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How to reconcile environmental and economic performance to improve corporate sustainability: corporate environmental strategies in the European paper industry

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Abstract

This paper discusses the relationship between environmental and economic performance and the influence of corporate strategies with regard to sustainability and the environment. After formulating a theoretical model, results are reported from an empirical analysis of the European paper manufacturing industry. New data are used to test hypotheses derived from the theoretical model, using environmental performance indices representing different corporate environmental strategy orientations. In particular, an emissions-based index largely reflecting end-of-pipe strategies and an inputs-based index reflecting integrated pollution prevention are distinguished. For the emissions-based index, a predominantly negative relationship between environmental and economic performance is found, whereas for the inputs-based index no significant link is found. This is consistent with the theoretical model, which predicts the possibility of different relationships. The results also show that for firms with pollution prevention-oriented corporate environmental strategies, the relationship between environmental and economic performance is more positive, thus making improvements in corporate sustainability more likely. Based on this last insight, managerial implications of this are discussed with regard to strategy choices, investment decisions and operations management.

Keywords: Relationship; Environmental; Economic; Performance; Econometric; Panel; Analysis; Paper; Industry; Europe; Corporate; Strategy

1. Introduction: a theoretical model of the relationship of environmental and economic performance at the firm level and the influence of strategy choice

The longer-term relationship between environmental performance and economic performance (in terms of both financial/accounting ratios and market-based measures) has been studied for over a decade with a more detailed review of this body of literature provided by Günther et al. (2004), Wagner (2001). Whilst earlier studies are based on both univariate (e.g. Jaggi and Freedman, 1992; Cohen et al., 1995) as well as multivariate (e.g. Cormier et al., 1993; Cormier and Magnan, 1997) analysis, more recent studies apply multivariate techniques (e.g. Cohen et al., 1995; Konar and Cohen, 2001; Ziegler et al., 2002) up to the point of using panel models (e.g. King and Lenox, 2001) and simultaneous equations approaches (e.g. Al-Tuwaijri et al., 2004). Next to empirical analyses with a longer-term time horizon, the short-term relationship between environmental and economic performance is analysed on the basis of so-called event studies, some of which also analyse the effect of environmental disclosure on the short-term influence of environmental performance on economic performance (e.g. Blacconiere and Patten, 1994). The study, which is reported in this paper analyses the longer-term relationship of environmental and economic performance based on multi-variate regression analysis making use of (fixed and random effects) panel models. This is to overcome the deficiencies of univariate techniques and take into account the panel structure of the data.

The objective of this research is to establish the relationship between the environmental performance and economic performance at the firm level in the European Union (EU), based on an analysis of companies in one

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specific industrial sector in four EU countries. The industrial sector chosen for analysis is the pulp and paper industry.[1] The countries in which firms in this sector are analysed are Germany, Italy, the Netherlands and the United Kingdom of Great Britain.[2] The main research question this paper addresses is 'What is the relationship between the environmental and economic performance of firms in specific industrial sectors and what is the influence of corporate environmental strategies on this relationship?'. Corporate environmental strategies (CES) are distinguished here in terms of end-of-pipe and integrated pollution prevention strategies (based on actual physical environmental performance of companies) both of which can also be linked to the Environmental Shareholder Value (ESV) concept of Schaltegger and Figge (1998).

Environmental performance is characterized throughout this paper on the basis of quantitative indicators describing mass, energy and pollutant flows, and different specifications of environmental performance (linked to end-of-pipe or pollution prevention orientations, respectively) are related to the economic performance of firms in order to address the above research question and to identify a possible relationship between environmental and economic performance of firms. An important extension of prior work is that this research accounts for the possibility of a non-linear link between environmental and economic performance.

Following the argument made by Schaltegger and Synnestvedt (2002) an inversely U-shaped curve would represent the 'best' possible case for the relationship between environmental and economic performance, since it allows for the existence of win-win situations with profitable environmental performance improvement activities. Alternatively, if environmental performance improvements can only increase costs and reduce profits for an individual firm, this would not be possible. Under such conditions, the optimal level of environmental performance for a firm would be the one prescribed by environmental regulations, i.e. compliance without over-compliance (represented by the dotted line in Fig. 1 below).

Fig. 1 summarises these considerations in joining both relationships in one graphic representation. This also shows the possibility of the relationship evolving over time due to innovation, as suggested by Porter (1991). This means, that over time, for a defined level of environmental performance,

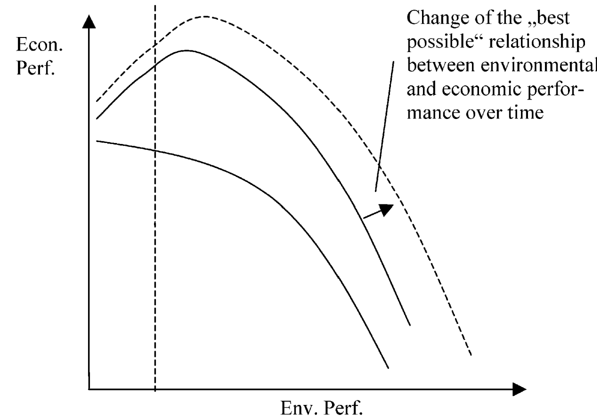

Fig. 1. The link of environmental and economic performance (based on: Lankoski, 2000; Wagner, 2000, 2003; Schaltegger and Synnestvedt, 2002).

the maximum realisable level of economic performance will increase (see Schaltegger and Synnestvedt, 2002).

The hypothesis is now that the relationship between environmental and economic performance of firms is either inversely U-shaped or negative in its functional form (as concluded in Fig. 1), and that strategy orientation with regard to sustainability and the environment (as a result of management's decision making) has some influence on the relationship as well, especially in terms of whether a firm puts its focus on end-of-pipe or pollution prevention strategies, respectively. The influence of firms choosing a particular strategy is captured here through different specifications of the environmental performance measure used in the analysis. Based on this, the following hypotheses are proposed:

H1. Environmental performance has either a uniformly negative or an inversely U-shaped relationship with economic performance, after controlling for other influences on economic performance. It is also possible that no significant relationship exists empirically, if the influence of environmental on economic performance is small compared to other factors.

H2. There is an influence of strategy orientation on the relationship between environmental and economic performance in that the choice of a strategic approach oriented towards pollution prevention results in a more positive relationship than that of an approach oriented towards end-of-pipe environmental protection.

Based on the statistical analysis of a multiple-country data set of firms in the European paper manufacturing industry, the hypothesis derived from the question stated above, that the relationship between environmental and economic performance is either inversely U-shaped or negative in its functional form, can be tested for different types of environmental performance measures reflecting different strategic orientations of a firm with regard to sustainability and the environment. This testing needs to take into account the influence of a number of important

[1] The sector classification is based on the NACE code, i.e. NACE 21.1 (Pulp and Paper Manufacturing).

[2] Apart from the environmental relevance, the sector and the four countries have been chosen because a high number of companies produce environmental reports or site-level environmental statements under EMAS in the pulp and paper manufacturing sector in these countries. These are usually externally validated and guarantee sufficient availability of data. Additionally the paper sector produces fairly homogeneous products, which makes a comparison of physical environmental performance across firms in the sector possible.

control variables. These variables are country membership, processes operated by firms, and firm size.

After briefly sketching out the basic research questions and hypotheses and the theoretical reasoning behind them, Section 2 will provide details on their measurement and on the empirical research methodology. Subsequently results of the econometric analysis are presented and discussed in detail.Section 4 draws conclusions and raises some policy issues.

2. Methodology

This section introduces the methodological approach adopted for the empirical analysis, used to test the hypothesis stated and theoretically justified in Section 1. The research design of the empirical analysis is a statistical design using purposive survey methodology. It includes a number of instruments (various environmental performance indicators (EPIs) and financial ratios), on which data were collected for subjects from one industrial sector, namely the paper-manufacturing sector. In the following, separate sections describe in detail (i) the subjects of this research, (ii) the instruments and measures used, (iii) the statistical analysis approaches and econometric specifications used in the empirical testing of the hypothesis formulated in Section 1 and (iv) the process data collection.

2.1. Subjects

The subjects of this research are firms from four European countries (Germany, Italy, the Netherlands and United Kingdom) in the pulp and paper-manufacturing sector (as defined by the 2-digit NACE code). The firms chosen were either single-site firms (i.e. sites) or firms with very few sites. This was done because the control of common system boundaries is easier for single-site firms and firms with few sites than for multi-site firms with many sites.[3]

Although the paper-manufacturing sector has different relative economic importance in the countries under observation, it contributes in all countries to essential human needs. To improve environmental performance in the paper-manufacturing sector whilst not deteriorating economic performance is therefore essential to ultimately achieve sustainable development and sustainability in this sector and thus a necessary condition for achieving sustainability in the industrial society as a whole. Behmanesh et al. (1993) found the paper sector to be consistently ranked fourth amongst all manufacturing industries with regard to its environmental impacts, which supports the environmental relevance of the paper manufacturing sector and the relevance of environmental aspects of firms' economic performance in this sector.

Regarding the choice of countries included in the first empirical analysis, data availability needed to be sufficient in the paper sector as a whole, as well as in each individual country. These requirements could be met by choosing four European countries, namely Italy, the United Kingdom (UK), the Netherlands and Germany. In Germany as well as the in Netherlands, the extent of corporate environmental protection has achieved relatively high levels. However, in Germany command-and-control regulation is predominant, whereas in the Netherlands, a strong focus is on voluntary/negotiated instruments (e.g. negotiated industry agreements, so-called ‘covenants’). Generally, the economic relevance of the paper sector in all four countries chosen is very high, as can be seen from Table 1 below.

Table 1 shows that with Italy and Germany, the countries with the two largest national paper manufacturing sectors in the EU are included in the data set. With the UK and the Netherlands, two further countries are included, in which the paper industry has relatively lower, yet still significant importance, as confirmed by their respective ranks.

2.2. Instruments and measures

Quantitative measures of environmental and economic performance are particularly suited for an analysis of the relationship between environmental and economic performance for a number of reasons. Firstly, they can often be derived from publicly available information sources, such as financial reports or pollutant release and transfer registers (e.g. the Dutch Emissions Register for Industry (ER-I), the US Toxic Release Inventory (TRI), and the UK Pollution Inventory).

Secondly, quantitative indicators measure the outcomes of firms' environmental management activities and are thus more suited for a description of environmental and economic performance than effort measures (such as the amount of environmental management activities).

Thirdly, environmental performance indicators (i.e. normalised measures of environmental performance) and financial ratios (as well as market-based measures) have been used in several empirical studies to analyse

Table 1
Number of pulp and paper mills and rank of the chosen countries[a]

Country	Paper mills	Pulp mills	Rank paper[a]	Rank pulp[a]
United Kingdom	97	4	5th in EU	10th in EU
The Netherlands	25	2	10th in EU	12th in EU
Italy	210	15	1st in EU	7th in EU
Germany	198	20	2nd in EU	3rd in EU

Source CEPI (1998).
[a] Rank is based on the share (%) of the respective country in total EU physical production of paper and pulp, respectively. The higher the share, the better the rank.

[3] However, there are only very few multi-site firms in Europe and hence proceeding like this did not introduce a bias in the analysis.

the relationship between environmental and economic performance (e.g. Cohen et al., 1995; Hart and Ahuja, 1996; Johnson, 1996; Edwards, 1998; Konar and Cohen, 2001; Ziegler et al., 2002; Al-Tuwaijri et al., 2004). Therefore, in the empirical analysis, no instruments developed specifically for this research are used, but well-established EPIs whose reliability and validity have been extensively tested (for example recently in the MEPI research project, see Tyteca et al., 2002) are chosen. To proceed this way is often advocated over developing new instruments in the literature (Rudestam and Newton, 1992).

The variables used to operationalise the concept of environmental performance are SO_2 emissions, NO_x emissions, COD emissions, total energy input, and total water input, all per tonne of paper produced. Olsthoorn et al. (2001) support the use of these indicators in the paper sector. Also, only for these variables used to operationalise environmental performance were data sufficiently available to allow for meaningful analysis and results (in terms of not reducing too much the representativeness and thus generalisability of the results). Regarding the use of value added instead of physical production output (i.e. tonnes of paper produced) as denominator to normalise absolute environmental performance, there are theoretical arguments justifying the use of either of the two. Physical production output was used nevertheless, since the price of paper on the world markets dropped significantly between 1995 and 1996. It was assumed that this would influence more strongly value added than physical production output. In order to avoid distortions because of this, the latter was used as denominator. This choice is further supported by the high correlation of value added and physical production output in the data set.

In order to use the above individual environmental performance indicators (all normalized to production output) in the regression analyses, two composite indices of these had to be calculated, using the method initially developed by Jaggi and Freedman (1992) in the adaptation used in Berkhout et al. (2001), p. 140 who also explain the precise method for index calculation. The indicators used to calculate scores for the first (outputs-oriented) index score were SO_2, NO_x, and COD. For the second (inputs-oriented) index score, total energy input and total water input were used. The reason for using two indices was, firstly, that differentiation between input and output orientation allows assessment of methodological effects on the results. Secondly, the data were used more efficiently this way, since more cases could be included in the analysis. Thirdly, the inputs-oriented index reflects more pollution prevention, whereas the outputs-oriented index reflects more end-of-pipe activities.

The reason for this last point is that pollution prevention activities have per definition a stronger effect in inputs to production than have end-of-pipe programmes. Therefore, an input-oriented index captures mainly the effect of integrated pollution prevention strategies on economic performance. The ESV concept (Schaltegger and Figge, 1998) argues that their effect on the latter should be more positive than that of end-of-pipe activities. Since end-of-pipe as well as pollution prevention activities both decrease emissions, an (undesired) outputs-based index of environmental performance reflects both strategies. Since ESV argues that end-of-pipe activities have generally a negative effect on economic performance, the relationship of such an index with the latter should be more negative.

Economic performance can be approximated in the short term through accounting-based measures such as profitability. Therefore, in this paper, economic performance is measured in terms of operating profit financial ratios (especially profitability/efficiency ratios). Profitability ratios considered in the following are return on sales (ROS) and return on owners' capital employed (ROCE), and return on equity (ROE). These ratios have been used in studies in the US and Europe (Cohen et al., 1995; Hart and Ahuja, 1996; Edwards, 1998) to assess the relationship between environmental and economic performance and are therefore considered particularly valuable, partly because they allow (at least to some degree) a comparison between the results of studies for Europe and the United States. Since multi-colinearity between these measures is high, they can only be used separately.

Next to the variables to be used to measure the concepts of environmental and economic performance, a number of economic control variables were included in this research in the regressions with economic performance as dependent variable. These are the asset turnover ratio, the gearing ratio/debt-to-equity ratio, firm size and the square of firm size, and country dummy variables. The use of the square of firm size addresses potential non-linearities and this variable is often used in applied econometric work (e.g. Wagner, 1998). Finally, a sub-sector classification was developed for the paper sector, on the basis of which sub-sector dummy variables were defined and included in the regression equations.

Use of the asset turnover ratio has been suggested by Russo and Fouts (1997) and by Schaltegger and Figge (1998) to control for differences in capital intensity. Hart and Ahuja (1996) suggest inclusion of the debt-to-equity ratio to control for differences in capital structure. The debt-to-equity ratio is calculated in this research as the inverse of the solvency ratio, minus one (i.e. debt-to-equity ratio = (1/solvency ratio) − 1). The solvency ratio is defined as the ratio of shareholder funds to total assets.

Next to the variables described above to measure the concepts of environmental and economic performance, respectively, and the sector dummy variables accounting for the sub-sectors firms are operating in, country dummy variables for the four countries in which data were collected for paper manufacturing firms, as well as a variable measuring the size of firms (in thousands of employees) were used as variables in the first empirical analysis of this research. Table 2 lists all variables used in the empirical

Table 2
Summary of variable definitions for all variables used in the empirical analysis

Concept	Variable	Description	Type[a]
Economic perfor-mance	ROCE	Return on capital employed (%), defined as: (pre-tax profit + interest paid)/(shareholders' funds + non-current liabilities) × 100	Continuous (cont.)
	ROE	Return on equity (%), defined as: pre-tax profit (loss)/shareholders' funds × 100	cont.
	ROS	Return on sales (%), defined as: pre-tax profit (loss)/operating revenue × 100	cont.
Environmental performance	COD	Emission of chemical oxygen demand per output (kt/t)	cont.
	SO_2	Emission of sulphur dioxide per unit of output (kt/t)	cont.
	NO_x	Emission of nitrogenous oxides per unit of output(kt/t)	cont.
	Energy input	Total energy input per unit of output (GW h/t)	cont.
	Water input	Total water input per unit of output (1000 l/t)	cont.
Control variables in regression analyses	Debt-to-equity ratio	Inverse of solvency ratio minus one (solvency ratio measured in %, defined as: shareholders' funds/total assets × 100), proxying for gearing/financial leverage	cont.
	Asset turnover ratio	Inverse of turnover-to-asset ratio (GBP/GBP), defined as: total assets per operating revenue, proxying for capital intensity	cont.
Country	United Kingdom	Firm located in the United Kingdom	dummy (dum.)
	Italy	Firm located in Italy	dum.
	Netherlands	Firm located in the Netherlands	dum.
	Germany	Firm located in Germany (reference group)	dum.
Sub-sector	Industrial	Packaging corrugated and other boards	dum.
	Cultural	Newsprint, magazine-grade, graphics fine paper (reference group)	dum.
	Mixed	Cultural and industrial paper production combined	dum.
	Other	Other paper production	dum.
Other	Firm size	Number of employees (thousands)	cont.

[a] In the table, cont. (abbreviation for continuous) and dum. (abbreviation for dummy) refer to continuous (interval/ratio scale) type and dummy type variables, respectively.

analysis of the research. The precise definitions of economic and control variables, as provided in Table 2, are according to Belzer (2000).

2.3. Econometric specifications

The analysis of the empirical relationship of environmental and economic performance of firms involves an estimation procedure based on a panel data model, in which the indicators used to measure environmental performance are considered to influence the economic performance variables which are treated as the endogenous variables. For the analysis, a pooled model based on Ordinary Least Squares (OLS) regression and ignoring the panel structure, a random effects panel data model and a fixed effects panel data model are used. The pooled model ignores the panel structure of the data and is estimated using OLS regression. It has the specification

$$y_{it} = \alpha + x_{it}\beta + z_i\gamma + u_{it} \quad (1)$$

where $i = 1\ldots N$ units under observation; and $t = 1\ldots T$ time periods for which data are collected. In this specification, y_{it} denotes the observation of the dependent variable (economic performance) for a firm i in a period t. $\mathbf{x}_{it}$ represents the set of time-variant independent variables (i.e. regressors), and $\mathbf{z}_i$ the time-invariant explanatory variables.[4]

However, ignoring the panel structure of the data can be problematic for two reasons (Johnston and DiNardo, 1997). Firstly this is because even though the pooled model yields consistent estimates of the regression coefficients, standard errors will be understated and significance levels hence are overstated. Secondly, compared to Generalised Least Squares (GLS) regression, the use of OLS as an estimation method does not result in efficient estimates of the regression coefficients.

To address these problems, two well-established models, random and fixed effects exist. The difference between the fixed effects and the random effects model is based on whether the time-invariant effects are correlated with the regressors (which is the case for the fixed effects) or (in case of the random effects model) not. For the random effects model for panel data, the specification is as in (1), however, with

$$u_{it} = \mu_i + \varepsilon_{it} \quad (2)$$

[4] The errors uit here are assumed to be identically and independently distributed, i.e. the observations are assumed to be serially uncorrelated across individuals and time and the errors are assumed to be homoscedastic, and the assumptions of the classical linear model are met. Under these conditions OLS is an efficient estimation method.

Table 3
Overall coverage of the paper sector in the countries (based on annual production)

	Coverage by sample 1995	Total 1995	Covered by sample 1996	Total 1996	Coverage 1996	Covered by sample 1997	Total 1997	Coverage 1997
Germany	3 775.290	N/a	3 589.170	15 890.000	0.226	3 984.900	16 893.000	0.236
Italy	561.471	N/a	579.199	7 850.000	0.074	801.695	8 415.000	0.095
Netherlands	1 208.100	N/a	1 211.600	3 266.000	0.371	1 275.000	3 316.000	0.384
United Kingdom	1 445.199	N/a	1 424.478	6 812.000	0.209	1 586.923	6 798.000	0.233
All Countries	6 990.060	N/a	6 804.447	33 818.000	0.201	7 648.518	35 422.000	0.216
Countries overall		N/a	33 818.000	79 115.000	0.427	35 422.000	87 408.000	0.405

Sources: own calculations for individual countries, CEPI (1998) for country totals; all values in kilotonnes (kt); country totals refer to production capacity, not actual annual production.

In (2), u_{it} is composed of the disturbance μ_i reflecting left-out variables that are considered time-persistent (in the sense that for each firm i, these remain broadly the same over time) and the idiosyncratic error ε_{it}.[5] For the fixed effects model, other than the random effects model, the assumption is that the individual effect μ_i is correlated with the time-variant independent variables $\mathbf{x}_{it}$. This means that although the basic specification given in (1) and (2) remains, the interpretation differs, in that the disturbance μ_i is a constant (and thus represented by a dummy variable) for each unit of analysis, i.e. here for each specific firm. The fact that the disturbance is a constant in the fixed effects model implies that all time-invariant variables will be dropped during the estimation.[6] To decide which of the two models (random or fixed effects) is more appropriate, the Wu-Hausman and the Breusch-Pagan tests are used.[7]

For testing the research question using the panel regression framework described above, incomplete panel data were used on a set of 37 paper firms in four EU countries (Germany, Italy, Netherlands and United Kingdom) over the period from 1995 to 1997. Table 3 provides an overview of the coverage of the paper sector as a whole in each country for the years 1996 and 1997. For 1995, data on the total production capacity, which were necessary for the assessment of coverage, were not available.

As can be seen from Table 3, percentage coverage changes little in each country from 1996 to 1997 due to the already mentioned even distribution of firms across countries and periods. Coverage is best in the Netherlands (approx. 37–38%) and worst in Italy (approximately 7–9%). However, this is also due to the fact that Italy has much larger total production capacity than the Netherlands. Also, it is necessary to take into consideration that total figures for each country are based on production capacity, not actual production. Thus, the figures are a conservative estimate of coverage. Given that production is always smaller or equal to capacity, coverage may well be better than suggested by coverage figures.

3. Results

This section reports the results found when empirically evaluating the relationship between environmental and economic performance in the European paper industry based on the statistical procedures introduced above (random effects (RE) and fixed effects (FE) panel regressions and OLS regressions). The research hypotheses stated in Section 1 of the paper were tested for two specifications of the environmental performance index (inputs- and outputs-based) during the empirical analysis. Results based on the panel regression framework described in Section 2 are reported in the following.

3.1. Results for the outputs-oriented environmental performance index

This section reports results for the outputs-oriented environmental performance. In addition to the variables

[5] In the random effects model, the disturbance is a random variable, which is, however, constant for each observation of one specific firm. This means that observations of that one firm are considered to be more similar, than those of different firms (Johnston and DiNardo, 1997; Kohler and Kreuter, 2001). In the random effects model, the individual effect μ_i is assumed to be uncorrelated with the time-variant independent variables xit. The estimation method for the random effects model is GLS, which is efficient (Johnston and DiNardo, 1997, p. 391).

[6] The reason for this is, that technically all time-invariant variables (represented by dummy variables) are fully multi-collinear with the (constant) disturbance (Kohler and Kreuter, 2001; Johnston and DiNardo, 1997, p. 397). Intuitively, this means that a change in the dependent variable for a specific unit of analysis for which observations exist cannot be attributed to a time-invariant variable, i.e. it cannot be said, which of the time-invariant variables has caused the change observed in the dependent variable (Kohler and Kreuter, 2001).

[7] If the Wu-Hausman test is significant, then the null hypothesis that there is no significant difference between the estimation results for both models is rejected. Assuming that the model is correctly specified, this implies that the fixed effects model is more appropriate, i.e. it results in consistent and efficient estimates, whilst the estimates in the random effects model are inconsistent. However, if the null hypothesis is not rejected, implying that the random effects model is valid, the fixed effects model still leads to consistent (but in this case inefficient) estimates (Johnston and DiNardo, 1997, pp. 402–403). To also test for the existence of random effects in cases, where the Wu-Hausman test turns out to be insignificant, the Breusch-Pagan test is additionally reported. If the test statistic of the Breusch-Pagan test is significant, the existence of random effects is confirmed. If it is insignificant, then in cases where also the Wu-Hausman test is insignificant, the pooled model based on OLS gives consistent and efficient estimates (StataCorp., 1997).

Table 4
Estimation results for ROCE as dependent variable (outputs-based index)

Model type	Pooled model		RE model		FE model	
Independent variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Environmental index	0.9413	1.8787	2.6506	2.5800	***33.0213***	8.4538
Square of env. index	−0.9618	1.8805	−2.6762	2.5923	−135.906	81.1471
Firm size	0.1486	0.1130	0.1513	0.1475	0.3435	0.2946
Square of firm size	−0.0273	0.0266	−0.0257	0.3508	−0.0443	0.0682
Leverage	0.0200	0.0174	0.0005	0.0221	−0.0523	0.0336
Asset turnover ratio	−0.0276	0.0311	−0.0306	0.0347	−0.0188	0.0406
Other sub-sector	**0.3380**	0.1429	*0.3398*	0.1863	–	–
Industrial sub-sector	−0.0250	0.0772	0.0002	0.1030	–	–
Mixed sub-sector	0.0035	0.0638	0.0202	0.0868	–	–
United Kingdom	**0.1901**	0.0753	*0.1829*	0.1014	–	–
Italy	0.1570	0.1235	0.1379	0.1611	–	–
Netherlands	0.0885	0.0833	0.0520	0.1162	–	–
Constant	−0.0996	0.1144	−0.0695	0.1491	13.6172	10.7321
Number of observations	63		63		63	
R-squared	0.1857		0.1494		0.4310	
F statistic	0.95				***4.04***	
Wald χ^2			7.03			
F statistic (all $u_i=0$)					**2.23**	
Breusch-Pagan test (χ^2)			0.42			
Hausman test (χ^2)					***24.94***	

Bold and italic figures refer to significance at the 5 and 10% levels, respectively. Figures that are bold and italicised at the same time refer to significance at the 1% level.

provided in Table 2, the squares of firm size and the respective environmental performance index were added in the regression in order to account for non-linearities in the relationship, especially for environmental performance, as argued in Section 1 of the paper. The results for the pooled data and the RE and FE models for different economic performance indicators are reported separately in Tables 4–6 for the three measures of economic performance used: return on capital employed (ROCE), return on sales (ROS) and return on equity (ROE). Also, the results of the Breusch-Pagan and Wu-Hausman tests are reported.

As can be seen for ROCE, as dependent variable used to measure economic performance, the model with fixed effects is the best specification, since the Wu-Hausman test is significant. The FE model is also overall significant, and the hypothesis, that no fixed effects exist for any firm (i.e. that all u_i are equal to zero) is also rejected. In the model, the linear term of the environmental index is significant (at the 1% level) and has a positive effect on ROCE. In addition to that, the squared term of the environmental index with a significance of 10.4% is almost significant (at the 10% level) and has a negative effect on ROCE, and the effects are economically relevant. However, the short time-horizon of the analysis cannot fully rule out that some longer-term positive effects are not accounted for and that hence the negative relationship is somewhat less severe than found here.[8] Firm size and its square, leverage, as well as the asset turnover ratio have no significant effect on ROCE. The level of environmental performance, which maximises ROCE in the FE model is equal to an index value of 0.12.

Concerning ROS as a measure of firms' economic performance, it was found that the fixed effects specification is most appropriate (as signified by the significant Wu-Hausman test and rejection of the hypothesis that all individual effects u_i are simultaneously equal to zero).

Results indicate that the linear term of the environmental performance index has a positive, but insignificant effect on ROS whilst the squared term of the index has a significant and negative effect, which is also relevant in economic terms. As for ROCE, not all longer-term effects may be captured in the analysis, since initial capital expenditure reduces profits in the short-term, thus potentially explaining that leverage has a significant negative effect on ROS (1% level). The level of environmental performance, which maximises ROS in the fixed effects model corresponds to an index value of 0.0188. Since the index takes only values between zero and one, this corresponds to a very low level of environmental performance, which is consistent with the observation that only a significant and increasingly negative effect of environmental on economic performance exists for ROS. Firm size and its square have no significant effect on ROS as a dependent variable. As well, the asset turnover ratio was found to be insignificant in the fixed effects model.

For the estimations with ROE as dependent variable, similar findings were made as for ROS. Here again, fixed effects were found to be the most appropriate model. As for

[8] I am grateful to one of the anonymous reviewers for having pointed this out. For the results, this limitation is uncritical, since the paper's argument mainly rests on comparing results for inputs- and outputs-oriented indices.

Table 5
Estimation results for ROS as dependent variable (outputs-based index)

Model type	Pooled model		RE model		FE model	
Independent variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Environmental index	−0.0674	0.7138	0.1024	1.0904	2.7342	2.8037
Square of env. index	0.0563	0.7159	−0.1129	1.1000	**−71.6610**	27.0024
Firm size	*0.0726*	0.0422	0.0609	0.0575	0.0781	0.0979
Square of firm size	−0.0117	0.0101	−0.0085	0.0140	−0.0123	0.0227
Leverage	**−0.0140**		***−0.0221***		***−0.0272***	
Asset turnover ratio	***0.0341***	0.0116	0.0151	0.0116	0.0149	0.0134
Other sub-sector	0.0563	0.0350	0.0408	0.0549	–	–
Industrial sub-sector	−0.0139	0.0275	−0.0087	0.0395	–	–
Mixed sub-sector	−0.0341	0.0249	−0.0274	0.0380	–	–
United Kingdom	**0.0599**	0.0281	*0.0699*	0.0421	–	–
Italy	0.0483	0.0476	0.0455	0.0669	–	–
Netherlands	*0.0562*	0.0309	0.0517	0.0478	–	–
Constant	−0.0285	0.0419	0.0165	0.0575	**8.7277**	3.3084
Number of observations	68		68		68	
R-squared	0.4399		0.3803		0.3114	
F statistic	***3.60***				**2.64**	
Wald χ^2			*20.85*			
F statistic (all $u_i=0$)					***3.66***	
Breusch-Pagan test (χ^2)			**5.89**			
Hausman test (χ^2)					**15.49**	

Bold and italic figures refer to significance at the 5 and 10% levels, respectively. Figures that are bold and italicised at the same time refer to significance at the 1% level.

ROS, the linear term of the index has a positive, yet insignificant, effect on ROE. Opposed to this, the squared term has a significant negative effect on ROE, with the ROE-maximising level of environmental performance corresponding to an index value of 0.0353. This effect is also relevant in economic terms, since a 10% increase in environmental performance reduces ROE by 22.6%, all else being equal. Compared to this the significant negative effect of leverage is relatively small in terms of economic magnitude. As for ROS, leverage was found to have a significant negative effect on ROE in the FE model.

Table 6
Estimation results for ROE as dependent variable (outputs-based index)

Model type	Pooled model		RE model		FE model	
Independent variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Environmental index	1.3953	2.6383	2.7703	3.7803	15.9770	10.5930
Square of env. index	−1.4857	2.6459	−2.8397	3.8100	**−226.0879**	102.0207
Firm size	0.2446	0.1559	0.2332	0.2063	0.4814	0.03700
Square of firm size	−0.0378	0.0374	0.0304	0.0501	−0.0726	0.0858
Leverage	0.0048	0.0231	**−0.0541**	0.0274	***−0.1505***	0.0352
Asset turnover ratio	−0.0148	0.0430	−0.0409	0.0448	−0.0177	0.0508
Other sub-sector	0.2067	0.1293	0.1760	0.1871	–	–
Industrial sub-sector	−0.0800	0.1015	0.0063	0.1372	–	–
Mixed sub-sector	−0.0398	0.0921	0.0029	0.1304	–	–
United Kingdom	0.1501	0.1039	0.1344	0.1449	–	–
Italy	0.2280	0.1758	0.1825	0.2332	–	–
Netherlands	0.1010	0.1142	0.0087	0.1648	–	–
Constant	−0.1196	0.1547	0.0470	0.2041	***26.5516***	12.4999
Number of observations	68		68		68	
R-squared	0.1650		0.0957		0.4662	
F statistic	0.91				***5.10***	
Wald χ^2			11.00			
F statistic (all $u_i=0$)					***3.45***	
Breusch-Pagan test (χ^2)			2.28			
Hausman test (χ^2)					***33.40***	

Bold and italic figures refer to significance at the 5 and 10% levels, respectively. Figures that are bold and italicised at the same time refer to significance at the 1% level.

Table 7
Estimation results for ROCE as dependent variable (input-based index)

Model type	Pooled model		RE model		FE model	
Independent variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Environmental index	−0.7853	1.4843	−0.7853	1.4843	−9.293	34.6386
Square of env. index	2.2771	2.6960	2.2771	2.6960	28.5100	352.7174
Firm size	0.0437	0.1078	0.0437	0.1079	0.1503	0.4495
Square of firm size	−0.0056	0.0256	−0.0056	0.0256	−0.0267	0.0915
Leverage	0.0208	0.0136	0.0208	0.0136	−0.0067	0.0319
Asset turnover ratio	*−0.0470*	0.0274	*−0.0470*	0.0274	−0.1093	0.1047
Other sub-sector	−0.1160	0.1066	−0.1160	0.1066	–	–
Industrial sub-sector	−0.1267	0.7255	−0.0127	0.0725	–	–
Mixed sub-sector	−0.0259	0.0656	−0.0259	0.0656	–	–
United Kingdom	**0.2256**	0.0883	**0.2256**	0.0883	–	–
Italy	0.1207	0.0826	0.1209	0.0826	–	–
Netherlands	0.0540	0.0787	0.0540	0.0787	–	–
Constant	0.0356	0.1186	0.0356	0.1186	0.3707	2.0381
Number of observations	55		55		55	
R-squared	0.3113		0.3113		0.0826	
F statistic	1.58				0.36	
Wald χ^2			*18.99*			
F statistic (all $u_i=0$)					0.58	
Breusch-Pagan test (χ^2)			1.34			
Hausman test (χ^2)					1.49	

Bold and italic figures refer to significance at the 5 and 10% levels, respectively. Figures that are bold and italicised at the same time refer to significance at the 1% level.

3.2. Results for the inputs-oriented environmental performance index

This section reports results for the input-based environmental performance index, again using the panel regression framework described earlier. As for the outputs-based index, in addition to the variables provided in Table 2, the squares of firm size and the respective environmental performance index were added in the regression in order to account for non-linearities in the relationship. The results for the pooled, the RE and the FE models are reported in Tables 7–9, respectively, and also the results of the Breusch-Pagan Lagrangian Multiplier and Hausman specification tests are provided.

Table 8
Estimation results for ROS as dependent variable (input-based index)

Model type	Pooled model		RE model		FE model	
Independent variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Environmental index	0.3741	0.5207	0.4179	0.6436	−9.8877	9.3986
Square of env. index	−0.7689	0.9664	−0.8542	1.1789	75.8150	98.3765
Firm size	0.0616	0.0396	0.0498	0.0531	−0.0155	0.1271
Square of firm size	−0.0084	0.0094	−0.0055	0.0128	−0.0011	0.0258
Leverage	*−0.0097*	0.0049	*−0.0105*	0.0057	−0.0101	0.0090
Asset turnover ratio	***−0.0279***	0.0099	−0.0137	0.0115	−0.0366	0.0278
Other sub-sector	−0.0044	0.0280	−0.0031	0.0433	–	–
Industrial sub-sector	0.0016	0.0250	−0.0205	0.0350	–	–
Mixed sub-sector	*−0.0412*	0.0237	−0.0318	0.0339	–	–
United Kingdom	***0.0873***	0.0304	**0.0898**	0.0444	–	–
Italy	*0.0601*	0.0302	0.0586	0.0425	–	–
Netherlands	**0.0731**	0.0281	0.0530	0.0402	–	–
Constant	−0.0498	0.0431	−0.0299	0.0575	−0.1023	.5305
Number of observations	59		59		59	
R-squared	0.4578		0.4181		0.0951	
F statistic	***3.24***				0.46	
Wald χ^2			15.02			
F statistic (all $u_i=0$)					*1.69*	
Breusch-Pagan test (χ^2)			0.17			
Hausman test (χ^2)					6.92	

Bold and italic figures refer to significance at the 5 and 10% levels, respectively. Figures that are bold and italicised at the same time refer to significance at the 1% level.

Table 9
Estimation results for ROE as dependent variable (input-based index)

Model type	Pooled model		RE model		FE model	
Independent variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Environmental index	−0.9554	1.6794	−0.7280	1.8663	−34.8707	32.6102
Square of env. index	1.4652	3.1169	0.9647	3.4336	241.249	341.3374
Firm size	0.0631	0.1277	0.0659	0.1525	−0.0332	0.4408
Square of firm size	0.0037	0.0303	0.0036	0.0366	−0.0136	0.0897
Leverage	0.0013	0.0157	−0.0084	0.0174	−0.0341	0.0312
Asset turnover ratio	−0.0333	0.0321	−0.0500	0.0355	**−0.2089**	0.0965
Other sub-sector	−0.0298	0.0902	−0.0304	0.1169	–	–
Industrial sub-sector	−0.0110	0.0808	0.0169	0.0979	–	–
Mixed sub-sector	−0.1141	0.0766	−0.1070	0.0941	–	–
United Kingdom	**0.2064**	0.0980	*0.2073*	0.1222	–	–
Italy	0.1562	0.0974	0.1756	0.1185	–	–
Netherlands	0.0782	0.0908	0.0347	0.1116	–	–
Constant	0.0581	0.1391	0.0904	0.1637	−0.0697	1.8406
Number of observations	59		59		59	
R-squared	0.2564		0.2424		0.2108	
F statistic	1.32				1.16	
Wald χ^2			11.85			
F statistic (all $u_i=0$)					1.32	
Breusch-Pagan test (χ^2)			0.04			
Hausman test (χ^2)					5.09	

Bold and italic figures refer to significance at the 5 and 10% levels, respectively. Figures that are bold and italicised at the same time refer to significance at the 1% level.

As can be seen for ROCE as a dependent variable used to measure economic performance, the model with RE is the best specification, since the Hausman test is insignificant (i.e. the fixed effects model is not better than the random effects model in that the estimated coefficients are not significantly different between the two models). Even though the Breusch-Pagan test is insignificant, i.e. it does not reject the null hypothesis that the variance of the u_i equals zero for all i, the random effects model is still preferred over the pooled model, since the former is overall significant, but the latter not. In the model, the linear term of the environmental index, as well as its squared term are insignificant. Also, firm size and its square, leverage, as well as most dummy variables have no significant effect on ROCE. Only the asset turnover ratio has a significant negative effect (at the 10% level) and the dummy variable for the UK has a significant positive effect on ROCE (at the 5% level) in the RE model as well as in the OLS model. However, the OLS model is overall insignificant. The effect of the asset turnover ratio is relatively small in economic terms. A unit increase in the asset turnover ratio would only decrease ROCE by 0.05%, all else being equal (since ROCE is measured in percent). The effect of a firm being located in the UK increases ROCE by 0.23%, relative to the case of a firm being located in Germany, all else being equal.

Concerning ROS, results indicate that the pooled model is most appropriate, since the Breusch-Pagan test is insignificant and since only the pooled model is overall significant. In the pooled model, the linear and the squared term for the environmental performance index are insignificant, as are the linear and the squared term of firm size, i.e. firm size has no significant effect on economic performance measured in terms of ROS. Both leverage and the asset turnover ratio have a significant negative effect on ROS at the 10 and 1% levels, respectively, in the pooled data model.

Concerning sub-sector dummy variables (with the 'Cultural' sub-sector being used as the reference group), the dummy for the 'Mixed' sub-sector has a significant negative effect (10% level) in the pooled model on ROS. Regarding country dummy variables (with Germany being used as the reference group), United Kingdom, Italy and the Netherlands were found to be significant and positive in the pooled regressions for ROS at the 1, 10 and 5% levels, respectively. However, for Italy and the Netherlands, the significant effects in the pooled model become insignificant in the random effects model. Only the positive effect of the United Kingdom (compared to Germany) dummy remains significant at the 5% level.

In terms of economic relevance, for ROS as dependent variable, leverage has a relatively small influence only, since a unit increase in leverage would only result in a 0.01% decrease in ROS, all else being equal, whereas a unit increase in the asset turnover ratio would result in an almost 0.03% decrease in ROS. Sector membership in the 'Mixed' sub-sector reduces ROS by 0.04%, compared to membership in the 'Cultural' sub-sector. Compared to these effects, country membership is more relevant in economic terms, since location in Italy, the Netherlands or the UK increases ROS by between 0.06 and 0.09%, relative to Germany.

Concerning the model with ROE as dependent variable, none of the models estimated is overall significant, nor are the Hausman and Breusch-Pagan tests. Since the pooled and the random effects models do not differ qualitatively, results are reported for these two, given that they are the most suitable ones in the absence of fixed effects (i.e. the hypothesis that all u_i are simultaneously equal to zero could not be rejected). In both, the pooled and the random effects models, both the linear and squared terms of the environmental performance index and of firm size were found to be insignificant, as were firm size and its square. In fact, the only significant independent variable was the dummy for firms located in the United Kingdom. This dummy was positive and had a significant effect at the 5% level in the pooled and at the 10% level in the random effects (RE) model. In terms of economic relevance, location of a firm in the UK increased ROE by 0.21%, relative to a firm being located in Germany. Whilst this is a relatively moderate increase in absolute terms, it is still approximately two to three times higher than the effect observed in the case of ROS. Therefore, the effect is also somewhat relevant in economic terms, at least in a comparative perspective with the other measures of economic performance. All other independent variables in the pooled and random effects models were found to be insignificant.

To end Section 3, the salient results of the empirical analysis are summarized, in particular with regard to their meaning for the research hypotheses H1 and H2. Following this, some more practical comments on the managerial implications of the results are made which bridge to the more general evaluation in Section 4.

One key salient finding of the analysis for all measures of economic performance is that for the outputs-based index of environmental performance, a largely negative relationship, as predicted in hypothesis H1, is found, whereas for an inputs-based index, the relationship is generally insignificant. With the indices taking values between zero and one, the economic performance-maximising values of environmental performance for the outputs-based index correspond to a relatively low level of environmental performance for all three measures of economic performance, ROCE, ROS and ROE. The managerial implication of this finding is, that focusing on improvements of environmental performance in terms of reducing (undesired) outputs (i.e. emissions) from production is unlikely to bring about a positive influence on economic performance beyond relatively low levels of environmental performance. Since an outputs-based index of environmental performance captures the joint effect of end-of-pipe and pollution prevention strategies, this implies that pursuing solely an end-of-pipe strategy is unlikely to result into a positive relationship between environmental and economic performance. This interpretation (which confirms hypothesis H2) is supported in two ways. Firstly, the corresponding result for the different measures of economic performance and an inputs-based environmental performance index (which solely captures the effect of pollution prevention strategies) is that there is no significant negative effect of environmental on economic performance. This means that for higher levels of environmental performance, the relationship is more positive than for an outputs-based index, all else being equal.

Secondly, the ESV concept (Schaltegger and Figge, 1998) provides theoretical justification for this interpretation. In short, ESV stipulates that for a defined level of environmental performance, economic performance can be improved more the stronger the environmental management activities of a company are linked to the key value drivers of shareholder value (Rappaport, 1986). The ESV concept from this derives that efficiency improvements brought about by means of an integrated pollution prevention strategy usually only require limited additional investments (compared with add-on equipment for an end-of-pipe strategy) and may as well result in reduced operating costs and therefore higher profit margins. All of these aspects have a favorable effect on the value drivers of shareholder value and should thus lead to a more potive relationship of environmental and economic performance. This theoretically explains why a pollution prevention orientation empirically results in a more positive relationship of environmental and economic performance. Table 10 briefly summarises all salient results.

4. Conclusions

Based on the results presented in Section 3, the significant coefficients in the panel regressions models are now discussed with regard to the implications they have for the relationship between environmental and economic

Table 10
Summary of results

Research aspect	Finding
Hypothesis H1	Confirmed: no significant relationship for inputs-based index; largely negative relationship for outputs-based index (except ROS: inversely U-shaped relationship)
Hypothesis H2	Confirmed in a comparative perspective: no significant effect of environmental on economic performance for inputs-based index; largely negative effect for outputs-based index
Firm size effects	No significant firm size effects on economic performance
Economic factors	Negative effect of leverage (stronger for outputs-based index)
Sub-sector effects	‘Mixed’ sub-sector has negative effect on economic performance
Country influence	Significant positive effect of UK location on economic performance

performance. Overall, the results confirm the inversely U-shaped relationship between environmental and economic performance formulated at the beginning of the paper for the outputs-oriented environmental performance index in the fixed effects models. The positive part of the relationship was, however, found to be relatively weak. For the input-oriented environmental performance index, where the pooled models are most appropriate, no significant relationship could be detected.

The results obtained for financial leverage in terms of the debt-to-equity ratio in the most appropriate models (fixed effects for the outputs-oriented index and the pooled model for the input-oriented index) do not show a very clear pattern. Generally, the non-significance of leverage in the case of ROCE for both indices is in-line with theoretical reasoning, since theoretically ROCE in the way it is calculated should not be affected by capital structure. Also, the significant negative effect of leverage on ROS and ROE on economic performance in the model with an outputs-based index of environmental performance is consistent with theory. This increases the confidence, which can be put into the basic model specification in terms of the dependent and independent variables. The fact that leverage is less significant for the model with an inputs-oriented environmental performance index should also be noted. Since firms in both regressions are identical, it cannot be explained with different levels of debt finance. Given that the inputs-based index is linked more strongly to pollution prevention, one explanation could be that initial capital expenditure (which reduces short-term profits) is smaller here than for an end-of-pipe approach more strongly reflected by the outputs-based index and that therefore leverage has a less significant negative effect in the set of regressions with an inputs-based index of environmental performance. Beyond this, the gearing/debt-to-equity ratio, as well as the asset turnover ratio (for which similar arguments hold) should partly be understood as necessary control variables in regression models with economic performance as dependent variable, without which equations may be misspecified and, as a result, estimates may be biased.

Firm size has no significant influence on the three economic performance variables in the relevant models (regardless of the type of environmental index) of the empirical analysis. This provides very strong evidence that as far as the effect of firm size on economic performance is concerned, no significant effect exists at the level of one individual industry sector.

Concerning sub-sector dummies in the estimations with the environmental index based on energy and water inputs, the 'Mixed' sub-sector dummy variable has a significant negative effect at the 10% level on ROS. For all other estimations with the index based on energy and water inputs, the coefficients for the sub-sector dummy variables were found to be insignificant. Also, sub-sector dummies were insignificant for all equations with the outputs-oriented environmental performance index based on COD, NO_x and SO_2, except for a significant negative effect (at the 5% level) of the dummy variable for the 'Other' sub-sector on ROCE in the pooled model. However, here the pooled model was inferior to the fixed effects model. Therefore, there is remarkable homogeneity in the results of the first empirical analysis in that of the sub-sector dummies included in the models (when focusing on the most appropriate specification for each estimation) only the 'Mixed' sub-sector has on one occasion only a significant effect on economic performance, which is negative. This seems to indicate that sub-sector influences are likely of lesser relevance.

A negative coefficient for the 'Mixed' sub-sector dummy means that firms in these two sub-sectors have lower returns on sales than firms in the 'Cultural' sub-sector, all other things being equal. In order to interpret this effect it has to be remembered that the 'Mixed' sub-sector was defined as including those firms which produce at least two types of paper of the three basic types (cultural papers, industrial papers and other papers (e.g. tissue)). The basic technological unit of a paper firm (and in this sense a better measure of production technology then the proxies used here based on sub-sector classification) is the individual paper machine. One paper machine can only produce one type of paper in the short term. Therefore, firms in the 'Mixed' sub-sector must have at least two different paper machines producing at least two different types of papers. This observation can be the basis for explaining why firms in the 'Mixed' sub-sector have significantly worse economic performance than firms operating in one highly profitable sub-sector. One argument can be that firms in the 'Mixed' sub-sector cannot realise economies of scale to the same degree as can firms in the other sub-sectors since they have fewer or smaller paper machines for one product. This is purely an effect of production economics, to which the analysis reported here is limited.[9] A related argument here is that the use of different production technologies only allows lower production outputs and therefore does not allow benefiting from economies of scale, which are significant in the paper manufacturing industry (Zavatta, 1993).

As a result of the findings for the country dummy variables in the models estimated in Section 3 of this paper, it can be concluded that if there is a significant difference, firms located in the United Kingdom perform better relative to firms located in Germany. For ROS and the input-based index, firms located in Italy and the Netherlands as well

[9] It would, however, be desirable in future research to also analyse the effect of the 'Mixed' sub-sector on environmental performance resulting from sub-sector membership having a simultaneous effect on both, economic and environmental performance. For example, environmental performance could be lower, ceteris paribus, if firms have smaller and more customised operations as is likely the case in the 'Mixed' sub-sector, where individual production runs consequently may have higher environmental impacts associated with them.

perform relatively better than firms located in Germany in the relevant model (pooled model).

The main research question of this paper was about the relationship between environmental and economic performance and whether a firm's choice of a specific strategy towards sustainability and the environment has a significant effect on it. Strategies were differentiated in terms of pollution prevention (which can be considered, as argued at the end of Section 3, an Environmental Shareholder Value (ESV) oriented strategy) and end-of-pipe (which cannot be seen as an ESV-oriented strategy). The analysis shows that in environmentally intensive industries such as paper manufacturing, it may be difficult to bring about a positive relationship, but that is made easier through a focus on integrated pollution prevention (as a special case of an ESV-oriented strategy). This is evidence in favour of hypothesis H2 of Section 1 and also confirmation that for firms with a pollution prevention strategy (and thus a strong ESV orientation) the relationship is more positive. Since the ESV concept links to the corporate environmental management activities pursued by a company it can also help managers to improve the relationship between environmental and economic performance. The confirmation of this proposition is of particular importance to practising managers.

The management consequences from this are that an end-of-pipe strategy (leading to improvements mainly in the undesired outputs of production processes, such as emissions to air and water, but not many efficiency improvements) results in little positive or even negative effects of environmental performance improvements on economic performance (as was found in the empirical analysis). Therefore, a strategy based on end-of-pipe activities alone should be avoided by management. This finding of the analysis, which indicates that corporate strategies with regard to sustainability and the environment have an important moderating effect on the relationship between environmental and economic performance carries considerable weight for the practical significance of the results of this research. As concerns the implications for future research from this paper, it should be noted that (i) the approach can be extended to various other industry sectors (as e.g. is done in Wagner (2003) for the electricity supply industry) and that (ii) there are indications that the internal (e.g. strategy choice) and external (e.g. market structure) factors influencing the relationship between environmental and economic performance carry different weight in different industries, thus suggesting a situational or contingency approach in future research on this subject. In addition to that, based on the findings reported in this paper, future research needs to take into account more the moderating effect of strategy choices than has been done to date. Furthermore, future research should address the potential endogeneity of the relationship between environmental and economic performance and strategy choice as well as other factors (see e.g. Al-Tuwaijri et al. (2004) and Wagner et al. (2002)) for application of simultaneous equation models to the relationship of environmental and economic performance) and the failure of this study to do so due to data restrictions has to be acknowledged as one of its limitations.

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