead suppliers will be discussed. Finally we will draw some conclusions regarding national lead market policies.

#### 2. The lead market approach

#### Lead market factors

The lead market approach suggests focusing customer interaction on those regions, which are likely to be ahead in international demand trends and show demand preferences that are later adopted in other regions, too. It was first suggested in the 1980s by Porter (1986) and Bartlett and Ghoshal (1990) and is receiving increasing attention worldwide during the last years (cf. e.g. Johansson 2000, Commission of the European Communities 2006, Cleff/Grimpe/Rammer 2009). Bartlett and Ghoshal (1990, p. 243) consider lead markets as "markets that provide the stimuli for most global products and processes of a multinational company. [...] [Local] "innovation in such markets become useful elsewhere as the environmental characteristics that stimulated such innovations diffuse to other locations".

A lead market can be defined as a country where users prefer and demand a specific innovation design that not only appeals to domestic users, but can subsequently be commercialized successfully in other countries as well. The technical design preferred by the lead market squeezes out other designs initially preferred in other countries and becomes the globally dominant design. The innovation designs adopted in the lead market have an advantage over other country-specific innovation designs competing globally to set the international standard. This advantage makes consumers from other countries follow the technological standard of the lead market and adopt the design preferred by users there. In some cases this means abandoning a design that was previously preferred on the national market (Beise et al., 2002). Where the scientific and technical knowledge for this purpose was actually generated is mostly not relevant, as companies in the lead market are able to appropriate this knowledge. More important for competitiveness is the ability to learn on the lead market about the applications and production of innovations (Meyer-Krahmer, 1997).

Therefore, lead markets have specific properties (lead market factors) that increase the probability of a wide take-up of the same innovation design in other countries (Commission of the European Communities, 2006). A theoretical lead market model has to provide these lead market factors and has to give an answer to the question under which market circumstances country's market characteristics are appropriate to the adoption of technological innovations that will succeed internationally and mark out the technological path to be followed worldwide.

At the moment there is no consistent and stringent lead market theory. However, Beise (2001 and 2006) and Cleff/Grimpe/Rammer (2007) were able to develop an eclectic approach of a lead market model. They have been investigating lead markets on the basis of detailed ex-post case studies focusing on the mechanisms at a national level and how these mechanisms are leading to global designs. Beise himself (2001) has been derived a system of five particular country-specific success factors for lead markets. A study on lead markets of environmental innovations has added a sixth success factor, the so called regulation advantage (Beise and Rennings, 2005). These factors are influencing the international competitiveness of innovations and a good performance of these factors at the national level increases the probability of the market becoming a lead market. The six factors, as shown in Fig. 1, are:

- price advantage,
- demand advantage,
- transfer advantage,
- export advantage,
- market structure advantage and
- regulation advantage.

# Fig. 1. Lead market factors



Source: Rennings and Smidt (2010)

A price advantage arises from national conditions that result either in relative reductions in the price of a nationally preferred innovation design compared with designs preferred in other countries or in anticipation of international factor price changes. Countries can gain a price advantage if the relative price of the nationally preferred innovation design decreases, thus compensating for differences in demand preference to foreign countries. This price mechanism is the centerpiece of Levitt's (1983) globalization hypothesis, according to which consumers in foreign markets "capitulate" to the attraction of lower prices and abandon their initial endowment of goods. Price reductions are mainly due to cost reductions based on static and dynamic economies of scale (learning-by-doing). Market size and growth are examples of country-specific factors creating economies of scale. Another price advantage emerges from anticipatory factor prices in the lead market. Factor price

changes can induce innovation. If the new relative prices occur worldwide, the same innovations are adopted worldwide as well. Price advantages play also an important role in leapfrogging strategies in emerging countries due to low labor costs.

Demand advantages originate from national conditions which result in the anticipation of the benefits of an innovation design emerging at a global level. A good example is provided by off-grid solutions in the energy and telecommunication sector. Such innovations are more beneficial and thus more likely to be adopted first in industrialized, geographically large countries with a low population density, such as in Scandinavia (Beise and Rennings, 2005). When other countries catch up, they demand the same innovation that has already been used in the country at the forefront of the trend. Another example is provided by trends related to environmental problems such as climate change. Some countries are more exposed to the risks of rising temperatures (e.g. countries with above-average risks of flooding like the Netherlands) than others and will thus anticipate these trends earlier.

Transfer advantages are national conditions that 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. The perceived benefit increases when information on the usability of the innovation design is made available. The initial adoption of an innovation of unknown merit reduces the uncertainty and therefore the risk for subsequent adopters and kicks off a bandwagon effect - also referred to as the demonstration effect of adoption (Mansfield, 1968). With regard to eco-innovation, international reputation in the field of environmental technologies plays an important role.

Conditions which promote the inclusion of foreign demand preferences in nationally preferred innovation designs constitute a national export advantage. Three national export advantage factors can be identified: domestic demand that is sensitive to the problems and needs of foreign countries, the established export experience of national firms, and the similarity of local market conditions to foreign market conditions. Dekimpe et al. (1998) support the hypothesis already proposed by Vernon (1979) that the greater the cultural, social and economic similarities are between two countries, the greater is the likelihood that an innovation design adopted by one of the two countries will be adopted by the other country as well.

The market structure effect focuses mainly on the degree of competition. Competition and entrepreneurial effort have been described as two of the main determinants of international patterns of innovations by researchers such as Posner (1961) and Dosi et al. (1990). The lead market is usually highly competitive. This is due to the fact that faster development and more market-oriented innovations are supported by competitive market structures. Firstly, companies engaged in fierce competition will demand more innovations from suppliers because they are able to reap greater competitive rewards from using innovative parts than monopolies (Porter 1990). Secondly, competing firms are under more pressure to emulate firms which have already adopted a new technology (Mansfield 1968). Thirdly, and possibly most importantly, more innovation designs are tested in a competitive market than in a monopoly market.

Regulation advantage is a specific determinant of environmental innovations (Rennings, 2000), thus it will be explained separately in the next section.

#### 2.2 Lead markets, eco-innovation and regulation

In this paper we define environmental innovation (or eco-innovation) as innovation of new or modified processes, techniques, practices, systems and products which are more environmental friendly compared to earlier innovations (Kemp/Arundel 1998 and Rennings/Zwick 2002).<sup>1</sup> Beise and Rennings (2005) have shown that lead markets exist for environmental innovations, with demand advantages being especially relevant e.g. for eco-efficient cars. However, for other eco-innovations such as renewable energies innovations are strongly driven by regulation. Beise and Rennings added regulation advantages of a country as a sixth lead market factor specifically for eco-innovations. Due to the – at least partial – public good character of new environmental products and processes it is evident that regulation will have an important influence on the innovation process and therefore on the lead market position. Two different types of eco-innovations can be distinguished:

1. Environmental innovations can have a typical business objective with the aim to reduce the costs in the production process or the product characteristics, to raise the product quality and thus to improve the competitive situation – with a reduction of environmental impact at the same time. This type of eco-innovation does not differ in its primary focus from other product or process innovations, which also have as target the increase of process- or market efficiency. Porter/van der Linde (1995) see this form of eco-innovation especially there, where resources are privately owned or possess a regular

<sup>&</sup>lt;sup>1</sup> Innovation in the organization of firms as it is described in the OECD (2005) guidelines on the collection and interpretation of innovation data is not within the scope of this paper.

market price and savings of respective resources are immediately cost-effective. Several eco-innovations have this "triple-benefit" for the environment, the firm and the user. Examples for such eco-innovations are innovation in energy and material efficiency (Rennings and Rammer, 2009).

2. On the other hand eco-innovations can have the exclusive focus on the reduction of environmental impacts. This is the case when policy regulations interfere in the economy and thus cause innovations. The prohibitions to use certain harmful products, resources or end-of pipe technologies are examples for this. This type of regulation can improve the international competitive situation for the home industry when the regulation policy is adopted by other countries so that the innovation design established on the home market can develop into a global design. One can speak – in terms of the lead market language - of an anticipation of existing regulatory trends by a national government. It is not very difficult to observe such long term regulation trends if we look at the issues of international agreements: low carbon economy, energy and material savings are for example megatrends of the current and future decades (Jänicke, 2008). Regulation can pick up such regulatory trends and lead to the development of new markets, for example for energy efficient refrigerators, dishwashers or washing machines. These new markets however, must orient themselves along the lead market factors and allow the development of a global design on the home market. However, there is the risk that other countries will not follow the regulation process or that they will choose another form of regulation and that there develops an idiosyncratic innovation design on the home market. But the development of environmental markets such as the rapid worldwide diffusion of energy efficiency labels shows that there is a quick adoption of innovative regulation in the area of eco-innovations.

#### 3. Innovation timing advantage

#### 3.1. Sources of first mover advantages

The "first mover" in theory is the very first firm to bring an innovative product or service to market, but in practice it means one of the first to do. Therefore, Gilbert/Birnbaum-More (1996) recommend to use the term "early mover" since it might be a more accurate description of most situations, which are discussed as first mover. "Second mover" or "late mover" mean all firms entering the market after the first mover(s). They typically imitate or adapt the innovation design.

Only the profits for innovation with well specified and protected intellectual property rights (IPR) are limited to a single first user. Where do the first mover advantages result from and why don't they come up in specific situations? Three basic sources of first mover advantages and another three of second mover advantages are often described in literature of business strategies (cf. e.g. Gilbert and Birnbaum-More, 1996; Lieberman/Montgomery, 1988).

The first source of a first mover advantage is technological leadership due to a quick reduction of costs, the learning or experience curve (Lieberman, 1987) or a success in R&D or patent races (Mansfield, 1986). When IPRs are well-specified and protected a firm gains competitive advantage through patenting or copyright, or as a trade secret. Theoretically this leads to a temporary monopoly. Mansfield (1985) however has found that successful protection of IPRs against imitation by other firms is a rare case.

Secondly, a source of first mover advantages can be the preemption of physical or spatial assets such as skilled workers, unique channels of distribution or manufacturing facilities. It is seldom the case however that those assets are completely appropriated by a single firm (Lieberman/Montgomery, 1988). It can thus be argued that pre-emption of assets is a kind of timing advantage available to several first movers, i.e. first movers securing anchor locations in a new shopping mall in a desirable area gain advantage over latecomers.

The third category of advantages is buyer switching costs. Switching costs develop due to initial transaction costs or investments when a user has to adapt to the new product. First of all, the user must be convinced of learning another system. This step demands for non-superior products specific marketing skills and additional costs from the followers. Additionally, there arise user-related qualification costs, which must be covered by the supplier or the user. All these costs have to be raised by the follower in order to compete with the first mover on the market. In case the first mover is able to convince the buyer of the uncertainty of the follower's product quality, then the user will seldom turn away from the first brand, which has already proven its quality. Switching costs may also arise through the users' contractual restraints with the first mover (Lieberman/Montgomery, 1988).

It can be summarized that out of the three sources of first mover advantages, only technological leadership – if at all is restricted to a single firm. And in the case of technological leadership it depends on the existence and protection of IPRs, and on the time potential imitators need to find ways around the restriction.

#### 3.2. Sources of second mover advantages

Second movers have a competitive advantage in specific situations, which are based on three theoretical arguments. There is no indication in the literature that second mover advantages may be limited to a single firm.

The competitive advantage for second movers is simply to free-ride on first mover investments. This is possible due to the positive spill-over of the first mover, especially when IPRs are not well-defined and specified. Many products and services can be easily and inexpensively imitated. In many cases also second movers can profit from improvements of the first mover regarding the learning and experience curve (Lieberman 1987).

A second source of advantages is technological developments or customer needs, which arise after the introduction made by the first mover. They may be overlooked by the first mover due to incumbent inertia. This argument is taken up by Markides/Geroski (2005) who argue that a first mover is colonizing the product and typically has a different – in most cases technology-driven mindset, while a fast second firm focuses on consolidation from niche to mass markets.

The third main advantage for second movers is leapfrogging (Fudenberg et al., 1983), i.e. catching up to the first mover in fast, big or even giant steps. While the developer of the new product or service had to experiment with a lot of different variations of the original innovation design, and thus had to pay a large amount of development costs, which are now sunk costs, the second mover has the advantage of reduced market, technological and regulatory uncertainty.

In the following we want to present the results of some empirical studies that have analyzed, which factors influence the innovation success of market pioneers / of a follower in dependency on different factors.

#### 4. Empirical evidence from the literature

# 4.1. Business management literature: Evidence on first vs. second mover advantages of firms

The empirical literature brings up reasons for and against first mover advantages, which have been analyzed broadly during the past decades. An analysis of studies shows that until the mid 1980's the opinion prevailed that only the market pioneer can secure a long-lived market share advantage (cf. e.g. Yip 1982, Urban et. al 1986, Robinson/Fornell 1985). Biggadike (1979) was convinced of having proved in his study that even after 5 to 8 years later entrants were not able to catch up the disadvantage.

This apparently natural symbiosis between the first mover and the innovation success was questioned by more recent studies. Studies conducted by Tellis/Golder (1996), Lellien/Yoon (1990) and Lambkin/Day (1989) confirm a higher failure rate of market pioneers. Golder/Tellis (1993) ask rightly whether the pioneer advantages are a "Marketing Logic or Marketing Legend". Olleros (1986, p. 8) even states that "we see industries emerge over the dead bodies of their early pioneers ".

Markides/Geroski (2005, p. 2) give a great number of anecdotic examples for unsuccessful pioneers, contributing to the discussion of first mover advantages for radical innovation. The authors show anecdotically that the process for radical innovations is mainly driven from small firms or startups, very often without an established brand name. Main criteria from Markides and Geroski are shown in Table 1.

According to Markides and Geroski (2005), first movers typically They develop a technology pushed innovation over a long period in niche markets and they feel less risk to pioneer a radical innovation. The innovation design is being developed in an elaborate exploration process, during which different variations have to be checked with regard to the market preference. The major role of the pioneer is the colonization of the new market. The established firms free-ride on the technological and market experience of the pioneer. They make use of the developing mass market and the dominant designs, by trying to drive out the first mover with rival variants of the dominant design, and to consolidate the market into a mass market.

	First Mover	Fast Second	
Focus of activity	Exploration and Creation of product on Niche Market Creation of Mass Marl		
Firm characterization	Young, small	Established, big	
Major role	Colonization (creation of product)	Consolidation (of market)	
Innovation drivers	Technology push	Market pull	
Object of competition	Rival innovation designs	Rival variants of dominant design	
Dominant innovation design	Variation, Exploration	Selection	
Market structure	Large firm population	Concentration, Shakeout	

#### Table 1. First and second mover strategies for radical innovations

Source: Own overview according to Markides/Geroski (2005)

This can also be seen in the area of eco-innovations, e.g. in the case of E-Mobility. Up to now it is not decided, which engine technology – if at all - will win the race for a sustainable transport technology, if it will be e.g. hybrid, fuel cell or battery cars? Thus, following Markides and Geroski, big firms should aim at a strategy of consolidating markets, i.e. taking up a radical innovation early enough to be able to develop it from niche to mass markets.

However, it is not the case that these results speak against a first mover advantage. Robinson/Min (2002) observe a 66 percent survival rate during the same time for market pioneers, whereas early followers only have a 48 precent chance. The results could not be more diverging, so that Min/ Kalwani/Robinson (2006, p. 15) come to the conclusion that first mover advantages depend on the respective environmental circumstances.

One of the first studies that took into account the environmental circumstances of the market is the study conducted by Urban et al. (1983). Data basis were the sales of 38 and in a later analysis 44 brands of frequently purchased consumer goods in connection with information from media audits and interviews. On the basis of regression analyses the authors analyzed the influence of the order of entry, the years between the entry, the product positioning, the preference of a brand of interviewees, and the advertising intensity on the market share of first movers. The authors assess that a later entrance has less market share on average than the market pioneer, but pioneer's share decreases with each new firm entering the market. This decline is higher if other brands can achieve superior price and product positioning. In order to avoid this market pioneer should occupy and defend the preferred product positioning.

Another regression-analyses approach was chosen by Robinson (1988). On the data basis of 1.209 companies from mature industrial goods manufacturing businesses he confirms that market pioneers gain a sustainable market share advantage. In addition, their products have a better quality and show a broader product line. While the product quality advantage decreases over the time, the advantage of the breadth of product line remains. Robinson (1988, p. 93) differentiates the results with regards to the different velocities of the technological development on markets. The market share of the pioneer decreases when the technological competition increases on the market. Only if the value added of an industry is high, the market pioneer is able to resist the technological competition and to extend the market share.

Some years later Gilbert/Birnbaum-More (1996) took up the findings of the influence of dynamics in technology and on the market in the framework of a meta study, in which they bring together the empirical results of different surveys. On the basis of different sources of competitive advantages, they propose the important influencing factors on the industry and technology level as well as on the product/ service level (cf. Table 2).

		Correlation with			
Level	Factor	1 <sup>st</sup> Mover Advantage	2 <sup>nd</sup> Mover Advantage		
Industry/ Technology	Degree of fragmentation	+	-		
	Velocity of innovation	+	-		
	Rate of innovation diffusion	-	+		
Product/ Service	Connection to technological infrastructure	+	+		
	Degree of novelty	-	+		
	Difficulty of production/complexity of technology	-	+		
	Customer resources invested (lock in)/switching costs	+	-		
Firm Strategy	Cost leadership	-	+		
	Differentiation	+	-		
	Core Competence	+	+		

Table 2. Correlation directions between factors and timing advantages

Source: According to Gilbert and Birnbaum-More (1996)

With increasing fragmentation of the industry and increasing velocity of the innovation the first mover advantage rises. This effect is being emphasized when switching costs are high and technological infrastructure is sufficiently available. The implementation of a first mover strategy is successful under these circumstances only by taking-over technological leadership and the herewith connected R&D expenditures. The diffusion rate, the degree of novelty and the complexity of the product however, have negative effects on the first mover advantage. The second mover has the advantage that the pioneer has already found technological solutions and has developed these for the market preference. There are no such costs for the followers, so that a cost leadership strategy is promising.

Min et al. (2006) look at radical and incremental innovation. The latter is "designed to satisfy a felt market need and uses an existing technology or refinement of it" (Min et al., 2006, p. 16). Using the Thomas' Register of American Manufacturers they identified 264 new industrial markets and they analyzed the influence of different factors on the survival rate of first movers. Indeed, the multivariate hazard rate analysis shows that market pioneers have a greater survival risk for radical than for incremental innovation. This context is not significant for early followers. For radical innovations the market pioneers show a significantly higher survival risk than the early follower. For incremental innovation it is vice-versa. "In conclusion, market pioneers are often the first to fail in really new product-markets. However, this is not true in incremental new markets, in which market pioneers have consistently lower survival risks than early follower" (Min et al. 2006, p. 30).

Summing up, it can be ascertained from the literature of business management that the successful innovator is not necessarily the first but very often one of the early movers within the competition of different innovation designs. The empirical literature on the firm level finds evidence that there is no simple yes or no answer to the question of first vs. second mover advantages. The studies based on correlation or regression analysis are inconsistent in the choice of factors, which are finally responsible for the development of successful global designs, but the results of the empirical studies find different factors leading to a successful timing strategy. They range from

- 1) "Luck", to
- 2) technological leadership, preemption of assets and buyer switching costs (Lieberman/Montgomery, 1988) to
- 3) industry, technology, firm and product-specific factors (Gilbert/Birnbaum-More 1996) and

4) leading time, market dynamic, and type of innovation (Min/Kalwani/Robinson 2006). It seems that radically new technologies are difficult to defend for a first mover, while it seems to be easier for incremental innovations.

# 4.2. Innovation and environmental economics literature: Evidence on first mover advantages of countries

Characteristics of different national country markets for the global success of an innovation design have hardly gained importance in the discussion. Although Beise (2006) and Beise and Cleff (2003) carried out an ex-post analysis of successful global innovation designs and identified typical patterns on the country level. According to this anectdotical evidence, "successful" global designs can be characterized by the to be following patterns (see.g. Beise 2006 and Beise and Cleff 2003). They

- firstly enjoy early national success,
- are then successfully commercialized worldwide and
- force other innovation designs out of the market in the medium term, to become the global design or the world standard respectively.

There are many examples of global innovation designs emerging from the adoption in one country, e.g. the cellular mobile telephony in the Scandinavian countries, the personal computer in the USA, the industrial robot or the fax machine in Japan, the airbag in Germany and the smart card in France (Beise 2001). All these examples show that the first country that adopts a specific design becoming the global dominant design is often not the country where the innovation was invented or the technology used for it mostly developed. On the contrary it is often another country that is leading the worldwide adoption of an innovation: This country can be called the lead market.

The pattern of successful lead market strategies was also confirmed by Beise and Rennings (2005) for environmental innovations. They have applied the lead market approach to the world market for renewable energies and especially wind energy which has grown rapidly in recent decades, see Fig. 2. The developing world market was in the 90ies dominated by countries that introduced feed in tariffs, especially by the small Nordic country of Denmark. Substantial differences can be identified where regulation systems are related to the development of a national wind industry. A wind industry tends to develop rapidly in countries with a feed in tariff system, such as in Denmark, Germany and Spain. Fig. 2 shows the penetration rate of wind energy use in different countries and identifies Denmark as the lead market. Germany follows closely, while other countries are developing wind energy with a considerable lag. The penetration rate has been measured as the percentage of exploitation of on-shore wind potential.





Source: Beise and Rennings (2005)

It remains however unclear if a lead market position is really profitable for a certain country. The discussion on this issue usually is very general and refers to the so-called Porter hypothesis postulating improved competitiveness for a country due to environmental regulation in the long run. A literature review on the Porter hypothesis faces however the problem that a "[. . .] systematic economic analysis is hindered by ambiguity as to exactly what the hypothesis is" (Jaffe and Palmer, 1997). This critique refers to the initial paper of Porter (1991, p. 168), where he claims: "Strict environmental regulations do not inevitably hinder competitive advantage against foreign rivals; indeed, they often enhance it. Tough standards trigger innovation and upgrading." In the literature the positive link from environ-

mental regulation to competitiveness is known as the strong version of the Porter hypothesis (Ambec et al., 2011).

In their recent comprehensive survey of the hypothesis Ambec et al. (2011) state that the overwhelming part of the literature does not find evidence for the strong Porter hypothesis. However Rexhäuser and Rammer (2011) find evidence that the Porter hypothesis is true only for innovations in energy and material efficiency (i.e. for type 1 mentioned in section 2.2, in contrast to eco-innovations aiming at a general reduction of external effects which may only produce a public benefits but not firm profits, i.e. type 2 in section 2.2.)

#### 4.3. Development economics literature: Empirical evidence on leapfrogging

While a lead market strategy may be attractive for countries with a high reputation in environmental technology, others as for example Eastern European or emerging countries start from a "catching up" position. For them a first mover strategy is not realistic since they are latecomers. And a late follower strategy is more attractive for those countries since it allows to "leave the initial risks of developing new products to and establishing a market for a new product to industrialized frontrunner countries" (Watson, 2011). This advantage of technological leapfrogging has been formulated by Soete (1985) as follows: "The opportunities offered by the international diffusion of technology to jump particular technological paradigms and import the more if not most, sophisticated technologies that will neither displace the capital invested nor the skilled labor of the previous technological paradigm, constitute one of the most crucial advantages of newly industrialized countries in their bid for rapid industrialization."

Watson reviews the evidence on successful leapfrogging strategies by reviewing three cases: The Korean Steel industry, the Korean automotive industry and wind energy in China and India. He concludes that "key factors for success are different in each case, but important latecomer advantages were in all three cases the cost advantage due to cheap labor costs. It is therefore not possible to generalize to a larger degree" (Watson, 2011). But he perceives also barriers to successful leapfrogging such as the lack of innovative capacities, lack of technological expertise, missing access to markets and the missing appropriate institutions.

This explains to a large degree the international differences in the diffusion of environmental technologies regarding abatement times. In a case study on the worldwide lead phase out Hilton (2001), using data for 48 countries, observes a

faster abatement of latecomers that is triggered by lower costs and lower innovation risks. The countries who started early with their abatement activities took about 50 percent more time (on average 15 instead of 10 years) than late abaters to complete their abatement. The quick catching up was enabled by "giant steps", i.e. at least one very large reduction in a 2 year period. While none of the early abaters has ever taken a giant step, 13 out of 20 latecomers have taken such a step. This is explained by innovation spillovers or, in the words of Hilton (2001), by accrued wisdom. As empirical studies show, historically late diffusion has been accompanied by faster diffusion, e.g. already in the case of railroads and channels in the 19th century. This accrued wisdom means that early abaters have demonstrated not only the feasibility of a new technology, but also showed how to implement the policy in practice.

The catching up of the Chinese and Indian wind industry is an impressive example of a successful leapfrogging strategy. Both countries have established a home wind industry within a decade. This was enforced by national renewable legislation and policies in support of domestic industries (Watson, 2011). According to Zhang et al. (2009) the progress can be explained by a bundle of domestic policies (such as a mandatory renewable market share) and international support (such as the Clean Development Mechanism). Jänicke and Rennings (2011) and Jin et al. (2010) see the main driver of the success story in a policy push in terms of ambitious domestic target setting. The Chinese renewable energy development plan from 1997 introduced a targeted share of renewable energy which was quantified as 10 of the total energy consumption by 2010 and 15 percent by 2020.

The change from a market dominated by foreign-owned manufacturers to a domestic wind industry is shown in Fig. 3. The success can be mainly explained by a requirement of the wind concession program that 70 percent of the added value of the components of the wind turbine should be manufactured by domestic firms (Zhang et al., 2009).



Fig. 3. Changes in market shares in Chinas wind energy market

Source: Zhang et al. (2009)

### 5. From lead markets to lead suppliers

# 5.1. Cost-benefit-analysis of lead markets: The case of feed-in tariffs

While there is agreement in the literature that lead markets for environmental innovations exist, and that Germany has successfully established such a lead market for renewables due to the system of feed-in tariffs, it is still controversial if it is profitable to be such a lead market. It is argued that subsidies for suppliers of renewables are much too expensive, and that the lead market position does not lead to a dominant position for German exporting firms. Thus this section will discuss the case of feed-in tariffs, based on this experience it will analyze if a lead market strategy is sufficient in terms of industrial policy targets.

Germans renewable industry is rapidly increasing, and is exceeding it's policy targets. This is mainly a consequence of a subsidy policy based on feed-in tariffs which was established in 1991, the year when the Electricity Feed-in Law was introduced (Frondel et al., 2010). The government provided excellent investment conditions in this Law by guaranteeing stable feed-in tariffs for up to 20 years, i.e. a price up to 43 Cents/kWh for solar electricity.

This brought the German market quickly into a demand advantage position, see also section 4.2. However, this did not lead necessarily to advantages for the German industry. Most modules for photovoltaic energy are imports from Japan or

China. While the imports in the era of solar electricity were 1.44 Bn  $\in$  in total, exports had only a value of 0.2 Bn  $\in$  (Frondel et al., 2010). As is shown in Table 3, the domestic production of installed capacities started in 2000 with only 16 percent. Although the share of German production has grown substantially over the past decade (the average growth rate is pgeom=61%), it is still lower than the growth of the domestic PV capacity (the average growth rate is pgeom=75%), i.e. Germany is still a net importer of photovoltaic cells. It seems that the German photovoltaic-industry was not able to develop relative export- or price advantages compared to producers from other countries such as China.

The debate on the cost-efficiency of feed-in tariffs is still ongoing. Wackerbauer (2009) for example argues that in 2007 one employee in the renewables sector needed public support between around 28.000  $\in$  for biomass and 41.000  $\in$  for solar energy. Frondel et al. (2010) count even 175.000  $\in$  as per capita subsidy for photovoltaics. According to Wackerbauer, the abatement costs of CO2 for photovoltaics in the year 2007 are estimated between 420 and 611  $\in$ /t CO2 since the subsidies have crowded out much cheaper investments in the area of e.g. residential buildings and heating systems. Frondel et al. (2010) estimate even higher abatement costs for photovoltaics of 716  $\in$ /t CO2.

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Capacity installed in MW	100	178	258	408	1018	1881	2711	3811	5311
Annual increase in MW	-	78	80	150	610	863	830	1100	1500
Annual cell production in Germany in MW	16	33	54	98	187	319	530	842	1450

Table 3. Photovoltaics capacities and solar cell production in Germany

Source: BMU (2009) and BSW (2009), cited in Frondel et al. (2010)

# 5.2. A lead supplier strategy: The case of e-mobility in Germany

The experiences from the renewables market have obviously motivated a change of the German policy approach from an unexceptional demand-oriented towards a broader approach, taking all lead market factors of the lead market model and the supply-side of the innovation into consideration. We have also seen in the example of the wind energy market in China that emerging countries do not follow an eco-innovation policy without considering the interests of the domestic industry, but more an industrial policy ensure a certain share of the production from Chinese firms.

The best example of the revised and broader German lead market strategy is the case of e-mobility. The German government follows the target of developing a domestic lead market for e-mobility. Until the year 2020 one million e-cars should drive on German roads. However, the concept is not only demand oriented. Maybe due to the negative experiences with the renewables market, a focus of the German strategy lies on either market pull measures such as tax reductions and technology push measures such as R&D and qualification (Acatech, 2010).

The German National Platform E-Mobility aims explicitly at becoming a market with high lead market potentials for all lead market factors, including both, the development of lead supplier structures by realizing price advantages through cost reductions in first market phase until 2014, a demand advantages by developing a pilot market for cars and infrastructure until 2017, and start a mass market later (Nationale Plattform Elektromobilität, 2011). A list of the foreseen policy mix is listed in Table 4.

Technology Push Measures	Market Pull Measures
R&D programme and networking in battery, engine, lightweight, information and communication technologies, recycling and integration	Privileges of e-cars regarding parking
Academic and occupational qualification and education	Compensation for users of company e-cars
Harmonisiation of international standards and norms	Tax depreciations for firms
	Programs from the Kreditanstalt für Wiederaufbau for private use of e-cars Annual tax incentives

Table 4. German measures for becoming a lead supplier in E-mobility

#### 6. Conclusion

In this paper the sources of first mover advantages were presented. There is agreement in the business management literature that first mover advantages depend on the respective environmental circumstances. It can be ascertained that the successful innovator is not necessarily the first but very often one of the early movers within the competition of different innovation designs.

The results of the empirical studies of successful timing strategies of firms find different factors leading to a successful timing strategy. They range from technological leadership, preemption of assets and buyer switching costs to industry, technology, firm and product-specific factors, and leading time, market dynamic, and type of innovation. It seems that radically new technologies are difficult to defend for a first mover, while it seems to be easier for incremental innovations.

There is also anecdotical evidence on the country level of both successful lead market and leapfrogging strategies. For countries with high reputation in environmental technology it is attractive to join the race for a lead market. For emerging countries however it seems reasonable to apply a leapfrogging strategy approach, by jumping into a first mover position when innovation capacities exist, and when there is large innovation pressure. However, the question under which conditions a country may switch from a second mover to a first mover position can't be answered by the existing literature. With regard to this questions, research needs can be stated.

The case of the German renewable policy showed that a strong demand-pull policy alone does not guarantee sufficient value added to the domestic industry. Industrial policy has to take into account the whole range of the lead market approach and the supply-side of the industry at the same time. Only if the supply-side is able to develop high lead market potentials for all lead market factors, country's industry may benefit from a governmental lead market strategy. This is also an important aspect for emerging countries, as it was demonstrated by the case of wind energy in China.

Interestingly, in all cases industrial policy played an important role. In the case of Germany this aspect can be identified as the reason why the country switched from a strict demand-oriented strategy with regard to renewables to a complementary lead supplier strategy with regard to e-mobility. Thus, if also industrial policy targets are relevant, a lead market strategy should be at least complemented by a lead supplier strategy, leading to a policy mix of technology push and market pull measures.

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