

## The Porter hypothesis and the role of innovation: a comparative analysis of theoretical reasoning and empirical studies

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## **Sonderdruck**

## The Porter Hypothesis and the Role of Innovation: A Comparative Analysis of Theoretical Reasoning and Empirical Studies

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### Summary

In 1991 US economist Michael Porter proposed that stringent environmental regulation under the condition that it is economically efficient leads to win-win situations, in which social welfare as well as the private net benefits of firms operating under such regulation can be increased. Innovation plays a pivotal role in this, since they are the mechanism which allows offsetting additional compliance cost from tightening environmental regulation. However, opponents of the hypothesis criticize the hidden assumption that firms would systematically overlook opportunities for voluntarily improving their environmental performance that would also increase their competitiveness.

This paper analyses the Porter hypothesis with regard to two aspects. First it analyses the theoretical reasoning behind the hypothesis by discussing and analyzing the arguments brought forward in favour of and against the hypothesis based on the discussion of different theoretical analyses and models. Second, I review empirical studies trying to test the Porter hypothesis. The analysis of empirical work allows to assess whether theoretical conclusions about the Porter hypothesis are confirmed by empirical research, thus providing further insights about the conditions under which the hypothesis holds and will thus provide important information for future policy making.

The paper concludes that factors related to capital structure make trade-offs less strong but also that this effect may be reversed if learning e.g. as part of innovation activities is taken into account. Empirically the evidence for the hypothesis is mixed, but largely pointing to limited positive effects of strict regulation on competitiveness in a dynamic and longer-term perspective most appropriate to capturing the effects of changes in innovation activity. Results also suggest that asymmetric reward structures for agents can provide incentives for them not investing into R&D despite of tightening environmental regulation and that a favourable demand structure and organisational inertia as well as use of specific economic instruments make innovation offsets more likely. The paper concludes by pointing out the sensitivity of these insights to different levels of analysing the hypothesis, the issues surrounding measurement of the stringency of environmental regulation and in particular the relevance of innovation as prime mechanism to make the hypothesis to hold.

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## Introduction

The debate on the relationship between environmental regulation and competitiveness has been a topic of debate for a number of years now. As early as 1991, the US economist Michael E. Porter introduced a new perspective to this debate. He proposed and subsequently elaborated that stringent (i.e. strict in terms of the compliance levels prescribed) environmental regulation (under the condition that it is efficient) can lead to win-win situations, in which social welfare as well as the private net benefits of firms operating under such regulation can be increased. This is the so-called Porter hypothesis (Porter 1991; Porter & van der Linde 1995). Whilst it is not surprising that environmental regulation increases social welfare (which usually is the very reason of introducing it), Porter's predictions about the effect of stringent regulations on private costs and benefits have been an issue of argument. One important reason for net benefits of stringent regulation at the firm level which is often cited by Porter and colleagues is that such regulation can induce innovatory activities in firms which increase their competitiveness. Innovation therefore has a pivotal role in the Porter hypothesis.

Opponents of the Porter hypothesis criticize its hidden assumption that firms systematically overlook opportunities for (voluntarily) improving their environmental performance that would also increase their competitiveness (Palmer et al. 1995). Metaphorically they argue that it is impossible to find a 10-Dollar bill on the ground because if it was there, somebody else would have picked it up already. Another frequently criticized aspect of the Porter hypothesis is the assumption that existing regulatory regimes are able to design stringent and at the same time efficient environmental regulation. Given the historically strong emphasis on command-and-control regulation in many countries (e.g. Germany) this critique indeed seems to have some merit.

This paper analyses the Porter hypothesis with regard to two aspects. Firstly, it will analyse the theoretical reasoning behind the hypothesis by discussing and analyzing the arguments brought forward in favour of and against the hypothesis. Secondly, the paper reviews the major influential empirical studies trying to test the Porter hypothesis. The analysis of empirical work will allow (at least to some degree) assessing whether theoretical conclusions about the Porter hypothesis are confirmed by empirical research. Whilst the approach is not a full meta-analysis, it will still provide further insights in the general conditions under which the hypothesis holds and will thus provide important information for future policy making. In particular, it will also address the measurement issues surrounding competitiveness at different levels and efficiency and effectiveness issues of environmental regulation, as well as the different levels (firm level, industry level, national level) of analysis at which the Porter hypothesis can be examined.

The discussion of results will particularly concern the level of consistency of the outcomes of formal models analysing the Porter hypothesis and the degree of homogeneity of empirical results. Also, it will be discussed whether a trend of convergence is observable in either field of study of the Porter hypothesis. The paper will conclude with a comparison between theory and empirical evidence and with conclusions that will also point to future research needs as well as open research issues.

## Method and Data Exposition

The analysis of analytical reasoning will be based on a discussion of different theoretical analyses and models in order to attempt a comprehensive assessment as regards the theoretical validity of the Porter hypothesis. Based on this, conditions are formulated under which a favorable (i.e. mutually reinforcing) relationship between environmental regulation and competitiveness exists. The review of empirical work again will be based on the relevant literature of the last 10 years and the attempt will be to (after comprehensively presenting all studies in an overview table) compare the different studies with regard to their conditions and results. In proceeding like this, the paper aims to contribute therefore to both, the practical policy making aspects as well as the theoretical research issues and hopefully provides new insights on both of them. The basis of the paper are published journal articles in major journals in the field and papers published in reviewed paper series (such as the FEEM Working Paper Series or the International Yearbook of Environmental Economics) up to September 2005.<sup>1</sup> However, other working papers will also be referred to in the text. It is not the objective of the paper, to provide a complete overview of the literature to date, but to present the most relevant contributions of the last 10 years to capture the various aspects and dimensions of the debate.

In order to make the different works better comparable for both, the theoretical and empirical literatures, overview tables are provided which summarise the salient features of the different analyses and form the basis for the comparative analysis. For the different theoretical analyses (reported in Table 1), it is firstly specified whether a formal model was utilized in the analysis or whether this was based on verbal economic reasoning (which is less frequent). Secondly, the focus of the analysis or model is reported and what are the salient features of the model. Finally, the major findings of the analysis are reported. In reviewing the empirical work, the focus lies on slightly different aspects, to better reflect those criteria which are most important when comparing empirical work. Firstly, this is the data set used in the analysis. Secondly, the

<sup>1</sup> Major journals include general economics journals such as *Journal of Economic Perspectives* or *Journal of Economic Literature* as well as the main journals focussing on topics of environmental economics as *Journal of Environmental Economics and Management*, *Environmental and Resource Economics* or *Journal of Environmental Management*.

Table 1. Overview of theoretical analyses of the Porter hypothesis

Publication	Model	Focus of analysis	Major findings
Simpson & Bradford (1996)	Cournot duopoly with a domestic and a foreign firm subjected to an effluent tax	Analysis of the optimality of an effluent tax in excess of marginal damages depending on international spillovers, innovation expenditures of the domestic firm and innovation activities of the foreign firm	Stringent regulation in terms of an effluent tax in excess of marginal external damages only rarely leads to a competitive advantage for the domestic firm selling into a foreign market
Xepapadeas & De Zeeuw (1999)	General equilibrium model in which firms invest in equipment of different ages and are subjected to an increasing emissions tax	Reaction of firms in terms of type and quantity of equipment invested in to changes in production cost	Increasing production cost lead to capital stock restructuring which increases firm productivity; tightening of environmental regulation leads to reduction of firm size; in sum, trade-offs between environmental quality and competitiveness are less severe, due to favourable changes in capital stock structure
Lankoski (2000)	Duopoly with vertical product differentiation for the cases of Bertrand competition and Cournot competition	Environmental performance as a quality variable and consumers with positive willingness to pay for environmental performance	When firms engage in a 2-stage game of first choosing environmental performance and then prices (Bertrand) or quantities (Cournot) they always supply products with different levels of environmental performance

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Publication	Model	Focus of analysis	Major findings
Gabel & Sinclair-Des-gangé (1993; 1999)	Multi-task principal-agent model where agent splits efforts between profit gaining and risk reduction	Organisational failures (i.e. missed profit opportunities) and inefficiencies; distinction of a binding / non-binding effort constraint of the agent	When the agent's effort constraint is binding, it may be inefficient to link risk reduction efforts to wages; Win-win chances for innovation are best when firms are far from the efficiency frontier / have low compliance cost
Alpay (2001)	2-country, 2-firm symmetric Cournot duopoly with convex abatement cost function and perfectly substitutable good facing a tradable emission permit system	Comparison of the Simpson & Bradford (1996) model with one based on a tradable emission permit system in which initially, all four firms are assigned the same amounts of permits. Subsequently, a country puts more stringent regulation in place. Firms can choose between carrying out R&D or may continue to use existing technology	For different outcomes analysed depending on whether firms choose to keep existing technologies or not indicating higher chance for Porter hypothesis to hold compared with Simpson & Bradford (1996) due to profits of a firm depending on permit market properties
Mohr (2002)	General equilibrium model of closed economy with many agents, constant population, perfect information, environmental externalities	Economies of scale in production imply that productivity depends on the cumulative experience with a given technology; environmental regulation in terms of a tax	The Porter hypothesis is shown to be a plausible outcome in the model when technological change with external economies of scale exist; however choosing a policy that at the same time increases productivity and reduces the envi-

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Publication	Model	Focus of analysis	Major findings
Mohr (2002)	lity, environmental tax and external economies of scale	increases productivity and reduces the negative environmental externality if an unused technology is available which is always more efficient than the one currently used and if environmental policy favours the unused but more efficient technology	ronmental externality may still not be optimal, because if the unused technology is more efficient, then it may be optimal for a government to allow an increase in pollution because the opportunity cost of abatement increases as long as the constant marginal disutility of pollution remains constant
Campbell (2003)	Cournot model with a foreign and a domestic firm (the latter producing a good causing emissions, the former one which is an imperfect substitute to the domestic firm's good) both competing on the domestic market	Domestic firm can invest into R&D at a cost with a fixed probability of success (i.e. uncertain outcome); foreign firm produces a good without emissions; agent faces an asymmetric reward structure imposed by the principal	An investment in a new technology avoiding the emission being not carried out as long as no environmental regulation forbidding or significantly limiting emissions is in place; once regulation is imposed, the investment (with uncertain outcome) may still be postponed due to the asymmetric reward structure for the agent which causes inertia; trade liberalisation can make an investment rational without any regulation, but this is not always the case so that liberalisation does not make the Porter hypothesis less relevant or even irrelevant



Table 1. Overview of theoretical analyses of the Porter hypothesis

Publication	Model	Focus of analysis	Major findings
Feichtinger et al. (2005)	Generalisation of the model by Xepapadeas and De Zeeuw which allows for non-linear functional forms and learning	Output production assumed to be a result of machines of different age; assumption that novel machines have higher productivity due to them embodying superior technology; technological progress included in the model by assuming increase in productivity with every new vintage of a machine	Critical influence of decrease of acquisition cost for investments with age of capital stock (if acquisition cost of investment convexly depend on age then average age of capital stock can increase with tightening environmental regulation); with learning tightening of environmental regulation results in stronger decline of industry profits than without; validity of Porter hypothesis (in that learning may mitigate the effect of tightened environmental regulation with regard to emission reduction) compared to the model of Xepapadeas and De Zeeuw

Table 2. Overview of empirical studies on the Porter hypothesis

Study	Data set	Measure for regulation	Measure for competitiveness	Major findings
Porte & van der Linde (1995)	Case studies in cell battery, printing ink, electronics, pulp & paper and refrigerator industries	No general measures, since it is argued that in many situations in cannot be judged if regulation is efficient and therefore a focus on cases is advocated	No measures of competitiveness are used, since only illustrative cases are reported to show how the Porter hypothesis works through a number of mechanisms	Cheaper materials, better process efficiency, premium prices and new markets can all be a result of innovation activities triggered by stringent, yet efficient environmental regulation which lead to innovation benefits that offset additional costs; characteristics of efficient regulation are clear goals, flexible approaches, incentives for innovation and regulatory coordination
Jaffe et al. (1995)	Review of 16 empirical studies on effects of regulation on competitiveness	Various, depending on study	Net exports, overall trade flows, plant location decisions, total factor productivity growth, average productivity	Limited evidence supporting that environmental regulations have a strong negative influence on competitiveness but also no evidence in favour of the Porter hypothesis in the sense that there is a systematic and significant positive effect on competitiveness

Table 2. Overview of empirical studies on the Porter hypothesis

Study	Data set	Measure for regulation	Measure for competitiveness	Major findings
Albrecht (1998)	CFC-using industries (freezers/refrigerators, industrial refrigeration, air conditioning) in U.S., Denmark, France, Germany, Japan for 1989–1995	Dummy variable taking unity for U.S. and Denmark to signify early action in these countries with regard to CFCs	Change in bilateral exports (country of origin) of five countries (U.S., Denmark, France, Germany and Japan) with their major trade partners in both, industrialised and developing countries	Analysis found that dummy variables for U.S. and Denmark (proxying for early action) were significant in regressions pooling all three industries chosen, as well as in the sector-individual regressions for refrigerators/freezers and industrial refrigeration, but not for air conditioning; product-specific evidence in favour of Porter hypothesis seems stronger, due to masking effects from aggregation of different industrial sectors
Murty & Kumar (2003)	92 firms in India in 12 water-polluting industries during 1996–1999	Regulation index as geometric mean of the absolute emissions of biological oxygen demand, chemical oxygen demand and suspended solid all normalised by the maximum value across all years to measure compliance	Conservation index defined as the ratio of wastewater output per unit of sales (being a proxy for technical inefficiency of production and therefore inversely related to competitiveness)	Simultaneous estimation of causal link between technical inefficiency and environmental regulation based on stochastic output distance function reveals that most parameters of the output and input functions are significant and that technical inefficiency is no linear function of the regulation index, conservation index

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Study	Data set	Measure for regulation	Measure for competitiveness	Major findings
				and time variable, respectively; regulation and conservation index are found to be significant, but time variable not; the higher a firm's compliance and the lower wastewater output per sales is, the lower is technical inefficiency of a firm lending support to the Porter hypothesis
Roediger-Schluga (2003)	Firm-level survey and disaggregated foreign trade data for Austrian manufacturers of paints, coatings, printing inks and adhesives	Austrian volatile organic compound (VOC) emission product and process standards (coming into force in 1996)	Foreign trade data at 5-digit level from UN commodity trade database, standardised in-depth interviews with 29 Austrian firms in 1999	No overall clear impact of tight Austrian VOC emission standards on the competitiveness of firms, but variation of results with firm size; some evidence that compliance-related innovation activities crowd out existing R&D activities and that compliance induced innovation lead to new product development and technology acquisition

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Study	Data set	Measure for regulation	Measure for competitiveness	Major findings
Popp (2005)	Simulation model of induced R&D with uncertain outcome	Expected value of R&D only with an environmental regulation positive	Profits from the R&D activity	In 8 to 24 percent of the simulations, profits after introducing an environmental regulation are higher than before confirming specific cases of full innovation offsets and macroeconomic cost of environmental policy

measures used for measuring the stringency of environmental regulation are reported, as are thirdly the measures used to assess competitiveness or economic performance. The choice of either category of measure may significantly influence the findings of the analysis, which is the fourth aspect reported in Table 2.

## Comparative Analysis and Conclusions

In the following, I analyse comparatively the theoretical arguments and models and empirical studies on the Porter hypothesis and will discuss implications for policy making and future research. It will also attempt to define more precisely conditions under which the Porter hypothesis is most likely to hold. Particular focus will be placed on different aspects that have emerged from the theoretical and empirical work on the Porter hypothesis. These concern the measurement of stringency of and approach to environmental regulation, the level on which the Porter hypothesis is analysed, and the role of innovation.

### *A comparative analysis of findings on the Porter hypothesis*

A comparative analysis of the Porter hypothesis can be done between different theoretical models, between different empirical studies, between theoretical and empirical work and between different interpretations and levels of analysis of the Porter hypothesis. For theoretical models it is found that in this respect:

- there are factors related to capital structure that make the trade-offs implied by critics of the Porter hypothesis less strong and thus the hypothesis more likely to hold (Xepapadeas & de Zeeuw 1999) but that these may also have reversed effects, especially if learning is taken into account (Feichtinger et al. 2005);
- asymmetric reward structures for agents can provide incentives for them not investing into R&D despite tightening environmental regulation (Campbell 2003);
- a favourable demand side can make the Porter hypothesis more likely, as can firm-internal organisational features or organisational inertia (Reinhard 1999; Lankoski 2000);
- specific (more flexible) types of instruments for environmental regulation (in particular tradable permit systems) bring about more favourable conditions and thus make it more likely for the Porter hypothesis to hold (Alpay 2001);
- conditions for the Porter hypothesis to hold seem to be depending on the pollutants concerned, i.e. the hypothesis is more likely to hold (more strongly) for some pollutants than for others and trade liberalisation can work both, in favour or against the hypothesis (Campbell 2003).

Concerning empirical work, the consensus emerging is that the negative macroeconomic impact of environmental regulation is likely small, but still existing (Popp 2005), as is its effect on employment in both directions, increasing or decreasing employ-

ment (see also Rennings et al. 2001; Morgenstern et al. 2002) and that environmental regulation empirically seems to have led to only very small increases of the rate of inflation and seems unlikely to be a prime cause for negative economic effects.<sup>2</sup> The effects of reduced compliance costs on employment, GDP growth rates and productivity have been shown to be only small empirically and thus environmental regulation is agreeable with economic growth. Nevertheless trade-offs resulting from higher spending caused by more stringent environmental regulation substituting spending leading to an increase in measured GDP, since simultaneous spending on both is impossible. In conclusion empirical research to date makes it likely that although Porter's hypothesis may hold in individual industrial sectors or in more narrow interpretations in specific countries under certain regulatory conditions, it is unlikely to hold (empirically as well as theoretically) in its most general form across all levels of analysis and forms of interpretation of the hypothesis.<sup>3</sup>

#### *Issues of measuring the stringency of and approach to environmental regulation*

As can be seen from empirical studies, it is of pivotal importance to distinguish precisely the measurement of regulatory stringency. As Mulatu et al. (2001) have shown, the choice of stringency measures has in many cases a significant influence on the results of empirical research. Romstad (1998) points out that from a theoretical point of view, it is absolutely indispensable that any study actually ensures that the regulatory system analysed empirically is economically efficient since otherwise a rejection of the Porter hypothesis can not be taken as such, given the additional costs of inefficient regulation would have to be taken into account.<sup>4</sup> It seems likely that in most countries analysed in empirical studies there is at least some economic inefficiency in environmental regulations. For example, in Germany environmental regulation has a long tradition of 'command-and-control' legislation and thus in many instances cannot be assumed efficient (Jaffe et al. 1995; Brännlund et al. 1995; Hahn 1989). In addition to this, of the multitude of instruments for environmental regulation discussed in the literature only a subset have been applied in practice. For example, tradable emission permit systems have only become relevant (except for regionally limited applications in the U.S.) for environmental policy making since the Kyoto protocol is on the agenda, and even after its implementation have only been implemented scarcely. One of the few examples is the emissions trading system for carbon dioxide which started

2 It has to be noted that these conclusions mainly apply to the U.S. and developing countries. See also Eliste and Fredriksson (2002) for a discussion of transfer effects on trade flows.

3 For example, Xing and Kolstad (2002) find evidence that for highly polluting industries in the U.S. less stringent environmental regulation in host countries is a significant factor determining foreign direct investment of firms from such industries in the host countries.

4 Total regulatory costs can be broken down into costs of achieving an emissions standard and the costs resulting from efficiency or inefficiency of regulation. Assuming globally increasing and converging emission standards for trans-boundary pollutants, efficiency costs become relatively more important (Romstad 1998).

in 2005 in the EU. Because of this situation, only very limited empirical work has been analyzing regulatory regimes predominantly based on tradable permit systems. Alpay (2001) shows that for the latter that compared to a tax based system as e.g. the one analysed by Simpson and Bradford (1996), the mechanisms behind the Porter hypothesis are more likely to work successfully. Finally, it seems to be an important topic for future research to develop a standard measure that (jointly) measures the stringency of and approach to environmental regulation, since both aspects have an effect.

Even though to date, empirical studies have differentiated to a lesser degree than theoretical work and reasoning between the different instruments of environmental policy making discussed in Chapter II.1, this will beyond doubt change in future with the increasing relevance of taxes, tradable emission permit systems and voluntary initiatives and agreement (such as the environmental management standards ISO 14001 and EMAS).

#### *Different levels of analysis and interpretations of the Porter hypothesis*

One important issue when analyzing empirically the Porter hypothesis is that it can be interpreted in different ways. According to Jaffe et al. (1995) the hypothesis may mean that specific industries will benefit from environmental regulation of their customers, that innovatory activity in specific technology areas will be increased because of environmental regulation, that some companies will benefit from more stringent regulation at the expense of other firms (which would e.g. be the case if inefficient firms in an industry go out of business), that there will be „early/first mover“ advantages for some firms, or that the (net) competitiveness of a whole national economy (i.e. across all industries or at least for the net changes across all industries) will be increased through stringent regulation (which would be the case if innovation caused by increase in the stringency of regulation leads to improved environmental quality and improved productivity). Given this wide range of interpretations, subsequent empirical analyses after 1995 have usually focused on a specific interpretation.

An aspect that can therefore influence empirical results is on which level the Porter hypothesis is analysed in empirical studies. It is therefore necessary to distinguish precisely between the different possible levels on which the Porter hypothesis can be analysed. At least, these are the level of the individual firm, the level of an industry, or the level of the national economy.

For individual firms, testing of the Porter hypothesis essentially means to analyse the relationship between environmental performance and economic performance at the firm level, taking into account the type of environmental management a firm uses and its specific regulatory environment. The firm level is the most disaggregated level of analysis for the Porter hypothesis and it is this level for which Porter and van der Linde (1995) cite evidence from numerous case studies, since only at this level it is possible to precisely measure full environmental costs and benefits. At the level of



individual firms, it needs to be considered as well if all or only a limited group of firms (e.g. only large firms) in an industry benefit from more stringent regulation, since the aggregated effect for an individual industrial sector is constituted of the effect of regulation on the competitiveness and economic performance of each individual firm.

Whilst an analysis at the industry level will mask any differences between individual firms, it is still more disaggregated than an analysis at the national level. As the empirical work of Albrecht (1998) shows, results at the level of individual industries may differ considerably from those for whole countries or national economies. Next to one specific industry, it is also possible to analyse a narrow cluster of (similar) industries. A parameter on which findings at this (but also at the more aggregated national) level critically depend is which industries are included in the analysis. For example, for the pulp and paper industry alone, empirical studies provide rather strong evidence that more stringent environmental regulations put firms in the industry at a competitive disadvantage (Brännlund et al. 1995; Barbera & McConnell 1990), whereas including resource-intensive process industries similar to the pulp and paper industry may actually alter results which may be completely different if industries with relatively low energy and resource intensity are considered. The different possible levels of analysis can be found in empirical studies, but are not much differentiated in theoretical reasoning of the Porter hypothesis, which usually focuses on simple models and country-level analysis. In the future, a more complex and disaggregated analysis would be desirable to supplement this, based on e.g. approaches in industrial economics and industrial organization (Hay & Morris 1991; Schmalensee 1989), and more elaborate modelling approaches.

#### *The role of innovation in the Porter hypothesis*

Porter and van der Linde (1995) note the particular role of innovations as a mechanism for putting the Porter hypothesis to work. This is because the concept of innovation offsets (i.e. private benefits to firms from innovative activity triggered by stringent, yet efficient, environmental regulation) is central to the Porter hypothesis.

Opponents to this view argue that the existence of profitable or at least cost-effective opportunities at the firm, industry or national level to reduce environmental pollution as proposed in the Porter hypothesis are not likely in most industries. In the best case it pays for firms in such industries to pursue emission reductions until they meet their industry's regulatory standards. Over-compliance in these industries is unlikely, since it would only be rational for firms if it can be achieved through cost-effective pollution abatement, which per definition is not possible and therefore regulation beyond the emission level corresponding to the private optimum would increase production costs and in turn reduce profitability and competitiveness (Romstad 1998).

One important assumption of this last view is however, that firms pursue maximisation and not satisficing (Simon 1945). In case of the latter, firms may not have explo-

red specific areas of technology or innovation and may be triggered by tightening or introduction of stringent regulation to do so. This seems to however be an interacting process of innovation activities aimed at achieving compliance with novel regulation crowding out discretionary innovation aimed at new product development whilst at the same time compliance-oriented orientation leading to discovery of new areas of product development, to search processes in different fields of technology and to acquisition of additional knowledge and capabilities by the firm (see e.g. Roediger-Schluga 2003).

Given their pivotal role in the Porter hypothesis, future research on the specific mechanisms of how environmental regulation influences innovation seems to have some merit. This could concern the relative influence of innovation drivers such as private investment or government expenditure in R&D, spending for improvement of education systems, regulation or price changes and whether innovation policy should focus on for example on correcting for negative externalities, or on eliminating subsidies.

Another aspect may be that environmental regulation in general should be providing incentives for innovation. These characteristics mainly apply to environmental taxes and tradable emission permit systems which should thus be applied more often in practice if it is wished to create conditions favourable to the Porter hypothesis (Endres 1994; Hemmelskamp 1997, see however Montero (2002) for a more detailed analysis of innovation incentives provided by different types of instruments). As is well-known from innovation theory and regulation theory in general, innovation should also not be focused on specific technologies and take into account equally the rate and the direction of innovation. As well, regulation should be close to the end-user of a technology and also consider voluntary agreements as well as standards and labels for environmentally more benign products (see e.g. Hemmelskamp 1999; Jaffe et al. 2002; Teisl et al. 2002; Rennings et al. 2003 for discussions of specific aspects mentioned here).

Despite the limitations of Porter's hypothesis<sup>5</sup>, it provides additional arguments for preferring incentive-based regulations over command-and-control type regulation, since the former likely reduce abatement costs. Incentive based regulation, in particular tradable emission permit systems maintain incentives for firms in an industry to reduce emissions through innovation, provides cost effective allocation and abatement solutions and are therefore likely to limit reductions in the profitability of firms. Economic efficiency of regulations is pivotal here because low cost regulatory approaches are most likely to reduce trade leakages which have adverse effects on

5 For Europe, there has been relatively little research on the Porter hypothesis (for exceptions, see e.g. Albrecht 1998; Hitchens 1999; Rennings et al. 2001; 2003) and therefore empirical research in future should put particular focus here.

overall social welfare and can reduce barriers to international cooperation on trans-boundary pollution (Romstad 1998). By doing so, regulation can indirectly produce competitive advantages (or at least reduce competitive disadvantages) for firms competing internationally, since it reduces part of the regulatory costs whilst at the same time having the potential to trigger innovation offsets that are at least equal to their environmental costs.

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### **Zusammenfassung**

Der US-Ökonom Porter formulierte 1991 die Hypothese, dass strikte Umweltgesetzgebung, soweit sie ökonomisch effizient ist, Win-Win-Situationen ermöglicht, in denen die soziale, wie auch die private Wohlfahrt verbessert wird. Gegner der Porterschen Hypothese kritisieren allerdings die dieser zugrunde liegende Annahme, dass Unternehmen systematisch Möglichkeiten zur freiwilligen Verbesserung ihrer Umweltleistung übersehen, welche gleichzeitig auch ihre Wettbewerbsfähigkeit verbessern. Der vorliegende Beitrag untersucht einerseits theoretische Modelle, die die Hypothese untersuchen. Andererseits werden empirische Studien zusammengefasst. Dadurch werden genauere Einsichten gewonnen, unter welchen Bedingungen die Hypothese Gültigkeit hat.

Der Beitrag schlussfolgert, dass die empirischen Belege für die Porter-Hypothese gemischt sind, wobei in einer dynamischen und längerfristigen Perspektive insgesamt ein leichter positiver Einfluss strikter Umweltgesetzgebung auf die Wettbewerbsfähigkeit von Unternehmen besteht. Abschliessend wird die Abhängigkeit der Ergebnisse von der jeweils gewählten Bezugsebene für die Hypothese und die Bedeutung von Innovationen als wesentlichem Mechanismus zur Realisierung des von der Porter-Hypothese behaupteten Zusammenhangs diskutiert.