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Linking Environmental Management Systems and Corporate Energy Management Strategies: New Drivers for Innovation from the Implementation of International Climate Policy**

This paper analyses the linkages of implementing international climate policy instruments with energy management strategies of European firms and the empirical determinants of corporate energy management activities. Based on different corporate energy management strategies identified, the factors influencing energy management activities linked to the different corporate energy management strategies are analysed empirically and the relationship of the implementation of environmental management systems with the energy management activities of firms is addressed.

1 Introduction

Today's environmental issues are very complex and often have a global dimension. Global environmental change concerns such diverse areas as acid rain, biodiversity, climate change, depletion of stratospheric ozone, hydrological processes and global fisheries and is underpinned by anthropogenic processes as for example demographic change, urbanisation, economic development and growth, industrialisation, expansion of the global tourism industry or changes in land use. Often there are complex interrelationships between the key drivers of these changes in which business plays a role both influencing and being influenced these processes and their outcomes. Therefore, the corporate sector (and in the remits of this paper in particular European firms) is pivotal in many ways for sustainable development and there is considerable agreement between business and governments that global co-operation is required in order to implement effective policies towards sustainable development.[1] One of the most important global environmental issues is global climate change due to anthropogenic greenhouse gas (GHG) emissions from various sources.

Due to its large emission levels and long lifetime in the atmosphere, carbon dioxide still contributes most to the greenhouse effect. The main source of carbon dioxide emissions is the combustion of fossil fuels to generate energy. Currently international co-operation to influence and stabilise global climate change is institutionalised within the Framework Convention for Climate Change.[2] Whilst the main objective resulting from Conference of Parties (CoP) 7, the ratification of the Kyoto Protocol did seem unlikely for a long time, the change in position of Russia has now brought the Kyoto Protocol in force. The slow progress on the ratification of

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** The author thanks two anonymous reviewers for valuable comments and suggestions.

1 See Browne, J.: Beyond Kyoto. In: Foreign Affairs. Vol. 2004, No. July/August, accessed 13/9/2004 at <http://www.foreignaffairs.org/20040701faessay83404/john-browne/beyond-kyoto.html>. - WBCSD (World Business Council for Sustainable Development): Innovation, technology, sustainability and society. Genf 2002.

2 See Mabey, N./Hall, S./Smith, C./Gupta, S.: Arguments in the Greenhouse. The International Economics of Controlling Global Warming. London 1997.

the Kyoto Protocol (and the global emission trading systems proposed to become active between countries under the Kyoto Protocol) had led the European Union (EU) in March 2000 to propose a closed European emission trading (ET) system (EU ETS), also to form the basis for inter-country ET from 2008 onwards. This was detailed in a draft EU directive on GHG emissions trading between firms in October 2001 which was ratified by the European Parliament in late summer 2003 after the second reading of the directive in the parliament. The system became active at the beginning of 2005 and enables trading between EU firms. The introduction of the EU ETS raises the issue of how emission trading influences corporate energy management strategies and activities of European firms and what the determinants are for the latter. Any analysis here needs to start with the broader strategic frame for energy management strategies and to take into account their linkage with environmental management systems, since this enables an interaction of the latter with climate policy initiatives such as the EU ETS or the mechanisms under the Kyoto Protocol. These initiatives are novel in that they are more economically efficient types of regulation with potentially very favourable innovation effects, as proposed in the Porter Hypothesis.[3] The remainder of the paper is structured as follows: after reviewing the literature (including the derivation of different energy management strategies for business responses towards climate change) and developing hypotheses, the paper introduces data and methods and, following this, provides empirical results on the drivers for energy management activities that reflect the strategies derived. The paper ends by drawing conclusions and detailing the implications that arise from the results of the empirical analysis.

2 Literature Review and Hypothesis Development

The ratification of the Kyoto Protocol and the introduction of the EU ETS represent new drivers for innovation in firms that especially build on the links of corporate energy management strategies and environmental management systems (EMS). The linking of EMS and energy management strategies is one special case of the integration of different management systems, as is also witnessed by the integration of environmental and social aspects with corporate strategy and the increasing integration of market and non-market strategies.[4] To address this in more detail, initially corporate energy management strategies are identified and, following this, their linkages with EMS is discussed.

2.1 Corporate energy management strategies

Building on earlier work on strategies in the context of climate change, three energy management strategies can be identified for the corporate sector to address climate change whilst at the same time not jeopardizing economic performance or other

3 See Porter, M. E.: America's Green Strategy. In: Scientific American. Vol. 264 (1991), No. 4, p. 96.

4 See Baron, D. P.: Private Politics, Corporate Social Responsibility and Integrated Strategy. In: Journal of Economics and Management Strategy. Vol. 10 (2001), No. 1, pp. 7-45. - Baron, D. P.: Integrated Strategy: Market and Non-Market Components. In: California Management Review. Vol. 37 (1995), No. 2, pp. 47-65. - Kolk, A./Pinkse, J.: Multinationals' Political Activities on Climate Change. In: Business and Society. Vol. 46 (2007), No. 2, p. 201-228.

central business objectives (such as earnings satisficing or profit maximization).[5] These are: improvement of energy efficiency, increased use of renewable energies or fuel switching and the use of flexible mechanisms.[6]

The first of these strategies, improvement of energy efficiency, has been on the agenda for quite some time. Unfortunately two factors limit the scope of this strategy. Firstly, because of its considerable history, energy efficiency improvements through direct plant-level or site-level measures have often reached a level that leaves only limited scope for cost-efficient improvement, since frequently the process-related limits are very close. Secondly, market imperfections such as lack of information hinder even cost-efficient investments in energy efficiency.[7] Nevertheless new technologies still carry potential in the EU. Also, in the consumer market segment of the electricity industry considerable potential also exists for profitable demand-side based energy management strategies.[8]

For the second of the strategies mentioned earlier, increased use of renewable energy technologies and sources (or more generally for fuel switching) the longer-term potential is high, since it leads to direct GHG emission reductions. An example of this is the attention currently paid to bioenergy and especially to second-generation biofuels. Whilst the optimal allocation of the biomass produced to different uses (e. g. food production, energy production etc.) seems to be still a challenge, recent regulation especially in Europe with regard to biofuels seems to indicate, that policy makers see considerable potential in substituting fossil with renewable energies.

Finally, a third strategy for corporate energy management to address climate change-induced demands that is consistent with the business objectives of a company is the use of flexible mechanisms such as JI (Joint Implementation) or CDM (Clean Development Mechanism) which are both elements of the Kyoto Protocol. Whilst CDM and JI enable European industry to exploit marginal abatement cost differences between countries, its incentives for early action are comparatively low. This is because firms do not change their established energy management activities and strategies fundamentally, but rather do so gradually. This is due to existing re-

5 See Dunn, S.: Down to Business on Climate Change: An Overview of Corporate Strategies. In: Greener Management International. No. 39/2002, pp. 27-41. - Kolk, A./Pinkse, J.: Market Strategies for Climate Change. In: European Management Journal. Vol. 22 (2004), No. 3, pp. 304-314. - Pinkse, J. Corporate intentions to participate in emission trading. In: Business Strategy and the Environment. Vol. 16 (2005), No. 1, pp. 12-25. - Boiral, O.: Global Warming: Should Companies Adopt a Proactive Strategy? In: Long Range Planning. Vol. 39 (2006), pp. 315-350.

6 The empirical analysis includes the reduction of air emissions for completeness. Strategies that conflict with business objectives (such as a sufficiency strategy based on limiting growth of a company) are not included in the analysis. The three strategies discussed in the following can all be applied simultaneously to reduce the carbon emissions of a company (which can be conceptualised in a 3-dimensional carbon footprint cube where each dimension can only be influenced by one strategy).

7 See Jaffe, A. B./Stavins, R. N.: Energy-efficiency investments and public policy. In: The Energy Journal. Vol. 15 (1994), No. 2, pp. 1-23. - Sanstad, A. H./Howarth, R. B.: 'Normal' markets, market imperfections and energy efficiency. In: Energy Policy. Vol. 22 (1994), No. 10, pp. 811-818.

8 See Greening, D. W.: Conservation Strategies, Firm Performance, and Corporate Reputation in the U. S. Electric Utility Industry. In: Research in Corporate Social Performance and Policy. No. 1/1995, pp. 345-368. - Rowlands, I. H./Scott, D./Parker, P.: Consumers and green electricity: profiling potential purchasers. In: Business Strategy and the Environment. Vol. 12 (2003), No. 1, pp. 36-48.

source allocations and because flexible mechanisms, whilst having positive reputation effects for firms, also run the risk of achieving more limited economic benefits since these projects usually require multi-partite partnerships, thus carrying additional risks due to their complexity, and limiting these increases costs. For example, an analysis of the Tahumanu Project in Bolivia has shown, that it is an important success criterion to analyse the incentive situation of all participants in a CDM project. Therefore, firms are expected to be cautious in implementing this third energy management strategy on a larger scale.[9]

Whilst the first two strategies (as well as end-of-pipe reductions of air emissions) result into lower GHG emissions and lower demand for certificates under the EU ETS, the third strategy (by using the flexible mechanisms of the Kyoto Protocol) results in certified emission reductions that can subsequently be used by firms to offset emissions remaining after use of the other two strategies introduced above plus use end-of-pipe emissions reductions. This further reduces certificate demand.

The drivers of energy management strategies are empirically analysed in this paper in terms of determinants for corporate energy management activities. The activities analysed empirically are the reduction of energy use in production and the reduction of energy use in transport, the substitution of non-renewable resources (e. g. renewable energy for fossil fuels), and the reduction of air pollutant emissions (carbon dioxide, sulphur dioxide, etc.).

There is broadly a one-to-one connection of the different energy management activities to only one of the three strategies introduced earlier. Reduced energy used in production and transportation is largely the result of energy efficiency improvements, whereas substitution of non-renewable resources is essentially related to fuel switching. Finally, reduction of air pollutant emissions is closely linked to emissions-oriented end-of-pipe approaches and often a result of flexible mechanisms.

2.2 Linking energy management strategies with EMS

Corporate energy management is usually embedded in the larger context of environmental management systems in most firms.[10] The literature argues that accounting for a company's emissions and setting reduction targets is in many cases a step towards more elaborated strategies.[11] Such initial activities are at the same time central to EMS and their implementation, e. g. during the initial review and when defining improvements for plan-do-check-act cycles to continuously improve the EMS. This relates for example to the expectation of reducing energy consumption through the implementation of EMS which has been identified in earlier research.[12]

9 See De Gouvello, C. C./Mollon, P./Mathy, S.: Rent Sharing in the Clean Development Mechanism: The Case of the Tahumanu Hydroelectric Project in Bolivia. In: Greener Management International. No. 39/2003, pp. 109-119.

10 See Boiral, O.: Global Warming, loc. cit, pp. 315-350.

11 See Kolk, A./Pinkse, J.: Business Responses to Climate Change: Identifying Emergent Strategies. In: California Management Review. Vol. 47 (2005), No. 3, pp. 6-15.

12 See Rondinelli, D. A./Vastag, G.: Panacea common sense or just a label? The value of ISO 14001 environmental management systems. In: European Management Journal. Vol. 18 (2000), No. 5, pp. 499-510. - McManus, M./Sanders, L.: Integrating an environmental management system into a business and operating culture: The real value of an EMS. In: Pollution Engineering. Vol. 33 (2001), No. 5, pp. 24-27. - Morrow, D./Rondinelli, D.: Adopting Corporate Environmental Management Systems: Motivations and Results of ISO 14001 and EMAS Certification. In: European Management Journal. Vol. 20 (2002), No. 2, pp. 159-171.

Other studies have revealed that cost reductions through more efficient energy use are another important driver for the implementation of EMS.[13] Furthermore, Swiss research has revealed that the most important benefit (and therefore likely a major motivation) to implement EMS is the systematisation of the environmental activities of the company.[14] Also there is evidence that the use of different energy management strategies is most valuable as one element of a broader set of activities. In this broader set, an implemented EMS can well be a complementary asset that enables better capitalisation on the outcomes of pursuing energy management strategies. This relates to the creation of competitive advantages or to making use of the instruments available in the context of an EMS (such as environmental reports) to communicate better the outcomes of pursuing ambitious energy management strategies.[15] This embeddedness of energy management strategies and activities into EMS suggests that EMS implementation has a positive effect on the adoption of energy management activities, leading to the first hypothesis:

Hypothesis 1: Full implementation of an EMS is positively associated with the energy management activities of firms.

As concerns innovation effects of the EU ETS and the Kyoto Protocol, Schumpeter defines innovations as new ways for the production of a good or a new quality of that good, the introduction of a new production method, the development of a new market, the identification of new production inputs or the implementation of new organisational structures.[16] Based on this definition, others have further subdivided innovation into technological, commercial and organisational innovation.[17] The introduction of management systems in general (and in the context of this paper especially environmental management systems) can be considered as a special case of the latter.[18] Given that the introduction of the EU ETS and the ratification of the Kyoto Protocol imply that carbon dioxide emissions become more costly, it can be expected that firms innovate in order to reduce emissions and one important organisational innovation in this respect can be the introduction of an EMS. This is also confirmed by research on the implementation of EMS which e.g. showed that in Switzerland 75% of the firms deciding to implement an EMS did not have previous experience with systematic environmental management.[19] The organisational innovation of introducing an EMS aims at ultimately reduce carbon dioxide emissions by means of energy management activities. Given this and the fact that initial activities can already be identified during the early stages of the process of imple-

13 See Chin, K.S./Pun, K.F.: Factors influencing ISO 14000 implementation in printed circuit board manufacturing industry in Hong Kong. In: Journal of Environmental Planning and Management. Vol. 42 (1999), No. 1, pp. 123-134. - Kirkpatrick, D./Pouliot, C.: Environmental management, ISO 14000 offers multiple rewards. In: Pollution Engineering. Vol. 28 (1996), No. 6, pp. 62-65.

14 See Hamschmidt, J./Dyllick, T.: ISO 14001: Profitable? Yes! But is it eco-effective? In: Greener Management International. No. 34/2001, pp. 43-54.

15 See Kolk, A./Pinkse, J.: Business Responses to Climate Change, loc. cit, pp. 6-15. - Teece, D.J.: Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy. In: Research Policy. Vol. 15(1986), pp. 285-305.

16 See Schumpeter, J.: The Theory of Economic Development. Cambridge/MA 1934. - Schumpeter, J.: Capitalism, Socialism and Democracy. New York 1943.

17 See Hauschildt, J. Innovationsmanagement. 3. Aufl., München 2004.

18 See Rennings, K./Ankele, K./Hoffmann, E./Nill, J./Ziegler, A.: Innovationen durch Umweltmanagement: Empirische Ergebnisse zum EG-Öko-Audit. Berlin 2005.

19 See Hamschmidt, J./Dyllick, T.: ISO 14001: Profitable?, loc. cit, pp. 43-54.

menting an EMS (e. g. as part of an initial environmental review as described above) the following hypothesis is proposed:

Hypothesis 2: The process of implementing an EMS as an organizational innovation is positively associated with the energy management activities of firms.

EMS are also an example of innovation activities of a company with an important environmental performance dimension. Such corporate innovation activities which refer to reducing negative externalities and hence environmental or social benefits that cannot be fully appropriated by companies have also been termed environmental or eco-innovations. An EMS can hence be understood as an organisational eco-innovation.[20]

Whilst the linking of EMS and corporate energy management strategies and activities is in principle possible for all firms, just how easily this linkage is brought about differs across firms depending on a number of factors. For example, it is argued in the literature, that for the first energy management strategy identified above (relating to energy efficiency) firm characteristics matter a lot and similar arguments apply also to the other strategies.[21] For example, leadership in each of these strategies is often more difficult for smaller companies, especially if they are not listed on the stock market, since for them the benefits of pursuing proactive strategies are less obvious (e. g. for non-listed firms, pursuing a proactive strategy cannot have an effect on a sustainability rating which is for many stock-listed firms an important motivation for pursuing a proactive strategy). Also, opportunity cost tends to be relatively high for smaller firms. Research has also found that industry and country context matter (e. g. through differences in regulation) for corporate energy management strategies in general.[22] This leads to the following hypothesis:

Hypothesis 3: There is variation in the firm, country and industry level influences and therefore significant association of firm, country and industry level variables with the energy management activities of firms exists.

3 Data and Method

3.1 Data

The empirical analysis for which results are presented in the following section is based on data collected during a survey on the state of environmental management in practice based on a mail questionnaire. The survey questionnaire asked firms to self-report the organisational and technological activities carried out in relation to the environment, and it asked about environmental management system implementation, as well as firm characteristics. *Table 1* summarises the data gathered during the survey.[23] Almost 2 100 firms across all manufacturing industries responded in nine European countries, based on random sampling, corresponding to an average

20 See Rennings, K.: Redefining Innovation - Eco-Innovation Research and the Contribution from Ecological Economics. In: Ecological Economics. Vol. 32 (2000), pp. 319-332.

21 See DeCanio, S. J./ Watkins, W. E.: Investments in Energy Effciency: Do the Characteristics of Firms Matter? In: Review of Economics and Statistics. Vol. 80 (1998), pp. 95-107. - Dunn, S.: Down to Business on Climate Change, loc. cit, pp. 27-41.

22 See Dunn, S.: Down to Business on Climate Change, loc. cit, pp. 27-41. - Jeswani No, K./ Wehrmeyer, W./Mulugetta, Y.: How warm is the corporate response to climate change? Evidence from Pakistan and the UK. In: Business Strategy and the Environment. Vol. 2007, forthcoming.

23 The survey questionnaire is available from the author on request.

Table 1: Summary of definitions for variables used in the empirical analysis

Aspect	Description of the variables used to measure the aspect (as referred to in *Table 2*)	Variable type
Energy management activities (proxying for different strategies)	Reduction of energy use in production ("Energy efficiency") Substitution of non-renewable resources ("Renewable energies") Reduction of emission through air pollutants ("Emissions to air") Reduction of energy use in transport ("Transport energy use")	Binary
Environmental management system implementation	Firm has not implemented EMS (reference) Firm considers EMS implementation ("Considering EMS") Firm is in progress of implementing an EMS ("EMS set-up in progress") Firm has implemented an EMS ("EMS implemented")	Binary
Country variables	Firm located in Belgium ("Belgium") Firm located in France ("France") Firm located in Hungary ("Hungary") Firm located in the Netherlands (reference) Firm located in Norway("Norway") Firm located in Sweden ("Sweden") Firm located in Switzerland ("Switzerland") Firm located in the United Kingdom ("United Kingdom") Firm located in Germany ("Germany")	Dummy
Sector variables	Firm in food and tobacco sector ("Food") Firm in textile products sector ("Textiles") Firm in pulp and paper products sector ("Pulp/Paper") Firm in printing and publishing sector ("Print") Firm in energy, oil and nuclear fuels sector ("Energy") Firm in chemicals and fibres sector ("Chemicals") Firm in wood products sector ("Wood") Firm in the leather products sector ("Leather") Firm in rubber and plastic products sector ("Rubber") Firm in non-ferrous mineral products sector ("Nonferrous") Firm in machines and equipment sector ("Machinery") Firm in electrical and optical products sector ("Electric") Firm in transport products sector ("Transport") Firm in metals products sector (reference) Firm producing other manufacturing products ("Other")	Dummy
Firm level variables	Number of employees in thousands ("Firm size")	Continuous
	Logarithm of firm age in years ("Firm age")	
	Target market size measured on a 5-point scale to assess if the company sells its products locally, regionally, nationally, Europe-wide or worldwide ("Market size")	Ordinal
	Overall profitability on a 5-point scale to assess if firm is profit-making or loss-making ("Firm profitability")	
	Dummy taking value 1 if firm is solely owned ("Firm legal status")	Dummy

response rate of 26 %. As concerns response bias, it is possible that the replies received contain over-proportionally many firms that are particularly active in terms of environmental management. Such a bias is common in surveys based on written questionnaires.[24] However this is not a serious issue here. For example, in the case of the German responses, the characteristics and response behaviour of the early respondents were not significantly different from the late replies, based on a comparison of the mean values for all variables used between the first and last 10 % of respondents, and similar findings were made in the other countries in which the survey was implemented.[25] Amongst the technological activities surveyed in the questionnaire were four relating to energy management. For each of the measures (detailed in *Table 1* below) the responding companies had to state whether they carried it out or not. Given these binary dependent variables are correlated, a multivariate probit model is applied.[26]

3.2 Method

I assume that a company will realize a specific type of energy management activity if the expected benefit from realisation is greater than the benefit from not realizing and that the latent variables describing the precise benefit are not observable. Observable is only the decision of a company concerning the realisation of a specific energy management activity (with a probability less than 0.5 corresponding to the activity not being realised and one greater than 0.5 to the activity being realised, i. e. the corresponding observable binary variable assumes the values of zero or one, respectively). The multivariate Logit model is then estimated by including the probabilities of the realisation of the energy management activities into the likelihood function. Maximum likelihood estimates the (unknown) coefficients of the known explanatory variables in the regression model so that they yield with the highest probability the observed decisions of the companies for realizing or not realizing a specific energy management activity.[27] Multivariate probit is a system estimation technique which uses the Geweke-Hajivassiliou-Keane (GHK) estimator and which allows for the dependent variables to be correlated, i. e. the binary dependent variables can occur simultaneously or only some of them can occur and the other ones not. Given that the energy management activities (proxying for different strategies) are independent from each other (as are the strategies), this is more appropriate then estimating individual discrete choice models for each of the four dependent variables. As *Table 2* shows, a more formal test also confirms that the four dependent variables are significantly correlated with each other and that therefore estimating a separate model for each of the four dependent variables would lead to biased and inefficient estimates and would thus be inappropriate.

24 See Armstrong, J. S./Overton, T. S.: Estimating Non-Response Bias in Surveys. In: Journal of Marketing Research. Vol. XIV (1977), No. August, pp. 396-402.
25 See Baumast, A./Dyllick, T.: Umweltmanagement-Barometer 2001. St. Gall 2001.
26 See Greene, W. H.: Econometric Analysis. New Jersey 2000.
27 See ibidem.

Table 2: Results of multivariate Logit model

Dependent variable	Energy efficieny	Renewable energies	Emissions to air	Transport energy use
Independent variable	Beta	Beta	Beta	Beta
Considering EMS	0.1238	0.1063	0.1810	0.2727
EMS set-up in progress	0.3359**	0.2886*	0.2047	0.1542
EMS implemented	0.8298***	0.5212***	0.5579***	0.3841***
Market size	-0.0728	0.0141	0.0713	-0.1197**
Firm legal status	-0.0256	0.0615	-0.0956	-0.0420
Firm profitability	-0.0700	-0.0200	-0.0246	0.0646
Firm size	0.0951**	0.0031	0.0361*	0.0065
Firm age	0.0685	0.0075	-0.0364	0.0832
Food	0.3905**	0.1392	-0.2148	0.6160***
Textiles	0.0603	0.0088	-0.4698*	0.1030
Leather	0.0013	0.4699	-0.1741	0.0437
Wood	0.0554	0.5202**	0.5259**	0.4138*
Pulp/Paper	-0.3985	0.8160***	0.0696	0.2743
Print	-0.2598	0.2720	0.2044	0.3811
Energy	0.7819	-4.0687***	-0.4610	-0.5706
Chemical	-0.0433	0.3495*	-0.0822	-0.0431
Rubber	0.4202**	0.0406	-0.0152	0.0877
Nonferrous	0.2449	0.7370***	0.5585**	0.4675*
Machines	-0.5097***	-0.1544	-0.1804	-0.0101
Electric	0.0943	0.2802	-0.0424	0.2086
Transport	-0.3184	0.2049	-0.4900*	0.3915
Other	-0.3224	0.0942	0.1913	0.3040*
Germany	-0.5796***	-0.3696**	0.1413	0.1167
Sweden	-0.6159***	-0.1342	-0.0464	-0.2206
Switzerland	-0.4309**	0.0102	0.2477	0.5143***
United Kingdom	-0.3883**	-0.0185	0.0088	0.0136
Hungary	-0.4335*	-0.3651	0.2937	0.6599***
France	-0.3770	-1.1978***	-0.3049	-0.3289
Belgium	0.0994	0.0058	-0.0251	0.0819
Norway	-0.5147**	-0.0528	-0.2443	-0.3257
Constant	0.5597	-1.1598***	-0.0404	-1.0892***
Number of observations		857		
Degrees of Freedom		120		

Correlations	Renewable energy use	Emissions to air	Energy use in transport
Energy use in production	0.2820***	0.3044***	0.2479***
Renewable energy use		0.2466***	0.2916***
Emissions to air			0.1238**
Likelihood Ratio test of no correlation (H_0: r = 0)		88.1971***	

* significance at the 10% level
** significance at the 5% level,
*** means significance at the 1% level

4 Results

Table 2 provides the results of the estimation and shows as the most important finding that a significant positive association of a firm having implemented an EMS. This fully confirms Hypothesis 1. In addition to this, also for the variable of EMS implementation being in progress which proxies for an organizational innovation, a significant positive association was found in the case of the two dependent variables referring to the reduction of energy use in production and to the substitution of non-renewable resources. This partially confirms Hypothesis 2. In the case of the other two energy management activities analysed empirically, no significant association with the implementation of an EMS being in progress could be identified. In the case of air emissions, this may be because such activities are more driven by regulation and existed anyway before the introduction of an EMS. In the case of reducing energy use in transport, the insignificant association of introducing an EMS may be due to the fact that EMS have a strong focus on production processes and not so much on auxilliary processes in the supply chain, such as transport activities. Therefore, introduction of an EMS may initially help to mainly identify and positively influence activities that are close to the core focus of an EMS, namely production processes. Once an EMS has been established for some time and many activities with regard to production processes have been adopted it becomes more likely, that also auxilliary activities such as energy use of transportation become the focus of the analysis. This interpretation is also consistent with finding a significant positive association for a fully (and long-time) implemented EMS and the reduction of energy use in the transportation activities of the company.

Concerning country effects there is considerable variation in the association with different energy management activities. The association is strongest in the case of energy use in production, but exists only to a lesser degree for the other energy-related dependent variables. Next to country effects, several industry dummy variables are significant relative to the reference group. Associations here are most frequent in the case of fuel substation towards renewable sources, and are least frequent in the case of reducing energy use in production, which may indicate that in most industries efforts are similar with regard to the latter activity whereas in case of the former activity, the potential for switching to renewable fuels varies more across industries. Overall, the variation across industries and countries with regard to the application of different energy management strategies and actions related to these is consistent with Hypothesis 3 and is also confirmed in other cross-country research.[28] Next to country and sector variation, variation in the effects of firm-level variables is also found in the analysis, further confirming Hypothesis 3. Concerning firm size, the direction of the effect is as expected, that is, if there is a significant firm size effect, it is generally positive. Yet, such an effect does not exist for all dependent variables, but only for energy efficiency in production and the reduction of air emissions.

A significant negative association of market size is only found for the reduction of energy use for transportation purposes. This is as expected, since the size of the relevant market correlates with the amount of transport activity. Whilst the firm size effects were positive and significant, they were not economically relevant, that is

28 See Jeswani H.K./Wehrmeyer, W./Mulugetta, Y.: How warm is the corporate response to climate change?, loc. cit.

they have almost no effects on the odd ratios. The result indicates, that that when the market is larger (i. e. European-wide or worldwide), companies seem to be less able to achieve reductions in transport energy use, likely due to their commitments within the supply chain.

5 Conclusions and implications

5.1 Conclusions

There are important conclusions from the empirical results for the interaction of the different determinants for energy management activities and strategies with the EU ETS and the Kyoto Protocol as an economically efficient regulations that can trigger (privately and socially beneficial) innovation activities in the sense of the Porter hypothesis.[29] The dependent variables of the above analysis are factors influencing corporate emission levels and proxy measures for different energy management strategies and are hence related to the demand companies have for emission certificates. If firms carry out activities aimed at energy efficiency improvement or fuel substation activities then certificate demand is (ceteris paribus) lower.

The emergence of the EU ETS and the ratification of the Kyoto Protocol therefore represent a new drivers for innovation in several ways. Firstly, they will drive technological innovation towards cleaner technologies because of increased incentives towards reducing GHG emissions. Secondly, they will trigger organisational innovation by providing incentives for implementing EMS, given the positive association of starting this implementation process (as a form of organisational innovation) with several of the dependent variables in the empirical analysis. This effect of implementing international climate policy instruments makes new links between EMS and corporate energy management strategies possible and in doing increases the efficiency and effectiveness of environmental policy making, as is explained in more detail in the final section.

5.2 Implications

The significant positive effect of EMS implementation on energy management activities that was identified empirically in the regression analysis reported in Table 2 ensures that a mechanism links EMS and climate policy instruments through the effect on certificate demand in that a significant positive effect means that the probability of firms to pursue such activities is positively associated with EMS implementation and EMS implementation being in progress (as one form of organisational innovation). This implies the demand for certificates will be reduced and the significant association of EMS implementation and energy management activities (proxying for the three energy management strategies identified) also ensures that the equilibrium market price for certificates is equal to the marginal abatement

29 See Porter, M. E./Linde C. van der: Toward a New Conception of the Environment-Competitiveness Relationship. In: Journal of Economic Perspectives. Vol. 9 (1995), No. 4, pp. 97-118. - Xepapadeas, A./De Zeeuw A.: Environmental Policy and Competitiveness: The Porter Hypothesis and the Composition of Capital. In: Journal of Environmental Economics and Management. Vol. 37 (1999), pp. 165-182. - Murty, M. N./Kumar S.: Win-Win Opportunities and Environmental Regulation: Testing of Porter Hypothesis for Indian Manufacturing Industries. In: Journal of Environmental Management. Vol. 67 (2003), No. 2, pp. 139-144.

costs from carrying out energy management activities under an EMS. This is because if the marginal cost of energy management activities is lower than the certificate price, then a company acting economically rationally carries out the activity. Conversely, if the cost of the activity is above the certificate price, then the firm would rather acquire certificates and therefore social welfare in a system using both instruments is higher than in one using only either EMS or climate policy instruments alone.

The mechanism enabling this rests on the assumption that EMS implementation enables the correct identification of marginal costs for each activity. If under this assumption the activities are ordered by increasing marginal costs, this implies that up to the point where the marginal cost of an internal activity equals the market price for certificates, a company will carry out all energy management activities below this point. Beyond this point, a company in a system combining EMS and climate policy instruments such as the EU ETS or the Kyoto Protocol will acquire certificates on the market. In addition to this, in such a combined system the optimal emission level of a company (which is inversely related to the extent of energy management activities carried out internally) will decrease, if the market price for certificates increases. This can be the case if certificates are taken from the market by the regulator in subsequent allocation rounds, and means that incremental tightening of such regulation is possible.[30]

Summary

I analyse linkages of implementing international climate policy instruments with energy management strategies of European firms and the empirical determinants of corporate energy management activities. To do so I introduce and discuss basic energy management strategies of firms to address climate change in the context of international climate policy, taking into account the link of energy management to environmental management systems, which enables innovation effects of the emissions trading directive of the European Union and the Kyoto Protocol. I will argue, that there are essentially three strategies for the corporate sector to address climate change by means of energy management whilst at the same time not jeopardizing central business objectives (such as e. g. earnings satisficing or profit maximization). Based on these different corporate energy management strategies, the factors influencing energy management activities linked to the different corporate energy management strategies are then analysed empirically and the results show that the implementation of environmental management systems has a very positive effect on the energy management activities of firms. The paper concludes by discussing the implications of these findings for international climate policy and the interaction of the different empirical determinants for activities and strategies with climate policy initiatives.

30 This again points to the role of economically (more) efficient regulation as a driver especially for eco- or environmental innovation or more generally innovation that next to private benefits for companies also brings about significant social benefits. This role of regulation, as proposed in the Porter hypothesis in the context of tightening emission ceilings is extended into a dynamic perspective similar to the adjustment of tax rates under the standard-price approach used in environmental economics to approximate a Pigouvian tax. As long as a tightening of emission ceilings results in innovation activities which bring about private benefits for companies it increases social welfare in that it triggers (privately and socially beneficial) innovation activities in the sense of the Porter hypothesis.

Zusammenfassung

Der Beitrag untersucht die Interaktion der Implementierung von Instrumenten der internationalen Klimapolitik mit den Energiemanagementstrategien europäischer Firmen und den empirischen Bestimmungsgründen betrieblicher Energiemanagementmaßnahmen. Drei generische Energiemanagementstrategien für Unternehmen werden unter Berücksichtigung des Zusammenhangs zu betrieblichen Umweltmanagementsystemen diskutiert. Dabei werden mögliche Innovationswirkungen der EU-Richtlinie und des Kyoto-Protokolls dargestellt. Im Anschluss daran werden die Bestimmungsgründe betrieblicher Energiemanagementmaßnahmen welche mit den Energiemanagementstrategien in Bezug stehen empirisch untersucht. Es zeigt sich, dass insbesondere die Einführung eines Umweltmanagementsystems in einer positiven Beziehung mit derartigen Aktivitäten steht. Der Beitrag endet mit einer Diskussion der Folgerungen aus diesem Ergebnis für die internationale Klimapolitik und deren Interaktion mit den Bestimmungsgründen für betriebliche Energiemanagementmaßnahmen und -strategien.