An Analysis of the Relationship between Environmental and Economic Performance at the Firm Level and the Influence of Corporate Environmental Strategy Choice

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Zusammenfassung

Die vorliegende Dissertation wendet ein theoretisches Modell zum Zusammenhang zwischen Wirtschafts- und Umweltleistung auf existierende und eigene empirische Untersuchungen an. Die auf Basis des Modells formulierten Hypothesen werden mit eigenen empirischen Daten aus Europa insbesondere mit Bezug auf betriebliche Umweltstrategien und auf input-orientierten bzw. output-orientierten Umweltschutz untersucht. Dies ermöglicht insbesondere eine Bewertung des Einflusses der Strategiewahl. Die empirische Untersuchung basiert auf zwei unterschiedlichen Datensätzen. Es werden zunächst empirische Daten zur Umweltleistung von Papierfirmen in verschiedenen Ländern (Niederlande, England, Deutschland und Italien) untersucht, und dabei bei einer output-orientierten Messung der Umweltleistung ein im wesentlichen negativer Zusammenhang zwischen Umwelt- und Wirtschaftsleistung ermittelt. Bei Verwendung eines input-orientierten Maßes für die Umweltleistung wird ein im wesentlichen insignifikanter Zusammenhang gefunden. In der zweiten empirischen Untersuchung wird im Rahmen einer Befragung von Unternehmen des verarbeitenden Gewerbes in England und Deutschland eine Unterscheidung von betrieblichen Umweltstrategien vorgenommen. Dabei erfolgt auf Basis der Kriterien des Environmental Shareholder Value eine Einteilung der Firmen in solche mit wertorientierten Umweltstrategien und solche ohne spezifische Wertorientierung. Auf Basis dieser Unterscheidung wird die aus der zentralen Fragestellung der Dissertation abgeleitete Hypothese untersucht, dass der Zusammenhang zwischen Umweltleistung und Wirtschaftsleistung für Unternehmen mit einer wertorientierten Umweltstrategie positiver ist als für solche ohne spezifische Wertorientierung des Umweltmanagements. Diese Hypothese wird dahingehend bestätigt, dass für Firmen mit wertorientierter Umweltstrategie ein weitgehend positiver Zusammenhang zwischen Umweltleistung und umweltbezogenen Dimensionen der Wettbewerbsfähigkeit nachgewiesen wird. Für Firmen die spezifisch wertorientierte Strategien haben, wird dagegen kein signifikanter Zusammenhang gefunden.

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List of Abbreviations

AMEX	American Stock Exchange
A/T	Asset-turnover ratio
BCG	Boston Consulting Group
BOD	Biological Oxygen Demand
BOD5	BOD measured according to 5-day method
BOD7	BOD measured according to 7-day method
CAS	Chemical Abstract Service
CAPM	Capital Asset Pricing Model
CEP	Council of Economic Priorities
CEPI	Confederation of European Paper Industries
CES	Corporate Environmental Strategy/Corporate Environmental Strategies
CERES	Coalition of Environmentally Responsible Economies
Coef.	Coefficient
Comp./comp.	competitiveness
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CRI	Chemicals Release Inventory (in the United Kingdom), since beginning of 1998 renamed to Pollution Inventory
CRSP	Center for Research in Security Prices
CSM	Center for Sustainability Management
DE	Debt-to-equity ratio
df	Degrees of freedom
EBEB	European Business Environment Barometer
EBIT	Earnings before interest and taxation
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System/Environmental Management Systems
Env./env.	Environmental
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPI	Environmental Performance Indicator
EPIs	Environmental Performance Indicators
EPS	Earnings per Share

ER	Emissions Register (Netherlands) for the Dutch Industry
EC	European Community
ESV	Environmental Shareholder Value
EU	European Union
FE	Fixed effects
FEEM	Fondazione Eni Enrico Mattei
FT	Financial Times
GJ	Giga Joules
GmbH	Gesellschaft mit beschränkter Haftung (equivalent to a limited company)
HMIP	Her Majesty's Inspectorate for Pollution
ICF	ICF Kaiser International Consulting Group
IRRC	Investor Responsibility Research Center
ISO	International Standards Organization
JERU	Jupiter Environmental Research Unit
JIGIT	Jupiter International Green Investment Trust
KMO	Kaiser-Meyer-Olkin
kt	Kilo tonnes
LCA	Life Cycle Assessment
LSE	London Stock Exchange
m^3	Cubic metres
max./max.	maximum/minimum
MEPI	Measuring Environmental Performance of Industry
MES	Minimum efficient scale of production
MIPS	Material Intensity per Unit of Service
N, n	Number of observations
NACE	Nomenclature generale des Activites economiques dans les Communautees Europeennes
NASDAQ	National Association of Securities Dealers Automated Quotation System
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxide
NPV	Net Present Value
NRA	National Rivers Authority
NYSE	New York Stock Exchange

#Obs., #obs.	Number of observations
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
PhD	Doctor of Philosophy
PRP	Potentially Responsible Party
PRTR	Pollutant Release and Transfer Register
R&D	Research and Development
RE	Random effects
REFS	Really Essential Financial Statistics
RCRA	Resource Conservation and Recovery Act
ROA	Return on Assets
ROCE	Return on Capital Employed
ROE	Return on Equity
ROS	Return on Sales
S&P	Standards and Poor's
SARA	Superfund Amendments and Reauthorization Act
SEC	U.S. Securities and Exchange Commission
Sig.	Significance
Stat./stat.	Statistic/statistic
Std. Dev.	Standard Deviation
Std. Err.	Standard Error
SIC	Standard Industry Classification
SME	Small and Medium-sized Entreprise, small and medium-sized firm
SMEs	Small and Medium-sized Entreprises, small and medium-sized firms
SO_2	Sulphur Dioxide
SR	Solvency ratio
TRI	Toxics Release Inventory in the United States
UK	United Kingdom
US, U.S.	United States of America
WACC	Weighted average cost of capital
WBCSD	World Business Counci for Sustainable Development
WEF	World Economic Forum

1. Introduction, Motivation and Core Concepts

1.1 Introduction

1.1.1 Objectives of and approach to the research

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), and to analyse the influence of corporate environmental strategy choice on the environmental competitiveness of firms. This will be done in a two-stage approach. In the first stage, companies in one specific industrial sector in four EU countries will be analysed. The industrial sector chosen for this analysis is the pulp and paper industry.[1] The countries in which firms in this sector are analysed with regard to the above objective are Germany, Italy, the Netherlands and the United Kingdom of Great Britain[2]. The main research question **"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?"** is in the first stage empirically analysed for a particularly environmentally intensive industrial sector in the EU (i.e. across the four listed EU countries) without taking into account the influence of corporate environmental strategies.

During this first stage, the environmental performance of a company is defined by its physical performance with regard to environmental aspects[3], based on physical environmental performance indicators. An environmental aspect here is defined as an element of an organisation's activities, products or services that interacts with the environment (DIN 1995). Physical environmental performance indicators (EPIs) are one way to describe environmental aspects and thus physical performance. Such physical EPIs describe mass, energy or pollutant flows through the manufacturing process (e.g. the use of energy or water resources or the emissions of pollutants from processes or products), which constitute a direct relationship between firms and the environment. Physical EPIs can be quantitative (i.e. measured on a continuous, interval or ratio scale) or qualitative (i.e. measured on a nominal scale, e.g. when assessing whether a firm is compliant with regard to specific emissions or not).

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[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.

[3] Next to the term 'environmental aspect' the terms environmental pressure, stressor, environmental intervention, loading and environmental burden are also used synonymously in the literature (Olsthoorn *et al.* 2001).

The quantification of mass, energy and pollutant flows through the system boundary between a firm and the environment describes with high precision the environmental aspects of a firm and consequently permits precise and detailed statements about the physical environmental performance of a firm. Therefore, in the first stage of this research quantitative physical EPIs are used, i.e. the physical performance of a firm is measured in quantitative terms.

With regard to the other core concept, economic performance, used in this research, the focus of the first stage of this research will be on measures for short-term profitability, operationalised in terms of common financial performance ratios. As will be discussed later it is rather difficult to define and measure competitiveness, since the factors that lead to the competitiveness of a firm are usually leading indicators, which precede the economic outcomes of firms' operations (measured e.g. as financial ratios) as lagging indicators (Kaplan & Norton 1997; 2001; Olve *et al.*1999; Weber & Schäffer 2000).[4]

In the first stage, the actual physical environmental performance of companies, characterised on the basis of quantitative indicators describing mass, energy and pollutant flows is then linked to the economic performance of firms' by way of an in-depth statistical analysis using mainly multiple regression analysis in order to address the above research question and to identify a possible relationship between environmental and economic performance of firms. Based on the statistical analysis of a multiple-country data set of firms in the European paper manufacturing industry, the hypothesis derived from the main research 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. This hypothesis needs to take into account the influence of a number of important control variables. These variables are country membership, processes operated by firms, and firm size. The results of the first stage indicate that corporate environmental strategies (CES) may have an important influence.

Therefore, based on the results of the first stage, a second stage is then introduced, which is aimed at more directly assessing the influence of firm-internal factors such as firms' corporate environmental strategies on that part of a firm's economic performance that can be influenced by environmental management activities. This was motivated by the observation, that largely a relatively small negative, or no significant relationship of firms' environmental and economic performance was found in the first stage, i.e. that the economic performance measures used seemed not to be influenced much by firms' environmental performance. Therefore, in its second stage, this research analyses the influence of corporate environmental

[4] In the second stage of this research it is however attempted to use measures of economic performance, which are more strongly related to competitiveness and to environmental performance.

strategies on that part of firms' economic performance, which is directly influenced by a firm's environmental management.

The main research question in the second stage is identical with that of the first stage, but in the second empirical research stage, this is expanded by the aspect: **"What is the influence of corporate environmental strategies (CES) on that proportion of corporate success, which is objectively influenced by corporate environmental management[5] (i.e. what is the influence of environmental performance on environmental competitiveness under different CES)?"** In particular, the second empirical research stage answers the question, whether the functional relationship between environmental and economic performance is influenced by strategy choice, and which relationship emerges under different CES choices.

Thus, the relationship between environmental and economic performance is again the focus of the research of the second empirical analysis, but in this second stage, a more specific measure for economic performance is used, and the influence of strategy choice is accounted for.

This second empirical analysis of the research seeks to identify general patterns in the data using a number of statistical methods (including factor and cluster analysis) in order to answer the hypotheses of the second stage. The data basis for this analysis is derived from a cross-sectional survey of the manufacturing industry in two countries (Germany and the United Kingdom) carried out within the framework of a long-term research project (Baumast & Dyllick 2001; Kestemont & Ytterhus 2001; Meffert & Kirchgeorg 1999; Wagner & Schaltegger 2001; Wolter 1999). The specific influences formulated during the first stage of the research were also, as far as possible, tested in the second stage of the research. This included the influences of country-specific legislation, firm size and approaches to environmental management as well as possible differences related to industry sectors/sub-sectors.

Until now, a two-stage analysis of the above relationship at the firm level as described here has not been carried out, due to the lack of physical environmental performance data that is comparable across EU countries and industrial sectors, and due to the unavailability of more direct measures of environmentally-related competitiveness. The research reported in the following is therefore considered to produce an important contribution to the body of knowledge on the relationship between firms' environmental and economic performance, in particular, with regard to the influence of firm-internal factors, especially corporate environmental strategy choices, and as concerns country-level and industry-level influences.

[5] The term environmental management here is referring to every activity of business, which aims at the reduction of its environmental impact, i.e., which aims at improving a firm's environmental performance (Schaltegger & Burritt 2000, p. 113). The term social management could be defined in the same way as every activity that allows the attainment of a firm's social goals, i.e., which improves the social performance of a firm.

1.1.2 Structure of the thesis and its relation to objective and approach of the research

To achieve the objectives stated and detailed above, the dissertation is structured as follows: the remainder of the introductory Chapter 1.1 and the next two chapters define the background of the research and review the relevant literature in order to establish the current state in this research field. In this, Chapter 1.2 focuses on the background of this research in terms of the relevance of the manufacturing sector, the EU's view on the research topic and the relevance of the research topic. Chapter 1.3 provides definitions of the core concepts of environmental and economic performance, as well as corporate environmental strategies. In Chapter 2, Chapter 2.1 reviews the theoretical, and Chapter 2.2 the empirical literature bearing on the research topic of this thesis. Overall, Chapter 2 as a whole attempts to identify trends in research activity in summarising the most relevant conclusions of the research carried out so far. It also aims to evaluate the contributions made so far in this field of research, in order to define areas of theoretical and empirical weakness, which can form the basis of this research.

Chapter 3 introduces the main research question of this thesis and, following this, a number of research hypotheses, which relate to the main research question, are derived.[6] Also, Chapter 3 discusses a number of important variables, as well as their relevance for the empirical research work, based on published theoretical and empirical work bearing on their influence.

Following the introduction of research question and hypotheses, Chapter 4 in Chapter 4.1 initially introduces the subjects, instruments, environmental and economic performance measures and other variables used in the first empirical analysis. Subsequently, it states the procedures adopted for data collection and for statistical analysis of the data. The latter focuses particularly on the econometric specifications used in multiple regression analysis. Chapter 4.2 provides an exploratory data analysis of the data set, focusing specifically on the time periods, sectors/sub-sectors and countries covered by the data set. The aim of this chapter is to ascertain to what the degree the data sets are representative for the underlying firm population. This allows assessing to which degree any results of the subsequent statistical analysis can be generalized. Chapter 4.3 then describes the findings of the statistical analyses applied to the data set for the first empirical analysis. The choice of analyses was

[6] Hypotheses will be partly formulated separately for the first and the second empirical analysis stage of this research. This was necessary, since the two stages are based on two different data sets utilized to test hypotheses. Since these two data sets differ in structure and collected data hypotheses partly had to be adapted to this.

based on the research hypotheses developed in Chapter 3 and the variables used in the study and is explained and justified in detail at the end of Chapter 4.1

Chapter 5 reports the second empirical analysis. In this Chapter 5.1 describes the methodology of the second empirical analysis, in particular with regard to empirical measurement of corporate environmental strategies, environmental competitiveness (as a novel measure of economic performance related to a firm's environmental management activities) and environmental performance. Also it introduces the statistical approach to the analysis (factor analysis, cluster analysis, multiple regression analysis). Chapter 5.2 provides an exploratory data analysis for the data set used in the second stage of the research, with particular regard to the representativeness of the sample. It also provides results of the empirical identification of corporate environmental strategies based on the Environmental Shareholder Value concept and the empirical identification and measurement of different dimensions of environmental competitiveness as well as environmental performance for the second empirical analysis. Chapter 5.3 finally provides results for the relationship between environmental and economic performance under different corporate environmental strategies. This is done separately for the four dimensions of environmental competitiveness identified, namely market-related, internally-oriented, efficiency-related and risk-related environmental competitiveness.

Chapter 6 draws in Chapter 6.1 a number of conclusions based on the results reported in Chapter 4 and 5. It also compares the results of the first and second empirical analysis, i.e. of both research stages. Finally, Chapter 6.2 synthesizes the overall findings of the research to derive recommendations for future research work in the field, implications for business administration and management and for policy making, i.e. for researchers, managers and policy makers.

1.2 Why the relationship between environmental and economic performance and the influence of corporate environmental strategies should be studied

There are at least three compelling reasons, why the relationship between environmental and economic performance at the firm level in the EU manufacturing sector should be studied:

(i) The findings of research into the relationship between environmental and economic performance can provide support to integrating appropriately the environment into industrial and other economically oriented policies which is a key objective of the European Union as stated in Article 6 of the 1997 Amsterdam EC Treaty (see e.g. EC DG Research 2001; European Council 1998; Industry Council 1999; 2001; Hertin & Berkhout 2001; Berkhout 1998a; 1998b).

(ii) Achieving simultaneously high economic and environmental performance in the manufacturing sector is a necessary (but almost certainly not sufficient) condition for sustainable development (see e.g. Elkington 1997; 2001; WBCSD 1996; 2000; Schaltegger & Sturm 1990; 1998; Pearce *et al.* 1993; Van Dieren & Köhne 1995; WCED 1987; Welford 1995; 1996; Welford & Gouldson 1993).

(iii) In order to ensure its long-term existence, it is necessary for industrial economies/ societies to reduce the environmental problems arising from their industrial sector (Jackson 1996; Jackson & Clift 1998, Georgescu-Roegen 1971; 1986).

The background to (i) is that the EU takes the view that de-coupling of economic growth from environmental degradation will contribute considerably to the quality of life in Europe as well as to the competitiveness of European firms. In order to achieve de-coupling it is necessary to reconcile economic and business objectives relating to competitiveness and growth with societal goals such as quality of life and a high quality natural environment. Because of this, the simultaneous improvement of firms' environmental and economic performance towards corporate sustainability is a major goal of the European Commission.

The idea behind (ii) is captured in the concept of eco-efficiency that covers operational changes beyond basic pollution prevention towards minimising throughputs of energy and materials and also includes product changes that involve suppliers and customers (Schaltegger & Sturm, 1990; 1998; Schmidheiny & BCSD 1992; WBCSD 1996; 2000; Reed 1998).

For example, Schaltegger and Sturm (1998) state that "… eco-efficiency as a measured variable for a sustained economic approach will [..] be interpreted and treated as economic-ecological efficiency (Schaltegger & Sturm 1998, p. 16) where "[..] economic-ecological efficiency

measures the pollution caused per monetary unit earned (Schaltegger & Sturm 1998, p. 15)". Here, eco-efficiency is understood as a ratio figure, with Schaltegger and Sturm (1990) suggesting the use of value added as monetary unit for calculating an eco-efficiency figure.
Similar, The World Business Council for Sustainable Development (WBCSD) defines eco-efficiency in terms of a rationale as economic and ecological efficiency (Schmidheiny & BCSD 1992; WBCSD 1996, 2000). Economic efficiency aims to maximise added value while ecological efficiency aims to minimise environmental impact i.e. to minimise use of resources, energy and emissions. From this definition, seven objectives of eco-efficiency are derived and operationalised in the following principles (WBCSD, 1996):

1) Reduction of the material intensity of goods and services (MIPS),
2) Reduction of the energy intensity of goods and services,
3) Elimination of toxic dispersion,
4) Enhancing materials recyclability,
5) Maximising sustainable use of renewable sources,
6) Extension of product durability and
7) Increase of the service intensity of goods and service.

By meeting these seven objectives, according to WBCSD, firms can achieve eco-efficiency i.e. they are able to produce competitively priced goods and services while progressively reducing ecological impact and resource intensity to earth's estimated carrying capacity.
Finally Elkington (1997, 2001) states that eco-efficiency, i.e. the simultaneous achievement of high environmental and economic performance is necessary, but is not sufficient for sustainable development. According to him, what is necessary is "… to make markets work strongly and consistently in support of sustainable development (Elkington 1997, p. 340)" and for sustainable development to "address such issues as population stabilization, poverty alleviation, employment creation, female empowerment, and human rights observance (Elkington 1997, p. 156)".
Concerning (iii), the relevance of the manufacturing sector and its products as part of the industrial sector (i.e. the primary and secondary sectors of an industrial economy) has often been emphasized. Jackson (1996) for example particularly stresses the relevance of the primary/secondary sectors over the tertiary sector. Georgescu-Roegen (1971, 1986) emphasizes the thermodynamic limitations of economic systems, which are particularly relevant to the manufacturing sector, due to the pivotal role it has in most transformation processes.
The manufacturing industry which makes up the largest part of the secondary sector is particular relevant for achieving sustainable development and has therefore been made the

focus of this research. The manufacturing industry has comparatively higher direct environmental impacts than the service sector, and thus *a priori* a higher relevance to achieving sustainable development. In addition to this, focussing on the manufacturing industry ensures sufficient comparability of sectors despite of the diversity in sector characteristics. Although the chosen sectors in the manufacturing industry (NACE codes 15-36) have different relative economic importance in different EU countries, their common characteristic is that they all contribute to essential human needs.[7] To improve environmental performance in these sectors through effective and efficient environmental management activities is therefore essential to ultimately achieve sustainable development and sustainability in the industrial society.

Another reason for the choice of the manufacturing industry is to have sufficient diversity in the scale of environmental impacts, the market structure, the environmental exposure/awareness and therefore ultimately the level and type of environmental management in the sectors. For example, the pulp and paper sector is highly regulated because of its high environmental impacts, whereas textiles and transport equipment are less strictly regulated sectors. Conversely, the different chemicals manufacturing sub-sectors (refined petroleum products, chemical products and plastic products) and the textiles sector are more strongly affected by end consumer demands than the pulp and paper and basic metals/fabricated metal products sectors. In terms of market structure, the pressure from downstream sectors is relatively high e.g. in wood and wood products (due to emerging forestry certification schemes), whereas it is lower in e.g. textiles (given that this sector of the manufacturing industry is close to end consumers and therefore often sets its own eco-standards, thus creating pressure on upstream sectors).

Relatively homogeneous country structures with regard to environmental regulation can be found in Europe, which is one reason, why four EU countries (Germany, Italy, the Netherlands and the United Kingdom) are the focus in part of the empirical work of this research. Another reason for their choice was the good data availability in these countries. Also, most research to date has been carried out in the U.S., which could be complemented by EU results.

The relevance of analysing the influence of corporate environmental strategies on the link of environmental and economic performance lies in the different views of contingency theory (Lawrence & Lorsch 1967) and strategic choice (see Schaltegger & Figge 1998; 1999; 2000 for an application to environmental management) and their implications for this influence.

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7 For example, the pulp and paper manufacturing sector generates annual sales in excess of 400 billion Euros and provides direct and indirect employment for about 4 million employees in Europe (EC DG Research 2001).

1.3 Core concepts for the research

1.3.1 Environmental performance indicators and measurement

Environmental performance can be defined as an aggregate index of emissions and inputs (based on ratio-scale variables) or as an environmental rating (based on ordinal or ratio-scale variables). An environmental performance indicator (EPI) can be defined as a "specific expression that provides information about an organization's environmental performance" (ISO 1999, p. 2). For the purpose of this definition, environmental performance has been defined as the "results of an organization's management of its environmental aspects" (ISO 1999, p. 2). EPIs attempt to fulfil several goals and have a number of functions. These can differ considerably across users. For example, retail consumers might require only simple indicators indicating whether or not a product fulfils certain environmental criteria and an appropriate EPI would be an EU eco-label for textile products. On the other hand, engineers involved in product design activities would likely require more complex information which would allow them to decide on specific design strategies. Such information can be represented by a set of EPIs informing about material and energy consumption of materials across the whole product life cycle and is usually derived using life cycle assessment (LCA) methods (Olsthoorn *et al.* 2001; Cowell 1998).

Reviews of the most relevant recent initiatives for EPIs (see e.g. Olsthoorn *et al.* 2001; Wagner & Wehrmeyer 1999) have so far established common trends in the development of EPIs, as well as theoretical requirements to be accounted for during the development of EPIs.

In addition to that, on the practical side, EPI development is further guided by the reliability of available data to which indicators can be applied. Since different firms and sites base their EPI development usually on common EPI initiatives (e.g. Berkhout *et al.* 2001a; EC 1993; ISO 1999; WBCSD 2000), data availability and data reliability at the firm- or site-level differs at least to the degree that the EPI initiatives themselves differ regarding these points. There is need (and to a lesser degree also a trend) of convergence amongst the initiatives towards a "core" set of indicators, which ultimately should also be highly standardised, i.e. should be based on well-defined data collection protocols to be used by all firms. It is evident, that a high level of standardisation is more easily achieved for a small number of indicators. However, if a small number of indicators is used, it is important to ensure that it covers all significant environmental aspects of a firm's or site's operations. This in turn would require having rather broad indicators covering broad environmental aspects, rather than very specific environmental problem areas. On the other hand, it needs to be ensured that indicators are reflecting the environmental issues of specific industry sectors. In addition to that, EPIs should also allow to some degree a more detailed focus on specific environmental problem areas, since these could be responsible for most of the environmental exposure of a firm or site. In addition to these theoretical aspects EPI development needs to take into account which data is likely available for the application of indicators from standard company records or public data sources. Data sources include, amongst others: cost, production or sales reports; annual financial reports; procurement files; site energy/fuel use inventories; facility management reports; manufacturing reports; plant surveys; EHS reports, as well as estimations and calculation based on these different sources and any public data sources which are based on primary company data from the above report types.

A study by Marsanich (1998) analyses the use of EPIs in EMAS environmental statements based on a sample of 62 certified statements collected by the Fondazione Eni Enrico Mattei (FEEM) Environmental Reporting Monitor. The Eco-Management and Audit Scheme regulation 93/1936/EEC requires participating firms to publicise an environmental statement, which includes data on the evolution of their environmental performance (i.e. a summary of figures on pollutant emissions, waste generation, consumption of raw materials, energy and water, as well as data on noise and other significant environmental aspects, where and as appropriate). Marsanich (1998, pp. 10-11) finds that with regard to management performance indicators, only 28% of the reports provide data, predominantly in the chemicals industry. Regarding air and wastewater emissions, 87% of the environmental statements provide information. Of this data, for air emissions 87% refer to mass flows and 19% to concentrations. For wastewater emissions, 52% of the data refer to concentrations, and only 37% to mass flows of pollutants. Since only 11% of the statements provided data on wastewater volumes this means that not in all cases concentration data can be transformed to mass flow data, which is however a requirement for comparing waste water emissions on a mass basis. As concerns energy use, 97% of the statements provided data, whereas only 93% provided data on waste generation (of which only 80% distinguish between hazardous and non-hazardous waste). Concerning water consumption, 90% of the environmental statements included in the sample provide data, of which 40% provide detailed breakdowns of sources, whereas 60% only report the total volume consumed. Only 60% of the surveyed statements provide data on raw material consumption (Marsanich 1998, p. 11). One direct conclusion from these findings is, that whilst it may be possible to apply EPIs for air emissions, waste water emissions, energy use, water consumption and waste generation, this may prove to be more difficult in the case of raw material consumption. In addition to that, EPIs for waste generation and water consumption are likely to be best available for total generation and consumption, but less likely for specific waste generation or water consumption categories. In summary, environmental performance is a multidimensional concept, which can be sufficiently approximated by means of separate EPIs for specific dimensions, which then need to be aggregated to arrive at a measure of overall environmental performance.

1.3.2 Economic performance and environmental competitiveness

1.3.2.1 Short-term economic performance and profitability

The definition of suitable measures to assess economic performance (i.e. short-term profitability and longer-term competitiveness) at the firm level is a key methodological question with respect to this research. This refers to the issue what quantitative proxy variables should be chosen for all relevant dimensions that need to be measured and to the degree of multi-colinearity that exists between the proxy variables, i.e. the question which of them are redundant or contribute only little to explain the variance found in the data.

Broadly, economic performance can be subdivided into profitability, which can be defined and measured in terms of accepted accounting-based measures, and in terms of longer-term competitiveness. Generally it is rather difficult to define and measure competitiveness, since it is more of a theoretical construct and since the factors that influence a firm's competitiveness change over time and are difficult to identify and measure before they manifest themselves in economic outcomes of the firm's operations in terms of its profitability, returns, market position and stock market valuation. Therefore, the focus of this research will be on measures for short-term profitability in the first stage, but in the second stage will also introduce a measure of environmental competitiveness for which measurement is much easier than for overall competitiveness.

Economic performance in the short term can be approximately measured through profitability. Profitability is to be measured through operating profit financial ratios (esp. 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 U.S. and Europe (Hart & 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 studies for Europe and the United States. Since multi-colinearity between these measures is high, they can only be used separately.

1.3.2.2 Longer-term economic performance and environmental competitiveness

Given the serious difficulties in defining competitiveness, it was not included in the analysis, but instead a measure of environmental competitiveness, which is a necessary condition for overall competitiveness and for which measurement is feasible.

The second stage of this research will analyse the influence of environmental management on economic performance more directly than the first stage using a measure of environmental competitiveness. Lankoski (2000) points out that economic performance is a multi-causal issue, and that therefore any causal effect on overall economic performance (or overall competitiveness) by a single explanatory factor (such as e.g. environmental performance) is likely small. Since "… it seems reasonable to believe that, at least in many cases, the magnitude of the non-environmental costs and benefits surpasses that of environmental costs and benefits. The contribution of environmental profit[8] to overall profit is thus likely to get lost in the noise of all the other factors affecting profit (Lankoski 2000, p. 55)". This would mean that any influence of environmental management or specific corporate environmental strategies (resulting in improved environmental performance) on overall economic performance in monetary terms is very difficult to detect. Lankoski points out, that measuring environmental profit can be very difficult in practice, since it assumes perfect information on the present and future costs and benefits of a particular environmental performance level or environmental performance change (Lankoski 2000, p. 15). Therefore an operationalisation of environmental profit (or, in the longer term, environmental competitiveness) is likely not based on accounting or stock market measures, but likely involves broad ratings, possibly based on the self-assessment of firms. Such an approach was successfully used by Sharma (2001) with U.S. and Canadian firms to measure organizational capabilities and competitive benefits. It requires definition of a set of items to approximate the theoretical concept of competitiveness or environmental competitiveness. Such items can include different drivers, which are hypothesized to increase competitiveness, as well as outcomes, which are perceived to be results of high competitiveness or environmental competitiveness. The European Business Environment Barometer survey, which forms the data basis for the second part of this thesis used such an item battery several times to let firms self-assess the perceived effects of the total of their environmental management activities on a number of drivers and outcomes of competitiveness. An index made of these items or sub-groups thereof can be understood as a measure of environmental competitiveness, i.e. the contribution of a firm's

[8] Environmental profit can be defined as "the isolated net economic impact on a firm of an environmental performance level: the stream of environmental-related costs and benefits discounted to the present (Lankoski 2000, p. 15)".

environmental management to its overall competitiveness. Environmental competitiveness is hence defined as that part of competitiveness or economic performance, which can be influenced by corporate environmental strategies and environmental management. In summary, the concept of economic performance is therefore operationalised in the first stage of the research by means of different commonly used profitability ratios and in the second stage by means of a well-tested item battery to measure environmental competitiveness based on firms' self-assessment.

1.3.3 Definition and measurement of corporate environmental strategy

A corporate environmental strategy (CES) can be defined (based on Mintzberg's definition of corporate strategy)[9] as a pattern of environmentally related management activities in a stream of decisions. Related to this definition, but as well to others, a number of CES typologies have been suggested in the last years, and the latest and most comprehensive reviews of these were carried out by Wehrmeyer (1999) and especially by Kolk and Meuser (2002).

What becomes apparent from the reviews of Kolk and Meuser (2002) and Wehrmeyer (1999) is that to date, the majority of approaches proposed to define and categorise corporate environmental strategies are exclusively deductive. They derive the environmental management type from theoretical deliberations and conclusions. Distinguished from this can be models derived from an inductive approach, i.e. models based on empirical observations (which of course also have a theoretical foundation, but are not exclusively deductive). Next to the distinction between empirically based (i.e. inductive) and theoretically based (i.e. deductive) classifications of corporate environmental strategies (CES), one can also distinguish between ordered (synonymously: linear, stages-based) and unordered classification schemes for CES. Since both dimensions are largely independent, the CES proposed so far can be classified generally in a matrix as exemplified in Table 1.1.

[9] Mintzberg (1989) suggests five different definitions of strategy as plan, ploy, pattern, position or perspective. In this plan means an intended course of action, whereas a specific course of action can be termed a ploy. Pattern defines a strategy as a pattern (whether intended or unintended) in a stream of decisions. This is regardless of whether the pattern is intended (in which case Mintzberg refers to it as an "intended strategy") or unintended (in which case Mintzberg terms it an "emergent strategy"). Position refers to the location of an organisation in the (economic, competitive, societal) environment and is closest to Porter's definition of strategy, whereas perspective is the view from an organization on its environment (Mintzberg 1989; Mintzberg & Quinn 1991).

Table 1.1: Classification of corporate environmental strategy classifications (examples)

Directionality of scheme	**Inductive CES schemes**	**Deductive CES schemes**
Ordered CES schemes	Steger (1996); Dyllick *et al.* (1997)	Hunt & Auster (1990); Roome (1992)
Unordered CES schemes	Kirchgeorg (1990); Wagner & Schaltegger (2001)	Schaltegger & Figge (1998)

One problem with ordered and/or deductive CES schemes is, however, that it is often difficult to fit these with empirical observations. For example, when attempting to classify companies into the ordered and deductive CES model by Hunt and Auster (1990) using empirical data from the Norwegian printing and food processing industries, Hass (1996) reports difficulties when attempting to apply the model. Instead an inductive approach using an empirically based model and cluster analysis methodology were able to classify firms appropriately.[10]

Therefore, the research reported here aims to use empirical data to classify firms' CES based on this information without imposing too much of a pre-defined typology and then links these to the environmental management activities that firms undertake. In doing so, this research bases its analysis on disaggregated variables, which describe individual aspects of firms' behaviour with regard to environmental management activities based on a typology found in the literature, namely the Environmental Shareholder Value concept by Schaltegger and Figge (1998, 1999, 2000). It will be described in more detail in Chapter 5 and forms the basis for deriving firms' corporate environmental strategies using empirical data collected in a survey.

[10] On similar issues see also Ghobadian *et al.* (1998).

2. Literature Review

2.1 Review of theoretical literature

2.1.1 Theoretical literature in economics analysing the relationship between environmental and economic performance

Economic theory provides different perspectives on the relationship between environmental and economic performance from which different predictions about the relationship can be derived. With regard to empirical analyses, Schaltegger and Synnestvedt (2002) argue that this is particularly important. They consider the frequent lack of theoretical foundations for empirical studies regarding the relationship between environmental and economic performance at least equally important as the statistical and data issues involved.

In the current discussion about the relationship between environmental and economic performance of firms it is often argued that there is a conflict between competitiveness of firms (and hence economic performance) and their environmental performance (Walley & Whitehead 1994).[11] For example, this is because at the level of a specific industry, the share of environmental costs in total manufacturing costs might be considerably higher than on average (Luken *et al.* 1996; Luken 1997). Also industries upstream in the production chain (such as primary resource extraction or primary manufacturing) have been shown to give rise to environmental impacts disproportionate to the value added associated with their production activities (Clift 1998; Clift & Wright 2000). Because firms have focused in the past on end-of-pipe technologies as the major approach towards pollution control and environmental performance improvements in general, environmental investments were often seen as an extra cost (Cohen *et al.* 1995).

Based on these considerations, the argument was brought forward that firms in industries with higher environmental impacts face a competitive disadvantage if stringent environmental regulation burdens them with higher environmental compliance costs (relative to total manufacturing or production costs) than other industries. This is the commonly held view of neo-classical environmental economics, which argues that the purpose of environmental regulation is to correct for negative externalities (which diminish social welfare) and that consequently environmental regulation (in internalizing the costs of the negative externality according to the polluter-pays-principle) will generally impose costs on the polluter (usually a

[11] Environmental performance is here understood conceptionally as a firm's total impacts on the natural environment, resulting from its total resource consumption and emissions.

firm). Environmental regulation in this corrects a market failure, which so far has resulted in sub-optimal resource allocation with respect to maximizing social welfare (Endres 1994).

Predominantly, this neo-classical perspective considered market or regulatory failures (in the case that regulation did not take place) as causes of negative (environmental) externalities and has developed a set of public policy instruments (e.g. tradable pollution permits, marketable quotas, assigning complete property rights, environmental taxes, corporate liability standards for firms or command-and-control systems) to address these (for details see e.g. Endres 1994).

Only recently has the notion (termed the “revisionist” view) emerged that improved environmental performance is a potential source of competitive advantage as it can lead to more efficient processes, improvements in productivity, lower costs of compliance and new market opportunities (Porter 1991; Porter & van der Linde 1995; Gabel & Sinclair-Desgagné 1993; Sinclair-Desgagné 1999; Gabel & Sinclair-Desgagné 2001). In this “revisionist” view, environmental regulation is mainly considered to be “… an industrial policy instrument aimed at increasing the competitiveness of firms, the underlying rationale for this statement being that well-designed environmental regulation could force firms to seek innovations that would turn out to be both privately and socially profitable (Sinclair-Desgagné 1999, p. 2)”. The “revisionist” view expands traditional neo-classical environmental economics in assuming that the link between environmental regulatory policy and the allocation of environmental resources is complex, multi-step, and imperfect (Gabel & Sinclair-Desgangé 2001). A number of reasons underpin this view.

Firstly, as Gabel and Sinclair-Desgagné (2001) argue that it would be “… inconsistent, albeit convenient, to assume that markets are flawed but that firms are perfect (p. 149)” and introduces the concept of organizational failures. According to him, these failures “… are analogous in many respects to the problems of externalities in … market-mediated transactions (Gabel & Sinclair-Desgagné 2001, p. 150)” and therefore “ … are relevant to the firm’s management as well … since their manifestation is frequently unachieved profit potential (Gabel & Sinclair-Desgagné 2001, p. 150)”.

Secondly, organisational failures are thought to be systematic and caused by e.g. perverse incentives, imperfect information, moral hazard, hidden actions and strategic behaviour. At the same time, (firm-internal, quasi-regulatory) instruments are at hand to address such failures, including contract design, centralization and decentralization of authority, task allocation decisions, accounting systems and monitoring technologies (Gabel & Sinclair-Desgagné 2001).

Thirdly and finally, organisational failure can be seen as a necessary precondition for the existence of so-called "low-hanging fruits" (i.e. cheap incremental innovations that simultaneously improve environmental and economic performance). However, "standard neoclassical-economics models [..] do not support the systematic presence of low-hanging fruits (Sinclair-Desgagné 1999, p. 3)" since in these models "[..] innovation itself is not free, and if one prices managerial time and all other inputs correctly at their opportunity costs, it should become clear that putting stronger environmental requirements on polluting firms generally increases their production cost more than their revenue (Sinclair-Desgagné 1999, p. 2)". If such increases in production costs (in terms of their proportion of total manufacturing costs), then this should have an observable effect on a firm's profitability. The existence of low-hanging fruits "[..] is logically most likely in situations where the firm is far from the efficiency frontier, where the burden of the compliance cost is light, and where the shift to the frontier can be made cheaply (Gabel & Sinclair-Desgangé 2001, p. 152)".

To sum up, opposed to traditional neo-classic economics, in the "revisionist" view companies facing higher costs for polluting activities have an incentive to research new technologies and production approaches that can ultimately reduce the costs of compliance since innovations can be conceived (in the "revisionist" view) which also result in lower production costs (e.g. lower input costs) due to enhanced resource productivity (Porter & van der Linde 1995). In addition to this companies can gain "first mover advantages" from selling their new solutions and innovations to other firms (Esty & Porter 1998). Therefore, according to the "revisionist" view, at least in a dynamic, longer-term perspective (but possibly even in the short term), the ability to innovate and to develop new technologies and production approaches is a greater determinant of competitiveness than traditional factors of competitive advantage (Porter & van der Linde, 1995).

2.1.2 Theoretically possible relationships between environmental and economic performance

Based on these two contrasting views outlined above two specifications of the direct relationship between environmental performance (measured physically in terms of resource consumption or emission levels) and economic performance (measured monetary in terms of stock market performance or financial ratios, or based on ordinal ratings) can be derived.[12] A first possible specification (based on the "traditionalist" view) would be that the relationship between the two is uniformly negative. This reflects the view of neo-classical economic

[12] For a first detailed discussion of this see Wagner (2000), for further analysis Wagner (2002).

theory, where pollution abatement measures are predicted to solely increase production costs and are assumed to have increasing marginal costs (i.e. pollution abatement and environmental performance improvements are assumed to have decreasing marginal net benefits), whereas no cheap (i.e. privately, not only socially profitable) innovations are possible. This situation is depicted in Figure 2.1 below, where high environmental performance (e.g. low emissions or resource inputs) corresponds to low economic performance (i.e. low profitability or market performance) and vice versa low environmental performance (e.g. in terms of high emissions) corresponds to high economic performance.[13] Generally, economic performance would be required, under the circumstances of Figure 2.1, to be monotonously decreasing with increasing environmental performance, i.e. the first derivative (of economic performance differentiated to environmental performance) is always negative. In addition to that, the second derivative is required to be negative, representing an increasing negative marginal impact of increasing environmental on economic performance.

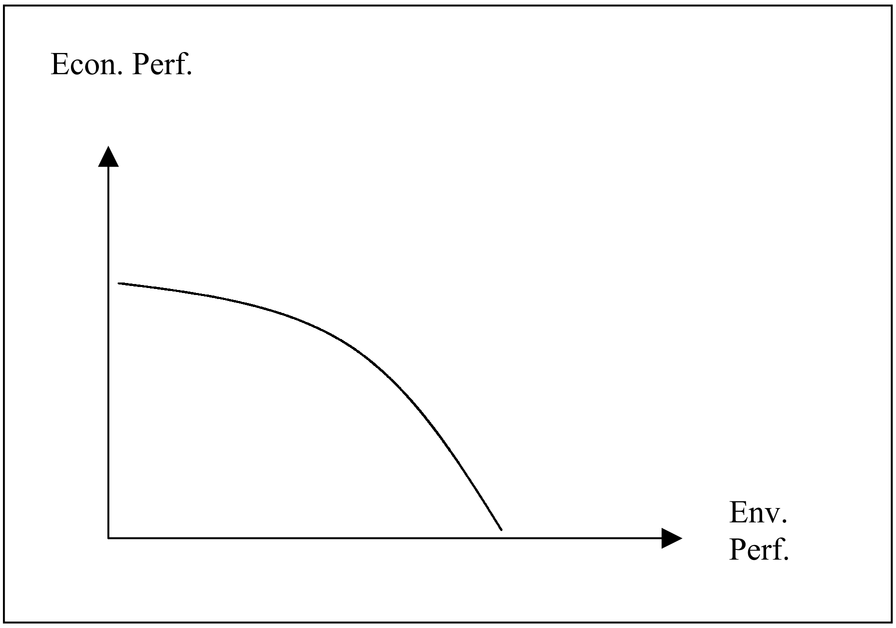

Figure 2.1: The "traditionalist" view of the relationship

Opposed to the "traditionalist" view, under the "revisionist" view, the expected shape of the relationship over the whole spectrum of environmental performance would be an inversely U-shaped (concave) curve with an optimum point (i.e. a level of environmental performance, where the benefits for economic performance net the costs (including opportunity costs) for achieving this level of environmental performance are maximised over the whole spectrum).

[13] In the figures, environmental performance can be either an aggregate index of emissions and inputs, or an environmental rating and economic performance can be an individual financial ratio or an aggregate index of economic performance variables or stock-market performance.

This curve (shown in Figure 2.2) is upward sloping for environmental performance levels below the optimum (which per definition is the point where economic performance is maximized). This means that the benefits reaped from increased environmental performance increase continuously for lower levels of environmental performance. The increasing part of the curve holds up to a certain point around or slightly above average environmental performance.[14] Beyond this point, the relationship is represented by a downward sloping curve, i.e. increased environmental performance corresponds to reduced economic performance. The inversely U-shaped curve proposed to represent the curve under the "revisionist" view has a monotonously decreasing first derivative and a negative second derivative (i.e. a decreasing positive / increasing negative marginal impact on economic performance from increasing environmental performance). In this, the part of the curve, which lies to the left of its maximum point is characterised by a positive first derivative and a negative second derivative. The part of the curve, which lies to the right of its maximum point is characterised by a negative first derivative and a negative second derivative. This specification of the relationship (representing the "revisionist" view) is depicted in Figure 2.2.[15]

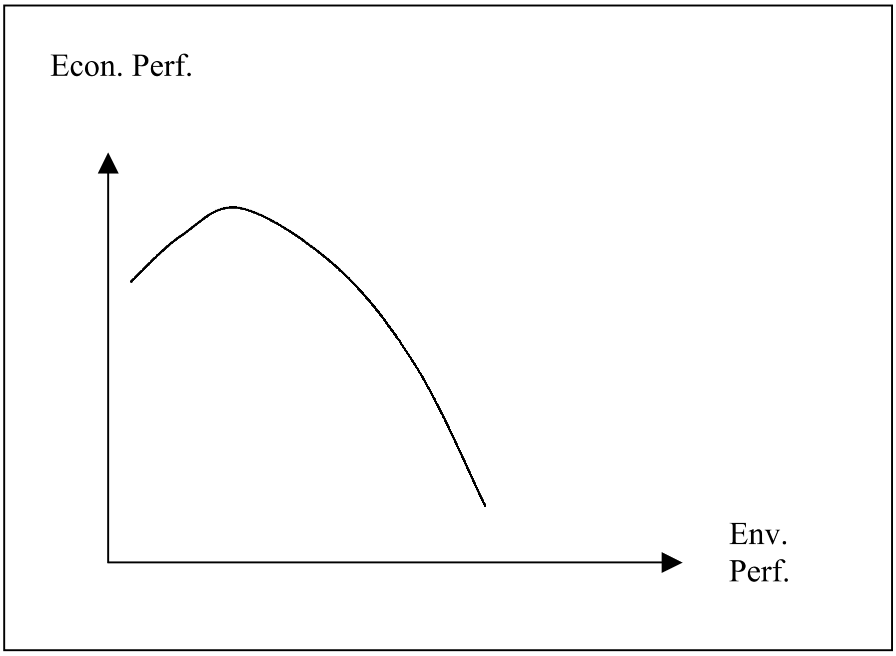

Figure 2.2: The "revisionist" view of the relationship

[14] It would be interesting to find out, where exactly the optimum (i.e. economically efficient) level of environmental performance lies, since this would shed considerable light on the degree to which 'pollution prevention pays'. However, this is beyond the scope of this exposition of possible specifications and will not be discussed further in this thesis, which primarily concerned with the qualitative shape of the functional relationship.

[15] The environmental performance axis and the economic performance axis are defined as before.

2.1.3 Conclusions on the theoretical literature

The theoretical literature on the relationship between environmental and economic performance has certainly been much shaped by the work of Porter (1991), Gabel & Sinclair-Desgagné (1993; 2001) Porter and van der Linde (1995) and Sinclair-Desgagné (1999) pointing to the possibility of a (partly) positive relationship between environmental and economic performance at the firm level. This proposition (also referred to as the "revisionist" view) has however been challenged. The critics (which adhere to the "traditionalist" view) predict an exclusively negative relationship between environmental and economic performance for individual firms (see e.g. Palmer *et al.* 1995). Taking a broader view, the two views represent extremes on a continuum, and more recent theoretical contributions to the discussion on the relationship take a more differentiated view whilst at the same time specifying more precisely conditions under which the "revisionist" vie is most likely to hold true (Simpson & Bradford 1996; Romstad 1998; Xepapadeas & De Zeeuw 1999).

The theoretical literature allows to conclude that approaches in economic theory (particularly standard microeconomic theory and the theoretical reasoning behind the Porter hypothesis) propose the relationship between environmental and economic performance to be either monotonously decreasing (as depicted in Figure 2.1) or to be an inversely U-shaped (i.e. concave) relationship (as depicted in Figure 2.2). Empirically, next to the two functional specifications of the relationship introduced on the basis of theoretical reasoning, a third possible option is that no significant relationship between environmental and economic performance emerges. This would mean that environmental and economic performances are independent of one another. This could either mean, that for a given level of economic performance, any level of environmental performance can be realised. Alternatively, it could also mean, that for a given level of environmental performance, any level of economic performance can be realised. The latter would e.g. be the case, if all firms were just compliant (assuming that the compliance level for all firms is identical) in which case all firms would realise the same level of environmental 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, thus representing the "revisionist" view. On the other hand, a monotonously falling curve would represent the "traditionalist" view. This would correspond to a situation where environmental performance improvements can only increase costs and reduce profits for an individual firm. 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. Figure 2.3 summarises these considerations in joining both relationships in one graphic representation. This also schows 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, the maximum realisable level of economic performance will increase (see Schaltegger & Synnestvedt 2002 for details of this aspect of the relationship between environmental and economic performance).

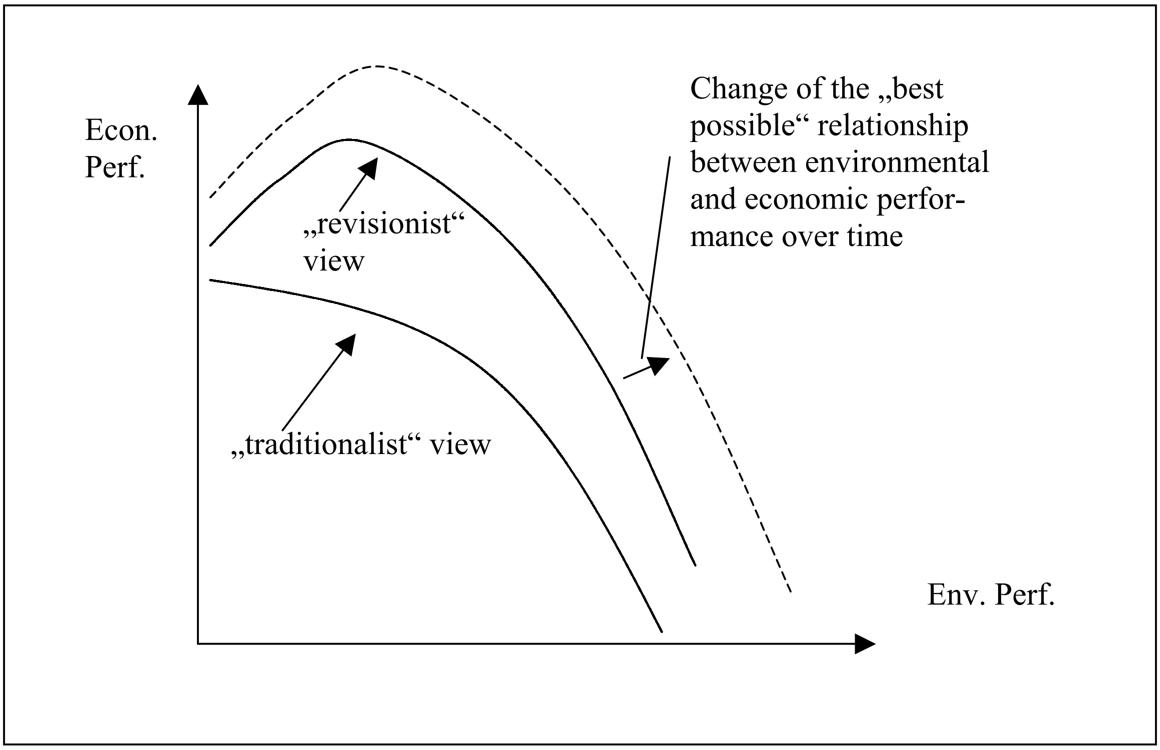

Figure 2.3: Synthesis of "traditionalist" and "revisionist" views (adapted from Schaltegger & Synnestvedt 2002, p. 341)

In summary, the analysis of the theoretical literature on the relationship between environmental and economic performance has therefore resulted in two possible specifications of the relationship between environmental and economic performance, corresponding the "traditionalist", and the "revisionist" views developed in economic theory. In the following, recent empirical studies shall be reviewed in order to establish, which of the specifications is most likely to hold. As will be seen, this also results in a number of questions to be addressed with regard to statistical, methodological and data issues linked to empirical studies on the relationship, which inform the design of future empirical studies.

2.2 Review of empirical literature

2.2.1 Introduction

The **empirical relationship between environmental and economic performance** of firms has now been studied for a considerable period of time. However, for several reasons, no conclusive results have been achieved so far. Firstly, early studies were based on relatively small samples, frequently lacked objective measures of environmental performance and used data that is now almost 25 years old (Konar & Cohen 1997). Frequently, these early studies lacked also objective measures of environmental performance (which is an output measure); early measures used were subjective rankings or pollution control expenditures, which are input measures (Cohen *et al*. 1995). Secondly, empirical studies often made no clear difference between different approaches (at the level of corporate environmental strategies and environmental management activities) towards improving environmental performance (e.g. end-of-pipe pollution abatement and control or pollution prevention at source). Similarly, they often did not account for important moderating factors for the relationship between environmental and economic performance at the firm and industry levels, such as firm size, processes operated, market structure of the industry, country location (which proxies stringency of and approach to regulation) and the production technology used to operate processes. Although at least some of these shortcomings have been addressed in the more recent studies, it is still a problem that often studies ask different questions (e.g. in assessing direct or indirect effects), apply different methodologies or examine different problems without making this explicit (Jaffe *et al.* 1995). Despite of these difficulties, this chapter shall attempt in the following to review those studies and results that are most relevant to this research in terms of their findings and methodologies.

In terms of methodology, studies about the relationship described above can be classified broadly into three groups (Day 1998; Jaffe *et al.* 1995).

- Firstly, **event studies** assess market responses after a positive or negative environmental event and are part of a broader strand of research which assesses the response of capital markets on events related to specific firms or industrial sectors (Blacconiere & Northcut 1997; White 1996a; 1996b; Jones & Rubin 1999; Hamilton 1995).
- A second group of studies looks at **model portfolios** of environmentally proactive and environmentally reactive firms and compare their respective returns (e.g. Cohen *et al.* 1995; Edwards 1998).

- Thirdly, studies apply **multiple regression analysis** to assess the influence of different factors (amongst them environmental performance) on firm profitability (e.g. Hart & Ahuja 1996; White 1996a; Johnson 1996). Amongst the last group of multiple regression studies, a specific type of study are those which add environmental variables to existing validation models (e.g. on predicting a firm's Beta value) to assess the importance of environmental performance levels or environmental management activities, but currently only one such study exists (Feldman *et al.* 1996).

Next to this classification of studies according to **different methodological approaches**, these can also be classified depending on whether they use only (or predominantly) **stock market or financial statement-based performance** data to assess a firm's economic performance. Another classification criterion is which **measures** studies use **for environmental performance** (emission data, pollution control or direct environmental compliance expenditure, or environmental rankings) but this is a rather difficult criterion, given that no universal definition of environmental performance exists. Other dimensions to classify studies are the time period covered and whether direct or indirect effects are assessed or, more generally, the basic research problem and question. These different ways of classifying empirical studies on the relationship between environmental and economic performance also illustrate the difficulty of comparing them amongst each other, since the classification categories can combine in many ways. However, within the different methodological categories, there is often a higher degree of homogeneity amongst studies. Model portfolio studies for example often use environmental rankings to divide firms into different portfolios and often take financial ratios as measures for economic performance. Similarly, regression studies are often based on emission data as a measure of environmental performance. Because of this, research problems and questions within each category are to some degree more comparable than across categories. It was therefore decided to compare studies according to methodological categories as far as possible and to otherwise mainly report results as well as the specific environmental and economic performance measures utilised by each study.

With regard to the geographical scope of empirical studies, these have the longest tradition in the U.S. where the relationship between environmental and economic performance at the firm or industry level has now been studied for over two decades. Also studies based on quantitative emission data have been almost exclusively carried out there, since the U.S. The Toxic Release Inventory (EPA 1997) mandates standardised emission reporting for a large number of firms in several industries. In the EU, a similar analysis using quantitative emission data has not been possible so far, due to the lack of physical environmental performance data that is comparable across EU countries and industrial sectors. Although some countries have emissions inventories similar to the TRI (such as the UK and its Chemicals Release Inventory (since 2000 renamed to Pollution Inventory) and the Dutch Emissions Register ER), data is often not comparable across inventories in different countries, due to different data collection standards and procedures. In the following, this chapter first reviews early studies, almost exclusively from the U.S., where these are defined somewhat arbitrarily as studies before and during 1992 (although this coincides with the Rio Summit and the subsequent emergence of various new initiatives in industry). The chapter then analyses in more detail recent studies published after 1992 and finally will tentatively summarise and evaluate their results.

2.2.2 Early studies

Four early studies (see Table 2.1 below), based on the same environmental performance data found both a significant link between environmental performance and financial performance as well as no relation between these (see Bragdon & Marlin 1972; Spicer 1978; Chen & Metcalf 1980; Ingram & Frazier 1980). All four analyses were based on pollution control record data published by the Council on Economic Priorities (CEP) for the petrol refining, steel, pulp and paper and electricity industries.[16] CEP indices are based on anecdotal information about regulatory compliance and the extent of proactive recycling or waste reduction programs, and CEP data was at the time the three studies were carried out the only reliable source of data on environmental performance (Cordeiro & Sarkis 1997). Significant correlation between financial performance and environmental ratings based on the pollution control records published by the Council of Economic Priorities (CEP) was found for the pulp and paper sector by Spicer (1978), but disappeared when differences in firm size were taken into account by Chen and Metcalf (1980). Spicer (1978) did not control for size in his analysis and Chen and Metcalf (1980) claimed that therefore the links he found might have been spurious and caused by not controlling for firm size. In another study using CEP ratings, Ingram and Frazier (1980) found no significant correlation between environmental and financial performance for 40 firms in four industries classified as pollution-intensive, based on CEP ratings of the firms' pollution performance. In summary, the overall evidence of the earliest studies seems to be that no clear significant (positive or negative) relationship between environmental and financial performance could be identified.

[16] CEP was founded in 1969 to inform the U.S. public on corporate performance on social issues and has published several reports on the social performance of various firms and industries (White 1996a; 1996b).

In another early study Jaggi and Freedman (1992) analysed the relationship between pollution disclosure and pollution performance, as well as the relationship between pollution disclosure and economic performance. It covered 109 firms during the fiscal years 1973-1974 and used annual statements and 10-K forms of firms in high polluting industries. No significant correlation between different indices measuring pollution disclosure and economic performance was found.[17] Opposed to this, Mahapatra (1984) when comparing pollution control expenditures in six industries with average market returns found negative correlation between environmental and market performance. The differences in the studies of Jaggi and Freedman (1992) and Mahapatra (1984) therefore illustrate the difficulty of comparing results when environmental and economic performance measures differ.

White (1991) using data from mutual funds that employed social responsibility criteria for screening found that these under-performed the Standard and Poor's (S&P) 500 index both, nominally and risk adjusted. However, Cohen *et al.* (1995) found (as discussed in more detail below when analysing the recent studies) no negative impact on market returns from investing in firms with high environmental performance. As an explanation for this discrepancy they suggested that financial performance of funds is not so much dependent on social or environmental criteria but on the quality of fund management. This is another example of the difficulties, which are encountered when comparing studies, which in this case differ in the level of aggregation of the unit of analysis (investment funds versus firms). In a later study using a data-set on social performance of firms manufacturing consumer products published by CEP (Shopping for a Better World), Erfle and Fratantuono (1992) found significant positive correlation of firm environmental performance and return on assets, return on investment and return on equity. This again illustrates how different measures can lead to different results. Table 2.1 summarises the early studies analysed.

[17] Indices consisted of various financial and operational ratios.

Table 2.1: Summary of results for earlier analyses

Data set	**Environmental performance measures and data**	**Economic performance measures and data**	**Major findings**
Bragdon & Marlin (1972)	CEP environmental performance measures based on pollution control records	Earnings per share growth, average return on equity and average return on capital	Significant positive correlation
Spicer (1978)	As above	Amongst others, market performance variables	Significant positive correlation for pulp and paper industry
Chen & Metcalf (1980)	As above	Unknown	No correlation, when firm size differences considered
Mahapatra (1984)	Pollution control expenditures in six industries	Average market returns	Negative correlation for a larger sample and time period
White (1991)	Social responsibility screening criteria of mutual funds	Nominal and risk-adjusted performance of the fund	Slight under-performance of “ethical” funds relative to Standard & Poor’s 500 index
Erfle & Fratantuono (1992)	CEP reputation indices of environmental performance	Return on assets, return on equity, and return on investment	Positive and significant correlation between environmental and economic performance
Jaggi & Freedman (1992)	Daily BOD, TSS and pH data, adjusted for firm size and aggregated into an Overall Pollution Index	Net income, return on equity, return on assets, cash flow/equity, cash flow/assets	Economic performance negatively associated with pollution performance in the short-term

Overall, looking at Table 2.1, the conclusion for earlier studies seems to be that they are largely inconclusive, since they find both, significantly positive as well as significantly negative relationships between environmental and economic performance, as well as no significant relationship at all. However, these results may also have been influenced by unavailability of comparable and meaningful data on the environmental performance of firms or by small sample sizes. After the 1992 Earth Summit in Rio, the attention given to the interrelation between environmental and economic performance has increased considerably. Partly as a result of this, much more comparable data was made available since then, thus allowing broader and larger studies on the relationship between environmental and economic performance at the firm level, in particular in the United States. These will be discussed in the following section, with the cut-off date being the end of 1999.

2.2.3 Recent studies

More recent studies, which were able to avoid some of the limitations of the early research use both, stock market-based and financial statement-based measures and can be classified according to the classification scheme provided in Table 2.2 (names refer to the citation of the study in the references and the year refers to its publication). Depending on the key feature of the methodological approach taken, studies can be classified in three groups (event studies, (model) portfolio studies, and (multiple) regression studies, including extension of validation models). In each group, either only stock market performance or only financial performance based on accounting profitability measures or both of them can be used to assess the economic performance of a firm. The second row of Table 2.2 therefore lists studies that only apply stock market performance measures to assess economic performance. The third row titled 'financial performance' refers to studies that either use only accounting profitability measures or use these predominantly, but also assess to some extend stock market performance. It is interesting to note, that next to these two sets of performance measures, others were only applied in one case: Cordeiro and Sarkis (1997) use industry analyst's earnings-per-share forecasts, which are partly based on stock market and partly on historical accounting information. Apart from that, measures that are not based on stock market data or historical accounting data (which both have limitations in assessing a firm's competitiveness) are never adopted. Such measures could be the relative market share of a company, the ratio between the firm's sales growth rate and the market growth rate, or measures based on portfolio planning concepts, such as the Boston Consulting Group (BCG) matrix. Although these measures have other limitations, they nevertheless can give additional insights in a firm's longer-term economic performance. Also it has to be noted that certain methodological approaches are implicitly limited to certain measures of economic performance. This is especially the case for event studies, which can only use stock market-based measures (such as excess returns) since only those are re-assessed on a short-term (here daily) basis, which is a precondition for assessing event effects.

Table 2.2: Different types of studies

Type of study	**Market performance**	**Financial performance**
Event studies	Barth & McNichols (1994) Hamilton (1995) Blacconiere & Northcut (1997) Klassen & McLaughlin (1996) White (1996a; 1996b)	Financial statement-based performance measures can not be used in the context of event studies, due to their requirement of using daily data
Multiple regression studies	Feldman *et al.* (1996) Butz & Plattner (1999) Thomas & Tonks (1999)	Johnson (1996) Hart & Ahuja (1996) Cordeiro & Sarkis (1997) Konar & Cohen (1997; 2001)
(Model) portfolio research	Diltz (1993; 1995) White (1995; 1996a)	Cohen *et al.* (1995) Edwards (1998) Steinle *et al.* (1998)

2.2.4 Event studies

2.2.4.1 Introduction

One particular type of study in the past has focused on market reactions following events involving information on low or high environmental performance of firms. Such events can be product recalls, public disclosure of oil spills, awards of environmental prices to firms, publication of external ratings of pollution performance such as data of the U.S. Toxic Release Inventory or announcement of high expected future pollution abatement expenditures (Konar & Cohen 1997; 2001). These events are analysed using event study methodology. Event study methodology is based on Efficient Market Theory, which assumes that share prices of publicly traded firms include current and expected firm financial performance in the market valuation, based on all publicly available information (Fama 1970). Therefore, a change in stock return following an environmental event being publicised implies that the market imputes a change in the net present value (NPV) of a firm as a result of this event

(Klassen & McLaughlin 1996). One characteristic of event studies is, that they can only be based on stock market-based company performance data (more precisely: on significant differences between actual and expected returns). This implies that event studies can only use stock-listed firms, which for example precludes the use of site-level data in almost all cases.

2.2.4.2 Specific studies

In an earlier event study, Barth and McNichols (1994) found that market valuation of firms includes assessment of future Superfund liability, although such type of liability reflects only past environmental performance. The study used annual reports and 10-K forms and financial and market data from Compustat and the Securities Data Corporation databases for 257 firms in four industries (utilities, automobiles, chemicals and appliances) over the period 1989-1993. These industries were chosen because of their high level of Superfund exposure.

In another event study, Hamilton (1995) found negative, statistically significant abnormal returns for 463 firms required to report emissions under the Toxic Release Inventory (TRI) when these were publicly released for the first time in June 1989. The market value of publicly traded firms dropped 0.3 per cent, the equivalent of $4million. In addition to this, the greater the difference between emissions reported prior to the first TRI data release (referring to TRI emissions reported for 1987) and the TRI results the higher were the stock price changes for a firm. Firms for which the release showed little or no difference between TRI data and prior available data outperformed chemical industry stock market indices. It was suggested that this would indicate that stock market reactions are not only based on the level of emissions, but also on the levels of disclosure and magnitude (Cordeiro & Sarkis 1997; Ganzi 1997; Cohen *et al.* 1995).

Blacconiere and Northcut (1997) carried out an event study on 72 companies in the chemical industry over the time period from February 1985 to October 1986. Based on 10-K forms they studied the market reaction (daily abnormal market returns) following the legislative events leading to the U.S. Superfund Amendments and Reauthorization Act (SARA) of 1986. Next to the 10-K forms utilised prior to SARA, Dow Jones News Retrieval, EPA Superfund data, Notice Letters and Records of Decision as well as the Compustat financial database were used to gather data on events and stock market performance of involved firms, respectively. Overall **stock market reaction** to SARA enactment was found to be **negative** with specific legislative actions (votes by Congress, decisions by Congressional committees or executive branch actions) leading to SARA resulting in negative abnormal returns. The correlation between firm-specific market reaction (in terms of cumulative abnormal returns) to specific legislative events was found to be significant at the 10% level, indicating that environmental disclosures in financial and environmental reports, as well as EPA information were individually relevant in explaining share value changes. This finding supports partially the hypothesis that **more environmental disclosure by firms results in less negative stock market reaction**, although results were found to be sensitive to the measure of environmental disclosure adopted. The most significant correlation was found for a variable proxying the maximum expected costs under joint and several liability. Also regression analysis found that further information disclosed by firms does not significantly reduce uncertainty concerning company exposure to Superfund liability. Overall, the evidence provided by Blacconiere and Northcut (1997) suggests that **extensive environmental disclosures** by a firm are interpreted by the stock market (i.e. investors) as a **positive** indication of a firm managing its regulatory costs well.

White (1996a) attempted to investigate whether a firm's intent to pursue more proactive environmental management activities would be rewarded by the stock market. This was measured by the formal adoption of the CERES principles by a firm. These principles require firms to use natural resources in an energy efficient and sustainable manner, to adopt pollution prevention, waste reduction and recycling activities and to properly inform and consult the public about its environmental performance and policies.

However, only six of the 56 firms that had signed the principles by mid-1995 were listed on either the New York or American Stock Exchange or the National Association of Securities Dealers Automated Quotation System (NASDAQ), which was a precondition for applying event study methodology. These were Ben and Jerry's Homemade Ice Cream, HB Fuller Company, Sun Inc., Timberland Co., General Motors and Polaroid Corporation. Only for these six firms daily stock returns were available from the Center for Research in Security Prices (CRSP) files, and consequently, White's event study only included these six firms, leading to a comparatively small sample.

To determine to what extent an event resulted in abnormal or excess returns, a market model was estimated for each of the six securities over a 255 trading day period ending six trading days before the event date which was defined as the day the firm signed the CERES principles. Abnormal returns were then standardised to allow the variation in the market during the estimation period to differ and to adjust for the number of observations in the estimation interval. Also, differences between firms in the effect of signing the principles were corrected for.

Using an eleven-day test period the study indicated an **immediate and significant increase in returns** the day after firms signed up to the CERES principles and found on average a 1.05 % increase in returns for the day after signing the principles (White, 1996a). However, it has to be noted that the positive wealth effect observed **was not persistent** and that the small sample size (n=6) made interpretation of these results more difficult, although the results were not due to the response of only one firm in the sample.

In another event study, White (1996b) tested several hypotheses on investor responses to the Exxon Valdez oil spill in Alaska, using Centre for Research in Security Prices (CRSP) daily stock price data. Proxying the market portfolio by returns on the CRSP value-weighted stock return index (including dividends) hypotheses were tested using Exxon itself as well as different portfolios of firms linked to Exxon (and therefore potentially liable), Exxon's ten largest retail competitors and portfolios of firms rated for their environmental performance by the Council of Economic Priorities (CEP). The study period was form March 1988 to September 1989 with Day 0 defined as 27 March 1989, which was the first stock market trading day after the Exxon Valdez oil spill accident.

Using broadly the same methodology as White (1996a) to estimate market models, standardised average abnormal returns for the event windows (-1,0), (0,+30), (0,+60), (0,+90) and (0,+120) relative to the event date (set t=0) were used to test the significance of the average abnormal return during any day t. The market model was estimated for each firm in the sample based on a 255 trading day period (ending two days prior to the event). This allowed estimating intercept and slope parameters through OLS regression. These parameters were then used to calculate abnormal returns for each share above or below the return predicted from the market model for a number of days after the event. Abnormal returns were in turn averaged over the number of firms in the sample (e.g. the group of firms linked to Exxon and its ten biggest retail competitors). Average abnormal returns were subsequently standardised, using the standard deviation of returns in the 255 trading day period ending two days before the event day.

The research found **significant cumulative and lasting negative abnormal returns for Exxon itself** on the days 5 and 10 after the oil spill accident of magnitudes -2.03% and -1.77% respectively. No significant abnormal returns were, however, found for the firms potentially liable together with Exxon and for its retail competitors. Although, no one-day abnormal returns were found for either of the three portfolios constructed based on CEP ratings, **significant positive cumulative abnormal returns were found for firms with above-average environmental performance** for the (0,+30) and (0,+90) event windows in the magnitude of 5.44% and 11.20% respectively. Thus, firms rated environmentally proactive by CEP were found to experience superior risk-adjusted returns compared to firms rated average and under-average environmental performers after the Exxon Valdez oil spill event. No superior stock market performance after the event was found for firms with average environmental performance, however, compared to firms with below-average environmental performance (i.e. a low CEP rating). Average environmental performers had better stock-market performance, though not at a high level of significance.

Overall, White (1996b) therefore provides **limited evidence, that a negative environmental event can affect negatively stock market returns of the firm directly involved**. The findings, however, also indicate, that indirect effects on firms potentially affected by litigation, as well as on other firms in the industry are likely much smaller. In addition to that, although firms with above-average environmental performance (as indicated by their CEP rating) showed significantly superior economic performance (i.e. positive average cumulative returns), whereas firms with average or below-average environmental performance did not.

In the last event study to be discussed, Klassen and McLaughlin (1996) found significant positive returns for strong environmental management and significant negative returns for weak environmental management.

Their theoretical model proposes two pathways that link investments in environmentally compatible products, processes and management systems to better financial performance (i.e. higher profitability or stock-market performance) through (a) market (revenue) gains or (b) cost savings, but the study only researches the second pathway of improved financial performance through cost savings.

As measures of environmental performance the study uses negative environmental events, e.g. product recalls, poor external ratings of pollution performance or announcement of oil spills and positive environmental events, specifically the announcement of environmental awards by an independent party or environmental certifications to assess market reactions to these events. These events were operationally identified by keyword searches of the NEXIS database.

Over the period 1985-91 a sample of 140 positive events were identified, covering 96 firms publicly traded on either NYSE or AMEX, which included 14 of the 20 manufacturing sectors (as based on SIC codes). In the same way as for positive events, the database was searched to identify negative events (i.e. environmental crises). Over the period 1989-90 a sample of 22 observations, covering 16 firms was identified.

Stock returns were used as a measure for firm's financial performance. Data on stock returns was obtained from the CRSP database and an equally weighted index of all securities traded on the NYSE and AMEX was used as a proxy for the market return.

A market model was estimated (using OLS regression) for each of the firms in the sample over a 200 trading day period ending ten trading days before the event date which was defined as the day the event was initially announced. The study then used a three-day event period (including the days immediately prior and after the event announcement and the day of the announcement itself) to calculate possible abnormal returns for each event.

As a result, the study found significant abnormal returns for first-time environmental awards, where announcements led to greater increases in market valuation. Relatively smaller increases were observed for first-time announcements of firms in high-polluting industries, revealing possible inter-industry differences between high and low polluting industries. As an explanation for these differences, greater scepticism in the evaluation of environmental performance in high-polluting industries is suggested by Klassen and McLaughlin.

The average cumulative abnormal return found for environmental awards was 0.63%, with the average environmental award having a market valuation of $80.5 million, equalling roughly $0.37 per share.[18] Similarly, the average cumulative abnormal return for an environmental crisis was found to be –0.82%, with the average environmental crisis having a market valuation of -$390 million, equalling -$0.70 per share.

In summary, **significant abnormal returns were found for both, crises and awards**. These remained stable and significant when contemporaneous financial and management announcements and firm size effects were accounted for. These results strongly support the hypothesis that firm-specific events related to strong environmental performance had a positive effect on the market valuation of the firm. This empirical support for a positive correlation between environmental and market performance was confirmed by an analysis of firm-level hazardous emissions and compliance ratios which found that award-winning firms had a significantly better performance than the industry average (Klassen & McLaughlin, 1996). Table 2.3 summarises the event studies discussed.

[18] These values can be interpreted as the market's perception of the net present value of future profits and cash flows that result from high environmental performance (Klassen & McLaughlin 1996).

Table 2.3: Summary of the results of the event studies (Table continued on next page)

Study	**Data set**	**Environmental performance measures and data**	**Economic performance measures and data**	**Major findings**
Barth & McNichols (1994)	Firms in the utilities, automobiles, chemicals & appliances industries, 1989-93 (n=257)	Future Superfund liability (data from annual reports and 10-K forms)	Market value (data from Compustat & Securities Data Corporation)	Market valuation of firms includes assessment of future Superfund liability
Hamilton (1995)	Firms reporting under TRI regulations, 1989 disclosure, based on 1987 data (n=463)	Toxic Release Inventory (TRI) emissions for 1987	Returns (stock price reaction)	Significant negative returns on the day TRI emissions data were first announced
Blacconiere & Northcut (1997)	Firms in the chemicals industry, February 1985-October 1986 (n=72)	Maximum expected costs, firm-specific information disclosed by EPA and by firms themselves	Daily abnormal stock market returns (Compustat database)	Correlation between cumulative abnormal returns and legislative events highly significant
White (1996a)	Listed firms that signed CERES principles (n=6)	Signing up to the CERES principles (until mid-1995)	Abnormal excess stock market returns	Significant positive excess returns for signatories (1.05%)
White (1996b)	Firms from oil industry, 3/1988-9 /1989 (n=1 to 10)	Announcement of the Exxon Valdez oil spill accident	Mean abnormal returns for diff. event windows	Significant cumulative negative excess returns for Exxon

Klassen & McLaughlin (1996)	Approx. 100 firms (n=162) (manufacturing, utilities, oil and gas extraction), 1985-91	Environmental awards in NEXIS database, chemical/oil spills, gas leaks or explosions)	Stock market returns (CRSP, NYSE & AMEX) data)	Significant positive/negative cumulative abnormal returns of 0.63% / -0.82%.

2.2.4.3 Summary of results for event studies

In summary, the event studies discussed in this chapter clearly show that **markets react to discrete (positive or negative) environmental events**. Generally, **positive events lead to a positive market reaction** (of about 0.63%-1% of excess returns over expected returns based on market models, equalling $0.37 per share) and **negative events lead to a negative market reaction** (of about the same size, i.e. approx. 0.3-1% of negative abnormal returns, in absolute terms approx. -$0.70 to -$0.85 per share). These results seem to be relatively low compared to the market valuation of other business-related events (such as e.g. mergers and acquisitions) and might thus indicate the (relatively) lower importance of environmental performance in general in its impact on firms' economic performance.

With regard to past environmental performance, Superfund liability seems to be incorporated in the market valuation of firms relatively more consistently than information about future environmental performance (possibly because the higher certainty of costs associated with this type of liability). This could indicate, that, results of event studies are sensitive to the measure(s) of environmental performance applied: catastrophic accidents (Exxon Valdez) and contaminated land clean-up liabilities produce stronger reaction, than e.g. TRI emissions disclosure (probably reflecting the higher certainty of costs form the former and the relative stronger uncertainty about cost implications of the latter).

Market reactions on positive events seem to be stronger in lower-polluting industries, possibly indicating caution towards positive news from firms in higher-polluting industries (i.e. individual firm events receive an industry 'framing' in terms of a premium for lower-polluting industries.

One possible difficulty of event studies is the problem of stock market overreaction. For example, negative returns could become smaller over time, e.g. based on the announcement of positive events that initially imply profit increases, which may be corrected downwards subsequently. Additionally, event studies do not lend themselves easily to assess time series data, are difficult to use for cross-country and inter-industry comparisons, and may be prone to "social amplification" of risk and media impacts of perceived risk stemming from an event (Löfstedt & Frewer 1998). Finally, event studies are limited in that they only allow the use of stock market performance as measure for economic performance, but cannot be extended to historic accounting profitability measures or financial statement-based measures in general.

2.2.5 Portfolio research

2.2.5.1 Introduction

Research on (model)[19] portfolios of firms with different environmental performance is based on the segregation of firms or equity portfolios into groups with different levels of environmental performance. Due to limited environmental performance data (such as CEP ratings or other non-continuous measures) environmental performance is usually determined on an ordinal scale (i.e. firms are segregated into only few, usually 2-3 environmental performance categories). The portfolios created in this way can be industry-matched (e.g. each portfolio has the same proportion of firms in different industries), and can be matched for additional criteria such as firm size or export orientation. The idea is, that firms with similar characteristics should show a similar economic performance. Portfolios can cover only one industry, several industries or all industries in a country (e.g. all manufacturing industries). Studies evaluating the relationship between environmental and economic performance study, for each portfolio, the average returns, based on accounting profitability or stock market performance measures across all firms and/or all time periods. The measures adopted to assess economic performance can be risk-adjusted (in the case of stock market-based measures) or adjusted for inflation, taxation or depreciation differences between countries (in the case of accounting profitability measures).

Another possibility next to creating a model portfolio is to analyse the portfolios of existing investment funds that target firms with different environmental performance, although this raises the issue of fund management effects on the average economic performance of portfolios. Next to the 'unavoidable' use of the portfolio approach in the case that insufficient data is available (i.e. when only broad ordinal classifications of e.g. environmental performance exist, rather than continuous-scale performance data), portfolio studies can also be pursued in the case that not only ordinal, but continuous environmental performance data is available. This is advisable for example to level out contingent (i.e. non-systematic) differences of economic performance for firms with similar environmental performance. In either case, the portfolio approach allows only comparing average risk-return characteristics or financial performance for portfolios of high and low environmental performers, since it only assess average performance across the portfolio and its variation. This however can be

[19] The term "model" here refers to the possibility to construct portfolios of shares/firms, which do not exist in reality as investment funds. In other words, "artificial" investment funds are constructed, consisting of either good or bad environmental performers. Alternatively, the performance of real investment funds actually in the market can be analysed.

strength in that it allows to establish more clearly systematic differences in economic performance over a larger spectrum of environmental performance levels.

So far, evidence about the relationship between environmental and economic performance at the firm level from (model) portfolio research is mixed. After briefly reviewing some older and/or smaller studies, the studies by Cohen *et al.* (1995), Edwards (1998) and Steinle *et al.* (1998) shall be discussed in more detail and compared in terms of their results.

2.2.5.2 Specific studies

Using existing portfolios of investment funds Diltz (1993, quoted in White 1996a) found for 28 common stock portfolios over the period 1981 to 1991 that good environmental performance (measured by CEP ratings) and above-average stock market performance were positively correlated and that social screening (which is broader than environmental screening) had little impact on portfolio returns (Diltz 1995, quoted in Cordeiro & Sarkis 1997; Adams 1997).

White (1995), in contrast, reports a negative relationship between environmental concern and financial performance (i.e. strongly negative risk-adjusted returns) for environmentally-oriented mutual funds in Germany and the United States. Comparing this with his more recent study discussed below (White (1996a) which covered approximately the same time period), he concludes, however, that his 1995 results probably indicate more the poor performance of the fund managers of these funds, rather than poor performance of the environmentally proactive firms themselves.

The study of White (1996a) uses three-element scale ratings published by CEP for the environmental performance of firms, where environmentally proactive firms are defined as having substantial activities in recycling, alternative energy sources, waste reduction and environmentally more benign products and packaging as well as few environmental non-compliance events (White 1996a). High polluting firms on this rating scale are characterised by several major accidents, significant non-compliance and constant lobbying against strict environmental policy, whereas companies with a middle rating are characterised as being in compliance with legal standards, but not pursuing proactive environmental programmes.

White's study uses CEP ratings based on the above scale for 97 firms that were publicly listed on the New York or the American Stock Exchange for the years 1989 to 1992 (i.e. four consecutive years). Monthly stock returns for all firms obtained from the Center for Research in Security Prices (CRSP) were combined with these ratings to analyse the relationship between shareholder value and firm's reputation for environmentally conscious behaviour.

Based on the CEP ratings, three portfolios of high-, medium- and low-rated firms respectively were created and monthly returns on these portfolios were then value-weighted, using monthly equity capitalisation data also obtained from CRSP. Using the CRSP value-weighted index to estimate market return and monthly returns on three-month U.S. Treasury bills to approximate the risk-free rate, Jensen's Alpha measure was used to measure the (risk-adjusted) performance of each portfolio and compare this to the others (White 1996a).

The Jensen measure (which is theoretically underpinned by the Capital Asset Pricing Model) is based on the ex post characteristic line of a portfolio and captures its risk-adjusted performance relative to the market (if the market is efficient, the Capital Asset Pricing Model predicts the Jensen measure to be zero). The monthly risk premiums of all portfolios were regressed against the monthly risk premiums on the market index, with the slope coefficient of the regression equation being an estimate of a portfolio's systematic risk[20] and the intercept coefficient being the Jensen Alpha measure.

The study found superior risk-adjusted performance (measured as the Jensen Alpha measure) relative to the market over the study period for the portfolio of high-rated firms with substantial environmental management activities. The other two portfolios expressed as well positive values for the Jensen alpha measure, but these were considerably smaller than in the case of the portfolio of high-rated firms.

The study of Cohen, Fenn and Naimon (Cohen *et al.* 1995) examines the correlation between environmental and financial performance in order to establish whether investing in companies that are environmental leaders in their industries provides a higher return than a more neutral investing strategy.

In order to do so, portfolios of low polluting firms were created and industry-matched with portfolios of high polluters and the financial performance of both compared. Also an initial analysis of the direction of causation in the relationship between environmental and financial performance was addressed and stock market reactions to new information of environmental performance were assessed.

Two industry-matched portfolios of firms (approximately five for each industry) with high and low environmental performance, respectively, were constructed for each of a number of environmental variable (based on the median value of each variable) using all firms listed in the S&P 500, for which values for the variable where available.

Nine variables were used to assess environmental performance of which some were not related to current or past environmental performance, others are likely correlated to the

[20] The slope coefficients for all portfolios were later found to be highly significant, indicating that systematic risk was an important determinant of portfolio return, which is consistent with finance theory.

environmental management activities of a firm. These variables were the number of Superfund sites, the number and monetary value of compliance penalties, the volume of toxic chemical releases, the number and volume of oil spills, the number of chemical spills and the number of environmental litigation proceedings. The first eight of these variables are government data releases, whereas the last one is disclosed by companies in Form 10-K report filings required by the SEC (U.S. Securities and Exchange Commission).

As measures for economic performance of a firm, the study used return on assets (ROA), return on equity (ROE) and total (risk-adjusted and risk-unadjusted) returns to common shareholders. Next to accounting for inter-industry risk differences by using industry-matched portfolios, the use of risk-adjusted stock market returns allowed for direct control of firm-level Beta values.

Data on the financial variables used was taken from the Compustat database. Data for most of the variables was collected for the years 1987-1989 and all values of the environmental variables were normalised using firm revenue. Using the standard parametric t-test as well as the non-parametric Mann-Whitney and Median tests, the study then tested whether the portfolio of low-polluting firms performed financially better than those in the high-polluting portfolio.

The study by Cohen *et al.* (1995) therefore found support for the hypothesis that **investments in an industry-balanced portfolio of firms with high environmental performance will not be penalised in terms of the portfolio's market performance**. Comparing the five measures of financial and market performance of the two portfolios over three time periods[21] for each of the environmental performance measures introduced above it found that in 73 out of 90 comparisons the portfolio of low-polluting firms performed better financially, although not always at a significant level. Very similar results were found when comparing only risk-adjusted stock market returns and portfolios for the upper and lower quartiles of firms in each industry, respectively.

Based on their findings, the authors concluded that it is possible to construct a portfolio that tracks an index whilst choosing only firms with high environmental performance in their respective industries (since their portfolios consist of balanced subsets of the S&P 500). They acknowledge, however, that "green" mutual funds usually do not invest in this way but often prefer choosing firms and industries performing environmentally high in absolute terms.

[21] These time periods were 1987-89 (using average values for all variables), 1990 and 1991.

A more detailed and disaggregated analysis of the relationship between environmental, operational and market performance shows, however, a more inconclusive pattern of results. This concerns the significance of differences as well as the time pattern of differences.

Broadly it can be seen that **operational as well as market performance is in general significantly higher for firms with high environmental performance during the period 1987-89** (based, however, on average values, only). For the periods 1990 and 1991 significant differences are generally much more sparse. Similarly, for some environmental variables mainly accounting returns are significantly different (e.g. in the case of the number of environmental lawsuits, the volume of oil spills and the volume of chemical spills), whereas for other variables, mainly market returns are significantly different (e.g. for Superfund Sites and TRI emissions).[22]

Overall, the study by Cohen *et al.* (1995) found thus tentative evidence (based on historical accounting profitability and stock market performance data) that investors are at least not penalised for choosing environmentally high-performing firms in an industry-balanced portfolio (as compared to choosing low-performing companies) and hence that it is feasible to construct an index-tracking portfolio of environmentally-high polluting firms (Cohen *et al.* 1995).

Edwards (1998) carried out one of the few European portfolio analyses of the relationship between environmental and economic performance for firms in different industries. He examined the historical accounting profitability of 51 environmentally proactive firms comparing each with a set of 3-5 firms with unknown environmental performance in the same sector matched for processes operated, firm size, scale economies and growth potential, investment level and export exposure (proxied by sub-sector, turnover, market capitalisation, capital expenditure per share and percentage of export turnover in 1995).[23] The environmentally proactive firms were chosen from the Jupiter Environmental Research Unit (JERU) Approved List of companies for the Jupiter International Green Investment Trust (JIGIT) Ecology Fund. This list contains about 100 UK firms. The assessment of a company listed there consists of a negative screen and an in-depth positive assessment of various aspects of the firm's environmental performance. Given the thorough assessment procedure, Edwards (1998) takes the view that the JERU assessment is currently "…amongst the most rigorous, comparable and consistent of any such assessments (Edwards 1998, p. 18)…)" of

[22] The results for Superfund Sites and TRI emissions also confirm the results of the earlier event study by Hamilton (1995).

[23] As will be discussed in the conclusions of this section, matching is a core problem in portfolio studies. Edwards matches firms only for one year (1995), whilst using the years 1992 to 1995 in the analysis. The criteria used for matching by Edwards almost certainly vary over these years.

company environmental performance in the UK. One limitation of the JERU assessment and list is however, that it is only available for UK firms, which makes comparisons across EU countries (and thus an assessment of the influence of a firm's country location, e.g. in terms of the stringency of and approach to regulation) impossible.[24]

Based on the JERU Approved list, Edwards (1998) identifies 51 environmentally excellent companies in eight industry sectors (as defined by the Financial Times All Share listing). These are: building materials and merchants, healthcare, engineering, electrical and electronic equipment, support services, food retailers, general retailers and paper packaging and printing. Firms from the JERU list are assumed to have the highest level of environmental performance in their respective sectors. JERU-listed firms were subsequently matched with a set of firms not included in the JERU list[25] (and thus having unknown environmental performance), which are assumed to have a lower level of environmental performance. Although this assumption may be justified Edwards (1998) acknowledges that it would be possible that a non-JERU list firm could have better environmental performance than a JERU listed firm. Measures for profitability adopted in the study are return on capital employed (ROCE) and return on equity (ROE). For both, data was gathered from the (July 1996) Company REFS (Really Essential Financial Statistics) publication for the time period 1992 to 1995.[26] In the first stage of the analysis, the average profitability (based on the two ratios above) of all firms in each sector which were not JERU-listed was calculated for each year and then compared to the profitability of the JERU-listed firms, using standard parametric t-tests (which assume normal distribution of the profitability data analysed).

In the second stage of the analysis, the profitability of the most profitable firm not JERU-listed is compared to that of the corresponding JERU listed firm, again using t-tests. Therefore differences in financial performance were found to be smaller and to a lesser extent significant for all sectors and years, than in the first stage. It is likely, that for both firms, profitability is above the industry average, but since the environmental performance is not known for both firms it is difficult to assess, whether the similarity or difference in economic performance is caused by, or a result of, the difference in environmental performance, or whether other factors are important in explaining it (this being the case if environmental performance of firms had been similar).

[24] However, several of the firms assessed also have significant amounts of operations in other European countries.

[25] All firms included in the study are based in the UK and listed on the London Stock Exchange.

[26] The publication reporting the Edwards (1998) study is imprecise about this. When presenting data sources, only the years 1992-95 are referred to, whilst results are also presented for 1996. This can at most refer to half-year results of firms in 1996, since the Really Essential Financial Statistics (REFS) were published in July 1996. Therefore, reported results in this paper only refer to 1992-95.

Overall, Edwards (1998) in his study found **limited support for the hypothesis, that environmentally excellent firms have above-average financial performance**. Both profitability measures were on average and across all sectors better for the JERU-listed firms than the firms not listed.[27] In the comparison between firms with highest profitability in both sets, the result is more inconclusive, however, since in **half of the years the listed firms perform better and in the other half the non-listed firms do**.[28] As suggested above, the difference in returns in this case are considerably smaller than in the comparisons of the 1st stage. The results, however, still support to some degree the proposition that environmentally excellent firms can show above-average economic performance. As for Cohen *et al.* (1995) at least firms are not found in their research to be penalised for their high environmental performance by low financial performance[29].

Steinle *et al.* (1998) in their empirical study take an opposite approach to portfolio definition. Instead of defining portfolios of firms with similar environmental performance, they define two portfolios of economically successful versus economically unsuccessful firms and analyse whether significant differences between the two portfolios exist with regard to a number of environmental characteristics. Based on a representative panel survey in the manufacturing sector of Lower Saxony, Germany, firms were surveyed in two waves in 1994 (n=1025) and 1995 (n=849) during the "Hannoveraner Firmenpanel (Hanoverian Enterprise Panel)". The survey waves were based on personal interviews of managing directors, owners and top managers of firms using standardised questionnaire and the resulting sample was found to be representative in terms of firm size and industry distribution (Schasse & Wagner 1995). In both the survey waves of 1994 and 1995 it was found, that environmental protection was ranked low as a corporate goal, indicating that the firms did not perceive environmental and economic goals as being complementary and that environmental protection is mainly part of a differentiation strategy. Economically successful firms were found in both waves to have a significantly more innovative/proactive approach with regard to environmental protection (at the 5% level, based on Kendal's Tau).

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[27] Although possible, no t-test results were reported across the whole data set.

[28] Only two t-tests at the 2nd stage found significant differences, which is likely due to the very low number of cases available for tests as a result of carrying these out within individual industries only. Because of this, sample sizes for tests ranged between n=16 and n=8 for the second stage of Edward's analysis. With such small sample sizes, normal distribution of the data is unlikely, warranting non-parametric tests. If assumptions for t-tests were met cannot be ascertained, since the raw data used is not reported in the publication.

[29] However no assessment of differences in stock market performance for the firms studied was made in Edward's study. This would have been desirable, since results may differ to those for accounting returns, and since all JERU-listed firms were traded on the London Stock Exchange, making an analysis of stock market performance in principle possible.

Only in the second survey wave in 1995, links with the structure of and tools for environmental management, functional organisation, type of environmental protection were analysed. Here, no significant link was found between economic success and structure of environmental management or the tools used (e.g. LCA, environmental accounting or EMS). With regard to functional organisation (i.e. the degree environmental management is attached to different functional departments) no significant differences were found in both waves, with the exception that economically successful had significantly more environmental management activities in the marketing department, indicating that environmental activities close to the market may be more successful (Steinle *et al.* 1998). With regard to the type of environmental investment, the portfolio of economically successful firms carried out more often environmental investments in 1994 (57% versus 42% for the portfolio of economically unsuccessful firms), and had significantly more integrated pollution prevention activities.[30] Overall, Steinle *et al.* (1998) conclude that environmental protection is likely not a generic explanatory factor for economic success and in particular suggest the use of multivariate analysis methods to analyse in more detail the relationship between environmental protection/ performance and economic success/performance.

Comparing the only two model portfolio studies that used accounting profitability measures (Cohen *et al.* 1995; Edwards 1998), several observations can be made. Firstly, both studies have only one economic performance measure (ROE) in common, and one of them (Cohen *et al.* 1995) uses also stock market performance measures. Secondly, the studies are based on different sets of environmental performance measures. Particularly, Edwards (1998) uses an overall assessment of environmental performance, whereas Cohen *et al.* (1995) use a set of measures for which economic performance is assessed separately. Thirdly, both studies address different time periods (1987-91 and 1992-96, respectively) in different countries (U.S. and UK, respectively). Comparability between the two studies is thus fairly limited, although both use portfolios of firms with good and bad environmental performance and control for industry- and firm-level influences. Given this, the similarity in their results is quite remarkable. Table 2.4 summarises the results of (model) portfolio studies.

[30] However, the survey also found, that both, economically successful, as well as unsuccessful firms most frequently carried out end-of-pipe environmental protection activities, which was interpreted as an indication that firms often carry out integrated pollution prevention activities alongside end-of-pipe activities (Steinle *et al.* 1998, p. 74).

Table 2.4: Summary of results for (model) portfolio studies (Table continued on next page)

Study	**Data set**	**Environmental performance measures and data**[31]	**Economic performance measures and data**	**Major findings**
Diltz (1993; 1995)	28 model stock portfolios, 1989-91 (14 matched pairs, based on CEP ratings of 159 US firms)	CEP ratings of firms for environmental performance including military/ nuclear business	Stock market performance (Jensen Alphas of portfolios)	Positive correlation between high environmental performance and higher stock market performance
White (1996a)	97 firms publicly listed on NYSE, 1989-1992 (inclusive)	Three-element scale ratings published by CEP[32]	Value-weighted monthly stock market return data from CRSP used to measure risk-adjusted portfolio performance	Significantly higher risk-adjusted investment returns for portfolios of environmentally high performing firms
Cohen *et al*. (1995)	Industry-matched portfolios of all S&P500 firms with environmental data available, based on median values, 1987-89 (average values), 1990, 1991	No. of Superfund sites, no. & value of non-compliance fines, volume of TRI emissions, no. & volume of oil spills, no. of chemical spills, no. of environmental litigation cases	Return on assets, return on equity, total return to common shareholders (risk-adjusted & risk-unadjusted), based on Compustat data	For all measures of economic performance and the 3 time periods, in 73 out of 90 direct comparisons between 2 portfolios, portfolios of low-polluting firms had better performance (not always significant)

[31] This refers to the measures used as criteria to define/select the portfolios
[32] CEP ratings are based on recycling activities, energy sources, waste reduction, environmentally benign products & low levels of non-compliance

Edwards (1998)	51 environmentally proactive firms in eight industrial sectors (as defined by the FT All Share listing) and for each of these firms 3-5 matching firms for the period 1992-93 (i.e. approx. 210 firms all together in the sample). Firms are based in the UK and listed on the London Stock Exchange	In-depth positive assessment of various aspects of each firm's environmental performance and management; performance assessed based on firm's products and services, environmental disclosure, greenhouse gas/ozone depleting substances emissions, packaging & labelling; environmental management assessed based on environmental policy, environmental management system, impacts monitoring, supplier auditing	Historical accounting profitability measures (return on capital employed, return on equity) from 1996 REFS (Really Essential Financial Statistics)	In 31 % of comparisons between portfolios of environmentally high-performing firms and other firms, the latter perform worse, though not in all cases significantly worse.
Steinle *et al.* (1998)	Representative survey of manufacturing firms in Lower Saxony as part of the Hanoverian Entreprise Panel, data for two survey waves in 1994 (n=1025) and 1995 (n=849) is analysed	A number of environmental management aspects is analysed, e.g. the tools used, functional organisation, degree of innovativeness with regard to environmental protection, structure of environmental management in the firm, level of environmental investments and type of environmental protection (end-of-pipe versus integrated)	Portfolios defined on the basis of economic success/failure using firms' self-assessment (overall profitability of firm and profitability relative to competitors in same market) and value added per employee	Some significant differences found between two portfolios concerning the innovativeness towards environmental protection, the degree to which environmental activities take place in the marketing department, the frequency of environmental investments and the proportion of integrated pollution prevention activities

2.2.5.3 Summary of results for (model) portfolio research

Most studies analysing (model) portfolios of firms or funds find significant above-average performance for portfolios of environmentally higher performing companies (with performance improvements in terms of returns in the range of 0.7-3% above-average returns for portfolios of low environmental performers). Overall, (model) portfolio studies therefore provide some evidence, that applying a positive environmental screen (i.e. the construction of an portfolio of environmentally high performing firms) does not penalise an investment fund and might well lead to significant, though modest above-average returns.

Furthermore, above-average returns are the case regardless, whether a portfolio includes the best environmental performer(s) relative to all other firms in an industry (including firms from higher-polluting industries) or if the portfolio consists of firms from specific industries with the highest absolute environmental performance. In the latter case, however, overall portfolio returns may be limited by lower average returns in certain (lower-risk) industries. In both cases the small magnitude of out-performance (of 0.7-3% higher returns) for environmentally higher performing firms is probably an indication for the still relatively small importance of environmental issues in comparison to other business issues.

The results of research on (model) portfolios also seem to indicate that negative screens to exclude firms perceived as higher-polluting from a portfolio (but still keeping average environmental performers) seem to have little value, as such portfolios earned returns commensurate with their levels of systematic risk (White 1996), which is only reduced in the case of a positive (absolute or relative) environmental screen.

When the best financial performers with high and low environmental performance are compared, the above studies provided only limited evidence, that firms with lower environmental performance tend to perform slightly better, based on accounting profitability measures (Edwards 1998, p. 27).

It is important to acknowledge that the model portfolios predominantly applied often do not represent the usual process by which fund managers decide on the portfolio for an investment fund (since they often focus on specific high-growth industries, which are not necessarily the lowest-polluting ones). Therefore results can only be generalised with caution to real-world investment funds. Additionally, the quality of fund management might considerably affect the level of returns and thus may potentially cloud any positive relationship between environmental and economic performance (White 1996).

Generally, as discussed in the introduction, (model) portfolio-based research is limited as it mainly compares groups of companies, which do not allow an evaluation of the relationship between environmental and economic performance over the whole spectrum of environmental performance. This latter can, however, be achieved by means of multiple regression-based research which assesses the effect of various (firm-, industry- and country-level) parameters on the relationship in a multivariate setting. A special case of multiple regression-based research is the addition of environmental variables to existing validation models used in corporate finance. Empirical studies based on both of these methods are discussed in the following two sections.

2.2.6 Multiple regression-based studies

2.2.6.1 Introduction

Next to event studies and portfolio research, multiple-regression-based studies are a third approach to assess the relationship between environmental and economic performance of firms. In its review of recent work, this chapter covers analyses that are using Superfund liabilities, studies that are predominantly based on TRI[33] emissions data (and have consequently all been carried out in the US), research base on proprietary environmental ratings (Butz & Plattner 1999), work based on environmental management activities (Thomas & Tonks 1999) and studies that are attempting an extension of existing validation models (Feldman *et al.*1996). From this it can be seen again that a) no definite and undisputed definition of environmental performance has been established yet and that b), accordingly, comparability between studies is relatively. In particular, confirmation of specific studies (over specific time periods and firms/industries) has almost never happened.

Generally (multiple) regression-based studies are suitable to examine multi-causal models, i.e. networks of interrelated determinants (Oppenheim 1970, p. 26). They represent advanced, multivariate statistical analyses which are able to assess not only the variance explained by a set of independent variables, but also how influential each individual variable is once its interaction with all other (independent) variables is accounted for (Oppenheim 1970, p. 27). However application of regression analysis should take a number of issues into account, in particular (Oppenheim 1970, p. 28):

- the need for a relatively large number of cases in order to achieve a variability adequate to indicate significant differences (with the additional problem of

[33] The Toxic Release Inventory is an annual report of releases of over 300 chemicals (based on Chemical Abstract Service (CAS) registry numbers) required for manufacturing facilities in the U.S. under the Emergency Planning and Community Right-to-Know Act 1986 (EPCRA). Over 5000 parent companies reported their toxic releases on a plant facility basis under the TRI in 1992 (Cordeiro & Sarkis 1997).

interdependence between the number of included independent variables and the number of cases required),

- the need for a sound theoretical model linking variables, in particular if the aim is to substantiate causal relationships, since regression does not allow to make causal reference in a strict sense – it only assists in disaggregating the variance encountered in the dependent variable and in attributing it to the different independent variables.

In the following section, this chapter covers studies that predominantly use emissions or environmental management data to construct measures for environmental performance. This also includes the the few multiple regression-based studies (Thomas & Tonks 1999; Butz & Plattner 1999; Ziegler *et al.* 2002), which have been carried out based on European data so far.

2.2.6.2 Specific studies

One of the most comprehensive and detailed pieces of research that has been using TRI emission data to construct a large set of environmental performance indicators was carried out by Johnson (1996) based on multiple regression analysis of firms listed in the Fortune 500 over a period of six years (1987-1992). He used several measures based on Toxic Release Inventory (TRI) discharges over the period 1987-92. These included fugitive, stack and total air emissions, water and land emissions, underground injection, discharges to publicly-owned treatment works and total discharges. All data were normalised, using the annual sales revenue of a firm for each year to account for production changes and firm size. Next to TRI emission data from the U.S. EPA, environmental fines and violations for the years 1987-89 under various statutes and acts were also used as environmental performance indicators. These included Resource Conservation and Recovery Act (RCRA), as well as other fines and violations in terms of the monetary value of fines and the number of violations for each year and each statute separately. Again, data was normalised using sales revenue. Next to these two groups of measures, the number of Superfund sites where a firm was PRP, the number of RCRA corrective actions required at a firm's sites and the number and volume of oil and chemical spills were adopted as further environmental performance measures. Data for these were again collected for the period 1987-92 based on IRRC compilations from public data sources. Superfund sites and RCRA corrective actions were, however, not normalised by sales revenue, since they were considered to be cumulative, not relative, indicators.

Although the total number of companies in the Fortune 500 listing over the 1987-92 time period was 684 (since some firms entered the listing whilst others dropped out), the number of companies included in the data sets for analysis of individual environmental performance measures and calculation of corresponding median values ranged between 250 and approx. 350 firms, due to limitations in the environmental performance data available. At the level of industry sectors, this transformed to data sets including 5 to 47 firms.

In summary, the study found that only for certain measures and types of environmental performance within specific industry sectors, superior environmental performance was positively related to higher economic performance, whereas many others had apparently no or even negative correlation to economic performance. This probably indicates a wide variance in the relationship between different types of environmental performance (as operationalised by the different environmental performance measures and indicators) and economic performance, so that a general relationship might be difficult to identify. Economic performance measures used in the study included return on assets, return on equity and total return to shareholders.

Amongst other results, the study found that across all industry sectors, higher numbers of oil and chemical spills, Superfund sites and RCRA corrective actions had a significant negative relationship with economic performance. This means, that the lower the number of spills or sites, the higher is economic performance, measured as ROA, ROE or total return. The fact, that higher numbers of spills, but not higher volume of spills are negatively correlated with economic performance may indicate that fixed costs per spill drive the relationship.

However, there are considerable differences between industrial sectors in the number of environmental performance measures that are improving economic performance and also in which these measures actually are. For example in the chemical industry, only reduction of violations and fines are resulting in improved economic performance, whereas certain groups of emissions (total emissions and underground injection emissions) are negatively related to economic performance at a significant level. Opposed to this, in the apparel/textiles sector, only reduction of land disposal emissions was found to improve economic performance (i.e. a significant negative statistical relationship was found). Finally, in the publishing/printing sector, the number of Superfund sites and total regulatory violations were found to have a significant negative relationship with economic performance (i.e. improved environmental performance in these two areas in terms of lower numbers of sites and violations was found to reduce economic performance). This shows the potentially considerable variance across industries in the relationship between economic and environmental performance. It is very likely that this variance is caused through differences in industry regulation (in terms of stringency and regulatory approach), in market structure (i.e. industry structure and demand side) and/or firm-level factors (e.g. firm size or environmental management) and other factors.

Across all industries, higher surface water emissions, underground injection emissions and total emissions of recorded toxic chemicals to all media were found to have a positive impact on the economic performance of firms, i.e. environmental performance improvements would lead to lower economic performance. However, the study found that at the industry sector level reductions in specific types of emissions resulted more often in improved economic performance than did reduction in regulatory violations and fines, with the notable exception of the chemicals industry, where this finding was reversed. However, this seemed to be specifically due to underground injection emissions, which Johnson (1996) suggests are a cost reducing waste disposal option in the chemicals and mining/oil/petroleum industries, and thus possibly reduce costs thereby improving economic performance.[34]

Hart and Ahuja (1996) used environmental performance data from the Investor Responsibility Research Center (IRRC) 1993 Corporate Environmental Profile directory to analyse the relationship between emissions reduction and financial and operational performance of 127 firms listed in the Standard and Poor's 500 (S&P 500). Firms were double-screened to ensure that only firms in manufacturing, mining or other production (i.e. SIC codes below 5000) were chosen and that at least four firms per industry (at the four digit SIC level) were included to ensure stability and reliability of industry means (Hart & Ahuja 1996). The IRRC Profile supplies data on a summary of reported emissions of selected pollutants from U.S. manufacturing sites, which are based on Toxic Release Inventory (TRI) data. Emissions reduction in the study was measured for each firm in the sample as the percentage change of the ratio of TRI-reported emissions (in pounds) to the company's revenues (in thousands of U.S. dollars) from 1988 to 1989. Operational and financial performances were measured by the accounting profitability measures return on sales (ROS), return on assets (ROA) and return on equity (ROE) for the years from 1989 to 1992. Including a number of firm-level and industry-level control variables (such as advertising intensity, R&D intensity, capital intensity and leverage, as well as industry average levels of environmental performance), multiple regression analysis was applied using three models with ROS, ROA and ROE, respectively as dependent variables and emissions reduction and control variables as independent variables. As a result the study found that two years after the emissions reduction (per unit of production) occurred, the above measures for financial performance showed improvements, which were highest for firms with higher emission levels prior to reduction. More precisely, the study found that the relationship between 1988-89 emissions reduction and ROS and ROA became significant in 1990 and even stronger in 1991 before dwindling in 1992, whereas the

[34] From the available literature it remains unclear, whether Johnson (1996) uses control variables.

relationship between emissions reduction and ROE became significant only in 1991 and strengthened slightly in 1992. Furthermore, emissions reductions had no significant effect on any performance measures in 1989, i.e. in the period when emissions reductions occurred.

Overall, findings indicate, that environmental and economic performance have a positive relationship with a time lag of 1-2 years and that ROE takes longer to be affected by improved environmental performance than ROS and ROE. The relationship was found to be more positive for firms with higher emission levels at the outset, indicating possibly decreasing marginal benefits of pollution abatement and prevention. This last result was supported by a split sample analysis, which found no significant effect on any of the operational and financial performance measures for the low-polluting sub-sample, whereas significant positive effects on performance measures were found for the high-polluting sub-sample. Low- and high-polluting firms were identified on the basis of industry means for the emissions reductions per unit of revenue, resulting in high and low polluting firms for each industry. These results proved stable under an extensive sensitivity analysis and relationships for control variables and the measures of firm performance were as expected (Hart & Ahuja 1996).

In another regression study, Cordeiro and Sarkis (1997) aggregated environmental performance data from the U.S. TRI to analyse the relationship between environmental performance and changes thereof and economic performance of 523 firms that report mandatorily their toxic releases based on the 1990 U.S. Pollution Prevention Act. Firms included in the sample are within the SIC codes 2000-3999 and their emission data was aggregated from the plant level TRI data.[35] TRI data on chemical emissions for each firm is then further aggregated to a measure for environmental proactivism which is defined as the sum of total releases (reported under TRI) that are recovered, treated, or recycled on-site or off-site and the total non-production releases from remedial actions, catastrophic or similar events. This sum is then normalised for firm size using sales revenue.[36] Economic performance of firms was measured based on one-year earnings-per-share and five-year earnings-per-share growth forecasts which are part of the Securities and Exchange Commission's (SEC) disclosure database and were provided by industry analysts of Zacks

[35] It remains unclear however, whether in each SIC category (4-digit level) more than one firm is included.

[36] Theoretical concerns against this measure could be mounted, since firms with higher non-production releases (ceteris paribus) would score higher on the measure and thus be rated more environmentally proactive. Non-production releases could well be measuring environmental under-performance, since they could be related to carelessness or lacking preventive/proactive environmental management. This problem is aggravated for the case that the total releases recovered, treated or recycled are much smaller than the non-production releases.

Investment Company.[37] Firm level controls applied are firm sales (to proxy firm size) and the debt-to-equity ratio (to proxy the firms leverage/gearing). Industry level was controlled for by entering industry-adjusted values in the analysis, achieved through deducting the variable mean value for the firm's industry (defined at the 4-digit SIC level) from the actual firm values. However results did not change structurally when the industry control was excluded and instead the non-industry-adjusted values were used.

Industry analyst's performance forecasts for 1993 (as dependent variables) were subsequently regressed in two separate multiple regression models against the level of firm environmental proactivism in 1992 (based on the environmental performance measure defined above) and against the change in proactivism from 1991 to 1992. It was found that both, the level of proactivism in 1992 as well as the change in proactivism from 1991-92 where significantly (at the 10% and 5% levels) negatively related to both the one-year earnings-per-share performance forecasts for 1993 and (slightly stronger) the five-year earnings-per-share growth forecasts. Principally similar results were found for the non-industry-adjusted values, although the values for the change in proactivism were not significant any more in this case. Based on their findings, Cordeiro and Sarkis conclude that security analysts systematically anticipate lower earnings-per-share for environmentally proactive firms in the short-term[38], but also point to the limitations of their study in terms of the short time period covered, the narrowly defined environmental performance measures and the need to use more disaggregated economic performance measures.

In another multiple regression study, Konar and Cohen (1997; 2001) disaggregate the market valuation of corporate environmental performance and attempt to segregate firm-specific effects. Based on the assumption that security prices provide the best available unbiased estimate of the present value of future cash flows, the authors decompose the market value of a firm into its tangible asset value (estimated from accounting values and replacement costs) and its intangible asset value (patents, trademarks, proprietary raw material sources, brand/name reputation and firm goodwill), net of possible intangible liabilities (such as consumer mistrust from fraudulent activities or future environmental risks). Based on this

[37] Cordeiro and Sarkis (1997) argue, that these measures are theoretically superior to stock market performance measures and accounting performance measures. Unfortunately, they do not include measures from the latter two categories, which makes a comparison of their results impossible. Since the environmental performance measures used are also different to those used by Hart and Ahuja (1996) this is unfortunate, since it is difficult to assess, what part of the results is due to the different environmental performance measures and which part to the (proposed) higher reliability of the economic measure adopted.

[38] Cordeiro and Sarkis (1997) define short-term somewhat arbitrarily as the period between one to five years. This raises the question, whether a long-term above five years is actually predictable and even if this is the case, whether this can in practice be captured in any of the measures for economic performance of firms commonly adopted.

decomposition, the study assesses the role of environmental reputation on market value. In order to do so, Tobin's q value (which should take the value of unity for firms without intangible assets and is closely related to the ratio between the tangible and intangible asset values) is regressed against several explanatory and control variables, which influence intangible asset values, including an environmental performance variable.

321 firms from the S&P 500 in the industries SIC 20-39 were analysed for 1989, the second year for which TRI emissions were disclosed. Control variables included in the study are firm market share (proxying for the monopoly power of a firm), industry concentration ratio (4-firm), 2-year firm sales growth rate, R&D and advertising expenditures, age of firm assets and the ratio of imports to total domestic consumption. Also firm size effects were controlled for through the natural log of the replacement value of firm assets, industry effects through industry dummy variables at the 2-digit SIC code level, and the 'dying firm' effect through the capital expenditure-depreciation differential.

Environmental performance measures adopted by Komar and Cohen were the aggregate mass of TRI-listed toxic chemicals emitted, normalised for size using firm sales and the number of environmental lawsuits pending against a firm. TRI data was based on 1988 emissions, which were reported in the beginning of 1989, and consequently predominantly affected market valuation of a firm with respect to its environmental risk in 1989. Firm-level TRI data was publicised by IRRC and litigation data is based on 10-K disclosure forms of firms to the SEC.

Using Tobin's q for the year 1989 as dependent variable in the multiple regression equation in several specifications, Komar and Cohen find that the included control variables are in sign and significance consistent with the literature. R&D expenditures, market share, level of industry concentration, firm growth rates and advertising expenditures are positively related to Tobin's q and tangible assets are related negatively. Accounting for these effects, the environmental performance measures used were found to have a negative effect on Tobin's q, with the effect being stronger for toxic chemicals disclosures in the TRI than for the number of lawsuits pending against a firm. Thus, the results broadly confirm the hypothesis, that low environmental performance has a negative effect on market valuation of a firm.

In a second series of regressions the effect of the environmental performance of a firm on its intangible asset value is assessed. Overall, findings are qualitatively similar to the findings using Tobin's q as dependent variable; especially environmental variables remain negative and statistically significant. It is found that losses due to low environmental performance are economically significant and that the average loss across all firms is U.S.-$ 380 million, equalling 9% of the studied firm's asset replacement value. Most of this loss in intangible asset value can be attributed to the level of toxic chemical emissions, whilst losses resulting from environmental litigation are in most industries and almost all firms studied below U.S.-$ 1 million.

However, significant industry differences are found regarding the economic significance of negative effects on market valuation from low environmental performance. Loss values (in percent of asset replacement value) are largest in the chemicals, miscellaneous manufacturing, primary metals and paper industries, i.e. losses are highest in the traditionally polluting industries (with values over approx. 20-30%). In industries such as transportation equipment, food products, electric machinery and non-electric machinery, losses were below 5% of tangible asset replacement value.

In one of the few analyses using European data, Thomas and Tonks (1999) examined the correlation between the excess stock market returns and environmental activities and features of firms. Their data set is based on 131 companies that replied to a questionnaire survey by Croydon Borough Council (a UK local authority) of its 297 biggest pension scheme shareholdings. The survey inquired whether firms had adopted an environmental policy, if they had been prosecuted by an environmental agency in the UK (NRA, HMIP or the Environment Agency) and if they had adopted routine staff training schemes to ensure staff compliance with their environmental protocols.

The replying companies covered a range of industries and the average market capitalisation of the companies surveyed was approximately £900m. The authors used a multiple regression framework to analyse the predictive value of dummy variables representing the adoption of an environmental policy, prosecution and staff training, alongside other possible explanatory variables for total stock market returns. Data on total returns was obtained on a monthly basis from the London Share Price Database for the time period 1985-97. This period was sub-divided in the three test periods: pre-1992, 1992-1995 and post-1995.

For each test period, as well as for the whole time period, the excess monthly stock market returns of a company over the risk-free rate were regressed against the monthly excess returns on the market index over the time period, a size factor accounting for the small capitalisation effect in UK stock returns and separately various dummy variables as proxy for the adoption of an environmental protocol/agenda, prosecution and environmental training for staff.

Overall, the analysis found that the adoption of an environmental policy by firms in an industry with a record of high pollution improved their stock market returns by reducing negative excess returns. More precisely, the coefficient on an interactive dummy variable for adoption of environmental policy and industry membership was found to be significant over all time periods and changed its sign (from negative to positive) over the three test periods. The interpretation of this is that firms in high-polluting industries (who were found to have below-average returns over all three periods) were reducing their negative excess returns over the period 1995-97 when adopting an environmental policy. In addition, adoption of an environmental policy was found to reduce the level of risk resulting from a firm's exposure to the size factor.

Furthermore, the study found that prosecution had a significant positive influence on firms' excess returns in the time period of 1985-1992, which, however, is reversed for the period 1995-97, when prosecution for breaches of environmental standards reduced corporate excess returns. This finding was supported by a significantly negative coefficient in this latter time period for an industry dummy variable taking on a value of unity if a firm is in a high-polluting industry and zero otherwise. Also it was found that prosecution for breaching environmental standards reduced the Beta value of a company (by means of a significant, negative interaction term of the prosecution dummy with the size factor). Finally, inclusion of a dummy variable for training on environmental protocol was generally found not to have significant explanatory power for the existence of (positive or negative) excess returns.

In a second study considering European data, Butz and Plattner (1999) researched 65 European firms from various industries and countries for which an environmental rating by the Swiss private bank Sarasin was available over the period May 1996-May 1997. The Sarasin environmental rating classifies firms into one of four categories ranging from "++" and "+", to "-" and "--", based on a number of quantitative and qualitative environmental performance criteria. Jensen's Alpha (i.e. the systematic, market risk-adjusted excess returns) are used as economic performance measure, based on the Capital Asset Pricing Model (CAPM). Butz and Plattner regressed the Alpha value calculated from CAPM on the environmental ratings as dependent variables (with the environmental rating being included in the regression by means of three dummy variables). They found a significant positive regression coefficient for the environmental rating (i.e. for the dummy variables), indicating a positive relationship between environmental and economic performance. However, this only held true for a subset of firms in environmentally intensive industries (n=39).[39] Coefficients became insignificant when the whole sample of 65 firms was considered. One key weakness of the study by Butz and Plattner seems to be that they do not (as e.g. Thomas and Tonks) include any control variables. This leaves the possibility, that factors other than the

[39] This result (i.e. higher significance for environmentally intensive, i.e. high-polluting industries) was found in both European regression studies, as well as in Hart and Ahuja (1996) and Konar and Cohen (1997; 2001).

environmental rating (but highly correlated with the dummy variables used to operationalise it) could have influenced the Alpha values.

In a third analysis using European data (Ziegler *et al.* 2002) an elaborated stock market-based regression model and the Sarasin data are brought together for an analysis of the influence of ecological and social sustainability on the shareholder value of European stock-listed companies. Based on CAPM and a multi-factor model it finds a significant positive influence of a sector's ecological sustainability on the average monthly stock return, and a negative (but not always significant) influence of a sector's social sustainability on firms' shareholder value.

Given that the three European multiple regression-based studies discussed do not use identical dependent or independent variables, studies cannot directly support the findings of one another. For example, the European regression studies discussed differ partly in terms of their environmental performance measures (single environmental management characteristics vs. a comprehensive environmental rating), their geographical scope (mainly UK vs. mainly EU, plus Switzerland), and their basic regression model (inclusion of control variables such as size factor vs. omission of control variables). This illustrates the general problems when attempting to compare any two studies. However, despite of the differences, there is some similarity in results, in particular the relatively higher influence of environmental aspects in higher-polluting industries.

Next to multiple regression models using specific environmental performance measures (e.g. based on contaminated land liabilities or on toxic emissions), a specific type of such models aims to describe the relationship between a firm's Beta value (representing the systematic risk it is exposed to) and a large set of possible predicting factors related to the firm's operations and capital structure. In corporate finance, such models are called validation models. Currently, only few of the existing validation models incorporate additional environmental variables to model in more detail the relationship between environmental and economic performance. One that has been used to analyse empirical data in the U.S. was published by Feldman, Soyka and Ameer (Feldman *et al.*1996). This study is based on a theoretical model linking environmental management and performance with firm value. The model proposes that improving environmental management systems or environmental performance leads to improved firm value in terms of the cost of equity capital, the market value of equity and credit risk. This, however, requires environmental signalling which can either be targeted environmental communications by means of industry codes of conduct, press releases, advertisements, or corporate environmental reports or else unmanaged communication in the form of regulatory compliance reporting or media coverage. The signalled environmental information forms the basis for financial stakeholders to judge the environmental risk profile of a firm (next to its business and financial risk profiles). If the financial community perceives that the environmental risk of a firm has been reduced it should, according to the model, be willing to offer that firm a lower cost of capital and also investors will be offering higher prices for the firm's stock, thus increasing the market value of equity.

As measures of environmental performance the study uses the proprietary environmental rating system methodology of ICF Kaiser. This rating system takes into account factors such as the quality of a firm's environmental policy, the level of detail of its implementation plan for the policy, activities undertaken and resources committed to improving environmental performance and the extent of performance measurement. The study classifies environmental risk as a systematic risk[40] and, based on the above model, proposes that the environmental risk of a firm should be positively correlated to the firm's Beta value. A reduction in the Beta value for the firm should in turn reduce its cost of equity capital and the firm's credit risk. This proposition was tested in the study through the addition of environmental variables to an existing validation model. To do so, the Beta values for 330 firms included in the S&P 500 stock index were estimated for the time periods 1980-87 and 1988-94, respectively. The two time periods were chosen to account for the emergence of distinctive corporate environmental management around the mid-80's as well as the first mandatory disclosure of firm emission data under the Toxic Release Inventory in 1988. The Beta values for these two time periods were estimated by regression of continually compounded daily returns over quarter-year periods against corresponding returns on a stock index consisting of all securities traded on the NYSE and AMEX. After estimating these Beta values, their changes between the above time periods were computed for each company and these changes then regressed against two environmental management and performance variables as well as a set of non-environmental variables. The first environmental variable was an environmental management system rating based on the environmental rating system methodology of ICF Kaiser which assigned a score from 1 (poor) to 35 (best environmental management system) to each firm. The second environmental variable measured actual environmental performance estimated as the average annual change in TRI-reported chemical emissions per unit of firm capital (consisting of the value of property, plant and equipment). The set of non-environmental variables used attempts to capture most other known and quantifiable factors that influence firm risk. It

[40] Systematic risk reflects factors that affect all firms in the market simultaneously and are measured by the Beta value, which describes the volatility of a firm's stock relative to the market's Beta, which is unity. Opposed to specific risk, which is unique to one firm and can be diversified away, systematic risk cannot be reduced by choosing a more diversified portfolio (Feldman *et al.* 1996).

included measures of financial (dept-to-asset ratio) and operating (fixed cost base of operation) leverage as well as productivity, variability in firm revenues (coefficient of variation of firm revenue) and operating income (coefficient of variation of firm operating income) as well as other performance variables at the firm level. These other performance variables were the correlation between the return on the market portfolio and firm costs, standard deviation of operating leverage, the change of the change in operating income, and the firm Beta values for the time period 1980-87. Finally, an industry dummy variable was included in the model, accounting for whether firm's primary operations are in a particular 2-digit SIC code.

Partial regression coefficients were estimated for the above multiple regression model. Due to confidentiality reasons, no parameter values were reported in Feldman *et al.* (1996). The coefficients for the environmental management and environmental performance variables were however both, positive and significantly different from zero at the 1% level. Most non-environmental coefficients were also statistically significant, not so, however, some of the industry dummy variables. The adjusted coefficient of determination (adjusted R-squared) of the model was 0.24 and significant evidence (at the 5% level) was found to reject the hypothesis that the independent variables together do not linearly affect the change in Beta value for the firm. Also statistically significant evidence was found to reject the hypothesis that the error terms in the model are correlated. As a result, the study found that as a firm improves the quality of its environmental management system and as it improves its actual environmental performance, the (systematic) financial risk of the firm declines. The study therefore provides empirical support for a positive correlation between environmental and financial performance at the firm level in that good environmental performance reduces financial risk exposure.

Table 2.5 summarises the major findings of multiple regression-based studies. The subsequent Table 2.6 gives an overview of the various independent variables applied in selected studies. The use of a wide range of control variables in regression studies allows a more direct assessment to what degree factors other than environmental performance contribute to the observed economic performance of a firm. In portfolio research controlling for these moderating factors is only possible indirectly through matching portfolios for industry membership, firm sizes, export orientation of firms or other firm- and industry-level factors that might moderate the relationship between environmental and economic performance. In multiple regression studies, these factors can be addressed directly through the control variables applied in the different studies.

Table 2.5: Summary of results for selected multiple regression studies (Table continued on next page and to be read in conjunction with Table 2.7)

Study	**Data set**	**Environmental performance measures and data**	**Economic performance measures and data**	**Major findings**
Feldman *et al.* (1996)	330 firms reporting under TRI regulations that are listed in S&P 500, 1980-87 and 1988-94	EMS rating on a scale of 1-35 (based on ICF methodology); Average annual changes in normalised TRI emissions	Average firm Beta values for the two periods 1980-87 & 1988-94 (NYSE & AMEX data)	Partial regression coefficients for both environmental performance measures found to be positive and significant
Hart & Ahuja (1996)	127 firms in SIC listed in S&P 500 with SIC codes below 5000, 1989-92 (economic performance) & 1988-89 (environmental performance)	Emissions reductions based on TRI from the IRRC Corporate Environmental Profile data	Return on sales (ROS), return on assets ROA) and return on equity (ROE)	Pollution prevention activities have a positive influence on financial performance within 1-2 years. ROE takes longer to be affected than ROA and ROS
Konar & Cohen (1997; 2001)	321 firms in the SIC codes 2000-3999 which are listed in S&P 500, 1988-89	Aggregated mass of toxic chemicals emitted normalised with firm revenues (TRI-based) & no. of environmental lawsuits	Tobin's q (as dependent variable in several specifications) and intangible asset value of firms	Low environmental performance has a Significantly negative effect on the intangible asset value of firms and is related significantly negative to Tobin's q
Cordeiro & Sarkis (1997)	523 firms in SIC codes 2000-3999 reporting under TRI regulations 1991-92 (environmental performance), 1993 (economic performance)	Change in the sum of TRI releases that are recovered, treated or recycled on-site & releases from remedial actions or accidents	1-year and 5-year industry analyst earnings-per-share growth forecasts by Zacks Investment Co	High environmental performance is found to be significantly negative related to 1-year & 5-year earnings-per-share growth forecasts

Thomas & Tonks (1999)	131 firms form various industries quoted on the London Stock Exchange (LSE), 1985-97	Adoption of an environmental policy, prosecution by a UK environmental agency, staff training on environmental protocols	Monthly excess stock market returns over the risk free rate (Treasury Bill 30-day rate) based on LSE data	Adoption of an environmental policy and prosecution by an environmental agency significantly reduce negative excess returns during 1996-97. Staff training not found to be significant
Butz & Plattner (1999)	65 European firms from various industries for which an environmental rating by the Swiss private bank Sarasin was available, May 1996-May 1997	Environmental rating classifying firms into 1 of the 4 categories "++", "+", "-" and "- -", based on a number of quantitative & qualitative environmental performance criteria	Jensen's Alpha (i.e. systematic, market risk-adjusted excess returns); Ratings regressed on Alpha as dependent variable	Significant positive regression coefficient for environmental rating variables (3 dummy variables) for a subset of firms in environmentally intensive industries (n=39). No control variables included.
Ziegler *et al.* (2002)	214 firms (covering 80% of the market capitalization of the MSCI Europe index) for January 1996 to August 2001 including major manufacturing sectors, banks, insurance, utilities, media, telecoms, construction, retail, medical and other services	As for Butz & Plattner (1999); separate ratings were included for the ecological/social/overall sustainability of industry sectors on the one hand and individual firms within one sector on the other, ordinally ranked 1 to 5 (5 representing the highest sustainability level)	Average monthly stock returns between January 1996 and August 2001 as proxy measure for firms' shareholder value (in the 2nd stage – in the 1st stage, CAPM/multi-factor model parameters are estimated for each individual firm	Significant positive influence of a sector's ecological sustainability on average monthly stock return. Negative (though not always significant) influence of a sector's social sustainability on firms' shareholder value. For overall sustainability of the sector, no significant influence on shareholder value. No significant influence of firms' ecological/ social performance on shareholder value.

2.2.6.3 Summary of results for multiple regression-based studies

Given that no two multiple regression-based studies use identical dependent or independent or control variables, studies cannot directly confirm the findings of each other. However, the power of regression models lays in their ability to assess the relative influences of a potentially large array of independent variables on one dependent variable, in this case economic performance. In this the studies discussed above can help to generate a more concise map of the relationship between environmental and economic performance at the firm level and the factors influencing it, such as industry membership, or firm level parameters.

With regard to studies analysing the relationship between Superfund liabilities and economic performance, it can be said, that there is generally a strong negative influence of such liabilities on the economic performance of firms. This could be explained by the fact, that investors are easily deterred by the potentially high clean-up costs stemming from such liabilities. However, studies using such liabilities as measures of environmental performance face the problem that liabilities represent past environmental performance, which is not necessarily a good predictor for future performance. However, when results are compared to those from TRI emission-based studies, they are often found to be similar, at least qualitatively. For example, Johnson (1996) finds in his study a negative relationship between the number of Superfund sites and fines and the economic performance of a firm, as well as a negative relationship for TRI emissions.

A large group of the multiple regression-based studies discussed in this chapter is based on emissions to air and water. All three studies in this category that have been discussed were carried out in the U.S. and are therefore based on Toxic Release Inventory (TRI) data (Hart & Ahuja 1996; Cordeiro & Sarkis 1997; Konar & Cohen 1997; 2001 and partly Johnson 1996). As can be seen from Table 2.6, all these studies use differently defined measures of environmental performance and different measures of economic performance (accounting returns, earnings-per-share forecasts and Tobin's q value). This illustrates well the difficulties encountered when attempting to compare different studies, even for broadly the same population of firms (large firms in the manufacturing industries) in one particular country (the U.S.). Limitations for comparisons exist for various reasons, for example in the case of the studies by Cordeiro and Sarkis (1997) and Hart and Ahuja (1996).

Firstly, as indicated, the studies use completely different measures for the firms' economic performance although it would principally possible to use the same measures. For example, Cordeiro and Sarkis did not take the opportunity to use the same measures that Hart and Ahuja used in their analysis. This could have shed considerable light on the question what part of the results is due to the different environmental performance measures both studies adopted and which part to the reliability of the economic measure adopted in the respective analyses.

Secondly, although this might have been somewhat more difficult, it was also not attempted by Cordeiro and Sarkis (1997) to use at least one of the environmental performance measures adopted by Hart and Ahuja (1996) in their more recent study, which could in a similar way have addressed the above question of the relative influence of both dimensions. However, it needs to be acknowledged, that in both studies changes in emission levels are used and that therefore the definition of environmental performance is relatively more similar than compared to Konar and Cohen (1997; 2001) who use absolute emission levels.

Thirdly, both studies cover different time periods. Therefore, the positive relationship between environmental and economic performance found in the earlier study by Hart and Ahuja could theoretically be caused by then-available "low-hanging fruit" in environmental performance improvements, whereas the negative relationship found in the later study by Cordeiro and Sarkis could indicate the more negative assessment of further performance improvements based on an already high absolute level of environmental performance (and a correspondingly low level of emissions) assuming decreasing marginal benefits and increasing marginal costs of pollution abatement. However, equally possible is an explanation based on the differences in economic performance measures (since accounting returns are oriented towards past performance, whereas earnings-per-share forecasts are oriented towards future performance). In the same way the different environmental performance measures could be the main cause for the differences in results between the two studies.

When comparing Hart and Ahuja's and Cordeiro and Sarkis's results with the study by Konar and Cohen (1997; 2001) the results found by the latter provide more support for the findings by Hart and Ahuja, although again environmental and economic performance measures are different. Since, however, the observation period for the latter two studies is the same it might well be that this had a major influence on the similarity of results, since (as explained before) it might have been a time of "low-hanging fruit" in environmental management and pollution prevention. Since the sample of firms in both studies is not the same it seems unlikely (though principally possible) that this difference in the survey design has led to the similar findings.

The study of Johnson (1996) might allow a less speculative interpretation of results, since he covers TRI emissions 1987-1991 and uses partly the same economic performance measures (ROA, ROE, and total stock market returns) as the other studies.

It thus allows for this type of environmental performance measure a broad qualitative comparison with the studies by Hart and Ahuja (1996), Cordeiro and Sarkis (1997) and Konar and Cohen (1997; 2001), who all use TRI emissions as environmental performance measures (though in differing specifications). Unfortunately, only Hart and Ahuja (1996) and Johnson (1996) use the same measures for economic performance (return on assets and return on equity).

These last two studies find similar results in so far that for certain measures and types of environmental performance within specific industry sectors, superior environmental performance and higher economic performance based on accounting returns are positively related. Johnson (1996) found that across all industry sectors, higher numbers of oil and chemical spills, Superfund sites and RCRA corrective actions had a significant negative effect on economic performance. Interestingly, in the chemical industry, certain groups of emissions (total emissions and underground injection emissions) reported under TRI regulations are negatively related to economic performance at a significant level, which is in some contrast to the findings of Hart and Ahuja. On the other hand, across all industries, total emissions of recorded toxic chemicals to all media (together with surface water emissions and underground injection emissions) were found to have mostly a positive relationship to the economic performance of firms. It can thus be concluded, that the generally positive relationship found by the Hart and Ahuja is only partly supported by Johnson's findings. Differences in the results may be due to the different time periods, which the respective studies analysed (especially in conjunction with the regression technique applied, such as pooled regressions), but also other factors such as the different samples of firms could have had a significant influence on the results.

The third group of multiple-regression based studies use environmental performance measures other than emissions of toxic chemicals or contaminated land liabilities. Studies in this category broadly find a positive relationship between environmental and economic performance, although partly on the basis of binary measures for environmental performance (Feldman *et al.* 1996; Butz & Plattner 1999; Thomas & Tonks 1999), but also find an insignificant influence of firm-individual environmental/social performance when separating this from industry sector-level environmental/social performance (Ziegler *et al.* 2002). Even though this last analysis uses a sophisticated 2-stage modeling approach (where in the first stage, the relevant parameters of the CAPM and multi-factor models are estimated in two variants for each individual firm and then inputted in the second stage as control variables for an averaged model including apart from a number of control variables - see Table 2.6 below – also variables for the ecological and social performance of the industry sectors and (within these) firms included in the analysis), it does not seem to apply a consequent approach to industry control variables in that it does not distinguish systematically between service and non-service sector firms in the sample analysed.

Overall it can be concluded that there seems to be a certain sensitivity of regression results, with regard to their main parameters (sample of firms, environmental and economic performance measures, time period analysed). However, due to the lack of directly comparable studies, it is difficult, if not impossible at the moment to attribute the total variation of results in regression studies to a specific parameter, such as the environmental performance measures adopted in a study. To illustrate the multitude of parameters that can influence results in multiple regression studies of the relationship between environmental and economic performance, Table 2.6 reports the different dependent and independent variables adopted in selected regression studies.

Table 2.6: Variables and data sets used in selected multiple regression studies (Table continued on next page)

Study	**Dependent variables**	**Independent variables**	**Data set**
Hart & Ahuja (1996)	ROS, ROA, ROE (1989-1992)	Advertising intensity, R&D intensity, capital intensity, leverage, reductions (1988-89) of total TRI emissions divided by sales revenue, industry average emission levels	Firms in SIC codes below 5000, n=127
Cordeiro & Sarkis (1997)	1-year and 5-year Industry analyst eps-forecasts (1993)	Firm sales, debt-to-equity ratio, normalised partial TRI emissions (1992), normalised change in partial TRI emissions (1991-92)	Firms in SIC codes 2000-3999, n=523
Konar & Cohen (1997; 2001)	Tobin's q value, firm intangible asset value (1989)	Firm market share, 4-firm concentration ratio, 3-year firm sales growth rate, R&D expenditure, advertising expenditure, asset age, ratio of imports to total domestic consumption, natural log of firm asset replacement value, industry dummy variables for 2-digit SIC code, capital expenditure-depreciation differential, normalised total TRI emissions (1988), no. of environmental lawsuits	Firms in SIC codes 2000-3999 which are listed in the S&P 500, n=321
Thomas & Tonks (1999)	Monthly excess stock market returns above the risk free rate (1985-97)	Monthly excess stock market returns above the market index, size factor for small capitalisation effect, dummy variables for adopting an environmental policy, prosecution by environmental agencies and routine staff training in environmental protocols, dummy variables for industry membership	Firms in several high- & low-polluting industries, n=131

Feldman *et al.* (1996)	Change in Beta value of firm between the periods 1980-87 and 1988-94	Changes (for 1980-87, 1988-94) in debt-to-asset ratio, in fixed cost base of operation, in productivity, in the coefficient of variation of firm revenue, in coefficient of variation of firm operating income, in standard deviation of operating leverage, in correlation between return on market portfolio and firm costs and in change of operating income, Beta value for firm during 1980-87, dummy for high-polluting industry membership, average annual change in TRI emissions per unit capital	Subset of firms listed in the S&P 500, n=330
Ziegler *et al.* (2002)	Average monthly stock returns between January 1996 and August 2001 as proxy measure for firms' shareholder value	Separate ratings the ecological/social/overall sustainability of industry sector and of individual firms within one sector, ordinally ranked between 1 and 5 (with 5 representing the highest sustainability level), Beta value for each individual firm during 1996 – 2001 (estimated individually on the basis of the CAPM and a multi-factor model), ratio of book value to market value for each firm, market capitalization of each firm (natural logarithm of market capitalization in billions of Swiss Francs), dummy variables based on the sector-level ecological/social sustainability ratings for sectors with very high social and/or ecological sustainability; country dummy variables for all European countries from which firms are included, dummy variables for summe industry sectors (technology sector, i.e. software, telecommunications,electrical consumer goods and electronics/ electrics; insurance; banks; construction)	Subset of firms representing 80% of market capitalisation of the MSCI Europe index, n = 214 (major manufacturing sectors, banks, insurance, utilities, media, telecommunications, construction, retail, medical and other services)

2.2.7 Conclusions

2.2.7.1 Introduction

Earlier reviews of literature on the relationship between environmental and economic performance concluded that a moderate positive relationship between these two dimensions exist, or that above-average environmental performance does at least not have a negative influence on a firm's financial or stock market performance, i.e. that no systematic relationship exists between the two (Adams 1997; Day 1998). This means that, although there is ample anecdotal evidence on the considerable economic benefits for individual firms from environmental performance improvements/corporate environmentalism (as one element of corporate social responsibility), systematic evidence for larger samples of firms across several industries is more inconclusive. Whereas evidence from earlier studies, according to (Cordeiro & Sarkis 1997), indicates no significant relationship between environmental and economic performance exists, more recent studies carried out on the relationship between the two indicate that a significant relationship exists between environmental and economic performance but give no clear indication about why it is sometimes positive and sometimes negative.

2.2.7.2 Summary of results for different methodologies

Summarising the results for different methodological categories (event studies, regression analyses, portfolios) is not a trivial task, given that different aspects of the relationship between environmental and economic performance are given different emphasis in that the different methodologies.

Overall, **event studies** show the influence environment-related events (positive or negative) have on stock market performance of firms in the short term (Bennett *et al.* 1999). Studies over a wide range of manufacturing industries consistently find significant positive abnormal returns after positive events and significant negative returns after negative environmental events. However, as Cormier *et al.* (1993) point out, several methodological and theoretical issues suggest caution when interpreting results from market valuation-based approaches, such as event study methodology. Nevertheless, only event studies provide direct evidence of a causal relationship between environmental and economic performance, indicating that bad (good) environmental performance is actually causing bad (good) economic performance, at least with regard to stock market performance. This, combined with other research, which found that market reactions in the form of abnormal returns in turn affects the future environmental performance of a firm[41] points also to the possibility of a circular relationship between environmental and economic performance at the firm level.

Portfolio research overall provides evidence, that application of an environmental screen (i.e. the construction of a portfolio of environmentally high performing firms) does not penalise an investment fund. A number of environmentally screened portfolios outperform un-screened ones, however, with different degrees of statistical significance. This is the case regardless of whether such a portfolio includes the best environmental performer(s) relative to all other firms in an industry (including the higher-polluting ones) or if the portfolio consists of firms from specific industries with the highest absolute environmental performance. In the latter case, overall portfolio returns may however be limited by lower average returns in certain (lower-risk) industries. In both cases, however, the small magnitude (of around 1%) of out-performance for environmentally higher performing firms is probably an indication for the still relatively small importance of environmental issues in comparison to other business issues.

Summarising the results for **multiple regression studies** it can be said that generally more negative results (for the relationship between environmental and economic performance) can be found for contaminated land (clean-up) liabilities as environmental performance measures, compared to emissions as environmental performance measures.

Therefore, studies based on liability-related environmental performance measures should be treated with more caution than those based on current emissions since they represent a) the environmentally less responsible past, and b) rather "extreme" environmental accidents, that are less likely to occur under current (more stringent) environmental regulation.

2.2.7.3 Methodological influences and data constraints

Regarding the different studies analysed in the review of the empirical literature, a number of conclusions can be drawn concerning methodology and data, which can be divided into purely methodological aspects and into data constraints.

Regarding methodological aspects, various points need to be considered. With regard to portfolio studies/research on individual firms, as well as of investment funds, there are issues, which arise when attempting to match pairs. Individual matching in portfolio studies (i.e. selecting for each member of one group another, very similar member for the other group) can be complicated in a situation where numerous independent variables are considered

[41] Konar and Cohen (1997; 2001) found that the firms with the largest negative abnormal stock market returns after announcement of their TRI emissions also had the highest subsequent reductions in their emissions.

simultaneously such as e.g. numerous control variables. Therefore, in practice, matching is only possible for a limited number of control variables and for a small number of time periods and this only within crude ranges so that always some variance remains unaccounted (Oppenheim 1970, p. 33).

Apart from matching issues in portfolio studies, there seems to be a need to assess the effect of sector/company rating systems e.g. regarding a „sector effect" or a "large firms effect" in environmental funds when investment fund-based portfolio research is concerned. For example, environmental funds can overweigh the telecommunication sector if in ratings this sector is considered to be particularly sustainable. As a result, such funds could have shown above average performance during the telecommunication boom in 2000, which could be erroneously attributed to environmental performance, whilst actually being caused by stocks of a specific industry.

Regression analysis allows carrying out "continuous" matching; it requires larger samples (to grow proportionally with the number of independent variables) as well as a sound theoretical model about causal relationships. The power of regression models is in their ability to assess the relative influences of a potentially large array of independent variables on a dependent variable. In this, the regression studies discussed above can help to generate a more concise map of the relationship between environmental and economic performance at the firm level and its moderators, such as industry membership, or firm level parameters (such as e.g. firm size).

Another conclusion, which can be drawn from the regression studies discussed is, that most likely certain sensitivity exists of regression studies in general with regard to their main parameters (sample of firms, environmental and economic performance measures, time period(s) analysed, control variables utilised). However, due to the lack of directly comparable studies, it is difficult, if not impossible at the moment to attribute the sensitivity of results to a specific parameter, such as environmental performance measures.

Next to purely methodological aspects, data constraints have severely limited research on the relationship of environmental and economic performance for European firms so far. For a start, as a result of data constraints, only a limited universe of firms is observable. When attempting to use continuous (i.e. interval-scale or ratio-scale) environmental or economic performance data only a very small subset of firms is observable in the EU. This situation is in contrast, for example, to the situation in the US and possibly explains, why so little research has been done in Europe up to now.

Regarding data constraints in Europe, it needs to be distinguished further between publicly available data (e.g. emissions data) and between privately generated data (e.g. environmental ratings by rating agencies). As far as publicly generated data is concerned, constraints are due to the non-existence of comparable pollutant release and transfer registers (PRTR) across the EU and the relatively low level of standardization of environmental performance data provided in environmental reports (Berkhout *et al.* 2001a). This situation is in relatively stark contrast to the US, where the TRI, SEC K-10 (and other) forms and disclosures required under the Superfund regulations facilitate considerably public access to high-quality environmental data. As far as privately-generated data is concerned, the proprietary nature of financial data about (or environmental ratings of) firms leads to unavailability of such data or to high additional research costs (in order to use such data), which in turn makes it less likely for this relatively high quality data to be used in research.

The review of empirical studies using different research approaches (portfolio studies vs. regression analysis vs. event studies) allows formulating a set of criteria, which can ensure an improved research design in the future. In particular, future studies should

- be based at disaggregated level, unless aggregation to e.g. multi-site level uses the same system boundaries for controls, financial and environmental performance data;
- be based on large or at least larger data sets, as far as possible;
- analyse relationships for both, individual industries (as far as data per industry is sufficient), as well as the whole sample in the case of multiple industry samples; and
- analyse (where necessary) country-level (sectoral/macro-economic) influences.

2.2.7.4 Variability in the relationship of environmental and economic performance

The variability of results based on different methodological approaches raises the question whether the variability encountered in the above findings represents more an artifact of the methodology or the research design or more a result of the intrinsically wide variance in the relationship between environmental and economic performance, due to various influence factors at the firm-, industry- and country levels.

On the one hand, there seem to be artifacts related to the methodology (regression studies, for example, yield to a certain degree different results than portfolio research), and to the measures for environmental and economic performance adopted in the research design (quantitative emission data yields other results than company ratings; stock market performance-based results differ from results based on historical accounting profitability measures). For example (model) portfolio research may partly assess the performance of fund managers, rather than firms themselves (in the case of portfolios actually held by 'green' funds in the market) or represent an investment approach rather non-existent in reality (in the case of model portfolios of matched firms and industries).

On the other hand, the findings probably also indicate a wide intrinsic variance in the relationship between different types of environmental performance (as operationalised by the different environmental performance measures and indicators) and economic performance, so that a general relationship might be difficult to identify. A recurrent problem is that a variety of different measures are used to assess environmental performance. One consequence of this is, that not two of the studies are similar in their measures.

Another approach, through which the variability of findings across different studies can be evaluated, is to analyse what can be said about stock market versus financial performance, respectively. Generally stock market evidence for the relationship between environmental and economic performance is mixed. Empirical evidence from accounting profitability measures indicates negative short-term (1-5 year) effects of high environmental performance on economic performance i.e. firms seem to pay a small financial penalty (in terms of reduced short-term profitability) for above-average environmental performance or substantial environmental performance improvements, (Hart & Ahuja 1996), although not all studies show this result. In the longer term results are positive for some measures (ROS, ROA), but negative for others (Tobin´s q, EPS forecasts). Finally, yet another important aspect with regard to variability seems to be the time period analysed in a study, in other words, the relationship between environmental and economic performance is likely changing over time.

Overall, it seems not possible at the moment to assess to which degree the variability encountered in the results (i.e. the variability in the relationship between environmental and economic performance) is due to methodological artefacts (e.g. whether portfolio studies, event studies or regression analysis were used to scrutinize the relationship), nor does it seem obvious to which degree variability can be attributed to other factors, such as environmental performance measures used, sectors analysed, countries covered, or the economic performance measures applied. In order to carry out such an assessment, it would be necessary to reproduce studies with all but one parameter held constant (i.e. under *ceteris paribus* conditions), in order to assess the effect of this one changing parameter on the results and to separate the methodological and the object-related sensitivity of results.

2.2.7.5 Important aspects to be considered in future research

Several reasons have been suggested to solve the discrepancies evolving from results of the studies presented and discussed above.

Firstly, although comparisons across industries might find no positive correlation between environmental and economic performance, there may still be important differences between industries.

Secondly, even if the correlation aspects surrounding the relationship could be resolved, this would, however, still leave open the question of the direction of causation between environmental performance and economic performance.

On the one hand, companies, which perform financially well, could have extra resources to spend on improving environmental performance. Alternatively, firms that aim for high environmental performance could save inputs and therefore reduce costs (Schaltegger & Synnestvedt 2002; Wehrmeyer 1999). Although event study research provides preliminary evidence, that increased environmental responsibility is actually causing an increase in a firm's market valuation, competitiveness or profitability, it would be desirable to test this proposition as well with ratio or interval scale time-series data.

Preliminary evidence in this respect exists insofar, that firms that had the largest negative excess returns upon disclosure of TRI emissions subsequently reduced their emissions more than other firms in the industry (Konar & Cohen 1997; 2001). This indicates that at least firms themselves perceive environmental performance improvements causing improvements in stock market (and possibly also financial) performance. However, it is also necessary to examine whether e.g. the firms experiencing the highest negative excess returns upon TRI emissions disclosure were as well those that had the highest levels of emissions, either in absolute terms or within their industry, in order to e.g. account for the effects of "low hanging fruits" for environmental performance improvements.

Another aspect is that different strategic approaches (such as end-of-pipe pollution abatement or pollution prevention) are likely to cause different investment requirements, running costs, process cost savings through input or emission reductions or opportunities to sell resulting by-products. This would of course considerably influence short- and long-term influences on stock-market performance and accounting profitability measures. In this respect it would be desirable to identify different (independent) dimensions or factors of environmental performance and subsequently to assess their relative importance. This would allow identifying which elements of a good environmental reputation (such as pollution prevention, energy conservation or improved risk communication) would reap the largest financial benefits for a firm and thus how to set out its corporate environmental strategy (White 1996a).

This could possibly be tested using an array of different measures for environmental performance. Measures in this respect could be quantitative data for emission reductions (possibly separated for air and water emissions), measures for energy consumption and efficiency, waste production and reduction, or separate measures for hazardous waste. Included in such an assessment should ideally a number of "softer" performance measures, addressing e.g. risk communication, quality of environmental reporting or actual environmental management activities. Time-series data for each of these variables could be derived and than compared with different measures for stock market and financial performance, searching for time-lagged correlation.

Another way of including strategy considerations could be to assess to which degree a firm's corporate environmental strategy is oriented towards simultaneously improving environmental and economic performance (see e.g. Schaltegger & Figge 1998; 2000).

An important result of the review of existing studies about the relationship between environmental and economic performance of firms is, that in order to test the possible explanations and hypotheses described above, it seems advisable to initially focus on individual industries in order to gain a deeper understanding of the forces influencing the relationship between environmental and economic performance.

As a final thought it is interesting to note that only recently studies on the relationship between environmental and economic performance at the firm level are reported for Europe (Butz & Plattner 1999; Edwards 1998; Thomas & Tonks 1999). This points out the difficulty of gathering data on environmental performance measures that is comparable across sectors and countries over the whole of Europe, which is a well-known problem in the field of environmental performance measurement in general (Bennett *et al.* 1999)[42]. However, at the same time Europe is probably one of the best geographical areas to identify country-specific factors, given the diversity of regulatory systems found there and therefore, it would be desirable to carry out more studies using European data.

[42] Wagner (1991) notes a similar situation for the case of empirical and econometric work on foreign trade involvement of different industries, where also most empirical analyses (at the time) had been carried out in the US.

3. Statement of Problem, Research Question and Generation of Hypotheses

3.1 Introduction and statement of the problem

The literature review carried out in the previous chapter pointed out (particularly in its summary sections and conclusions) gaps in the current literature from which promising future alleys of research can be derived, and hence also particular contributions that can be expected from this thesis. One of the most striking results of the literature review is the large variability encountered in the relationship between environmental and economic performance, and the question how this is linked to methodological aspects and factors potentially moderating this relationship (e.g. corporate environmental strategies).

Based on a critical discussion of empirical studies carried out so far, in the last section of the literature review, promising directions of future research have been identified. These include a more detailed analysis of individual industries (e.g. by focusing on individual industries, rather than multiple industry samples) and the influence of corporate environmental strategies as a moderating factor (since strategies essentially determine environmental management actions, and actions in turn result in outcomes, i.e. performance). Also, to better understand the relationship between environmental and economic performance in a comparative perspective, a Europe-based study controlling for country-related influences seems necessary and timely, given the strong US focus in the literature.

For these reasons, this research in its first empirical part wants to investigate the relationship between environmental and economic performance of firms in the pulp and paper manufacturing sector in four EU countries (United Kingdom, Netherlands, Italy, and Germany). Since the influence of high environmental performance on economic performance is likely mainly affected by industry membership, this should be the focus of the analysis. So far, no empirical study in the field has focused on one individual industrial sector. Therefore, the research carried out for this thesis is expected to produce a contribution to the body of knowledge in the research field with regard to specifically analysing the influences of the industry level that affect the relationship between environmental and economic performance.

A key reason for choosing the pulp and paper sector for the first empirical stage is that, amongst all industry sectors, it has one of the highest shares of environmental costs in total production costs. Because this share of environmental costs in resource-intensive manufacturing industries (e.g. pulp and paper) is higher, the interaction of environmental performance and competitiveness should be more visible (either in a positive way, if firms pursue a type of environmental management aimed at simultaneously improving environmental and economic performance[43], or negative, if they do not) there. A resource-intensive sector like the paper sector therefore provides an "upper-limit" assessment of the interaction between environmental and economic performance of firms, in that the relationship is likely more pronounced here.

Nevertheless it is possible that even an improved assessment of the relationship between environmental and economic performance, as set out above does not find a clear link. As Schaltegger and Synnestvedt (2002) point out, the limited size and coverage of data sets used to establish the empirical relationship between environmental and economic performance can potentially explain the different relationships identified (positive, negative, neutral, changing). The situation regarding environmental performance is complicated by the fact that its influence on economic performance is likely to be much smaller than that of many other factors. At the same time, due to the lower level of standardization of environmental performance data in the EU, there is likely noise around the (small) environmental performance signal.

Therefore, in a second empirical analysis, this research wants to analyse the relationship between environmental and economic performance more directly. According to Lankoski (2000), it is desirable, from a theoretical standpoint, to analyse the relationship between environmental performance and environmental profit (or more broadly, environmental competitiveness, which would include more aspects than only short-term profits), rather than the relationship between environmental performance and overall profitability (as is done in the first part of this thesis), or the relationship between private environmental costs (which are not directly linked to environmental performance) and overall profit. Additionally, Schaltegger and Synnestvedt (2002) argue that not only the environmental performance levels reached matter, but also the means (in terms of corporate environmental strategies or environmental management activities) utilized to achieve this level. Therefore, as far as possible, research into the relationship between environmental and economic performance should assess not only the (absolute) level or (relative) change of environmental performance in its influence on firms' economic performance, but also how performances and their relationship are influenced by the corporate environmental strategies and the environmental management ac-

[43] Such type of environmental management or corporate environmental strategy aimed at implementing this type of environmental management will in the remainder of this thesis be termed "value-oriented".

tivities of firms. This will therefore be the focus of the second empirical phase of this research project.

The analysis in the second stage concentrates on only two of the four countries incorporated in the first empirical research stage, which is nevertheless considered to be sufficient to achieve an appropriate, yet defined, spread of regulatory, socio-economic and market-based influences. This is possible because of the relatively distinct environmental regimes found in the United Kingdom (UK) and in Germany (Gordon 1994; Peattie & Ringer 1994; James *et al.* 1997; Wätzold *et al.* 2001; WEF *et al.* 2000; 2001).

The analysis in the second phase centers on the influence of corporate environmental strategies on the relationship between environmental competitiveness and environmental performance. Almost all of the models proposed and used to date to analyse empirically the relationship between environmental and economic performance do not consider differences in the corporate environmental strategies of firms as a moderating factor for the relationship of environmental and economic performance of firms or the level of environmental competitiveness of a firm. Schaltegger and Synnestvedt (2002), point to this weakness and to the pivotal role of the environmental management concept a firm pursues (e.g. ISO 14001, EMAS, Eco-controlling, value-oriented environmental management). As Wagner (2001) points out, different strategic approaches (such as end-of-pipe pollution abatement, pollution prevention or value-oriented environmental management) are likely to cause different investment requirements, running costs, process cost savings through input or emission reductions or opportunities to sell by-products. These will of course influence short- and long-term economic performance or environmental competitiveness of firms differently.

Until now, a two-stage analysis of the above relationship at the firm level as subsequently presented in this thesis has not been carried out for European firms, due to the lack of data that is comparable across EU countries and industrial sectors. The research carried out for this thesis can therefore produce a contribution to the body of knowledge, in particular, with regard to country-level and industry-level influences, as well as the influence of firm-internal factors, especially strategy choice. Also the research will contribute to the body of knowledge in that it explicitly analyses to which degree the relationship between environmental and economic performance is non-linear. To date, such non-linearity of the relationship has not been modeled in empirical studies. In the next sections, initially, the major research question of this thesis shall be recapitulated and transformed into the basic research hypotheses.

3.2 Research question and research hypotheses

The central research question refers to the direct influence of either environmental on economic, or of economic on environmental performance. The direct relationship for individual firms is what is captured by the functional relationships derived from theory, which have been discussed in Chapter 2.1. Aggregating individual firms will lead to (identical) relationships e.g. for a specific industry or a set of industries, such as the manufacturing sector.

The direct interaction between environmental and economic performance is mainly based on the insight that the direct costs of compliance are not the only environmental costs borne by a firm (even if often firms perceive just this to be the case). As research in environmental accounting has shown, the indirect costs related to (unnecessary) material and energy flows in firms' production processes often make up a significantly larger amount than direct compliance costs (see e.g. Schaltegger & Burritt 2000, p. 133). Based on this view, the environmental performance of a firm in one period is directly linked to its economic performance in that period since all material and energy flows avoided in the period also avoid some part of the general overhead costs of the period, thereby implicitly improving economic performance.[44] Therefore, the **central research question** of this thesis 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?

The corresponding research hypotheses are:

H1: Environmental performance has either a uniformly negative or an inversely U-shaped relationship with economic performance, after controlling for firm-level, industry-level, and country-level/location-related influences on economic performance. It is also possible, that no significant relationship exists empirically, if the influence of environmental performance on economic performance is very small.

H2: There is an influence of corporate environmental strategy choice on the relationship between environmental competitiveness and environmental performance, after controlling for firm-, industry- and country-level influences in that the choice of a value-orien-

[44] Of course it should be noted that even though avoided material and energy flows reduce costs in the period they are avoided, they also have effects on period other than the current one. This concerns for example changes in inventories. Also, reduction of material and energy flows and associated improvement in environmental performance does not only influence raw and indermediate materials costs, but also personnel and administration costs related to these as well as revenues and sales (Schaltegger & Burritt 2000).

ted type of corporate environmental strategy or management leads to a more positive relationship between environmental performance and environmental competitiveness.[45]

Hypothesis H2 can be further disaggregated into two sub-hypotheses, H2.1 and H2.2:

H2.1: For firms pursuing a value-oriented corporate environmental strategy environmental performance should have a significant inversely U-shaped relationship with environmental competitiveness, after controlling for other relevant influences on environmental competitiveness. There should be a significant positive component in the relationship.

H2.2: For firms not pursuing a value-oriented corporate environmental strategy, environmental performance should have no significant or a significant negative relationship with environmental competitiveness, after controlling for other relevant influences.

In the next section, potential influence factors, which need to be controlled for and their interaction with environmental and economic performance shall be discussed in more detail.

3.3 Influence of other factors on economic and environmental performance

In Figure 3.1, a general model is shown for the interaction between control variables, environmental performance, and economic performance, which is subsequently used to develop the econometric models to be used in the empirical analysis. This model is inspired by theory-led empirical work in industrial economics and organization (see e.g. Schmalensee (1989) for a detailed review). The model in Figure 3.1 shows the factors considered most important to influence environmental and economic performance. In the model, the thick arrow on the left side refers to direct influences of a number of factors on the economic performance of firms. The small arrow on the right shows a potential direct influence of corporate environmental strategy choice on environmental performance. If corporate environmental strategy choice would be included in the same way as the other variables in the analysis, then this would need to be accounted for through special techniques (e.g. if this would concern an econometric analysis, it would be necessary to apply 2-stage least squares (2SLS) or 3-stage least squares (3SLS) estimation instead of standard OLS estimation of the regression coefficients). However, since corporate environmental strategy choice is only used as a variable in the analysis of the relationship between environmental and economic performance, in which case its direct influence on environmental performance does not have to be accounted for.

[45] As described in Section 1.3.2.2, environmental competitiveness is understood as that part of competitiveness or economic performance, which can be influenced by corporate environmental strategies and management.

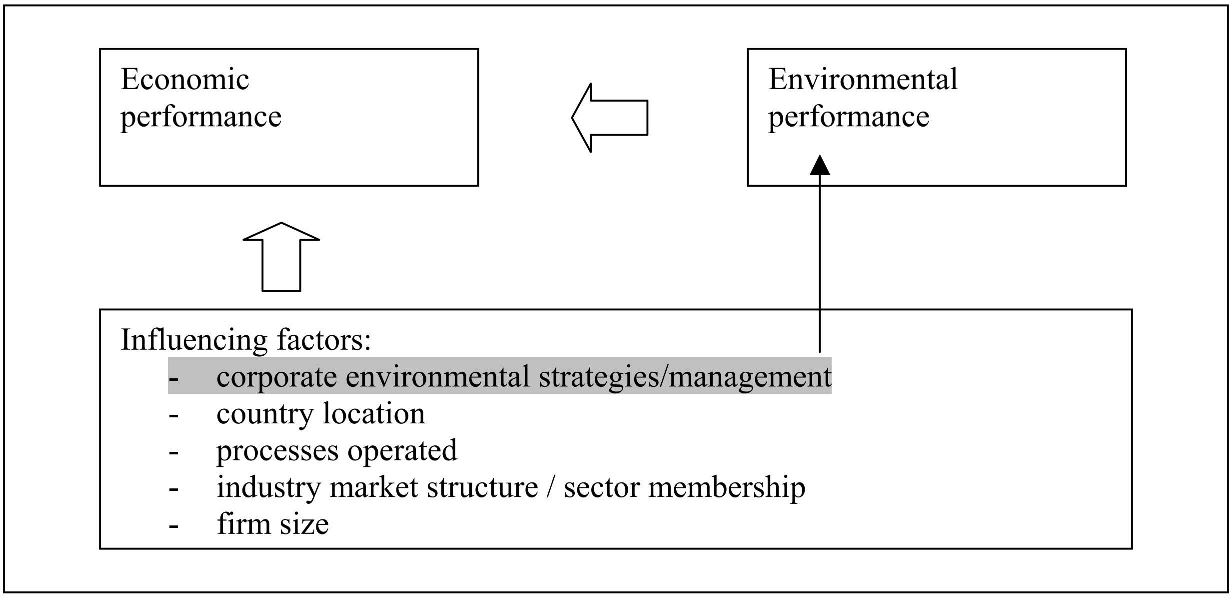

Figure 3.1: Model for the interaction of environmental and economic performance

There are two more noteworthy aspects. Firstly, the control variables can in principle also interact amongst each other. For example, firm size might e.g. have an influence on corporate environmental strategies/management: it is often argued that small firms are laggards, which have a relatively reactive stance towards environmental management (Bradford 2000). As well country location can have an influence on the processes operated (via environmental regulation): for example in Germany, the Kraft pulping process is indirectly prohibited through very stringent emission limits for pulp manufacturers, whereas in other countries, limits are not as strict and thus operation of the Kraft process is possible (Ganzleben 1998, p. 24). If the influences and interaction between any two-control variables are very direct and/or very strong, they need to be taken into account. They can only be neglected, if the interaction between any two variables is very weak (in terms of their correlation) compared with the influences the variable has on environmental and/or economic performance. On the basis of the empirical correlations between the control variables, this assumption is made for the remainder of the analysis.

Secondly there is one specific factor, namely corporate environmental strategies (CES) or the type of environmental management, which in the model has an influence on both, environmental as well as economic performance. This needs to be accounted for.

Based on the model developed above, several influencing factors or control variables can be identified which potentially influence economic performance (environmental management, industry structure, processes operated, firm size and country location). In the following, the factors considered relevant in the above model (Figure 3.1) shall therefore be discussed in more detail in order to justify their theoretical relevance, particularly that they are likely to be the most important factors influencing economic performance. This will concern the following factors necessary to explain the variance of economic performance encountered in the data set to be analysed:

- Country location (proxying for e.g. regulation),
- Firm size, leverage and capital intensity,
- Processes operated (i.e. sub-sector membership),
- Environmental management (in terms of corporate environmental strategies), and,
- The market structure[46] of an industry in a country (which is proxied by industry membership).

Additional influence variables will not be considered, since they are assumed to be either industry- or country-related. In the former case they are assumed to be constant and similar in their influence on all firms and thus not relevant if only one industry sector is considered. In the latter case, they are captured in the country variables included in the analyses.

3.3.1 Country location

Country-level (or regional) influences have so far often been excluded from the analysis, partly due to the dominance of US-based studies (focusing on only one country). To better understand the relationship between environmental and economic performance, a Europe-based study incorporating more than one country therefore seems to be both, necessary and timely. Country location jointly proxies for a number of influences. This can e.g. be the level of stringency of environmental regulations, the type of instruments used to implement these (e.g. economic instruments, or command-and-control legislation), which may have an influence on the efficiency of environmental regulation in different countries, or the level of general business taxes in the country. The joint influence of these factors is captured in a dummy variable for country location.

The most important factor in the context of this research is likely to be the regulatory regime in a country in general and for specific industries, e.g. the strictness of and approach to environmental legislation and regulation.[47] If it is accepted that country influences on the

[46] Market structure is basically defined through the demand side and the industry structure (i.e. the supply side) of an industry. It is relevant only, if more than one industry sector is analysed which is the case only for the second empirical phase of this research. In the case of multiple-industry samples, the influence can be addressed through sector dummy variables.

[47] A third important aspect is the degree of certainty, in a specific country, regarding the future development of environmental regulation. This aspect is however very difficult to capture and is therefore excluded here.

relationship between environmental and economic performance result mainly from the fact that in different countries the stringency of, as well as the approach to (and thus the efficiency of) environmental (and to a lesser degree other) regulation may differ[48] then under the assumption that firms are compliance-oriented (and not over-compliant) it can be expected that the level of environmental performance (i.e. the emission levels) of a firm is proportional to the stringency of environmental regulation. The reason for this relationship between stringency of regulation and environmental performance is that it initially only pays for firms to pursue emission reductions until they meet the emission standards for their industry, since only such reductions yield an economic benefit for firms in terms of minimising their compliance costs by avoiding fines. In a compliance-oriented situation, the environmental performance of a firm (measured in terms of its emissions) can be considered as a "revealed regulatory stringency" (as opposed to a "stated regulatory stringency" as expressed by emissions standards set by regulators). Aiming for over-compliance is only rational for firms if it can be achieved through cost-effective pollution abatement measures. Most cost-effective measures have, however, amortisation periods of more than two years so that annualised returns can usually not compete with other investment options. In addition to that, over-compliance needs a firm's careful consideration since it could signal to regulators a scope for tighter environmental regulations without significantly affecting companies´ profitability and competitiveness. Therefore, over-compliance is likely to be the exception, rather than the norm. Nevertheless, the effect of distortions from over-compliance (resulting, for example from firms´ anticipation of future tightening of regulations) needs to be taken into account and assessed prior to assuming the above relationship between stringency and performance.

Next to the stringency of environmental regulation, it is also necessary to consider the efficiency of regulation depending on the instruments used. From the point of economic theory it is usually argued that the use of economic instruments is more efficient than a command-and-control approach. For example, some countries have generally a very strong legal stance in their environmental regulation, whereas others lean more towards economic instruments, such as taxes, and yet others tend to prefer voluntary or negotiated agreements. Germany, the UK and Netherlands would be respective examples. However, it is at times

[48] The same situation applies equally to sectoral differences in regulation. For example, Henriques and Sadorsky (1996) argue that costs of regulation differ across industries, and that "firms in more regulated industries are more likely to embed environmental issues into their management strategies … since the costs associated with non-compliance tend to be significantly higher (p. 385)". Nevertheless, differences with regard to regulation seem to be much more pronounced between countries, since within one country usually one specific regulatory body and process produces environmental regulation for various industries. Also, as long as only one industry sector is considered, industry effects on regulation do not have to be considered further.

difficult to distinguish such regimes clearly, since governments usually apply a mix of economic, legal and voluntary or negotiation-based instruments simultaneously. However, it has also to be taken into account, to what degree regulations are designed and implemented efficiently and are enforced properly.

In Germany and the UK, the level of corporate environmental protection has increased significantly over the last decade. The socio-political, regulatory and economic climates of the two countries show clear differences, which has meant that companies in each country have developed management approaches and corporate environmental strategies that are specific to their national circumstances, with likely different influences on the economic performance of firms. For instance, Gordon (1994) acknowledges that, whilst awareness of broader political and social aspects in environmental policy is greater amongst British firms, the level of analysis and the efficiency of environmental policy making is often greater in Germany. Consistent with this observation, Peattie and Ringer (1994) report strong enthusiasm for environmental management amongst British companies, and suggest that in organisational terms, they are not significantly lagging behind, but may increasingly do so due to weak environmental legislation. Finally, James *et al.* (1997) find that specific socio-political dimensions, such as stringency of regulation, the character of existing competitive strategies within firms, or the level and quality of public concern for environmental issues, have led to distinct environmental management types in both countries.

Compared to Germany and the UK, in the Netherlands, two key trends in Dutch policy influenced the situation with regard to the environmental regulatory regime. This is firstly the strong stance for deregulation (also concerning environmental regulation) in the early as well as the rising level of political and public environmental awareness in the late 1980s (Wätzold *et al.* 2001). Secondly, within the Dutch National Environmental Policy Plan in particular, this implied two specific new government strategies targeted towards industry. Firstly, this was the introduction of environmental management systems (EMS) within industry target groups, and secondly, the negotiation of voluntary agreements (so-called covenants) in which the target groups' contributions to the achievement of various environmental policy goals (e.g. greenhouse gas emission reductions) were defined (Wätzold *et al.* 2001).[49]

Based on WEF *et al.* (2001), the stringency of regulation and the orientation of regulation towards flexible instruments (as a proxy for the efficiency of environmental regulation) of the four countries (Germany, Italy, Netherlands and United Kingdom) studied in the first

[49] Regulatory relief was granted equally to EMS regardless if verified under EMAS or certified to ISO 14001.

empirical phase of this thesis (and of which two, the United Kingdom and Germany are further analysed during the second empirical phase) can be classified in different ways as set out in Table 3.1 below:

Table 3.1: Stringency of regulation and orientation towards economic instruments (ranks in brackets after score, 1 = highest)

Country	**Stringency of regulation**[50]	**Use of flexible instruments**[51]	**Transparency of regulation**[52]	**Innovation through regulation**[53]	**Regulation & management indicator**[54]	**Regulatory regime index**[55]
Germany	1.82 (1)	(3)	4.1 (3)	0.7 (3)	1.34 (2)	1.205 (2)
Italy	0.25 (4)	(4)	2.8 (4)	-0.50 (4)	0.08 (4)	0.035 (4)
Netherlands	1.53 (2)	(1)	4.4 (2)	1.34 (1)	0.75 (3)	1.623 (1)
United Kingdom	0.99 (3)	(2)	4.5 (1)	1.18 (2)	1.54 (1)	1.087 (3)

As stated above, with regard to the level (i.e. strictness of regulation), efficiency (determined mainly by the approach to regulation) and future development of environmental regulation, it can be expected that the level of environmental performance will be higher in countries and sectors with (i) more stringent environmental regulation (i.e. more stringent emission standards), (ii) a more efficient approach to regulation. In particular, the reason for (ii) is that despite the limitations of the mechanisms proposed in the Porter hypothesis, it is likely that incentive-based regulations using economic or negotiated instruments reduce private and social abatement costs as compared to command-and-control type regulation. The former thus maintain incentives for firms in an industry to reduce emissions, provide cost-effective

[50] Data for the measure "Stringency and consistency of environmental regulation, in 2000" was taken from WEF *et al.* (2001).

[51] Ranking is based on author's assessment of how much a country applies voluntary or economic instruments (e.g. voluntary or negotiated agreements, environmental taxes, tradable permission permits), based on reviewing the relevant literature (e.g. Gordon 1994; Peattie & Ringer 1994; James *et al.* 1997; Wätzold *et al.* 2001). Based on this it was possible to construct an ordinal ranking, not assuming equidistant differences between countries.

[52] Data for the measure "Transparency and stability of environmental regulation, in 1999" was taken from WEF *et al.* (2000).

[53] Data based the on measure "Degree to which environmental regulation promotes innovation, measured in 2000." in WEF *et al.* (2001).

[54] Data based on "Regulation and management indicator" in WEF *et al.* (2001) which comprises of the measure "Stringency and consistency of environmental regulation, in 2000" in WEF *et al.* (2001) as one component.

[55] Data of the index is based on Esty & Porter (2001). The index assesses stringency of standards, subsidies, regulatory enforcement, regulatory structure, information and environmental institutions.

allocation of resources and abatement technologies. As a result these considerations, it is expected that economic performance is influenced positively, the lower the stringency of and the higher the efficiency of environmental regulation in a country is.

3.3.2 Processes operated and industry sectors

The transformation of Europe into an industrial economy and society since the beginning of the 19th century has fundamentally changed the relationship between humankind and the environment. Whilst the industrial economy has brought massive benefits to humankind in terms of e.g. life expectancy, technological progress and quality of life in general, it has at the same time significantly altered the scale and complexity of interactions with the environment in that the material requirements of the industrial economy and society (i.e. industry) in Europe extend far beyond basic survival needs of humankind (Jackson 1996). This change in scale of complexity has resulted into a number of environmental problems. The underlying pattern which has lead industry to become a major source of environmental problems is that (different to natural ecosystems), industrial economies are largely linear systems in the sense that energy and material flows enter the system at one point and soon after exit it at another point. Opposed to this, natural ecosystems are largely cyclic systems, i.e. energy and material flows are transformed in a cascading process in order to make maximum use of the exergy which energy and material flows supply to ecosystems. In addition to this, the industrial economy is an open system, i.e. it exchanges energy and materials with the system environment, whereas the global ecosystem is a materially closed (but not energetically isolated system) since it only exchanges energy with its system environment (i.e. the universe). The global ecosystem hence receives high-exergy energy flows from the sun, transforms these in a cascade of material transformations into low-exergy energy flows (in this way exporting entropy into the system environment) and then dissipates low-exergy energy flows (i.e. thermal radiation) into the system environment (Jackson 1996). The system environment of the industrial economy is the global ecosystem (i.e. the industrial economy is part of the global ecosystem). The industrial economy therefore exports entropy in the form of low-exergy energy flows and dissipative material flows into the global environment. In doing so it reduces or keeps constant the entropy level within the industrial economy, but at the price of increasing the entropy of the global ecosystem.

Increased entropy in the global ecosystem for example implies the destruction of high-order structures, e.g. species, resulting in e.g. reduced biodiversity within the global ecosystem.

The global ecosystem itself can, however, also reduce its entropy level by exporting entropy to its system environment, the universe. However, the ability to export entropy is limited for the global ecosystem by the amount of high-exergy solar radiation that flows into the system per period of time. This is reflected by the so-called solar constant, which has the value of 1.35 kW per square metre at the border of the atmosphere (Heinrich & Hergt 1990, p. 15). Therefore, over geological periods, a dynamic steady-state equilibrium has developed in which the global ecosystem as a dissipative structure[56] balances entropy in- and outflows so that the net entropy change is approximately zero. The industrial economy is considerably disturbing this equilibrium between the global ecosystem and its system environment, since it produces additional entropy, which it transfers to the global ecosystem, in this way adding considerably to the overall entropy production of the global ecosystem (which subsequently needs to be exported). One factor that increases the problem is that since the industrial economy and society is largely linear, it is not minimising its entropy production (which would require as a precondition largely cyclic systems, similar to natural ecosystems). In summary, industry (i.e. the manufacturing sector) in Europe, but of course also elsewhere in the world is causing significant environmental problems. According to Jackson (1996, p. 20), environmental management[57] therefore needs to find a development path for industry, which retains the advantages for humankind achieved through industrialisation whilst at the same time allowing for future health of the environment by reducing the environmental impacts of industry, by e.g. making industrial systems more alike to natural ecosystems (e.g. more cyclic).

The manufacturing industry (as the focus of this research) is particular relevant for achieving sustainable development. Generally, the processes operated at a site are more a classification criterion, rather than an influencing factor to be hypothesized about, since only firms and sites with fairly comparable processes can *per se* be compared with regard to the relationship of environmental and economic performance. Processes operated are therefore operationalised in the first empirical research stage by means of a broad classification scheme, in which newsprint, magazine-grade and graphics fine paper are represented by one category "Cultural" papers, and packaging corrugated and other boards by another category, "Industrial" papers. Also "Mixed" and "Other" categories are defined, resulting in a classification based

[56] The term "dissipative system" has been used for macro-level structures by Prigogine (1979) and Prigogine and Stengers (1981; 1984) and was originally developed by Prigogine for the molecular level during earlier work on chemical systems far away from the equilibrium.

[57] As explained in Footnote 5, the term environmental management refers to every activity of business, which aims at the reduction of its environmental impact, i.e. which aims at improving a firm's environmental performance (Schaltegger & Burritt 2000, p. 113).

on four (broad) sub-sectors. Another very important influence captured by these dummy variables is market development (e.g. measured in terms of the market growth), which can be expected to vary significantly more between than within sub-sectors. Russo and Fouts (1997) as well as Konar and Cohen (1997; 2001) include a measure for market growth in their analyses of the relationship between environmental and economic performance. Given that no direct measure of market growth was available for the data set analyzed in the first empirical stage of this thesis, it seemed appropriate to at least address the influence of market growth on firms' economic performance by means of a sub-sector variable. Even though this would not capture the full effect of market development on an individual firm, it would at least discriminate between homogenous subgroups of firms. Given this argument, significant sub-sector effects can be controlled for by including a sub-sector dummy. Sector dummy variables are introduced as control variables in the second empirical analysis, since it is assumed, that the economic performance of a firm strongly depends on the sub-sector it operates in.

3.3.3 Firm size

It is often argued that firm size has an influence on corporate environmental performance. On the one hand, it is stated that firm size reflects firm visibility, and since larger firms tend to be more susceptible to public scrutiny, they are more likely to be industry leaders with regard to environmental performance (Henriques & Sadorsky 1996). In addition to that, it is frequently argued, that smaller and medium-sized firms[58] are often laggards who have a relatively reactive stance towards environmental management (Bradford 2000). Small and medium-sized firms (SMEs) are often found to be unaware of their legal duties regarding waste disposal and frequently consider their operations not to have a significant environmental impact. In addition to that they tend to be unfamiliar with environmental management systems and standards and tend to respond strongest to regulation as a stimulus for environmental improvement (Bradford 2000; Meffert & Kirchgeorg 1998).

These findings from a research project looking at environmental awareness in SMEs in five EU countries, Germany, Sweden, Netherlands, Italy and the UK (Bradford 2000) is also supported by a Swedish survey which found in 1998 that small firms with less than 50 employees in Sweden had no significant ambitions to become environmental leaders although

[58] Usually, small firms are defined as those with less than 50 employees, whilst medium-sized companies are considered to be those in the range of 50-250 employees (EIM 1997, p. 329). Such a definition, however, needs to account for potential distortions from transitory growth and size class changes of firms.

attitude changes were noted in medium-sized companies above 50 employees, mainly triggered by the introduction of EMS, customer requirements and organizational change (Heidenmark & Bakman 1999). Consistent with these empirical findings it was found that competitiveness is the highest priority for SMEs, whilst avoidance of legal problems (under which environmental performance can be subsumed to a large degree due to the fact that SMEs were found to be mainly compliance- and regulation driven) was ranked very low (Bradford 2000).

On the other hand, research within the MEPI project on the same countries (excluding Sweden) found largely no significant effect of firm size on environmental performance when measured on the basis of quantitative emissions and input data (Berkhout *et al.* 2001b). Given this finding, it seems that the often-assumed influence of firm size on environmental performance may be more a reflection of firms' perceptions than of factual results. SMEs themselves seem to mainly perceive the relationship between environmental and economic performance to be negative or at least non-existing, since competitiveness (as a basis for good economic performance) is usually not considered by them to be linked to environmentally-related legal problems (such as non-compliance with environmental standards) or is thought to be conflicting with the avoidance of legal problems. For a full sustainability assessment of small firms, social sustainability aspects need to be taken into account as well (for e.g. an analysis of the link between firm size and job creation see Wagner (1995) for details).

Concerning the link between firm size and economic performance, economic theory provides four main reasons for differences in firm size (You 1995, Moschandreas 1994).

These are:

- the existence of U-shaped or L-shaped long-term average cost curves, i.e. existence of a minimum efficient scale of production (MES) with the argumend based on production theory;
- the existence of transaction costs, resulting in a substitution of allocation mechanisms, i.e. firms as organisational structures for allocation instead of markets with the argument being transaction cost theory-based;
- the existence of heterogeneous (monopolistic, incomplete) competition, i.e. markets with many sellers and differentiated products with the argument based on demand conditions in the market and postulating niche markets for small firms;

- the stochastic explanation for firm size differences with the argument based on the notion that changes in concentration are the net effect of a large number of uncertain and thus stochastic influences (for a recent analysis of this, see Wagner 1992).

Basically the different economic approaches to explain differences in firm size allow the conclusion that small firms exist where this is not a competitive disadvantage, e.g. where MES or transaction costs are low, or where the market structure allows the existence of niche markets. Therefore, no clear effect of firm size on economic performance is expected. Concerning the relationship between environmental and economic performance, this would imply that from the point of economic theory, no direct explanation is provided as to why the influence on economic performance should be less positive for smaller firms than for larger firms or vice versa. Nevertheless it is possible that for small firms a negative influence exists if there are economies of scale in environmental management strategies and activities. This is possible (but ultimately an empirical question), since environmental management is likely to have a high level of fixed (i.e. output- and therefore size-independent) costs.

3.3.4 Debt-to-equity ratio (gearing ratio) and asset-turnover ratio

The debt-to-equity ratio/gearing ratio and the asset-turnover ratio were mainly included in the analysis to avoid misspecification of the econometric equations, since both have been argued in the literature (see 2.2.6.2 and 2.2.6.3) to affect profitability and economic performance of firms in general.

The asset-turnover ratio (i.e. the ratio of total assets to operating revenue) can be considered to measure the capital intensity of a firm's operations. Russo and Fouts (1997) as well as Hart and Ahuja (1996) suggest including this ratio as a control variable when carrying out regressions with ROCE, ROE or ROS as dependent variable. A low ratio would indicate a firm with below-average capital intensity, which Schaltegger and Figge (1998) argue can also be considered beneficial in terms of value-oriented environmental management.

The debt-to-equity or gearing ratio can be defined as the inverse of the solvency ratio minus one. The solvency ratio addresses a firm's longer-term solvency (and thus its capital structure) and is concerned with its ability to meet its longer-term financial commitments (Arnold *et al.* 1985).[59] Defined as the ratio between shareholder funds and total assets, it is a measure for capital structure and investment/financial risk (Pendlebury & Groves 1999, pp.

[59] Longer-term solvency is related to the composition of a firm's capital structure. The higher the proportion of a firm's finance that consists of loan capital, the higher are its interest payments. The increased risk of the firm failing to meet these in turn affects estimates of its future performance (Arnold *et al.* 1985).

262-263). This means that the inverse of the solvency ratio (after deducting one) is a measure of financial leverage.[60] Therefore, the debt-to-equity ratio was included as a control variable in the regressions with ROCE, ROE and ROS as dependent variables. However, ROCE should not be affected by capital structure differences, and therefore, the debt-to-equity ratio should not turn out significant in analyses with ROCE as dependent variable.

The very different views about the gearing/debt-to-equity ratio seem to reflect (at least to some degree) the underlying theoretical debate about the influence of gearing/financial leverage on firms' costs of capital. Hay and Morris (1991) suggest at least five different phases in thinking about the gearing/leverage and its effect on firms' capital costs and, as a result, profitability. Whereas the traditional view of gearing suggests an optimal debt-to-equity ratio for which the weighted average cost of capital (WACC) are minimal, the work of Modigliani and Miller proposes that gearing has no effect on firms' cost of capital (if investors are rational and capital markets efficient) and thus does not affect a company's value nor equity yield (Hay & Morris 1991). As a third approach making predictions about gearing, the tax-bankruptcy trade-off model takes up again the view of the traditional model but for a different reason, which is the trade-off for a firm (under the assumption of tax deductible debt interest payments and better credit terms for successful companies) between predominantly tax-related benefits and bankruptcy-related costs to a firm from a higher debt-to-equity ratio. These in turn would again lead to a U-shaped WACC curve with the optimal level of gearing corresponding to the minimum of the curve (Hay & Morris 1991). This tax-bankruptcy trade-off model received criticism in a subsequent phase in the form of the Miller equilibrium model which was based on the observation that " … there appears to have been very little change in debt-equity ratios in the USA between the 1920s and the 1950s despite taxation increasing by a multiple of perhaps five times (Hay & Morris 1991, p. 394)". The Miller equilibrium model (as the fourth phase of thinking about gearing/leverage) argues that the tax-bankruptcy trade-off model is incorrect because bankruptcy costs tend to be small and because arbitrage opportunities render tax advantages irrelevant in many cases. As a result of this, a firm's level of gearing (represented by its debt-to-equity ratio) is incidentally and historically determined and does not have any relationship to firms' cost of capital and profitability. Morris and Hay (1991) argue however, that empirical evidence and theoretical considerations suggest that "… the Miller equilibrium [model, M.W.] and the irrelevance of a

[60] The inverse of the solvency ratio equals the ratio of total assets (i.e. the sum of debt and equity) to shareholder funds (i.e. equity). It thus equals the ratio of debt to equity plus one. Deducting one results in the inverse of the solvency ratio minus one equalling to the ratio of debt to equity, i.e. the debt-to-equity ratio.

firm's gearing even in a world of taxes seems less convincing than the tax-bankruptcy trade off model (Hay & Morris 1991, p. 398)". Finally, the fifth and (to date) last phase in the thinking about the gearing focuses on agency costs and signalling which again proposes an optimal level of gearing. The discussion of the different phases shows that even theoretically, there is no unique and uncontested prediction about the relationship between gearing (i.e. the debt-to-equity ratio), cost of capital and profitability or firm-level economic performance. Also, the different explanations for gearing are not mutually exclusive, but interact, and thus any gearing level observed in reality may be determined by a rather complex combination of all the explanations discussed, making predictions even more difficult. Finally, gearing ratios vary widely across similar firms, indicating that considerations other than risk, taxation or agency costs may affect observed gearing ratios. In fact, there seems to be evidence that firms tend to have target debt-to-equity ratios (Hay & Morris 1991). The debt-to-equity ratio (as well as the asset-turnover ratio) are therefore included as necessary control variables in regression analyses with economic performance as dependent variable, without which equations may be mis-specified. Beyond this, any further interpretation of the meaning of coefficient signs or significance levels seems to be very speculative. Therefore, the debt-to-equity ratio is analysed here only on a descriptive level, since it was only included as a control variable in the regressions.

3.3.5 Corporate environmental strategy and management

Different to country location, sector and sub-sector membership, firm size, gearing and capital intensity, corporate environmental strategies and management can be expected to have a direct effect on environmental as well as economic performance of firms, and hence on the relationship between the two. However, this effect of corporate environmental strategies will only be addressed in the second empirical analysis of this research, due to the unavailability of strategy data in the first empirical analysis.

Environmental management systems (EMS) have become increasingly relevant over the last 5 years. At least partly this can be attributed to the (perceived) cost-reducing, sales-boosting and innovation-inducing effects of such systems (ASU 1997). For example, the German Federal Environment Agency stresses in its review report on experiences with the EU Eco-Management and Auditing Scheme (EMAS) in Germany that approximately 50% of the companies surveyed reported cost savings (UBA 1999). However, Dyllick states that "areas of environmental competition exist where environmental problems may lead to competitive advantages or disadvantages depending on whether they are solved or not (Dyllick 1999, p.65)" and stresses that "both, costs and possibilities for differentiation are important to look at in this respect (Dyllick 1999, p. 65)". Therefore, it is probably necessary to incorporate a (much more difficult to-do) monetary valuation of benefits achieved by EMS through environment-based differentiation strategies and EMS-induced product or process innovations.[61]

Regarding corporate environmental strategies and environmental management, Schaltegger and Figge (1998; 1999; 2000) argue that the amount of corporate environmental protection in itself neither spurs nor reduces shareholder value (or other measures of economic performance). Contrary to the commonly held view that the amount of environmental protection (and thus the level of environmental performance which is related to it) is (negatively or positively) related to the economic performance of firms, they argue that such a relationship strongly depends on factors internal to the firm. Particularly the corporate environmental strategies and environmental management approaches pursued by the firm are seen as major factors which moderate the relationship between environmental and economic performance at the firm level. For a defined level of environmental performance, the economic performance can be improved more if the environmental management activities are linked to the key value drivers of shareholder value (or economic performance in general). Only if a company's environmental management approach (represented e.g. by its EMS or CES) has a positive effect (or a minimized detrimental effect) on these value drivers, then high shareholder value (or financial profitability) can be achieved simultaneously with high levels of environmental performance. This line of argumentation potentially also explains why some empirical studies carried out so far did not uniformly identify one clear (positive or negative) link between environmental and economic performance at the firm level.

With regard to EMS certification, the arguments made by Schaltegger and Figge imply that such certified systems cannot be judged "face value" with regard to their effect on environmental and economic performance but need to be considered in detail regarding organizational structures resulting from them as well as activities initiated by them. This would imply two different lines of argument regarding the effect of EMS certification on

[61] The influence of environmental management system (EMS) certification was analysed separately (Wagner 2003) but is not discussed further in this thesis. The reason for this was, that for 1995, none of the firms in the data set used during the first empirical phase had a certified EMS and including an EMS variable would have resulted in distortions in the analysis. Firms studied in the first empirical analysis were contacted two times in order to record information on their corporate environmental strategies. Unfortunately, response rates were too low to use this data in any meaningful way. Therefore, it was decided to exclude environmental management aspects from the analysis in the first empirical stage.

environmental and economic performance, depending on the theoretical approaches underlying the line of argument (Russo (2001).

On the one hand, institutional theory would predict that EMS certification in well-managed firms leads less well-managed firms to also seeking it (Russo 2001). This would imply, that certification of an EMS would not lead to improved environmental or economic performance, since it is essentially a „symbolic gesture“ and „mimicry“ (Russo 2001).

On the other hand, ressource-based theory argues that firms would only use such factors to differentiate, which are difficult to imitate by competitors (Russo 2001). Hence, only if firms would feel that EMS certification is difficult to imitate by competing but less well-managed firms, they would choose it as a differentiator. This would imply, that EMS certification should have a significant positive influence on environmental as well as economic performance (Wagner 2003). Only if this latter line of argumentation holds, would the implementation and external verification/certification of an environmental management system as signaled and proxied by EMAS verification or ISO 14001 certification be a potentially strong proxy for the fact that a company has a value-oriented corporate environmental strategy (CES).

The argument developed by Schaltegger and Figge (1998, 1999, 2000) based on Environmental Shareholder Value implies that only firms with a value-oriented CES would benefit from systematic EMS implementation in terms of improved environmental performance. This is also independent from EMS certification, since EMS implementation does not depend on it. Consequently, it was found that EMS certification does not have a significant positive influence on environmental as well as economic performance nor does it result in a more positive relationship between environmental and economic performance (Wagner 2003). Therefore, it seems appropriate to analyse EMS effects solely on the basis of EMS implementation data.

Unfortunately, data on EMS implementation was only available during the second empirical analysis and it was therefore decided to exclude environmental management aspects from the first empirical analysis.

All research and derived hypotheses are summarized in Tables 3.2 and 3.3 below, together with the intended methods of testing, and the data set used to empirically test the hypotheses. Also, the outcome of the test is described, with an indication of its usefulness and relevance.

Table 3.2: Summary of research hypotheses, methods for testing, data sets for testing, possible outcomes and usefulness/relevance

Research hypothesis	**Method(s)**	**Data set**	**Outcomes**	**Usefulness/Relevance**
H1: Economic performance has either a uniformly negative or an inversely-U shaped relationship with environmental performance, after controlling for firm-level, industry-level, and country-level/location-related influences. It is also possible, that no significant relationship exists empirically, if the influence of environmental performance on economic performance is very small.	Multiple regression analysis (framework for firm size, country location, sub-sector/sector membership, economic (and other) control variables), Factor analyses, Cluster analyses	MEPI[62] paper sector data (n=106), EBEB manufacturing sector data (n=301)	Conclusions about the relationship between environmental and economic performance, especially with regard to its possible non-linearity.	Academic novelty: non-linear relationship modelled. Policy making relevance: is the relationship of environmental and economic performance sector-specific? Is it equally strong for different economic perf. measures?
H2: There is an influence of corporate environmental strategy choice on the relationship between environmental competitiveness and environmental performance, after controlling for firm-, industry- and country-level influences in that the choice of a value-oriented type of corporate environmental strategy or management leads to a more positive relationship between environmental and economic competitiveness.	Multiple regression analysis (framework for firm size, country location, sector membership, economic and other control variables), Factor analyses, Cluster analyses	EBEB manufacturing sector data (n=301)	Conclusions about influences of corporate environmental strategy (CES) choice as a moderating variable for the relationship between environmental and economic performance for different dimensions of environmental competitiveness.	Academic novelty: so far the influence of corporate environmental strategy as a moderating variable has not been analysed. Relevance for policy making: Allows an assessment if value-oriented CES are more successful in firms.

[62] The project MEPI was funded under the 4th Framework Programme (Environment and Climate) of DGXII of the European Commission (see Footnote 69 for more details).

Table 3.3: Sub-hypotheses derived on the basis of hypothesis H2

Derived hypothesis	**Method(s)**	**Data set**	**Outcomes**	**Usefulness/Relevance**
H2.1: For firms pursuing a value-oriented corporate environmental strategy environmental performance should have a significant inversely U-shaped relationship with environmental competitiveness, after controlling for other relevant influences on environmental competitiveness. There should also be a significant positive component in the relationship.	Multiple regression analysis (framework for firm size, country location, sector membership, economic and other control variables), Factor analyses, Cluster analyses	EBEB manufacturing sector data (n=301)	Derived hypothesis based on H2. If this hypothesis holds, then this a necessary condition for H2 to hold.	Relevance to environmental policy makers: is there a positive (or non-linear, but initially positive) relationship between environmental and economic performance for firms with a value-oriented CES?
H2.2: For firms not pursuing a value-oriented corporate environmental strategy, environmental performance should have no significant or a significant negative relationship with environmental competitiveness, after controlling for other relevant influences.	Multiple regression analysis (framework for firm size, country location, sector membership, economic and other control variables), Factor analyses, Cluster analyses	EBEB manufacturing sector data (n=301)	Derived hypothesis based on H2. If this hypothesis holds, together with H2.1 than this is a sufficient condition for H2 to hold.	Relevance to environmental policy makers: is there a negative or insignificant relationship for firms that have no specifically value-oriented CES?

4. First Empirical Analysis: The Paper Industry in Europe

4.1 Methodology

4.1.1 Introduction

This section of the thesis introduces the methodological approach adopted for the empirical analysis, used to test the hypotheses developed earlier.

The research design of the first empirical analysis is a statistical design using purposive survey methodology. It includes a number of instruments (various EPIs and financial ratios), on which data was 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 procedures used for data collection, and (iv) the statistical analysis approaches and econometric specifications used in the empirical testing of the hypotheses developed in Chapter 3. Following this, the explanatory data analysis and results of this first empirical analysis of the research will be presented.

4.1.2 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.[63] Therefore, as far as possible, the site level was used to identify subjects. In very few instances, however, this was not possible, and in these cases some firms with more than one site were included, which still had, however, only few (i.e. less or equal to five) sites.

The choice of the paper manufacturing sector for the first empirical analysis has been guided and is justified by the following considerations which needed to fulfilled by any sector potentially to be used in the empirical analysis:

- Relevance of the sector for sustainable development;
- Focus on significant environmental effects, which advocates concentrating on a manufacturing sector (ideally with resource-intensive processes) rather than a service sector;

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

- Ensuring an appropriate spread of regulatory, socio-economic and market-based influences on the sector;
- Sufficiently high numbers of firms in the sector which can provide environmental and economic performance data;

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 in the industrial society as a whole. Behmanesh *et al.* (1993) find the paper sector to be consistently ranked fourth amongst all manufacturing industries with regard to its environmental impacts. In addition to that, Silveira (2000) reports that the share of environmental investments in total manufacturing costs is 15% in the Portuguese paper sector, which is an indication for the relevance of environmental performance for economic performance in this sector. These findings support the environmental relevance of the paper manufacturing sector, as well as the relevance of environmental aspects for 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 4.1 below.

Table 4.1: Number of pulp and paper mills and rank of the chosen countries

Country	**Paper mills**	**Pulp mills**	**Rank paper**	**Rank pulp**
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)

Table 4.1 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.

4.1.3 Instruments and measures

4.1.3.1 Introduction

In this section, the case is made for the use of the instruments and measures adopted for use in this research. It will be argued, that the chosen environmental and economic performance measures are suited to address the research questions and hypotheses formulated in the previous chapter. This particularly concerns (Rudestam & Newton 1992):

(i) appropriateness of using the instrument/measure with the intended subject population,

(ii) the measurement characteristics of the instrument, and

(iii) the administration and scoring of the instrument's scales.

Quantitative measures of environmental 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 environmental reports or pollutant release and transfer registers (ER, TRI, CRI). Public availability is not given for ratings, since these are usually prepared by private sector ranking agencies or companies for commercial purposes and are thus proprietary.

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

Thirdly, environmental performance indicators (i.e. normalised measures of environmental performance) and financial ratios have been used in several empirical studies to analyse the relationship between environmental and economic performance (e.g. Hart & Ahuja 1996; Edwards 1998; Johnston 1996). Therefore, in the first empirical analysis, no own instruments are developed, but well-established EPIs whose reliability and validity has been extensively tested (for example recently in the MEPI research project, see Berkhout *et al.* 2001a) are chosen. To proceed this way is often advocated over developing new instruments in the literature (Rudestam & Newton 1992).[64]

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[64] Data is not always available on quantitative measures. This is for example the case for the second empirical analysis presented in Chapter 5. Here, it was necessary to fall back on ordinal rankings and ratings instead.

4.1.3.2 Environmental performance indicators for the analysis in the paper sector

Introduction

Similar findings to those by Marsanich (1998, see Chapter 1) were also made specifically for the paper sector in the "Measuring Environmental Performance of Industry (MEPI)" project (Berkhout *et al.* 2001a). The MEPI project surveyed a large number of environmental performance indicators available in different industry sectors, amongst them pulp and paper manufacturing. It found that data availability differs significantly for the different types of environmental data. Across all years 1985, 1990 and 1994 to 1998 the environmental performance data best available (at the level of production sites and with a total of 372 sites) are for air emissions NO_x (210) and SO_2 (187); for water emissions COD (212) and BOD (186); and hazardous waste (142). For water inputs the data covered best was total water (133) and water from direct extraction (132). As concerns energy data, the best-covered data were gas input (226), input of externally generated (i.e. bought-in) electricity (167) and oil input (122). The availability of total waste output and total energy input data can however be improved when the different types of waste and energy are added up where available. This is desirable as well, since partial waste outputs or energy inputs cannot ensure that performance for one partial output or input is only improving at the price of deterioration for other partial outputs or inputs. Therefore only total waste, energy or water data allow a comprehensive assessment of environmental performance in these areas. Regarding sector specific indicators, data on recycled fibre input into paper production (165) was better available then data on additives input into production (97).

Finally, with regard to potential normalisation measures, production output by weight (293) and number of employees (165) were best available, whereas other data, e.g. on total sales (65) or profits (21) were only available to a lesser degree. With regard to management performance indicators, data on EMAS (236) and ISO (256) was available best, where as data on environmental investments (170) and on non-compliance events (22) was only available to a considerably lesser degree (Berkhout *et al.* 2001a).

Based on the theoretical and practical considerations made so far in this thesis, the set of EPIs for the paper industry proposed for use in this research are summarized in Table 4.2 below. Each indicator will be defined and described in detail in Table 4.2. With regard to CO_2, it was decided not to include an EPI for these emissions, since in a longer-term sustainability perspective CO_2 is not very relevant for the paper sector given that the net CO_2 balance (including forestry) of the paper sector is negative. CEPI (1999) estimates the long-term storage of carbon dioxide in paper products to be approx. 51 kg CO_2 per ton of paper per year.

The main negative effect in the balance here is due to carbon dioxide sequestration in forests. Partly due to this fact, CO_2 indicators are less frequently available in the paper sector. In addition to that since energy efficiency improvements and increased use of non-fossil fuels are considered to be the most relevant strategies to reduce CO_2 emissions during paper production, appropriate energy indicators can substitute a CO_2 emissions indicator. The following Table 4.2 summarises a set of possible environmental performance indicators (together with their respective definitions) to be potentially used as instruments to measure environmental performance in the paper sector during the first empirical analysis of this research. The subsequent Section 4.3.3 chooses the most appropriate of these for the analysis.

Table 4.2: Paper EPIs as defined in Berkhout *et al.* (2001a) and MEPI (2000) (Table continued on next page)

Indicator name	**Definition**	**Relevance**	**Unit**	**Measurement method**	**Relevant data sources**
NO_x emissions (Non-product outputs to air of nitrogen oxides)	Emissions of NO_x comprising both, NO and NO_2, measured as NO_2.	Acidification, Local air pollution	Kilo tonnes [kt] per annum		Environmental reports verified under EMAS or ISO, Pollution inventories, Surveys
SO_2 emissions (Non-product outputs to air of sulphur dioxide)	Emissions of sulphur dioxide from production processes.	Acidification, local air pollution	Kilo tonnes [kt] per annum		As above
Total waste (Non-product outputs to land of total solid waste)	Aggregated total amount of municipal waste, recycled waste and hazardous waste	Transport, treatment and disposal of municipal waste leads to a range of environmental impacts	Kilo tonnes [kt] per annum		As above
BOD emissions (Non-product outputs to water (before treatment) of biological oxygen demand BOD)	Annual biological consumption of oxygen by contaminants in wastewater discharged by production unit.	BOD of waste water (before treatment) measure the potential to cause waterway pollution from de-oxygenation	Kilo tonnes [kt] per annum	BOD is measured in specified experiments measuring the amount of oxygen dissolved over 5 (BOD5) or 7 (BOD7) days	As above

COD emissions (Non-product ouputs to water (before treatment) of chemical oxygen demand COD)	Annual chemically determined demand of oxygen from wastewater contaminants discharged.	COD of waste water (before treatment) measures the potential to cause waterway pollution form de-oxygenation	Kilo tonnes [kt] per annum		As above
Recycled fibre input (Physical input of recycled fibre)	Share of waste paper in total materials input of pulp and paper making	Information is relevant for environmental evaluation of paper production	Kilo tonnes [kt] per annum		As above
Total energy input (Physical input of energy in total into production)	Aggregate amount of total energy input, i.e. sum of total fuel input and total electricity input	Information allows to assess overall energy efficiency of production if no breakdown of data is available	Giga Joules [GJ] per annum		As above
Total water input (Physical input of total water into production)	Annual aggregate input of water, either from direct extraction or from public supply	Water is a vital resource with various important functions for human health and the environment	Cubic metres [m^3] per annum	Generally, the amount of directly extracted water seems to be larger, than the amount of publicly supplied water	As above

Suitability and choice of indicators for the empirical phase

In the following, based on the theoretical criteria developed for suitable EPIs and based on the indicators developed in the MEPI project, a final selection of indicators will be made to be used in the first empirical analysis to be carried out in this research. This will also take into account aspects concerning the interrelation between different indicators developed within the MEPI project.

Regarding the possible EPIs for waste generation (total solid waste, hazardous solid waste and municipal waste) total waste is the most relevant indicator since it is not confounded by definition problems. However, data availability on this EPI was very low. Therefore it could not be used in the empirical analysis. Similar problems arose with recycled fibre input, where many observations had missing values. Also in some cases, the values were above 100%, which is theoretically not possible. This last observation might indicate a low standardisation level for this variable. As for waste generation, it was therefore also decided to exclude recycled fibre input as a variable from the empirical analysis.

Also regarding BOD and COD several important qualifications of the indicators are necessary. Firstly, BOD can be measured according to the 5-day or 7-day method, resulting in the BOD5 and BOD7 indicators, respectively. For example, BOD7 measures the content of biologically degradable substances in wastewater during a period of seven 24-hour periods (Lundin 1999). However, BOD5 and BOD7 indicators differ usually only by approximately 10% in their values (Lundin 1999), therefore even if it is not known, on which basis BOD was calculated, the distortion from this is small compared to the range of indicator values experienced in practice. COD is not faced with the problems identified for BOD, since it measures total oxygen demand required for chemical breakdown of wastewater contaminants. Since this always includes biological breakdown, COD values are theoretically always larger or equal to BOD values, and normally BOD takes values between about 1/3 and 1/4 of COD (Grabowski 2000). For both, COD and BOD of wastewater it is however important to note that a distinction is made between measurements prior to wastewater treatment or after treatment (Grabowski 2000). BOD and COD values after treatment depend on the performance of the paper mill's wastewater treatment plant. Usually specifications of these plants are determined by regulatory requirements with regard to BOD and COD values after treatment. Given that plants have to achieve the values prescribed by regulators, their treatment plants need to be the more powerful, the higher the BOD or COD levels are immediately after the wastewater leaves the paper making process.

Since there is no large difference between BOD and COD in terms of their relevance and interpretation, it was decided to use only COD as an environmental performance indicator in this research, given that data availability in the data set used was better for COD than for BOD.

With regard to energy and water indicators some important aspects need to be taken into account when interpreting these indicators. Firstly, regarding the possible EPIs for energy generation (total energy input, total fuel input and self-generated electricity), total energy input is the most reliable indicator since it is not confounded by definition problems. The same is the case for water input. For both, energy and water indicators partial indicators (such as e.g. total fuel input and self-generated electricity) were therefore added up to total energy and water input, where total energy/water input was not directly available in order to not loose data. This procedure was considered based on the observation that it did not alter significantly mean values and standard deviations of the respective distributions for total energy and water input.

The variables finally used to operationalise the concept 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, data was 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, as summarised in Tables 4.3 and 4.4 and the corresponding scatterplots below. Also, for a homogenous good such as paper, value added and physical production output should also be correlated highly, from a theoretical point of view.

Table 4.3: Correlations between production output and value added (averages 1995-1997)

Variable	**Statistics**	**Average number of employees**	**Average physical production output**	**Average value added**
Average number of employees	Pearson Correlation	1.000	0.760	0.810
	Sig. (2-tailed)	-	0.0001	0.0001
	N	34	33	24
Average physical production output	Pearson Correlation		1.000	0.965
	Sig. (2-tailed)		-	0.0001
	N		34	25
Average value added	Pearson Correlation			1.000
	Sig. (2-tailed)			-
	N			25

Table 4.4: Correlations between production output and value added (pooled)

Variable	**Statistics**	**Number of employees**	**Physical production output**	**Value added**
Number of employees	Pearson Correlation	1.000	0.932	0.914
	Sig. (2-tailed)	-	0.0001	0.0001
	N	104	104	94
Physical production output	Pearson Correlation		1.000	0.935
	Sig. (2-tailed)			0.0001
	N		108	95
Value added	Pearson Correlation			1.000
	Sig. (2-tailed)			-
	N			95

As can be seen from Figures 4.1 to 4.6, the correlation between physical production and value added is highly significant for both, pooled and average 1995-1997 data. The absolute height of the correlation coefficient is slightly lower for the pooled data (i.e. the pooled data is resulting in the more conservative estimate). Also the correlation between the number of employees and production output is very high (for pooled as well as for average data) as is the correlation of the number of employees with value added. In these cases, correlation is slightly lower for average data than for pooled data, possibly due to serial correlation in the latter. Based on these results the use of physical production output for normalisation of environmental variables is well-supported and throughout the empirical analysis in this research, production output will be used normalisation measure.

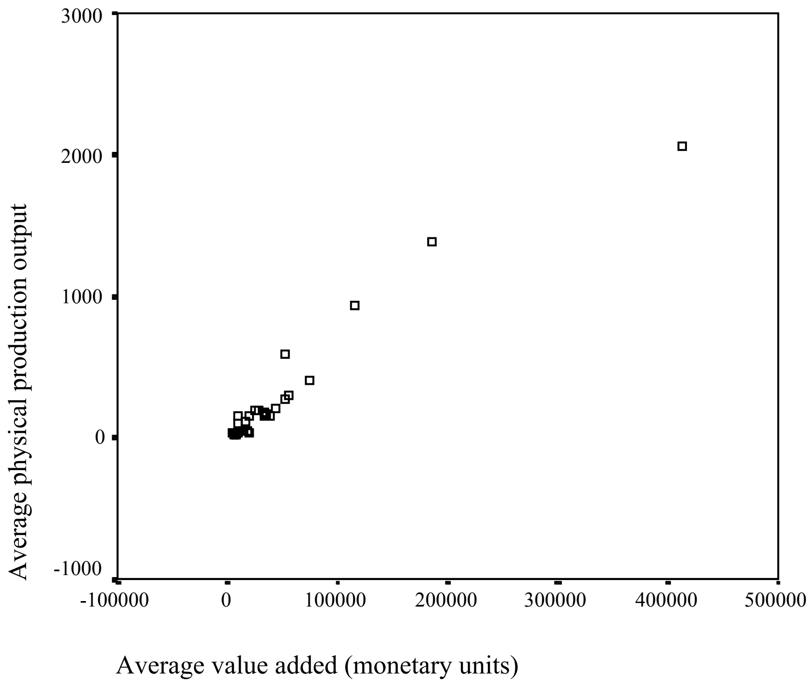

Figure 4.1: Average physical production output and average value added (1995-1997 average data)

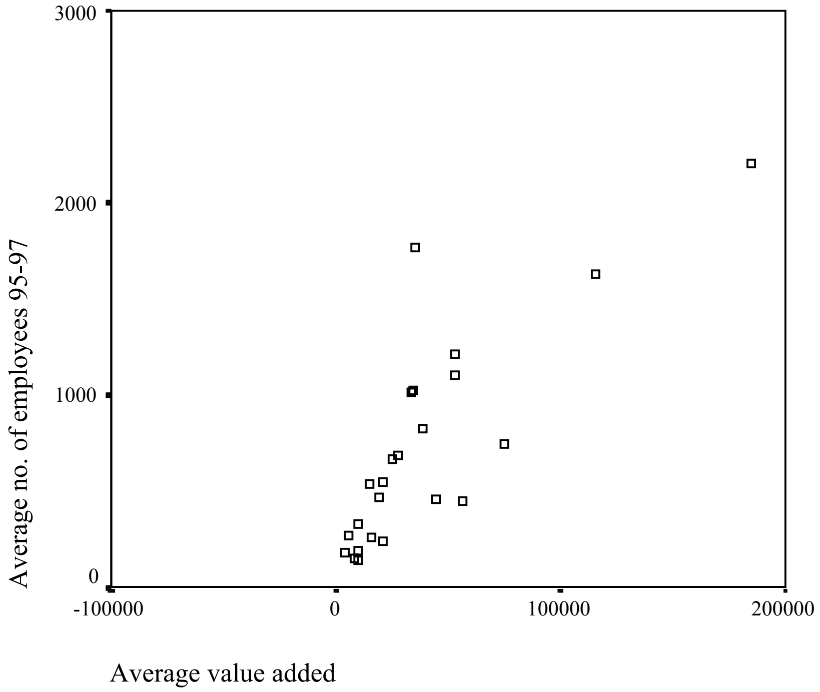

Figure 4.2: Average number of employees and average value added (1995-1997 average data)

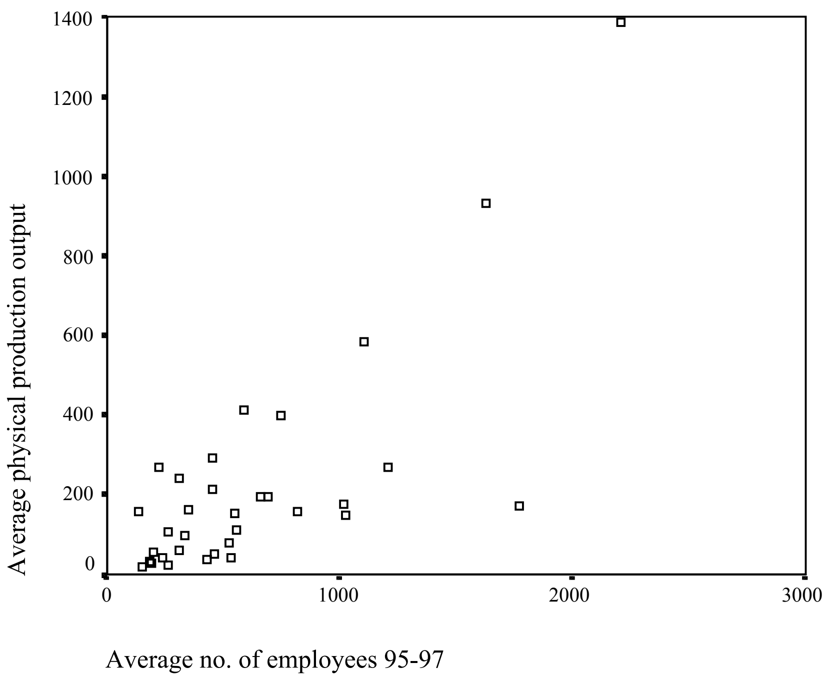

Figure 4.3: Average physical production output and average number of employees (1995-1997 average data)

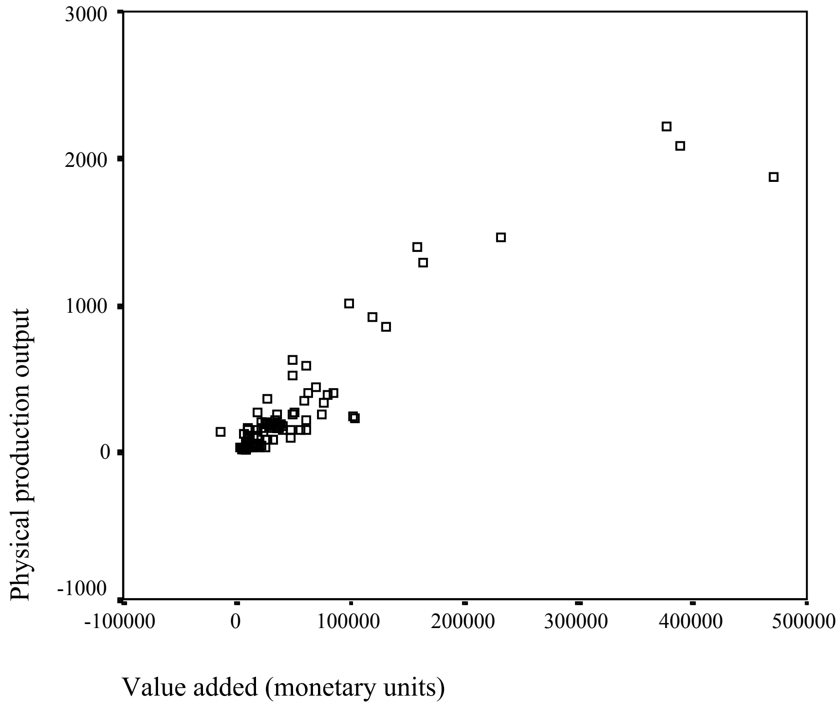

Figure 4.4: Scatterplot of physical production output and value added (1995 – 1997 data pooled)

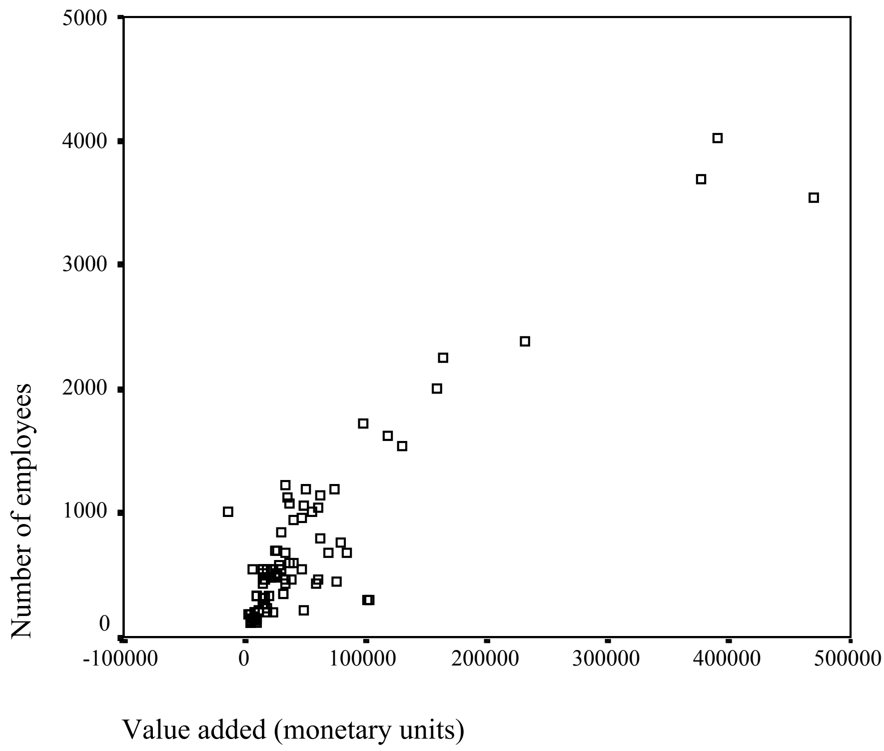

Figure 4.5: Scatterplot of number of employees and value added (1995 – 1997 data pooled)

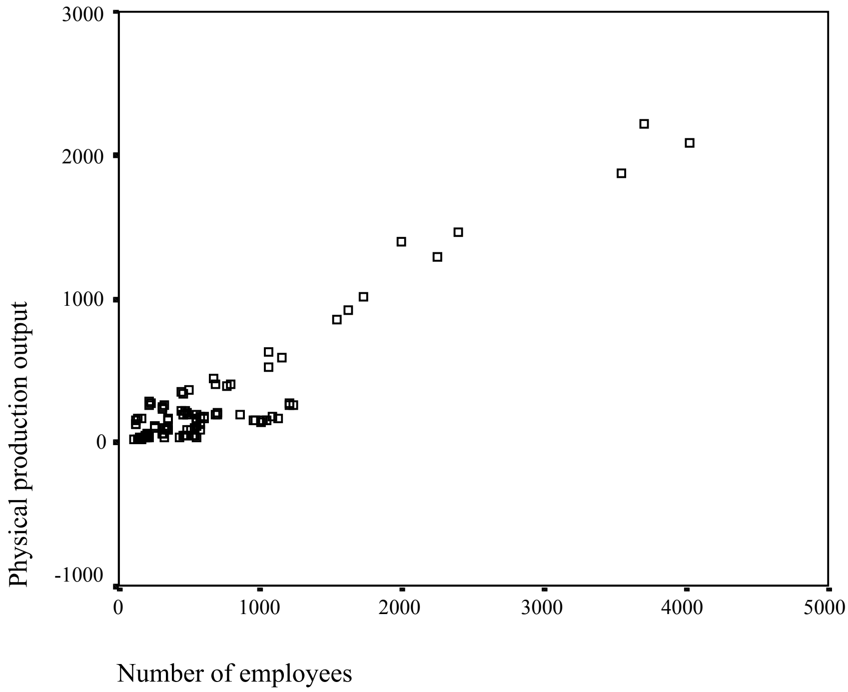

Figure 4.6: Scatterplot of physical production output and number of employees (1995 – 1997 data pooled)

Method for index calculation

Overall, the analysis of possible environmental performance indicators resulted in a set of EPIs, which covers most significant environmental aspects of the paper industry and at the same time meets most theoretical criteria for EPIs. Also, data availability for the selected EPIs is sufficiently high to ensure usability. It was therefore decided to use the EPIs NO_2, SO_2, and COD, total energy input and total water input in the empirical study to test the hypotheses formulated in Chapter 3 and to answer the research question of this thesis.

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 adaption used by Tyteca *et al.* (2002). The indicators used to calculate scores for the first (output-oriented) index score were SO_2, NO_x, and COD. For the second, input-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 was used more efficiently this way, since more cases could be included in the analysis. Thirdly, the input-oriented index reflects more to pollution prevention, whereas the output-oriented index reflects more end-of-pipe activities.

To calculate the index, data on a set of analogous units focused on a specific type of production (e.g., firms in the paper manufacturing sector), and characterized by variables reflecting inputs, desirable outputs, and undesirable outputs (emissions) needs to be available (Tyteca *et al.* 2002; Berkhout *et al.* 2001a, p. 140).

The principle for calculating the index (hereafter referred to as *IND*) is to make reference to the units that perform best among the given set, i.e., those that, in the context of this research, release the least of emissions, for given levels of output production (i.e. have the lowest specific emissions per unit of production output, i.e. per tonne of paper). It is in the following assumed, that the index will be calculated for *k* different individual environmental performance indicators (e.g. the emissions SO_2, NO_x, and COD) where *k* designates the total number of individual variables/indicators taken into consideration to evaluate the performance (Berkhout *et al.* 2001a).

The variable describing the specific emission V_k for the production unit *i* (in this case a specific firm) is defined as:

V^k_i = *Absolute emissions for variable k of firm i / Unit of production output* [65] (1)

This variable can be calculated for each of the *n* firms considered. Based on this, in the next step, the minimum value for this variable is identified, over the whole set of firms:

$$V^k_{\min} = \min_i \left\{ V^k_i \mid i \in 1 \,..\, n \right\} \tag{2}$$

Subsequently, for each firm, a new variable C^k_i is defined according to the following equation:

$$C^k_i = V^k_{\min} \Big/ V^k_i \leq 1 \tag{3}$$

The value taken by this ratio will be 1 only for the unit(s) performing best for the variable considered. For all other units, it will be strictly less than 1, but larger than 0. It can be interpreted as the contribution (hence the variable name C^k) of variable V^k to the index (or global performance indicator) for firm *i*. When calculating (3), a problem arises, if the minimum emission in the data is equal to zero, since then the ratio calculated in (3) will be equal to zero for all cases in the data set. In such a case, this research followed Berkhout *et al.* (2001a, p. 141) in using as minimum value an arbitrary, strictly positive value, which was smaller than the smallest emission value different from zero in the data. At the same time, those cases with zero emissions on the variable in question were assigned the value of 1.

Prior to calculating the index IND_i for each firm, it is necessary to adjust the contribution C^k for inhomogeneities in the individual variables. Otherwise, some variables may be given a much higher weight than others. The reason for this is that the contribution C^k calculated for one variable may be sometimes on average several orders of magnitude higher or lower than that for another variable (Berkhout *et al.* 2001a, p. 140). In such a case, when summing up the contributions into the index, only the variables with the highest average order of magnitude will influence the value of the latter. In order to adjust for this (essentially differences in the skewedness of distributions), an adjustment factor is calculated according to the following formula:

$$Adj^k = \underset{j=1..k}{Max}\left[Median\left(C^k_i\right) \right] \Big/ Median\left(C^k_i\right) \geq 1 \tag{4}$$

For the calculation of the index, the C^k_i for each firm *i* is then multiplied with corresponding Adj^k. Finally, the index IND_i is calculated for each firm, according to the following formula (5). As can be seen from (5), when summing up the adjusted contributions of each individual environmental performance variable, these will be implicitly assigned an arbitrary weight of

[65] In the case of the research reported here, data on specific emissions was readily available and did not need to be calculated separately.

one. In the formula, the sum of the adjusted contributions is divided by the number of variables, resulting in an index which takes values smaller or equal to one (Berkhout *et al.* 2001a, p. 140):

$$IND_i = \frac{1}{k}\left[\sum_{j=1}^{k} C_i^k \cdot Adj^k \quad / \quad \frac{1}{k}\sum_{n=1}^{k} Adj^k\right] \tag{5}$$

Tyteca *et al.* (2002) emphasize that with this index calculated according to the method suggested by Jaggi and Freedman (1992), the variables are treated independently of each other, rather than being all considered simultaneously in a multi-dimensional space (as e.g. in Tyteca 1999). Since the likelihood of a specific firm being the best on all individual indicators/variables is very small, the index therefore usually takes values strictly less than one.

As stated earlier, two indices were used, which differentiate between inputs-oriented and outputs-oriented. The inputs-based/inputs-oriented index basically assesses to a larger degree the effect of the orientation towards integrated pollution prevention, since this should have an influence mainly on inputs. The outputs-based/outputs-oriented index allows predominantly an assessment of the effect of the degree of end-of-pipe environmental protection, since this can be expected to predominantly influence emissions, rather than inputs.

4.1.3.3 Economic performance measures for the empirical analysis

Defining measures for short-term economic performance and profitability

Economic performance in the short term is measured as profitability. Profitability is measured by means of operating profit financial ratios (esp. profitability and efficiency ratios). Profitability ratios considered in the following are return on sales (ROS) and return on capital employed (ROCE), and return on equity/owners' capital (ROE). These ratios have been used in analyses in the U.S. and Europe (Hart & 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 studies for Europe and the United States.

The remainder of this chapter will therefore discuss possible measures for financial performance and operational performance, which are to be used in the empirical analysis. These are return on sales, return on equity and return on capital employed (all of which address short-term performance and profitability). Given the serious difficulties in defining competitiveness, it was decided not to include this in the first empirical analysis, but only short-term economic performance and profitability, both of which are a necessary condition for longer-term competitiveness.

Return on sales (ROS) can be based on net profit before interest or on gross profit. The first yields the net profit percentage (also called net profit margin). It is defined as the net profit before interest and tax divided by sales revenue and measures the percentage of sales revenue generated as profit for all providers of long-term capital after deduction of cost of goods sold and other operating costs. For the purpose of this research, return on sales is defined as the ratio of profit (loss) before tax to total sales (i.e. operating revenue), in accordance with the literature (Reid & Myddelton 1995). This ratio indicates to what degree a firm was successful in achieving the maximum sales possible whilst simultaneously keeping costs low (Pendlebury & Groves 1999; Myers & Brealey 1988).

Return on equity (ROE), also called return on shareholders' funds is defined as the ratio of profit before taxation (but after interest and preference dividends) to ordinary shareholders' funds (Pendlebury & Groves 1999). Ordinary shareholders' funds consist of average ordinary share capital, reserves and retained profit for the period. Return on equity shows the profitability of the company in terms of the capital provided by ordinary shareholders (which are the owners of the company). It thus focuses on the efficiency of the firm in earning profits on behalf of its ordinary shareholders, by relating profits to the total amount of shareholders' funds employed by the firm. In doing this, return on equity is the most comprehensive measure of the performance of a company and its management for a period since it takes into account all aspects of trading and financing, from the viewpoint of the ordinary shareholder (Pendlebury & Groves 1999; Reid & Myddelton 1995). As a consequence of this, ROE can be affected by a firm's capital structure (i.e. its gearing), which is not the case with the next ratio discussed, the return on capital employed.

The **rate of return on capital employed (ROCE)** measures the profitability of the capital employed. It is defined as the ratio between gross trading profit (net of depreciation) and the capital employed (Hay & Morris 1991). However, this is only one possible definition, since no general agreement exists on how capital employed should be calculated (Lumby 1991). More recent definitions fairly consistently define ROCE as the ratio between earnings before interest, taxation and exceptional items (EBIT) to the (average) net assets (i.e. total assets less current liabilities) for the period (Pendlebury & Groves 1999; Reid & Myddelton 1995). This is also the definition adopted in this research. Generally, ROCE measures the efficiency, with which capital is employed in producing income. It indicates the performance achieved regardless of the method of financing (i.e. the firm's capital structure), since it uses total capital employed (i.e. net total assets) before financing charges (i.e. interest), rather than only the part of total capital that relates to shareholders' interests (Pendlebury & Groves 1999; Reid & Myddelton 1995).

All variables suggested to operationalise the concept of (short-term) economic performance (return on sales (ROS), return on equity (ROE), and return on capital employed (ROCE)) are measured as percentage figures in the first empirical analysis.

Additional economic control variables

Next to the variables to be used to measure the concept of 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 into 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, less than one (i.e. debt-t-equity ratio = (1/solvency ratio) – 1). The solvency ratio is defined as the ratio of shareholder funds to total assets.

Value added per employee is an efficiency ratio and measures the labour productivity of a firm (Pendlebury & Groves 1999). Value added here is defined as the sum of taxation, profit/loss for the period, cost of employees, depreciation and interest paid. Value added per employee was found to correlate highly with the asset turnover ratio in the data set. To avoid multi-collinearity it was therefore decided not to use value added per employee as control variable in the regressions. The current ratio (also called working capital ratio) is defined as the ratio between the current assets and the current liabilities of a firm (Myers & Brealey 1988). It measures the liquidity of a firm and thus indicates a company's ability to meet its short-term cash obligations out of its current assets without having to raise finance through borrowing, issuing more shares or the sale of fixed assets (Arnold *et al.* 1985).[66]

Conclusions on economic performance measures and control variables

[66] Raising additional finance in either one of these ways can adversely affect a company's ability to generate future net cash flows.

Financial ratios such as profitability or efficiency ratios and liquidity ratios are essentially historical, accounting-based performance measures (Cordeiro & Sarkis 1997). This is a specific group of performance measures, which has been criticised for several weaknesses (see e.g. Johnson & Kaplan 1987). Weaknesses relate to their uni-dimensionality which makes them unsuitable of assessing fully the strategic outcomes and performance of a firm and to the possibility of managers manipulating reported accounting profits to their advantage (Johnson & Kaplan 1987; Kaplan & Norton 1997; 2001; Venkatraman & Ramanujam 1986; Schipper 1989). The latter include techniques such as switching between inventory policies, switching between depreciation methods and pension fund allocations (Cordeiro & Sarkis 1997).

Liquidity ratios, such as the current ratio, are particularly limited for two reasons. Firstly, because they are usually based on the historical or replacement costs of stock, not the current selling price of stock (net of its costs of sale). Secondly, no common classification of fixed and current assets for purposes of calculating the total of current assets for liquidity ratios exists, which is particularly problematic, if data on ratios comes from different sources (Arnold *et al.* 1985). Therefore, the current ratio is not used in this research as a variable.

Despite of this criticism, financial ratios have proved to be useful in practice in terms of their predictive power, both used separately or when aggregated into a single measure for e.g. the likelihood of bankruptcy as in the Z score method (Myers & Brealey 1988). Successful applications of financial ratios include the separation of successful firms from firms heading for insolvency (Beaver 1966), and estimation of market risk ('beta') from accounting data and financial ratios (Beaver *et al.* 1970; Rosenberg & Marathe 1975, quoted in: Myers & Brealey 1988). Also, financial ratios were used successfully to predict bond ratings for newly issued bonds. This latter research revealed that issuers of more highly rated bonds had usually lower debt ratios, higher returns on assets and higher ratios of earnings to interest. As well, higher ranked bonds were more often issued by firms with lower market risk, which, as said, is successfully predicted by financial ratios (Kaplan & Urwitz 1979, quoted in: Myers & Brealey 1988). All these findings are as predicted by theory and therefore increase confidence in the use of financial ratios.

Overall, the balance of evidence suggests therefore, that financial ratios, and in particular profitability ratios can be reliably used as measures of economic performance. However, due to the possibilities to manipulate such measures they are more suitable for short-term analyses. For a more long-term analysis, financial ratios should be supplemented by other measures that are not (or at least not solely) based on accounting data (e.g. earnings per share forecasts or competitiveness ratings). Since accounting data-based measures such as financial ratios can be distorted and thus misleading under inflationary conditions (Hay & Morris 1991; Johnson & Kaplan 1987), it has to be ascertained, that such conditions do not apply during the observation period studied. If this cannot be ascertained, it should be attempted to correct data for the distorting effects of inflation on depreciation, stock appreciation, asset value appreciation and monetary liabilities. For the period covered (1995-1997) no inflationary conditions could be detected in the countries analysed.

4.1.3.4 Sub-sector classification in the pulp and paper sector

Product differentiation exists in the paper sector, since a range of product attributes in this sector exists. However, it is difficult to find one commonly agreed sub-sector classification in the literature bearing on the subject. Generally, a primary sub-division can be made between paper and paperboard, accounting for 55% and 45%, respectively, of global production and consumption (IIED 1996). Beyond that, paper grades can be classified according to end uses (ranging from commodity applications like newsprint to over 300 special end-uses such as banknote, bible, or filter paper) or according to paper properties (such as uncoated or coated, wood free or wood-containing). Physical paper properties depend on fibre characteristics, pulping method, additives used during the wet processing stage of paper making, and surface treatments during paper dry processing (IIED 1996). During wet processing, chemical additives such as sizing agents, mineral fillers, starches or dyes are used to influence paper properties. During dry processing, mainly three processes are carried out, either separately, or in combination. The first of these, calendaring (pressing of paper with a roll) aims to reduce paper thickness and to impart smoothness to the final product (which can be e.g. super-calendared paper). The second process, sizing, aims to impart resistance of the paper against liquid penetration. Finally, the third process of coating (carried out with a mixture of fine mineral pigments and adhesives) provides improved gloss, slickness, colour, printing detail and brilliance (IIED 1996). Physical properties and the processes described could form one basis for defining sub-sectors of the pulp and paper sector, resulting in a technology –based categorisation.

However, a sub-division according to paper properties (resulting from specific wet and dry processing of the paper) does not indicate well specific end-uses. Also, even within one end-use, price differences prevail and do even more so between the two basic sub-sectors of cultural paper and industrial paper/paperboard (Gobbo 1981). This, together with the fact that the "true" unit of analysis is more the individual paper machine within one site than the whole site with several paper machines, makes it difficult to identify one sub-sector classification scheme suitable for every type of analysis, and suggest a more end-use oriented classification. For example, Zavetta (1993) classifies products in the pulp and paper industry into four broad categories, according to their end uses:

a) Cultural or graphic papers, especially newsprint

b) Printing and writing papers, especially magazine and book papers

c) Industrial papers, especially packaging and wrapping papers and paperboard

d) Household and sanitary papers, especially tissue paper.

Generally, the papers from the different categories are not substitutes, giving rise to several separate or only partially related markets, in which paper products can however be in competition with non-paper products, e.g. plastic bags with paper bags (Zavetta 1993). The only pulp traded is bleached Kraft pulp whereas 80 per cent of pulp output is integrated with paper production at the plant level (i.e. the pulp produced is used for paper production at the same plant). Therefore, no separate category for pulp was defined for this research.

The Paper Federation of Great Britain distinguishes the categories newsprint (for newspaper production), graphics (printing, book publishing, office papers), case materials for corrugated box making, folding boxboard, sanitary (toilet and household tissues) and wrapping papers (Paper Federation of Great Britain 1999).

The International Institute for Environment and Development (IIED) in its publication „Towards a Sustainable Paper Cycle“ provides yet another classification for paper grades. It consists of the main categories communication grade papers, household and sanitary, paperboard and packaging and other paper and paperboard (IIED 1996). Communication grade papers are further sub-classified into the categories „newsprint“ and „printing and writing“ (and therefore fit the other classification schemes presented above). The newsprint sub-sector mainly consists of low-cost mechanically pulped papers and recycled fibre, which are increasingly used as raw material base in this sub-sector.

In the printing and writing sub-sector, uncoated wood-free papers account for approx. 50% of consumption The other 50% are roughly equally subdivided between coated wood-free, coated mechanical and uncoated mechanical papers. Uncoated mechanical paper is mainly used for catalogues and magazines of lower quality. Coated papers are predominantly used for catalogues and magazines of higher quality, book publishing and direct mail. Uncoated wood-free papers are mainly used as business and consumer communication papers, such as photocopier or typing paper (IIIED 1996).

Paperboard and packaging in the classification scheme used by IIED is further sub-divided into the categories „board“, „containerboard“ and „packaging paper & board“ and basically represents the primary „industrial“ classification category of the global paper manufacturing industry. For these industrial papers, the division between producers and converters is more distinct than for cultural papers. The containerboard sub-sector accounts for 50% of total paperboard and packaging production, followed by packaging paper and board (30%) and board (20%). Containerboard (corrugated case materials) is mainly used for corrugated board products (e.g. shipping containers) and is supplied by converters for the manufacture of corrugated board products. Board includes all types of paperboard, which are not used for making containerboard and include in particular folding cartons (folding boxboard), food cartons, and beverage carriers. Finally, packaging papers and board include mainly grocery bags, shipping sacks, and wrapping papers. Other paper and paperboard comprises a variety of special paper grades, such as building paper and board or filter papers (IIED 1996).

CEPI, the Confederation of European Paper Industries classifies paper production into sub-sectors based on the grade definitions graphic papers, sanitary and household, packaging and other (CEPI 1998). Graphic papers are further sub-classified into newsprint, uncoated mechanical, uncoated wood-free and coated papers (wood-free and wood-containing). Packaging is further sub-divided into the case materials, folding boxboard, wrappings and other papers mainly for packaging purposes. Other papers comprise of papers and boards for industrial and special purposes not falling in one of the other categories (CEPI 1998). In summary, despite the difficulty to establish one sub-sector classification scheme meeting all demands, the above classification schemes show considerable overlap, as is shown by the following Table 4.5:

Table 4.5: Summary of different classification schemes

Study	Categories						
Zavetta (1993)	Cultural/ graphics papers	Printing/ writing papers	Industrial papers			Household & sanitary papers	--
UK Paper Fede-ration (1999)	Newsprint	Graphic papers	Case materials	Folding boxboard	Wrapping papers	Sanitary (toilet & household tissues)	--
IIED (1996)	Communication pap.		Paperboard & packaging			Household & sanitary	Other paper & board
	Newsprint	Printing & writing	Container-board	Board	Packaging paper & board		
CEPI (1998)	Graphic papers		Packaging			Sanitary & household	Other
	Newsprint; Uncoated Mechanical	Uncoated Woodfree; Coated	Case materials	Folding boxboard	Wrappings; Other papers for packaging purposes		

Based on the discussed classification schemes, a relatively broad classification scheme was adopted for this research, in which newsprint, magazine-grade and graphics fine paper were combined into one category “Cultural” papers, and packaging corrugated and other boards into another category “Industrial“. Together with the “Mixed“ (combination of the two previous categories) and “Other“ (any other paper manufacturing) categories, this resulted in broad classification based on four (broad) sub-sectors.[67] One important reason for introducing a “Mixed“ sub-sector is the fact that the actual unit determining the product is not the site, but the individual paper machine. Since one site usually runs more than one paper machine, it can be the case, that two different products are produced at that site. A sub-sector category “Mixed“ accounts for this.

[67] Another reason to introduce a broad classification scheme was that for regression analyses a high number of sub-sectors (up to 10 in the case of the more detailed schemes discussed above) might have proven to be proble-matic. In addition to that, a classification in four categories was considered to be sufficiently detailed.

4.1.3.5 Other variables used for hypothesis testing

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 was 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 4.6 lists all variables used in empirical analysis of the research. The precise definitions of economic and control variables, as provided in Table 4.6, are according to Belzer (2000).

Table 4.6: Summary of variable definitions for all variables used in the first empirical analysis

Concept	Variable	Description	Type[68]
Economic performance	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 [GWh/t]	cont.
	Water input	total water input per unit of output [1000 litres/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, i.e. asset turnover 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.

68 In the table, cont. and dum. refer to continuous (interval/ratio scale) type and dummy type variables, respectively.

4.1.4 Procedures

4.1.4.1 Introduction

The data set used in this study was obtained through purposive sampling. All firms in the four countries Germany, Italy, Netherlands and United Kingdom were included, for which simultaneously (sufficient, i.e. 3-year long time series) environmental and economic performance data was publicly available. Publicly available in this context means that data was publicised by firms themselves in (mostly externally verified/accredited) environmental reports or published by governmental agencies/authorities (e.g. by means of an emissions register, such as the ER in the Netherlands, or the Chemicals Release Inventory (CRI, since beginning of 1998 renamed to Pollution Inventory) in the UK (Owens 1999). Thus the data set used was obtained through a non-random procedure, which requires paying special attention to the sample characteristics in comparison with the universe of pulp and paper manufacturing firms in the four countries included. The data set nevertheless equals the universe/total population of firms fulfilling the condition of simultaneous availability of environmental and economic performance data (but of course not the universe of all paper firms). It was therefore the most extensive data set available for testing the hypotheses proposed in Chapter 3.

4.1.4.2 Data collection method for environmental performance data

Collection of most of the environmental performance data used in the first empirical analysis took place during the project Measuring Environmental Performance of Industry (MEPI).[69] Further environmental performance data (as well as most data on country location, sub-sector, and firm size) was collected after the MEPI project finished, based on the method used in the MEPI project (see Berkhout *et al.* 2001a for details) and incorporated in the database developed for this research.

The main data sources for collection of environmental performance data were corporate environmental reports (all countries except Italy), EMAS statements (especially Germany and Austria), public pollution inventories (especially Netherlands and UK), and company surveys (especially Italy). The variety of data sources proved to be problematic in so far, that the

[69] The project has been funded under the 4th Framework Programme (Environment and Climate) of DGXII of the European Commission. Further information on MEPI can be found at www.environmental-performance.org. MEPI was coordinated by the Science Policy Research Unit - SPRU, University of Sussex, UK. The research has also been conducted by the (Centre Entreprise-Societe-Environnement - CEE, Université Catholique de Louvain, Belgium; the Institute for Environmental Studies - IVM, Vrije Univesiteit Amsterdam, Netherlands; the Department of Economics and Production, Politecnico di Milano, Italy; the Institut für Ökologische Wirtschaftsforschung - IÖW, Austria; the Institute for Prospective Technological Studies - IPTS, Sevilla, Spain and the Centre for Environmental Strategy - CES, University of Surrey, UK. MEPI ran from the early 1998 to mid-2000.

sources partly focus on different levels of activity. EMAS statements and pollution inventories for example focus on the site level, whereas corporate environmental reports usually report data aggregated across a number of sites. Nevertheless, this is not problematic, since single-site and multi-site firms can easily be integrated in one research design, as long as system boundaries for environmental and economic performance are matched. Generally, the data collection strategy attempted to gather as much information as possible from public sources, whilst at the same time filling data gaps through direct contact with companies. Specific national approaches had to be developed, due to the fact that data availability and data sources varied between countries (see Berkhout *et al.* 2001a; 2001b).

All data used in this research was collected following one unified and defined approach, based on the data collection protocol developed for the MEPI project. Prior to discussing in detail the structure and contents of the data collection, the following section reports in more detail on the data sources and data collection strategies used in different countries.

4.1.4.3 Data sources and data collection strategies in different countries

Data collection aimed to gather information on a core set of variables, which allows the construction of technically sound and useful environmental performance indicators for the paper manufacturing industry. The initial set of variables included five categories of data: resource input (e.g. water consumption), emissions (e.g. sulphur emissions), environmental management information (e.g. whether or nor a firm has a certified EMS), production output (e.g. paper production) and business data (e.g. number of employees). A full list of the initial variables for which data was sought can be found in Berkhout *et al.* (2001a, Appendix 3). Despite serious efforts, it was not possible to collect sufficient environmental data on all the initial variables, given the variability found with regard to the data categories. For example, emissions data is found in most sources, whereas resource inputs are not covered by the pollution inventories in the UK and the Netherlands, but are included in most corporate environmental reports and EMAS statements.

Given that data availability and data sources varied between countries, specific national approaches had to be developed (for details see Berkhout *et al.* 2001a, Appendix 3). In Germany data collection focused on environmental statements published under the EMAS regulations. It was attempted to gather data from all EMAS registered firms (as of 1998) in the paper manufacturing sector. With few exceptions, data has been collected from the EMAS statements and has been included in the research database. Because the collection and input of the EMAS registered companies' data involved a major effort, no other data sources (other CERs, surveys, databases etc.) were used.

In Italy, due to the lack of public environmental information, data was mainly collected through direct contact with firms since corporate environmental reporting was (in 1998/1999) less common than in other European countries. Even where reports existed they did often not disclose quantitative information consistent with the MEPI data collection protocol requirements. Also, in the paper manufacturing sector, neither public authorities, nor trade associations held databases on corporate environmental data, or did not disclose data to stakeholders.

The Dutch emissions register ER was the main data source for data collection in the Netherlands. However, the ER data only refers to air and water emissions. Additional data was therefore collected from negotiated agreements between business and government on environmental policies (so-called covenants). For data collection on energy consumption, physical production output and other information, mainly corporate reports and case studies were used as sources. Data for the paper manufacturing industry is nearly complete (Olsthoorn 2000).

Generally, main data sources for the UK were corporate environmental reports, questionnaires and the public Pollution Inventory, formerly Chemical Release Inventory (Environment Agency 1999). In addition to that, two private consultancy companies provided additional data. Data in the paper manufacturing sector, however, was mainly collected from corporate environmental reports of sites and their parent firms, and in direct contact with firms' environmental managers.

Even though the sources of the collected data are diverse, it needs to be kept in mind, that the data collection strategy aimed to gather as much information as possible from public sources, whilst simultaneously filling crucial data gaps by direct contact with firms (see Berkhout *et al.* 2001a for details).

Subsequent to data gathering, the environmental data collected was matched with financial data and data on economic performance. Financial data and data on economic performance was collected from the Amadeus database maintained by Bureau van Dijk. Matching of records in the two databases was carried out based on the name and address of firms/sites, as well as the number of employees for each year (as far as employee figures were available for both, environmental and financial data). Given that not for all firms, environmental and economic/financial data was available simultaneously, the initial number of firms for which environmental performance data was available was reduced to the number of firms as described in Tables 4.7 to 4.11 in Chapter 4.2 below.

4.1.4.4 Data comparability and data quality

For the research, it emerged, that even once data have been collected, ensuring data comparability and data quality were equally difficult tasks since this required that data be expressed in the same units of measurement. Frequently, however, data was not fully standardised. Coal input to production e.g. was reported in tonnes, Gigajoules, Gigawatt hours and tonnes of oil equivalent and waste was measured in tonnes, cubic metres and litres. In order to facilitate the conversion of measurement units and to minimise errors, a data conversion template was therefore developed in the MEPI project. This template facilitated automatic conversion between currencies, as well as weight, length and energy measurement units (for details see Berkhout *et al.* 2001a, Appendix 3). It also converted coal, gas and oil inputs from weight to energy units, using standard conversion factors for each country.[70]

A second problem encountered was that environmental and financial data did not always refer to the same period. Most environmental data refers to the calendar year. However, most business and financial data and a large part of environmental data stemming from corporate environmental reports refer to financial years (in the UK the financial year is April to March, whereas e.g. in Germany it is January to December). In the context of this thesis, it was not possible to correct this mismatch. Data (on environmental, as well as economic performance) was attributed to the calendar year it best matched (e.g. if the financial year was April 1995 to March 1996, then the data was recorded as 1995 data). This seemed acceptable, since a three-month shift of financial against calendar year was the maximum mismatch.

The majority of environmental data collected in the MEPI project has not been object of rigorous verification procedures. Only EMAS data is systematically and formally verified. However, there are no such requirements for voluntary corporate reporting and even the quality of pollution inventories varies, for example, the UK Pollution Inventory has long been criticised for having insufficient quality checks. Environmental data gathered through questionnaires is entirely unverified. However, since the large majority of data in the paper manufacturing sector was collected from environmental reports prepared in the context of verified environmental management systems (either based on EMAS or ISO 14001) data quality can generally be expected to be good. The former is the case in the UK and Germany, where corporate environmental reports and EMAS statements were the main data sources. For example, one German firm with several sites/business units in the data set stated that their data is based on site data from validated environmental statements under EMAS where validation included an assessment of the quality and reliability of quantitative data by external

[70] Factors were extracted from Houghton *et al.* (1995) and IPCC (1995).

environmental auditors (Wende 2000). The same applies generally for the UK where data mainly stems from validated corporate environmental reports. Only in exceptional cases, members' of firms' environmental department were contacted for additional data not available in the reports.

For the Netherlands data has been taken mainly from the Dutch national emissions register ER and negotiated agreements between the paper industry and the Dutch government. Generally this data is considered to be highly reliable (Berkhout et. al. 2001a, Appendix 1). The only exception in respect to data quality is Italy, where data was usually directly supplied by company representatives, and thus can only be audited indirectly with regard to quality. As stated at the beginning of this section, in order to address the above and other related problems of data comparability and data quality, a data collection protocol was used. This protocol, which was the basis for all data collection activities within the MEPI project, as well as for the collection of additional environmental performance data in the pulp and paper manufacturing industry. No data quality issues exist with regard to the financial and economic performance data collected. The next section describes in detail the process for collection of data for the financial variables used in the first empirical analysis.

4.1.4.5 Collection of financial data and data on economic performance

Financial data and data on economic performance was collected from the Amadeus database maintained by Bureau van Dijk.[71] Matching of records in the two databases was carried out based on the name and address of firms/sites, as well as (as far as data was available) number of employees for each year. The Amadeus database contains detailed reports of 3 Million European companies, including descriptive information and standardized annual accounts for several years for each company (Taylor 2000). According to Bureau van Dijk the database covers all companies for which financial data is available. The standardized format of the annual accounts in Amadeus is derived from the most common formats used for the presentation of financial accounts in Europe, based on EU guidelines. For the UK, Germany, Italy and the Netherlands, there is no legal requirement for a specific presentation of company accounts. However, even though firms can use any type of presentation, there is a tendency to use the same accounting formats. In order to create the annual accounts in Amadeus, the local

[71] The Amadeus database was chosen as a data source, since it contains the most complete and most disaggregated data set of European firms. Other databases, such as Disclosure/Worldscope Global, Companies House, Fame, Markus, aida, reach or Compustat contain either more aggregated data for a number of firms worldwide (though with a less comprehensive coverage of European firms) or only data for one country, which is not usable in cross-country comparisons. In addition to that, cost-effective access to Amadeus was available which was not the case for the other databases.

information providers of Bureau van Dijk use purpose-designed national formats of accounts, which accommodate, as closely as possible all types of formats for company accounts, which are used in the respective countries. The transformation from any national format to the format of the annual accounts in Amadeus is based on Bureau van Dijk’s Correspondence Tables (Belzer 2000). The coverage of European firms in the Amadeus database is very high, since all European companies are legally required to file their accounts at the official government registries of their respective countries. The local information providers of Bureau van Dijk collect this information directly from the official registries and transform it into the standardized format of annual accounts prior to entering the data into the Amadeus database (Belzer 2000). At the time of data collection (between November 1999 and November 2000), financial data was usually only available up to and including 1998. Only in some cases, 1999 financial data was available. Therefore, it was decided to concentrate the data collection on the years 1995 – 1998, since this matched well the period (1995-1997) for which most environmental performance data was available. In the data collection process, the firm for which environmental performance data was available in the MEPI database was matched with a firm record in the Amadeus database, based on the name and address of firms/sites, as well as (as far as data was available) number of employees for each year. The data sheet for the Amadeus firm record was then printed out, and the relevant data on the economic and financial variables to be used in the research was then manually incorporated into the database, which already contained the environmental performance data for the firm in question.

4.1.5 Statistical analysis approaches and econometric specifications

The analysis of the empirical relationship of environmental and economic performance of firms involves an estimation procedure which is based on a panel data model in which environmental and economic performance are considered to be in a causal relationship, i.e. the indicators used to measure environmental performance are considered to influence the economic performance variables which are the endogenous variables. For the separated equations, a pooled model based on OLS regression and ignoring the panel structure, a random effects panel data model and a fixed effects panel data model are used. The specification of these models are presented in the following (Kohler & Kreuter 2001; Johnston & DiNardo 1997).

The pooled model ignores the panel structure of the data and is estimated using OLS regression. It has the specification:

$$y_{it} = \alpha + \mathbf{x}_{it}\beta + \mathbf{z}_i\gamma + u_{it} \quad (6)$$

where i = 1 .. N units under observation; and t = 1 .. T time periods for which data is collected. In this specification, y_{it} denotes the observation on 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.

The errors u_{it} here are assumed to be identically and independently distributed (iid) 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 (Johnston & DiNardo 1997). Hence, OLS is the efficient estimation method.

However, ignoring the panel structure of the data can be problematic for two reasons (Johnston & DiNardo 1997, p. 391). Firstly, because even though the pooled model yields consistent estimates of the regression coefficients, standard errors will be under- and significance levels hence be overstated. Secondly, compared to GLS regression, the use of OLS as estimation method does not result in efficient estimates of the regression coefficients.

To address these problems, two well-established models, the random and the fixed effect models 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 (Johnston & DiNardo 1997, p. 403). For the random effects model for panel data, the specification is (variables as in (6) above):

$$y_{it} = \alpha + \mathbf{x}_{it}\beta + \mathbf{z}_i\gamma + u_{it} \quad (7)$$

with

$$u_{it} = \mu_i + \varepsilon_{it} \quad (8)$$

In (8), 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}.[72] In the random effects model, the individual effect μ_i is assumed to be uncorrelated with the time-variant independent variables $\mathbf{x}_{it}$. The estimation method for the random effects model is Generalised Least Squares (GLS), which is efficient (Johnston & DiNardo 1997, p. 391).

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 (7) and (8) remains, the interpretation differs, in

[72] More precisely, in the random effects model, the disturbance is a random variable, which is however constant for each observation on one specific firm. This means that observations of one specific firm are considered to be more similar, than observations of different firms (Johnston & DiNardo 1997; Kohler & Kreuter 2001).

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 (Kohler & Kreuter 2001). 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. The reason for this is, that technically all time-invariant variables (which are also represented by dummy variables) are fully multi-collinear with the (constant) disturbance (Kohler & Kreuter 2001; Johnston & 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 which part of the change observed in the dependent variable (Kohler & Kreuter 2001). To decide, which of the two models (random or fixed effects) is more approriate, the Wu-Hausman test is used. If the 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 (Johnston & DiNardo 1997, p. 402). 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 of the identifiable parameters, which here are the time-variant variables (Johnston & DiNardo 1997, p. 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, which is a Lagrangian Multiplier test, is additionally carried out. If the test statistic of the Breusch-Pagan test is significant, this confirms the existence of random effects. If it is insignificant, then in cases, where also the Wu-Hausman test is insignificant, conclusions can be drawn on the basis of the pooled model estimated with OLS (StataCorp 1997).

For testing the hypothesis H1 using the panel regression framework described above, incomplete panel data was 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.

4.2 Exploratory data analysis

4.2.1 Characteristics of the data set: periods, sub-sectors and countries

To ensure sufficient generalisability of results for the detailed statistical analysis, it is necessary to consider in detail, how well characteristics of the data set match the characteristics of the universe of paper firms in the four countries, and also, what degree of coverage of the total population of paper firms was reached in each country. The data set used in this study comprises firms in the paper manufacturing sector from four European countries (Germany, Italy, Netherlands and United Kingdom) for the years 1995 to 1997.[73] In order to avoid a time or country bias, an approximately equal number of firms in each country was selected, for which in most cases data was available for all three years. This chapter analyses the structure of the data set, particularly in terms of coverage of the universe/total population of firms in each country and in terms of sub-sector coverage. The following Table 4.7 gives an overview of the number of companies[74] in each country on which data was collected and how these are distributed across sub-sectors.

Table 4.7: Companies covered in different countries and sub-sectors

Country	**Germany**	**Italy**	**Netherlands**	**United Kingdom**	**Total**
Newsprint	2	-	1	2	5
Magazine grade	3	-	-	1	4
Graphics fine paper	2	2	2	1	9
Packaging corrugated board	1	1	1	2	5
Packaging container board	-	1	1	-	2
Mixed	1	3	3	2	9
Other	1	2	1	1	5
Sum (of total of firms)	10 of 167	9 of 166	9 of 27	9 of 62	37

Source: own calculations and CEPI (1998)

The following Table 4.8 provides a breakdown of firms in different sub-sectors across countries (numbers in brackets in the table refer to the broader classification into 4 sub-sectors which was used in the analyses).

[73] The data of the first empirical analysis is available from the author by mailing to mwagner@gmx.co.uk.
[74] Companies in this are defined as entities with independent financial reporting. In the case of Germany, due to data availability, this means that in one case subsidiaries of larger parent companies were included.

Table 4.8: Breakdown of firms into sub-sectors across countries

<table>
<tr><th>Country</th><th colspan="2">Germany</th><th colspan="2">Italy</th><th colspan="2">Netherlands</th><th colspan="2">United Kingdom</th></tr>
<tr><td>Newsprint</td><td>2</td><td rowspan="3">(7)</td><td>-</td><td rowspan="3">(2)</td><td>1</td><td rowspan="3">(3)</td><td>2</td><td rowspan="3">(4)</td></tr>
<tr><td>Magazine grade</td><td>3</td><td>-</td><td>-</td><td>1</td></tr>
<tr><td>Graphics fine paper</td><td>2</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td>Packaging corrugated board</td><td>1</td><td rowspan="2">(1)</td><td>1</td><td rowspan="2">(2)</td><td>1</td><td rowspan="2">(2)</td><td>2</td><td rowspan="2">(2)</td></tr>
<tr><td>Packaging container board</td><td>-</td><td>1</td><td>1</td><td>-</td></tr>
<tr><td>Mixed</td><td colspan="2">1 (1)</td><td colspan="2">3 (3)</td><td colspan="2">3 (3)</td><td colspan="2">2 (2)</td></tr>
<tr><td>Other</td><td colspan="2">1 (1)</td><td colspan="2">2 (2)</td><td colspan="2">1 (1)</td><td colspan="2">1 (1)</td></tr>
</table>

Since data for each company is recorded for 3 years in most instances (for one firm only two years of data were available and for two further firms only one year) the number of firms in the above Table 4.8 transforms into the number of cases provided in Table 4.9 below. In the data set, the number of cases in each sub-sector in each individual year is almost invariable, since none of the firms included in the data set changes its sub-sector over the whole period under observation and only for three firms cases are included for less than three periods.

Table 4.9: Crosstabulation of countries and sub-sectors across all years with data available[75]

Country / Subsector	Germany	Italy	Netherlands	United Kingdom	Total
Newsprint	6	-	3	6	15
Magazine grade	9	-	-	3	12
Graphics fine paper	6	6	5	3	20
Packaging corrugated board	-	1	3	-	4
Packaging container board	3	3	3	6	15
Mixed	3	9	9	6	27
Other	3	4	3	3	13
Total	30	23	26	27	106

Source: own calculations

For some statistical analyses, all countries could be pooled since, theoretically, country differences is not relevant for differences between firms/sites. This is for example the case for the influence of environmental management systems (EMS) because EMS aim for voluntary

[75] This refers to the total number of cases (i.e. firm-years) available in the data set.

over-compliance, and therefore the effect of national regulation (considered to be the most important country influence) is mostly irrelevant. Regulation seems to be only relevant for the uptake of EMS implementation amongst firms (often supported by government grants which may vary across countries), but not for the outcomes of EMS implementation. ISO-certified and EMAS-verified firms were distributed across countries as described in Table 4.10 below.

Table 4.10: Data distribution and EMS certification across countries (of total of firms in data set)

Year	**1995**	**1996**			**1997**		
Country	Total	ISO 14001	EMAS	Total EMS	ISO 14001	EMAS	Total EMS
Germany	10	1/10	3/10	3/10	5/10	6/10	7/10
Italy	7	0/7	0/7	0/7	1/9	0/9	1/9
Netherlands	9	1/8	0/8	1/8	4/9	1/9	4/9
United Kingdom	9	0/9	1/9	1/9	6/9	1/9	6/9
Total	35	2/34	4/34	5/34	16/37	8/37	18/37

It is important to note, at this point, that the inclusion of 3 years of data of one firm as three independent cases in the data set can cause non-conservative influences (for example in the case, that environmental performance data is very similar for one firm, year-on-year) for certain types of analyses (e.g. the calculation of correlation coefficients). Therefore, for any subsequent analysis, potential biases resulting from these influences need to be considered (e.g. through using panel regression methods). With regard to data availability across years, the following situation emerges:

Table 4.11: Cases covered in different countries and years

Country	**Germany**	**Italy**	**Netherlands**	**United Kingdom**	**Sum**
1995	10	7	9	9	35
1996	10	7	8	9	34
1997	10	9	9	9	37
Sum	30	23	26	27	Total: 106

Source: own calculation

As can be seen, the distribution of cases in the data set across years and across countries is relatively even, although data availability and hence representation in the data set is slightly above-average for Germany and slightly below-average for Italy. This however is considered to not introduce a significant bias in the data set, which has been confirmed through the Chi-Square tests reported in Table 4.12 below. The first test below shows that there is no significant difference between expected and observed frequencies of firms across countries and periods (the expected distribution being an even distribution of cases across countries and sectors). Therefore the null hypothesis is accepted that there is no significant association between specific countries and years.

Table 4.12: Chi-Square test for homogenous distribution of cases across countries and periods

Measures	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.288[a]	6	1.000
Likelihood Ratio	0.285	6	1.000
Linear-by-Linear Association	0.013	1	0.910
No. of valid cases	**106**		

[a] Zero cells (0.0%) have expected count less than five. The minimum expected count is 7.38.

Table 4.13: Symmetric measures test for homogenous distribution across countries and periods

Measures		Value	Approx. Sig. [a, b]
Nominal by Nominal	Phi	0.052	**1.000**
	Cramer's V	0.037	1.000
	Contingency Coefficient	0.052	1.000
No. of valid cases	**106**		

[a] Not assuming the null hypothesis. [b] Using the asymptotic standard error assuming the null hypothesis.

Next to the question whether there is significant association between countries and periods, it is also important to consider whether there is significant association between countries and sub-sectors. However, for such an analysis, a too detailed sub-sector classification used above would be problematic, since for all cells, the expected number of cases would be below 5, raising doubts about the quality of approximation of the actual distribution of the cases in the data set by a chi-square distribution and thus providing findings with only limited meaning.
The Table 4.14 below therefore utilizes a broader sector classification, in which packaging boards are aggregated into "Industrial" papers and newsprint, graphic and magazine papers

are aggregated into "Cultural" papers. Next to the problem of low cell numbers when using a detailed sub-sector classification, the question how good the data set approximates the distribution of firms in different sub-sectors in each country is also further confounded by the fact, that countries may well have developed a competitive advantage (and thus a specialization of firms) in a specific sub-sector. In order to assess this, the coverage by sector, of the total of firms in each sub-sector and country is assessed at a later stage to address this issue. In the following Table 4.14, expected numbers of cases in each cell are derived based on the assumption that they correspond to the distribution of all cases in the different sectors of the broad sector classification. This had to be done since appropriate statistics for the actual distributions in each country could not be identified in a common format across all countries.

Table 4.14: Crosstabulation of country and broad sector

Country	**Statistics**	**Broad sub-sector classification**				**Total**
		Cultural	Industrial	Mixed	Other	
Germany	Count	21	3	3	3	30
	Expected*	13.3	5.4	7.6	3.7	30.0
Italy	Count	6	4	9	4	23
	Expected	10.2	4.1	5.9	2.8	23.0
Netherlands	Count	8	6	9	3	26
	Expected	11.5	4.7	6.6	3.2	26.0
United Kingdom	Count	12	6	6	3	27
	Expected	12.0	4.8	6.9	3.3	27.0
Total	Count	47	19	27	13	106
	Expected	47.0	19.0	27.0	13.0	106.0

* Expected refers to the expected count in each cell assuming proportional distribution of cases.

The next Table 4.15 below shows the result of a Chi-Square test carried out for the variables crosstabulated in Table 4.14. It can be seen that there is an association between countries and sub-sectors, which is just significant at the 10% level when pooling the three periods surveyed (1995, 1996, 1997). Therefore, it cannot be completely excluded that significant differences for individual environmental or economic variables that might be found between countries are in reality due to significant differences in the distribution of sub-sectors across the four countries as it is found in the data set. This can be clarified by e.g. analyzing, where appropriate, whether such differences in e.g. profit levels correspond to what would be expected from the market situation in the different sub-sectors. The identified significant difference has however to be treated careful, since, as described above, one important condition for application of the Chi-Square test (i.e. that less than 20% of the cells in the crosstabulation have an expected count of less than 5) is violated, and thus the significance level may be overstated. Given this and the relatively low significance level, it is likely this will not distort results.

Table 4.15: Chi-Square tests for homogenous distribution of countries and sub-sectors across years

Measures	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.109[a]	9	0.088
Likelihood Ratio	15.504	9	0.078
Linear-by-Linear Association	1.346	1	0.246
No. of valid cases	**106**		

[a] Seven cells (43.8%) have expected count less than five. The minimum expected count is 2.82.

4.2.2 Representativeness of firm distribution for sectors, countries and firm size

In the following, the general coverage of the paper sector in each country (across all sub-sectors) will be assessed, followed by an assessment of the coverage by plant size in each country. This will provide further insights with regard to the representativeness of sample used in this analysis for the paper sector in the four countries under study. The following Table 4.16 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 was necessary for the assessment of coverage, was not available.

Table 4.16: 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
Utd. 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 kt; Country totals refer to production capacity, not actual annual production

As can be seen from Table 4.16, 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 (approx.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.

Across all four countries covered in the sample, average percentage coverage is 20-22%, which is reasonable compared to survey response rates in general (often said to be around 15%). Together, the four countries from which company data was collected cover 40-43% of the total EU paper production capacity. Therefore the conclusion with regard to coverage of the sample analysed is that it is (i) covering a significant amount of production in each individual country, (ii) covering on average a significant amount of production across all four countries, (iii) given that the four countries together cover a considerable share of EU production capacity, the sample is also covering a considerable amount (approx. 40%) of the total EU production capacity. Although the overall coverage of the sample is reasonable, further assessment is necessary as to how well the sample fits plant size and sub-sector distributions of production/production capacity in each country. With regard to plant size, results are summarised in Table 4.17:[76]

[76] Due to data unavailability, sites in the sample were classified into size categories based on actual production, and not site production capacity. This however has little influence, since only in very few cases it has led to year-on-year changes of a site from one to adjacent size categories.

Table 4.17: Plant distribution in the data set according to size categories for 1996

Year: 1996	**Germany**	**Italy**	**Netherlands**	**United Kingdom**	**Total**
0-10000 t/yr	0/61 (0%)	0/84 (0%)	0/2 (0%)	0/22 (0%)	0/169 (0%)
Size share in country total	*30.81%*	*40.00%*	*8.00%*	*22.68%*	*33.80%*
10001-25000 t/yr	0/40 (0%)	4/55 (7.3%)	0/3 (0%)	2/20 (10%)	6/118 (5.1%)
Size share in country total	*20.20%*	*26.19%*	*12.00%*	*20.62%*	*22.26%*
25001-50000 t/yr	0/23 (0%)	1/32 (3.1%)	2/7 (28.6%)	5/19 (26.3%)	8/82 (9.8%)
Size share in country total	*11.62%*	*15.24%*	*28.00%*	*19.59%*	*15.47%*
50001-10000 t/yr	1/31 (3.2%)	1/22 (4.5%)	1/3 (33.3%)	3/18 (16.7%)	6/74 (8.1%)
Size share in country total	*15.66%*	*10.48%*	*12.00%*	*18.56%*	*13.96%*
100001-250000 t/yr	5/28 (17.9%)	3/17 (17.6%)	3/6 (50%)	2/15 (13.3%)	13/66 (19.7%)
Size share in country total	*14.14%*	*8.10%*	*24.00%*	*15.46%*	*12.45%*
250000 t/yr and more	5/15 (33.3%)	0/not avail. (0%)	2/4 (50%)	2/3 (66.7%)	9/22 (40.9%)
Size share in country total	*7.58%*	*not available*	*16.00%*	*3.09%*	*4.15%*
Average mill coverage	11/198 (5.6%)	9/210 (4.3%)	8/25 (32%)	14/97 (14.4%)	42/530 (7.9%)
Sum of country size shares	*100%*	*100%*	*100%*	*100%*	*100%*

Sources: Own calculations for individual countries, CEPI (1997) for country totals

What Table 4.17 shows, is for each country the number of plants that are covered in the data set used. Since some of the companies in the data set comprise of more than one site, the number of sites in each country is greater or equal to the number of firms in the corresponding year (here: 1996). The rows first give for each size category (e.g. 0-10000 t/yr) the number of sites covered in the data set out of the total number of sites in that size category in a given country. This is followed by the percentage share the covered sites represent of the total of sites in that size category in a given country. Below that row, the second row (in all cases labeled 'Size share in country total') provides the percentage of sites in the size category in question out of the total of sites in the country (e.g. in Germany, 61 sites are in the category 0-10000 t/yr, out of a total of 198 plants operating in the country, thus, the size share of the 0-10000 t/yr size category in the country total is 30.81%). This description of the coverage of a given size category in the data set in relation to the size share in the country total (i.e. the comparison of two percentage shares) can give an indication, how well the data set reproduces the size distribution of paper mills in a given country. Such a comparison is however limited in so far that it is not known whether e.g. the two largest, or the three smallest plants in any size category are covered, i.e. from the percentage figures it remains uncertain, what percentage of the production volume or production capacity in a given size category is covered. Although the statistics available (CEPI 1997; 1998) allow a breakdown of plants by size category, as well as a breakdown of production capacity by sub-sector, they do not provide a combined breakdown of size category by sub-sector production capacity.

Therefore, the percentage figures in Table 4.17 can only provide an estimate of how well the data set picks up the size distribution of plants in each country. They would only provide a precise estimate if it is assumed that each plant in a given size category has the same size. In this case, number of plants and production capacity covered by them would be directly proportional. However, since this is not the case and since the production capacity in each size category is not available from CEPI statistics, no direct conclusions can be drawn from the table above, about how the production output covered by the data set used in this study covers the total production (capacity) in each size category. Nevertheless it can be stated that production in higher size categories represents considerably higher production output than production in lower categories (particularly due to the non-linear sub-division of plant size groups).

The above also explains, why the coverage measured in terms of percent of production capacity covered as reported in Table 4.16 is higher (around 20%, on average) than coverage measured in terms of average mill coverage (7.9% in 1996 and 8.5% in 1997). Given that essentially emissions are the cause of environmental impacts and that emissions are broadly linear proportional to production output (except probably of a relatively small fixed level), it does not matter from this point of view, whether emissions come from a small or a large mill. What matters is the overall amount of emissions and from this point of view, measuring coverage in terms of percent of production capacity covered by the firms in the data set seems to be the more relevant figure. However it needs to be borne in mind that concerning the relationship between environmental and economic performance, Table 4.17 above and Table 4.18 below show that the category of very small plants is not covered at all in this research. This is due to several reasons. Firstly, small mills rarely produce environmental reports or disclose environmental data in other ways. This is part of the larger issue that SMEs often tend put lesser relevance on questions of environmental performance (see for a more detailed discussion: Bradford 2000). Secondly, it is often not compulsory for small firms (depending on country regulation) to report their financial and economic performance publicly. For example, in Germany, firms with the legal status of a GmbH (approx. similar to a limited company (Ltd.) in the UK) are not required to publish their accounts. Therefore, SMEs in general represent to some extent an “unobservable” universe of firms. Given that this group of firms represents on average 30% of the paper sector in the four countries under study (in terms of mill numbers – their contribution to production capacity is considerably smaller), application of the results to this size category is limited.[77] Table 4.18 provides the same information about plant size coverage for 1997, as Table 4.17 provided for 1996:

Table 4.18: Plant distribution in the data set according to size categories for 1997

Year: 1997	**Germany**	**Italy**	**Netherlands**	**United Kingdom**	**Total**
0-10000 t/yr	0/60 (0%)	0/76 (0%)	0/2 (0%)	0/19 (0%)	0/169 (0%)
Size share in country total	*30.46%*	*36.36%*	*8.00%*	*19.39%*	*29.68%*
10001-25000 t/yr	0/34 (0%)	4/55 (7.3%)	1/3 (33.3%)	2/23 (8.7%)	7/115 (6.1%)
Size share in country total	*17.26%*	*26.32%*	*12.00%*	*23.47%*	*21.17%*
25001-50000 t/yr	0/26 (0%)	1/35 (2.9%)	2/7 (28.6%)	5/20 (25.0%)	8/88 (9.1%)
Size share in country total	*13.20%*	*16.75%*	*28.00%*	*20.41%*	*16.64%*
50001-10000 t/yr	1/29 (3.4%)	3/22 (13.6%)	1/3 (33.3%)	2/18 (11.1%)	7/72 (9.7%)
Size share in country total	*14.72%*	*10.53%*	*12.00%*	*18.38%*	*13.61%*
100001-250000 t/yr	4/25 (16.0%)	3/18 (16.7%)	3/6 (50%)	3/14 (21.4%)	13/63 (20.6%)
Size share in country total	*12.69%*	*8.61%*	*24.00%*	*14.29%*	*11.91%*
250000 t/yr and more	6/23 (26.1%)	0/3 (0%)	2/4 (50%)	2/4 (50%)	9/34 (29.4%)
Size share in country total	*11.68%*	*1.44%*	*16.00%*	*4.08%*	*6.43%*
Average mill coverage	11/197 (5.6%)	11/209 (5.3%)	9/25 (36%)	14/98 (14.3%)	45/529 (8.5%)
Sum of country size shares	*100%*	*100%*	*100%*	*100%*	*100%*

(Sources: Own calculations for individual countries, CEPI (1998) for country totals)

What can be seen from Table 4.18 above is that changes in individual size categories from 1996 to 1997 are small for both, the percentage covered in the data set, as well as the percentage share of individual size categories in the total of mills in any one country. Both tables show the bias of the data set used towards large sites, where in most cases a higher percentage of sites are covered than is the share of the respective size category in all plants of the country in question. Although, as said earlier, this limits applicability of results to small paper manufacturers, it also results in a better coverage of the sector in each country in terms of production capacity covered (on average around 20% in 1996 and 22% in 1997, with the lowest coverage of 10% in Italy and the highest of 38% in the Netherlands). This leads to the question how well the sample fits sub-sector distributions of production/production capacity in each country. This is analysed in the following Table 4.19.

[77] This is even more so since other research (Hillary 2000; Bradford 2000) indicates that the relationship between environmental and economic performance in SMEs might be different to the one encountered in large(r) firms.

Table 4.19: Coverage of sub-sectors in the data set by country

Coverage by sub-sector	Year	Cultural	Country total	% Coverage
Germany	1997	3,471.120	8,297	41.83584
	1996	3,118.790	7,875	39.60368
Italy	1997	38.750	3,430	1.12974
	1996	36.520	3,165	1.15387
Netherlands	1997	595.600	1,301	45.78017
	1996	539.400	1,254	43.01435
United Kingdom	1997	1,047.570	2,937	35.66803
	1996	927.420	3,008	30.83178
Total Countries	1997	5,153.040	15,965.000	32.27711
	1996	4,622.130	15,302.000	30.20605
		Industrial		
Germany	1997	171.000	6,438	2.6561
	1996	149.000	5,950	2.5042
Italy	1997	174.600	3,755	4.6498
	1996	39.250	3,670	1.06948
Netherlands	1997	386.000	1,819	21.22045
	1996	383.000	1,817	21.0787
United Kingdom	1997	208.900	2,752	7.59084
	1996	186.600	2,748	6.79039
Total Countries	1997	940.500	14,764.000	6.37022
	1996	757.850	14,185.000	5.34262
		Mixed		
Germany	1997	3,919.220	14,735	26.59803
	1996	3,530.870	13,825	25.53975
Italy	1997	596.640	7,185	8.30397
	1996	469.060	6,835	6.86262
Netherlands	1997	1,105.200	3,120	35.42308
	1996	1,044.200	3,071	34.00195
United Kingdom	1997	1,534.200	5,689	26.96783
	1996	1,373.350	5,756	23.85945
Total Countries	1997	7,155.260	30,729	23.28504
	1996	6,417.480	29,487	21.76376
		Other		
Germany	1997	65.680	2,158	3.04356
	1996	58.310	2,065	2.82373
Italy	1997	205.050	1,230	16.67073
	1996	110.140	1,015	10.85123
Netherlands	1997	169.800	196	86.63265
	1996	167.400	195	85.84615
United Kingdom	1997	52.730	1,109	4.75473
	1996	51.320	1,056	4.85985
Total Countries	1997	493.260	4,693.000	10.51055
	1996	387.170	4,331.000	8.93951

Sources: Own calculations for the sample, CEPI (1997, 1998) for country totals. All absolute values are in kt

Table 4.19 above shows what percentage of sub-sector production capacity is in the sub-sectors “Cultural” (graphic papers), “Industrial” (packaging grades), and “Other” (sanitary and household tissue and other) for both, the firms covered in the data set (3rd column) and the country in question as a whole (4th column “Country total”). The 5th and last column in Table 4.19 above gives the percentage coverage (as the ratio of columns 3 and 4) in Table 4.19.

In the case of the “Mixed” sub-sector, direct matching was not possible, since CEPI statistics do not include such a sector. The “Mixed” sub-sector is defined for purposes of this research as mills or firms that produce cultural, as well as industrial papers, or firms that produce mixed cultural papers (e.g. newsprint and magazine-grade paper, or magazine-grade and graphics fine paper). The by far larger proportion of firms in the “Mixed” sub-sector is of the former type. Since, with few possible exceptions, the “Mixed” sub-sector firms are included in CEPI statistics in either the category Cultural (graphics papers) or in the category Industrial (packaging grades) coverage here had to be estimated indirectly. In order to do so, the sum of production outputs of firms in the “Cultural”, “Industrial”, and “Mixed” sub-sectors in the database for the sample was calculated for each country individually. This sum was then divided by the sum of the production capacities in the CEPI statistics categories Cultural (graphics papers) and Industrial (packaging grades) to arrive at a percentage coverage ratio.

What can also be seen from Table 4.19 is, that coverage across sub-sectors differs between countries. For example in the Cultural (graphics paper) sub-sector, the data set covers around 40% of German, around 43-46% of Dutch, and between 31-36% of British production capacity, but only approximately 1% of Italian capacity. If in all countries, the sub-sector coverage in the data set would correspond to the share of this sub-sector in total production capacity in the country in question, then the percentage coverage should be similar for all countries. Although this is broadly the case for Germany, the Netherlands and the United Kingdom for the “Cultural” sub-sector, Italy is much less covered, making comparisons more difficult.

A similar situation is given for the Industrial (packaging grades) sub-sector, where percentage coverage in the Netherlands is considerably higher, than for the other three countries. As well, coverage is on average only ca. 6%, compared to an average coverage from approximately 30% for the “Cultural” sub-sector. Thus, any relationship identified between environmental and economic performance could potentially be affected by differences in sub-sector coverage (although regression analysis can account for such influences to some degree).

Finally with regard to the sub-sector of sanitary and household tissues and other papers the above table shows, that coverage is with an average of 10.5% better than for the Industrial sub-sector, but worse than for the "Cultural" sub-sector. In addition to that, the difference between countries is considerable, with approx. 86% of Dutch, but only 10-17% of Italian, around 5% of British, and only 3% of German production capacity being represented in the data set.

Although this analysis shows that coverage of sub-sectors differs to some degree between countries, it needs to be remembered, that the sub-sector classification used, as discussed earlier is only very broad, since unavoidably production in specific mills (and thus to a degree as well sub-sector classification) changes. In addition to that sub-sector classification in different sources is frequently differing and the effort put into it needs to be balanced against the purpose it serves. The main reason for introducing a sub-sector classification scheme for individual firms and sites is to have some control on the effect of product orientation at the sub-sectoral level on environmental and economic performance characteristics.

4.2.3 Conclusions on the data set for the European paper industry

The analysis of the data set structure and its relationship to production and capacities in the different countries reveals four important points:

(i) The structure of the sample is homogeneous in itself, e.g. the number of cases is evenly distributed across countries and years, with no significant associations identified, except possibly for the distribution of sub-sectors across countries.

(ii) The sample covers a considerable proportion of production capacity in each country, on average 20% in 1996 and 22% in 1997. Only in Italy, coverage is below average (reducing the probability that the Italian sample is fully representative).

(iii) With regard to coverage according to size distribution, the sample is biased towards larger firms, with the smallest size category of 0-10,000 t/yr production not covered at all. However, this is mainly due to general difficulties regarding "observability" of data for subjects (i.e. plants and companies) in this firm size category.

(iv) Concerning the question of how well the sample replicates the sub-sector distribution of production capacity in each country (in terms of the broad sub-sectors "Cultural", "Industrial", "Mixed" and "Other") it was found that the sample has a slight bias towards the "Cultural" sub-sector compared to the "Industrial" sub-sector. Also, the below average coverage of Italy in terms of production capacity could be observed in the coverage of individual sub-sectors.

The identified characteristics of the data set implicitly qualify the applicability of results. For example, it would be difficult to draw conclusions for the 0-10,000 t/yr size category of mills since it is not represented in the data set in any way. Similarly, it is potentially more difficult to make predictions for the “Industrial” (packaging grades) sub-sector, since it is relatively under-represented compared to the “Cultural” sub-sector.

Regardless of the limitations discussed above and their implications for the generalisability of results derived from an exploratory statistical analysis of the data set, it needs to be stressed, that the data used in this research is likely to be the maximum data set available. This means that all firms known for which matching environmental and economic data is simultaneously available have been included. Therefore, the structure of the data set, as analysed, is considered to be sufficiently valid and reliable to proceed with further statistical analysis regarding the relationship between environmental and economic performance at the firm level.

Prior to reporting results of the statistical analysis, descriptive statistics on all variables used in the analysis are reported in Table 4.20 below. For the economic performance variables, it is found that the mean for ROCE is decreasing from 1995 to 1997, whereas the means for ROE and ROS are oscillating. Consistently with this, the minima and maxima for ROCE are changing most, year-on-year. Nevertheless, descriptive statistics for the economic performance variables vary much less over time than do those for environmental performance variables. Here, it is found that the mean for COD increases from 1995 to 1997 by a factor of 5. The mean of SO_2 oscillates in a similar way as the economic performance. However, the mean of NO_x increases from 1996 to 1997 by more than one order of magnitude. This is mainly due to a very high maximum value for NO_x in 1997. Mean, standard deviation, maximum and minimum of the water and energy input data (defined as described in the section on environmental performance measures) varies strong across the three years. Of the control variables, firm size varies relatively little across the years, whereas the inverse of the solvency ratio and the inverse of the asset turnover ratio vary more in their descriptive statistics across 1995 to 1997. The dummy variables for country membership only vary very little across years, as would be expected of these rather structural factors. For both, the economic, as well as environmental performance variables, data was usually not available for all firms in the data set. Therefore, the set of firms differs slightly from one statistical analysis to another. However, always the largest data set available was used.

Table 4.20: Descriptive statistics (based on all cases – regressions are carried out on differing sub-sets of cases, depending on data availability)

Variable	**1995**					**1996**					**1997**				
	n	mean	std. dev.	min.	max.	n	mean	std. dev.	min.	max.	n	mean	std. dev.	min.	max.
Employees	33	687.3333	690.7376	119	3548	33	691.3333	756.4154	132	4019	36	627.2778	682.4697	110	3697
A/T ratio	33	1.279736	0.4949782	0.177782	2.290431	32	1.147943	0.543463	0.282866	2.388247	32	1.186721	0.550339	0.337002	2.636996
ROCE	32	15.50156	21.70242	-12.54	104.3	31	11.29774	15.51713	-36.41	55.82	29	9.820345	8.719116	-11.46	34.6
ROE	33	12.77545	20.87975	-27.13	70.32	32	13.25594	23.64395	-51.4	79.51	32	7.764062	23.34394	-86.01	53.38
ROS	33	4.219697	6.643444	-7.11	23.21	32	5.019375	8.072457	-12.64	25.4	33	2.127576	12.12898	-53.16	19.02
Current ratio	33	1.559697	1.026019	0.49	4.87	32	1.50375	0.776376	0.44	3.62	33	1.371212	0.7981963	0.47	4.65
Solvency ratio	33	34.66545	17.55697	8.33	82.14	32	36.045	17.26244	16.35	75.74	32	37.8159	18.2280	14.53	80.48
SO_2	28	0.0033497	0.009559	0	0.4914	28	0.0034133	0.010105	0	0.051948	31	0.0024419	0.0089888	0	0.0496278
NO_x	30	0.0020188	0.0047285	0	0.0256	29	0.0019533	0.005576	0	0.030703 7	33	1.11916	4.896068	0	26.45455
COD	28	0.0079413	0.0085049	0.000290	0.027296	28	0.0099113	0.0157274	0.000330	0.080057	33	0.0413956	0.1871874	0.0004293	1.082353
Energy	24	12782.09	6191.979	286.9827	27951.1	22	11763.14	6092.688	264.6378	27597.05	23	11803.91	5336.011	289.7793	20409.6
Water	27	41909.11	27598.0	6371.543	107279.7	27	38833.6	26361.74	2174.367	97645.79	31	34643.41	24172.35	1239.412	88333.65
UK	35	0.2571429	0.4434396	0	1	34	0.2647059	0.4478111	0	1	37	0.2432432	0.4349688	0	1
Italy	35	0.2	0.4058397	0	1	34	0.2058824	0.4104256	0	1	37	0.2432432	0.4349588	0	1
Netherlands	35	0.2571429	0.4434396	0	1	34	0.2352941	0.4305615	0	1	37	0.2432432	0.4349588	0	1
Germany	35	0.2857143	0.4583492	0	1	34	0.2941176	0.4624973	0	1	37	0.2702703	0.4502252	0	1

4.3 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).

Hypothesis H1 was tested for two specifications of the environmental performance index during the first empirical analysis. Results based on the panel regression framework described in Chapter 4.1 are reported in the following Chapters 4.3.1 and 4.3.2.

4.3.1 Results for the output-oriented environmental performance index

This chapter reports results for the output-oriented environmental performance index using the panel regression framework described in Chapter 4.1.5. In addition to the variables provided in Table 4.6, 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 data and the random effects (RE) and fixed effects (FE) models for economic performance indicators are reported separately in Tables 4.21 to 4.23 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 Lagrangian Multiplier and the Hausman specification 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 Hausman test is significant. The fixed effects (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 positive effect on ROCE. In addition to that, the squared term of the environmental index with a significance of 10.4% is also almost significant (at the 10% level) and has a negative effect on ROCE. The result is also economically relevant, since a 10% increase of environmental performance increases ROCE by 33.02 units, all else being equal (the high increase is due to the environmental index taking values between zero and one). Also the squared term is economically relevant. 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 fixed effects (FE) model is equal to an index value of 0.12. With the index taking values between zero and one, this corresponds to a relatively low level of environmental performance.

Table 4.21: Estimation results for ROCE as dependent variable (output-based index)

Model type	**Pooled Model**		**RE Model**		**FE Model**	
Independent variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
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.

Concerning ROS as measure of firms' economic performance, it was found that the fixed effects specification is most appropriate (as signified by the significant 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: a 10% increase of environmental performance reduces ROS by 7.2%, all else being equal. 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 dependent variable. However, leverage was found to have a significant negative effect on ROS (1% level), whereas the asset turnover ratio was found to be insignificant in the fixed effects model.

Table 4.22: Estimation results for ROS as dependent variable (output-based index)

Model type	**Pooled Model**		**RE Model**		**FE Model**	
Independent variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
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**	0.0062	***-0.0221***	0.0073	***-0.0272***	0.0093
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.

Table 4.23: Estimation results for ROE as dependent variable (output-based index)

Model type	**Pooled Model**		**RE Model**		**FE Model**	
Independent variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
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.

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 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.

4.3.2 Results for the input-oriented environmental performance index

This chapter reports results for the input-based environmental performance index, again using the panel regression framework described in Chapter 4.1.5. As for the output-based index, in addition to the variables provided in Table 4.6, 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 random effects (RE) and the fixed effects (FE) models for are reported in Tables 4.24 to 4.26, respectively and also the results of the Breusch-Pagan Lagrangian Multiplier and Hausman specification tests are provided.

As can be seen for ROCE as dependent variable used to measure economic performance, the model with random effects (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 (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 per cent). 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.

Table 4.24: Estimation results for ROCE as dependent variable (input-based index)

Model type	**Pooled Model**		**RE Model**		**FE Model**	
Independent variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
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.

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, as well as 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.

Table 4.25: Estimation results for ROS as dependent variable (input-based index)

Model type	**Pooled Model**		**RE Model**		**FE Model**	
Independent variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
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.

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 of ROS, all else being equal, whereas a unit increase of the asset turnover ratio would result in an almost 0.03% decrease of 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 any Italy, the Netherlands or the UK increases ROS by between 0.06% to 0.09%, relative to Germany.

Table 4.26: Estimation results for ROE as dependent variable (input-based index)

Model type	**Pooled Model**		**RE Model**		**FE Model**	
Independent variable	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
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.

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 relative 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.

5. Second Empirical Analysis: Influence of Corporate Environmental Strategies on the Relationship between Environmental and Economic Performance

5.1 Methodology

5.1.1 Introduction

The instrument used in the second empirical analysis of this thesis was the European Business Environment Barometer (EBEB) questionnaire. The EBEB is a bi-annual survey on the state of environmental management in practice carried out in several European countries. The data used in this thesis refers to the last survey round in 2001. The questionnaire used in the EBEB survey was identical in Germany and the UK, except of course that the former survey was carried out in German. Great care was taken to ensure full comparability of the questionnaires by means of extensive pre-testing in both countries with subsequent comparison of pre-test results. The questionnaire asked about specific environmental issues, such as the main environmental effects; the main management and technological actions to address these; questions to evaluate the degree of sophistication, and extent of the corporate environmental programme. This is followed by questions about the self-assessment on the motives, drivers, benefits and obstacles of environmental management.

The analysis of the relationship between different environmental management approaches and CES with the core concept of environmental competitiveness will be the focus of the second empirical analysis.

In order to answer the hypotheses formulated in this respect in Chapter 3, some important aspects that have not yet been addressed by previous work (and thus are considered to be a contribution to knowledge in themselves) need to be analysed:

(a) Do firms have consistent strategy patterns and can these be classified using the Environmental Shareholder Value (ESV) approach (Schaltegger & Figge 1998; 1999; 2000)?

(b) How can environmental competitiveness of a firm be measured, and is this a one- or multi-dimensional concept?

These two aspects will be addressed first from a methodological standpoint in Chapters 5.1.2 to 5.1.4. Chapter 5.2 will provide an exploratory data analysis and Chapter 5.3 will then report results for the overall research question and hypotheses of the research.

The most important instruments in the questionnaire for the research reported here are the item batteries for Environmental Shareholder Value (Schaltegger & Figge 1998; 1999; 2000; Figge 2001) and the battery of items for environmental profit, which shall be explained in detail in the following.

5.1.2 Empirical measurement of corporate environmental strategies (CES)

One approach to operationally measure corporate environmental strategies (CES) is to base them on one overall concept. For the research reported here, this approach was adopted, i.e. it was decided to measure CES as one overall concept, based on the Environmental Shareholder Value concept developed by Schaltegger and Figge (1998; 1999; 2000). The aim is then to analyse the corporate environmental strategies, which can be empirically derived from this framework.

Regarding environmental management in general, Schaltegger and Figge (2000) argue that the amount of corporate environmental protection in itself neither spurs nor reduces shareholder value (or similarly other measures of economic performance). Contrary to the often-held view that the amount of environmental protection (and thus the level of environmental performance which is related to it) is (negatively or positively) related to the economic performance of firms, it is argued that such a relationship strongly depends on factors internal to the firm (Schaltegger & Synnestvedt 2002). Particularly, corporate environmental strategies, environmental management approaches used and activities adopted by the firm, as well as the tools utilized are seen as major factors which moderate the relationship between environmental and economic performance at the firm level.

Schaltegger and Figge (1998, 1999, 2000) link environmental performance and shareholder value (which is, strictly speaking, not based on profit, but on free cash flows) by means of the theoretically derived value drivers for shareholder value. These value drivers derived from the original shareholder value concept (Rappaport 1995) are (Schaltegger & Figge 1998, p. 18):

- The level of fixed capital and working capital investments (which jointly determine the expected capital investment),
- The systematic risk, the return of risk-free investments, and the return of the market portfolio (which determine costs of capital and thus the discount rate), and finally,
- Sales growth, operating profit margin, income tax rate and value growth duration (which in combination with the fixed and working capital investments determine the expected cash flow).

Together, the expected capital investment, the discount rate, and the expected cash flow determine the long-term (discounted) risk-adjusted return, and thus the shareholder value. Schaltegger and Figge (1998) then go on discussing the expected influence of different types of environmental strategies on the described value drivers. For example, if large sums have to be invested by a firm in end-of-pipe pollution abatement, this likely reduces free cash flow and therefore economic performance, although environmental performance might have improved considerably. Also, growing internalisation of external environmental costs by means of e.g. taxes will bring the objective of cost reduction increasingly in line with the ecological goal of reducing environmental burdens and thus for both, a strategy of cost leadership as well as one of quality leadership, appropriate environmental management will become increasingly important. Figge (2001) proposes a checklist, which was partly used as the basis for the items included in the questionnaire of the survey used to gather data for the empirical analysis. The items, in their appearance in the survey, are reported in Table 5.1. For each item (which was in each case a full statement), respondents were asked to evaluate the extent to which they agree or disagree with the statement. Responses had to be given on a 5-point Likert scale ranging from "Fully disagree" via "Disagree", "Neutral" and "Agree" to "Fully agree". Respondents were asked to focus on environmental management alone and to disregard the influence of other activities of their firm on the statements when evaluating these.

Table 5.1: Questions for operationalisation of the Environmental Shareholder Value concept

- Through eco-products or eco-marketing we can achieve above-average market prices for our current products
- Eco-products or eco-marketing help us to charge above-average market prices for possible future products
- Environmental management helps us to have lower costs for our processes
- Eco-products or eco-marketing help us to sell more of our current products
- Environmental management in our company leads to lower capital investments for our current processes
- Environmental management in our company helps us to utilize better existing equipment
- Environmental management in our company helps us to create a competitive advantage that is difficult to imitate
- Environmental management helps our company to better predict its costs
- Through environmental management the proportion of variable costs in our company is higher
- Through its environmental management our company can defer investments to a later point in time
- Environmental management helps our company to extend the operational life of our production equipment
- Environmental management helps our company to better predict its future investments
- Environmental management helps our company to extend the operational life of our products

In the empirical analysis to follow, corporate environmental strategy orientation will be measured according to the above items operationalising the Environmental Shareholder Value (ESV) concept.

5.1.3 Empirical measurement of environmental competitiveness

As said earlier, measurement of environmental competitiveness is not an easy task, since no commonly accepted definition of this concept exists. Consequently, there is no quantitative data available for environmental profit or competitiveness of individual companies. In principle, measurement of benefits resulting from environmental management activities is possible, if firms would adopt environmental accounting methods, but to date this has only be done do a very limited degree (for details, see Schaltegger & Burritt 2000). Clearly, measurement of environmental competitiveness should include as many business performance dimensions as possible to provide a holistic view of the effects of environmental management on firms' economic performance. Therefore, the most feasible way seems to be the use of self-assessment by firms, based on a number of items, since this allows accounting for as many dimensions as considered relevant. Environmental competitiveness thus was measured for the purposes of this thesis by means of a battery of items that are detailed below in Table 5.2. For each of the items, the survey questionnaire asked to which degree environmental management activities over the years 1998-2000 were beneficial for a number of corporate goals over that period of time. Respondents were asked to provide answers on a 5-point Likert scale ranging from "very negative" via "neutral" to "very positive".

Table 5.2: Items used for measuring environmental competitiveness

- Competitive advantage through environmental management activities
- Product image improvements through environmental management activities
- Sales increases through environmental management activities
- Market share gains through environmental management activities
- New market opportunities through environmental management activities
- Corporate image improvements through environmental management activities
- Shareholder satisfaction increases through environmental management activities
- Management satisfaction increases through environmental management activities
- Worker satisfaction increases through environmental management activities
- Better recruitment and staff retention through environmental management activities
- Higher short-term profits through environmental management activities
- Higher long-term profits through environmental management activities
- Higher cost savings through environmental management activities
- Productivity increases through environmental management activities
- Improved insurance conditions through environmental management activities
- Better access to bank loans through environmental management activities

5.1.4 Empirical measurement of environmental performance

Unlike in the first empirical analysis of the research, environmental performance could not be measured by means of physical environmental performance data in the second phase, since comparable data across sectors and countries was not available. Therefore, it was decided to measure environmental performance in terms of an index that assesses the reduction of a firm's environmental impacts in a number of categories, each measured by a separate variable. The index value is based on the mean score across all these variables for each firm and is standardized for differing for country and sector mean values using the method proposed by Aragon-Corea (1998, p. 559). For each standardized index value, a low score indicates environmental performance improvements below the mean (for a specific sector and county), i.e. on average no or low reduction, across a number of environmental performance dimensions. Conversely, a high score on the index indicates environmental performance improvements above the mean, i.e. much or very much environmental impact reduction. The calculation of the index of environmental performance is based on a number of item variables referring to individual environmental performance dimensions, which were added up to result in the index score. For each of the items, the survey questionnaire asked about the degree to which environmental management activities over the years 1998-2000 reduced the company's environmental impact in a number of environmental performance dimensions shown in Table 5.3 below over the period of 1998-2000. Respondents were asked to provide answers on a 5-point Likert scale ranging from "no reduction", "little reduction", via "average reduction" to "strong reduction" and "very strong reduction" with the highest score corresponding to the strongest reduction.

Table 5.3: Variables used for measuring environmental performance

- Reduction in use of water
- Reduction in use of energy
- Reduction in use of non renewable resources
- Reduction in use of toxic inputs
- Reduction of solid waste
- Reduction of soil contamination
- Reduction in waste water emissions
- Reduction in emissions to air
- Reduction of noise
- Reduction of smell/odour emissions
- Reduction of landscape damage
- Reduction in the risk of severe accidents

5.1.5 Statistical analysis methodology in the second empirical analysis

For the statistical analysis the data files for UK and German with all firms that are in manufacturing sector (approximately 300 altogether) were merged into one analysis file. Then an exploratory data analysis was carried out, establishing the number of firms in each sector and country and with the figures being compared to the population matrix of firms in the manufacturing sector in each country. By doing so, it could be established that the sample is representative in both countries as far as firm size and sectoral distribution of firms are concerned.

Following this, factor analyses were carried out for the items used in the survey to assess the ESV orientation of a company (as a proxy for its orientation towards value-oriented environmental management). The resulting factors/components were labeled, and it was compared to which degree these factors/components (which are essentially empirically derived (independent, i.e. uncorrelated) dimensions of corporate environmental strategies) were consistent with the propositions made by the ESV concept (Schaltegger & Figge 1998; 1999; 2000). Finally, cluster analyses were carried out in order to assign firms to specific types of CES based on the factors established in the factor analyses.

After establishing which CES firms pursue, principal component analysis (PCA) was carried out on the environmental competitiveness items (as listed in Chapter 5.1.3) used in the survey. This allows identifying the different components (factors) of environmental competitiveness. The resulting factors/components were labeled, and were compared to the standardized environmental competitiveness items (see 5.2) with regard to the degree to which both sets of factors correspond. Use of a sector and country standardised environmental impact reduction index means that environmental performance is not an endogenous variable with respect to sector membership and country location. Therefore, the remaining hypotheses can be tested (separately for each set of firms with a specific CES) by linear multiple regressions of the type:

$$y_{it} = \alpha + \mathbf{x}_{it}\beta + \mathbf{z}_i\gamma + u_{it} \quad (9)$$

Where i = 1 .. N are the units under observation; and t = 1, since a cross-sectional data for only one year is considered. $y_{it} = y_i$ denotes the observation on the dependent variable (environmental competitiveness component j, with j = 1 .. 4) for a firm i. $\mathbf{x}_{it} = \mathbf{x}_i$ represent the set of ordinal or continuous independent variables (i.e. the regressors firm size, square of firm size, market growth rate, firm age, overall profit, environmental impact reduction index, square of environmental impact reduction index), and $\mathbf{z}_i$ the binary explanatory variables (i.e. the sector dummies, country dummies, legal form, as well as dummies for level of EMS implementation). Given, that the second empirical analysis concerns cross-sectional data, OLS is the efficient estimation method. Less formal, the multiple linear regression equation estimated via OLS reads as follows:

Environmental competitiveness component i = linear additive function (firm size, square of firm size, sector dummies, country dummies, market growth rate, firm age, legal form, overall profit, dummies for level of EMS implementation, environmental impact reduction index, square of environmental impact reduction index) plus residual value u_i

Based on this equation, the unknown coefficients for $\mathbf{x}_i$ and $\mathbf{z}_i$ are estimated using OLS. The control variables used in the first empirical analysis (this concerns country location, firm size, and industry sector (instead of sub-sector) dummy variables) were also included in the second analysis, however, in slightly different specifications. Additionally, the EMS implementation status was measured in the second empirical analysis on four levels ranging from "No implementation", via "Considering implementation", "In process of implementation" to "Yes, implemented". Measuring levels of EMS implementation focuses on the actual process of implementation, which is considered to be a more direct driver of performance improvements than EMS certification (Schaltegger & Synnestvedt 2002). However, instead of using an ordinal variable to represent the 4-point scale ranking, three dummy variables were included for the four possible states.[78] Industry sector membership was accounted for by binary dummy variables. These are taking unity value, if a firm is located in the sector designated by the dummy variable and zero otherwise. The metals industry, which had the highest number of cases in the data set (n=43) was taken as the reference, i.e. a significant dummy variable for a sector indicates that for this sector, the influence on an environmental competitiveness factor (as dependent variable) is significant relative to that on the metals industry. Finally, firm size was measured in thousands of employees and the square of firm size was also included in the regression (as was in the first empirical analysis of the research to account for the possibility of non-linear relationships). In addition to the control variables already included in Chapter 4.1, a number of further control variables were included, given the novelty of the dependent variables. These are market growth rate, legal form and overall profitability. As explained in the first part of this thesis, market development is a potentially very important influence,

[78] Only if all coefficients for these dummy variables would be found to have proportionally increasing or decreasing values, the use of one ordinal variable instead would be appropriate. Therefore, the use of dummy variables relaxes the assumptions made with regard to environmental management systems implementation, i.e. this does not have to be a linear, stepwise process, at least as concerns its influence on different dimensions of environmental competitiveness.

which is why Russo and Fouts (1997) as well as Konar and Cohen (1997; 2001) include a measure for market growth in their analyses of the relationship between environmental and economic performance. Given that no sub-sector information was available for the cross-industry data set analysed during the second empirical analysis of this research, it seemed appropriate to address the influence of differences in market development in terms of a firm-specific measure of market growth. This was based on firms judging on a 5-point scale the development in the market they mainly sell into. Judgements ranged from “The market has decreased significantly” (which was considered to represent decreasing sales for the firm) to “The market has increased significantly” (which was considered to reflect high sales growth for the firm). Nguyen Van *et al.* (2000) argue for inclusion of control variables for firm age and firms’ legal structure. Therefore a measure for firm age (here the logarithm of firm age) was included in the analysis, but was found to not have any significant effect in any of the regressions.

Also, a binary dummy variable distinguishing between sole proprietorship and a firm being part of a larger company was included and kept in the regressions. Finally, a measure of firms’ overall profitability (measured on a 5-point scale ranging from “gross profits well in excess of expenditure” to “highly loss-making”) was included in the regressions. Table 5.4 summarises all variables with their definitions and value ranges.[79]

[79] The survey questionnaires used during the second empirical analysis for gathering data on the variables described in this section and in Table 5.4 can be found in full at http://www.agf.org.uk/pubs/pdfs/German.pdf and http://www.agf.org.uk/pubs/pdfs/English.pdf.

Table 5.4: Summary of variable definitions for all variables used in 2nd empirical analysis

Concept	Variable	Description	Type
Economic performance	Environmental profit indices 1-4	Indices calculated based on factor analysis of items used to measure environmental competitiveness in the survey (each item scored on 5-point scale)	continuous
Environmental performance	Environmental impact reduction index	Averaged index score, standardized for industry sector and country location (based on a set of variables measuring different dimensions of environmental performance in questionnaire)	continuous
Firm size	Number of employees	Number of employees (in thousands)	continuous
EMS implementation status	"No"	Firm has not implemented EMS (reference group)	dummy
	"Considering"	Firm considers EMS implementation	dummy
	"In process"	Firm is in progress of implementing an EMS	dummy
	"Yes, implemented"	Firm has implemented an EMS	dummy
Country	United Kingdom	Firm located in the United Kingdom	dummy
	Germany	Firm located in Germany (reference group)	dummy
Sector control variables	Food / tobacco	Firm in food and tobacco sector	dummy
	Textiles	Firm in textile products sector	dummy
	Pulp and paper	Firm in pulp and paper products sector	dummy
	Printing	Firm in printing and publishing sector	dummy
	Energy, oil etc.	Firm in energy, oil and nuclear fuels sector	dummy
	Chemicals	Firm in chemicals and fibres sector	dummy
	Rubber and plastic products	Firm in rubber and plastic products sector	dummy
	Non-ferrous minerals	Firm in non-ferrous mineral products sector	dummy
	Machines and equipment	Firm in machines and equipment sector	dummy
	Electrical and optical products	Firm in electrical and optical products sector	dummy
	Transport products	Firm in transport products sector	dummy
	Metals products	Firm in the metals products sector (reference group)	dummy
	Other manufacturing products	Firm in sector producing other manufacturing products	dummy
Other control variables	Firm age	Logarithm of firm age in years	continuous
	Market development	Measure in survey questionnaire on 5-point scale to assess whether firm has decreasing sales or sales	ordinal
	Firm legal status	Dummy variable taking the value 1 if firm is under sole proprietorship and 0 otherwise	dummy
	Firm overall profitability	Measure in survey questionnaire on 5-point scale to assess whether firm is profit-making or loss-making	ordinal

Given that approximately 28 independent variables are used in the regressions, data for the UK and for Germany were pooled in the analysis.

5.2 Exploratory data analysis

5.2.1 Representativeness of responses in Germany

The sample for the German survey was based on random sampling. The sampling frame was the manufacturing sector in Germany, with firm population equal to the total number of firms in the manufacturing sector. Their sectoral breakdown, based on the industry NACE classification is provided in Table 5.5, data for which was provided by the Bundesanstalt für Arbeit.

Table 5.5: Number of companies in different firm size categories and industries in Germany

Sector NACE code	50-99 employees	100-499 employees	500 and more employees
15	1267	1206	100
16	3	12	7
17	328	316	20
18	181	154	13
19	68	70	5
20	320	216	25
21	231	329	43
22	785	626	78
23	20	28	18
24	459	578	171
25	781	730	110
26	583	494	58
27	384	509	134
28	1630	1229	115
29	1610	1740	316
30	62	58	23
31	439	526	139
32	188	239	89
33	534	561	96
34	199	287	158
35	90	115	62
36	476	463	42
All sectors	10638	10486	1822

Source: Bundesanstalt für Arbeit (German Federal Bureau for Employment), Number of manufacturing firms in Germany as of 31 December 1999, data provided to University of Lüneburg on 8 November 2000.

The questionnaires of the German survey were addressed to the environmental managers of the companies and were in most cases answered by them. In some cases, quality managers completed the questionnaire instead. Especially in small firms, often the managing director her- or himself completed the questionnaire. After having sent questionnaires to 2000 companies, 166 usable questionnaires in total were returned, corresponding to an effective response rate of 8.3%. The number of responses is consistent with the average of the other countries (Hungary with responses of 187 firms, and Switzerland, with 181 responses), in which the 2000/2001 survey round of the European Business Environment Barometer (see Harkai & Pataki 2001; Baumast & Dyllick 2001). The final sample of respondents resulting from the German survey is described in Table 5.6 in terms of industry and firm size distribution.

Table 5.6: Breakdown by industry sector and firm size (number of employees) in Germany

Sector of industry	**10-99**	**100-249**	**250-499**	**>500**	**Total**
Food and tobacco	5	8	3	5	21
Textile	2	5	3	4	14
Pulp and paper	2	2	-	-	4
Publishing and printing	4	3	4	2	13
Energy, oil products and nuclear fuel	-	-	-	1	1
Chemicals and fibres	3	2	-	4	9
Rubber and plastic	3	2	1	2	8
Non-ferrous mineral products	2	5	1	2	10
Metals	4	8	6	2	20
Machines and equipment	5	11	3	4	23
Electrical and optical equipment	5	5	4	6	20
Transport products	2	2	2	7	13
Other manufacturing	2	4	3	1	10
All sectors	39	57	30	40	166

As can be seen, sector coverage is relatively high in food and tobacco products, metal products, machines equipment and transport products, whereas it is low in energy, cokes and oil fuels, as well as pulp and paper products. Except for three (timber industry, leather processing and recycling), all target branches are represented in the returned questionnaires. The biggest share of respondents involved the production of machines and equipment (n=23), the food and tobacco industry (n=21), the manufacture of metal products and electrical and optical equipment (each n=20). Following these, the best-covered industries are the textile industries (n=14) and publishing and printing and transport products (n=13).

With regard to the number of employees, in Germany, firms with 500 and more employees are clearly over-represented in the response sample (24.10% of the total number of responding firms are in this size category, as opposed to 7.94% for the German manufacturing sector as a whole) compared to companies with 100-499 employees (52.41% of all responding firms, of which 34.34% are in the category of 100-249 employees and 18.07% in the category of 250-499 employees) and companies with less than 100 employees (23.49% of all firms). This compares to 46.36% of firms below 100 employees, and 45.70% of firms with between 100 and 499 employees for the German manufacturing sector as a whole. These findings for firm size distribution are, however, consistent with the firm size bias towards larger firms found in previous surveys on environmental management (Baumast & Dyllick 1998; Baumast 2000). To some degree, due to their response behaviour, the group of small firms is a sub-universe almost “unobservable”.

5.2.2 Representativeness of responses in the United Kingdom

In April and May 2001 the EBEB questionnaire was sent to approx. 1000 British firms, which were representative (in terms of industry sector membership) for large and medium-sized firms in the UK manufacturing sector. 135 usable questionnaires were returned (correspon-ding to a response rate of approximately 16.25%). With regard to the size of the firms it was found, as for Germany, that the response rate of bigger firms are above the average. This is, however, not considered a problem in the current survey since the analysis has revealed considerable variability in firm behaviour, which indicates that any bias is likely not very strong (Pacheco & Wehrmeyer 2001). The UK firm population from which the representative sample was drawn is based on the number of firms for which the job function “Environmental/Recycling Manager” exists. From a database, 5996 manufacturing firms were identified who had this job function category available. The sectoral breakdown, based on the broad 1992 SIC industry classification is provided in Table 5.7 below.

Table 5.7: Number of companies in different industries in the UK

Sector NACE code	50-99	100-249	250-499	500-999	1000+	Total
15	441	0	0	118	0	559
16	0	0	0	0	0	0
17	283	283	103	33	9	711
18	217	122	37	23	20	419
19	64	50	16	0	0	130
20	144	76	16	0	0	236
21	176	204	63	17	9	469
22	502	297	112	61	21	993
23	14	13	10	6	3	46
24	262	224	121	68	47	722
25	394	370	127	34	19	944
26	206	158	61	23	22	470
27	164	170	73	23	11	441
28	782	409	97	26	10	1324
29	601	483	177	76	30	1367
30	30	40	0	0	18	88
31	255	248	84	41	23	651
32	107	121	0	0	24	252
33	245	165	66	27	10	513
34	163	169	89	52	24	497
35	98	87	34	31	35	285
36	341	0	0	0	5	346
Other manufacturing	125	750	402	113	128	1518
All sectors	5614	4439	1688	772	468	12986

Source: Eurostat, Number of manufacturing firms in the UK as of 1997, data provided to University of Lüneburg on 14 March 2002 (Eurostat New Cronos database, Industry, Trade and Services, Structural Business Statistics (Industry, Construction, Trade and Services), annual enterprise statistics broken down by size classes).

In the survey, 135 usable questionnaires were returned in the British manufacturing sector, for which the distribution according to industry sectors and firm size is shown in Table 5.8.

Table 5.8: Breakdown by industry sector and by firm size (number of employees) in the UK

Sector of industry	**10-99**	**100-249**	**250-499**	**>500**	**Total**
Food & tobacco	2	3		1	6
Textile	2	4	1	1	8
Pulp & paper				3	3
Publishing & printing	3	3	3	5	14
Energy, oil products & nuclear fuel	1	1		1	3
Chemicals & fibres	3	6	5	5	19
Rubber & plastic	2	3			5
Non-ferrous mineral products	2	1		4	7
Metals	8	7	4	4	23
Machines & equipment	3	2	4	3	12
Electrical & optical equipment	5	3	2	3	13
Transport products	3	3	2	3	11
Other manufacturing	5	3	1	2	11
All sectors	39	39	22	35	135

As can be seen, the main sectors are metal processing (n=23), chemicals and fibres (n=19), publishing and printing (n=14), electrical and optical equipment (n=13), and machines and equipment manufacture (n=12). With regard to the firms' size distribution it was found that 28.89% of the responding firms have less than 100 employees and another 28.89% of the replies came from medium-sized firms (100-249 employees). The group of larger firms (250-499 employees) has a share of 16.30% in the total of responses, and the group for largest firms (500 and more employees) is 25.93%. Again, there is a slight bias towards larger firms, compared with the UK manufacturing sector as a whole. According to Pacheco and Wehrmeyer (2001), approximately 25% of the responding firms are stock-listed companies, ca. 20% are privately owned firms and 40% are companies with privately held stock. Approximately 41% of the firms are totally independent, whereas almost half of them (49.3%) are fully owned by another enterprise (Pacheco & Wehrmeyer 2001, p. 18).

5.2.3 Empirical identification of corporate environmental strategies based on the Environmental Shareholder Value concept

In the following, the results of a classification of firms based on the concept of Environmental Shareholder Value (Schaltegger & Figge 1998; 1999; 2000) are presented. A factor analysis was carried out on eight items chosen from the questionnaire survey to operationalise the concept of ESV. Prior to this, responses for each ESV item were standardized by subtracting from the item score the mean for the appropriate sector and country. Doing so is advocated for multi-industry samples by Aragon-Corea (1998, p. 559) who states that in this way, scores are more comparable between sectors since after standardisation, they provide a measure relative to industry mean. Since two countries are included in the research, separate calculation of sector means for each country was necessary. For each standardised ESV item, the resulting mean score is zero.

By means of the factor analysis the eight items could be condensed into two underlying factors:

- The first factor can be interpreted as the "expected profitability" resulting from a firm's environmental management activities. This mainly refers to cost reductions, margin and sales increases, better control of capital-intensive investments and extension of product and process lifetimes. This factor is characterized by high agreement of respondents to the following items (and thus high factor loadings of the items on this factor):
    - Through eco-products or eco-marketing we can achieve above-average market prices for our current products;
    - Eco-products or eco-marketing help us to sell more of our current products;
    - Environmental management helps us to have lower costs for our processes;
    - Environmental management in our company leads to lower capital investments for our current processes;
    - Environmental management in our company helps us to utilize better existing equipment;
    - Environmental management in our company helps us to create a competitive advantage that is difficult to imitate;
    - Environmental management helps our company to better predict its future investments.
- The second factor consists of only one item with a high positive factor loading, which refers to variable costs:

- Through environmental management the proportion of variable costs in our company is higher.

This factor has therefore been termed “variable costs”, and, since variable costs are strongly linked to the risk exposure of a company (Figge 2001) it refers to risk reduction i.e. the variability of profitability. Higher variable costs in this imply a lower risk for the company, and therefore a high score on the “variable costs” factor corresponds to a lower environmental risk exposure of the firm. Table 5.9 below provides information about the variance explained by each factor.

Table 5.9: Variance explained by factors in Environmental Shareholder Value factor analysis

Factor	**Initial Eigenvalues and Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.570	44.624	44.624	3.479	43.486	43.486
2	1.125	14.067	58.692	1.216	15.206	58.692
3	0.902	11.272	69.964			
4	0.578	7.225	77.189			
5	0.545	6.818	84.006			
6	0.505	6.309	90.316			
7	0.458	5.731	96.047			
8	0.316	3.953	100.00			

Extraction Method: Principal Component Analysis.

The percentage values provided in the three columns under the heading “Extraction Sums of Squared Loadings” in Table 5.9 for each factor refer to the share of the total variance, which is explained by the respective factor. The variance explained indicates how much of the variability encountered in the total of the initial variables is explained by the respective factor (Backhaus *et al.* 2000, p. 308). For example, the factor “variable costs” (i.e. the second factor) explains approx. 14% of the total variation in the data. Overall, approx. 59% of the total variation encountered in the data is explained by the two factors extracted (i.e. the two factors with Eigenvalues greater than unity).

Table 5.10 reproduces the rotated component matrix of the factor analysis, providing information about the factor loadings of each item on the two relevant factors.

Table 5.10: Rotated component matrix for Environmental Shareholder Value factor analysis[80]

Item Variable	**Component/Factor**	
	Value creation	Risk reduction
Through eco-products or eco-marketing we can achieve above-average market prices for our current products	0.629	0.381
Environmental management helps us to have lower costs for our processes	0.673	-0.434
Eco-products or eco-marketing help us to sell more of our current products	0.694	0.377
Environmental management in our company leads to lower capital investments for our current processes	0.744	0.04846
Environmental management in our company helps us to utilize better existing equipment	0.754	-0.02057
Environmental management in our company helps us to create a competitive advantage that is difficult to imitate	0.729	0.174
Through environmental management the proportion of variable costs in our company is higher	0.08587	0.840
Environmental management helps our company to better predict its future investments	0.699	0.04871

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 3 iterations. Shaded fields are considered for interpretation of factor content.

The above two factors identified on the basis of the Environmental Shareholder Value items are basic dimensions, according to which firms can be classified with regard to their corporate environmental management behaviour. Per definition, the factors derived in a factor analysis are not correlated with each another. In order to identify groups of firms with similar behaviour (i.e. based on a similar profile in terms of the degree to which the different strategic orientations are pursued by a firm) cluster analysis is an appropriate method to define groups of firms with similar characteristics with regard to the above two factors.

According to Hair *et al.* (1998, p. 473) "cluster analysis is the name for a group of multivariate techniques whose primary purpose is to group objects based on the

[80] The KMO measure for the factor analysis was 0.835, which is a sufficiently high value. In addition to this, the individual KMO measures based on the anti-image correlations on the main diagonal of the anti-image correlation matrix were all above 0.6. Therefore the correlation matrix of the data set is considered suitable for carrying out a factor analysis on the data set (see Backhaus *et al.* 2000; Bühl & Zöfel 2000 for details).

characteristics they possess". According to them, whilst factor analysis is mainly concerned with grouping variables, cluster analysis is grouping objects. Because of this, the researcher's definition of the cluster variate (i.e. the set of variables which represent the characteristics that are used to compare objects, e.g. firms, in the analysis) is very important. Hair *et al.* (1998) state that cluster analysis is descriptive, atheoretical and noninferential and is mainly used as an exploratory technique. Therefore it seems suitable to establish groups of firms with different environmental strategies with this technique.

In the current research, cluster analysis was based on the Ward linkage procedure for generating clusters. Ward's method is a "hierarchical clustering procedure in which the similarity used to join clusters is calculated as the sum of squares between the two clusters summed over all variables. This method has the tendency to result in clusters of approximately equal size due to its minimization of within-group variation." (Hair *et al.* 1998, p. 473).

According to Backhaus *et al.* (2000, p. 366), the Ward procedure is suitable if the variables are uncorrelated. This is the case for the two above factors resulting from the factor analysis. In addition to that, in order to apply the Ward procedure, variables need to be measured on an interval scale, outliers should not exist in the data, the number of elements in each group should be of about equal size, groups should have about even spread and the use of a distance measure is appropriate for establishing similarity of cases (Backhaus *et al.* 2000, p. 366).

To identify the optimal number of clusters, the algorithm underlying the Ward linkage procedure is based on the variance criterion and incremental change of the number of clusters. The variance criterion states that the optimal number of clusters is achieved if a further reduction of the number of clusters would result in a considerable increase of the heterogeneity (Kirchgeorg 1990). If the Ward procedure uses the squared Euclidian distance to measure the distances between the objects to be clustered, then use of the Elbow criterion, which states the optimal number of clusters to be such, that the sum of error squares is minimally increased, is also appropriate (Backhaus *et al.* 2000, p. 360). The Ward linkage procedure is to be preferred over other procedures, since it has been shown in simulations to achieve very good partitions, i.e. to assign cases to the "right" cluster. It is therefore a very reliable fusioning algorithm (Bergs 1981). Based on the Ward procedure and the squared Euclidian distance measure to gauge the distances between the objects to be clustered, the optimal cluster solution should be determined using the Elbow criterion (Backhaus *et al.* 2000). The cluster analysis as described was carried out on the two Environmental Shareholder Value factors derived in the factor analyses described above. The result was that the 2-cluster solution was found to be optimal according to the Elbow criterion. Figure 5.1

below shows the resulting distribution of the two clusters in a coordinate system whose axes are defined by the two factors derived in the factor analysis

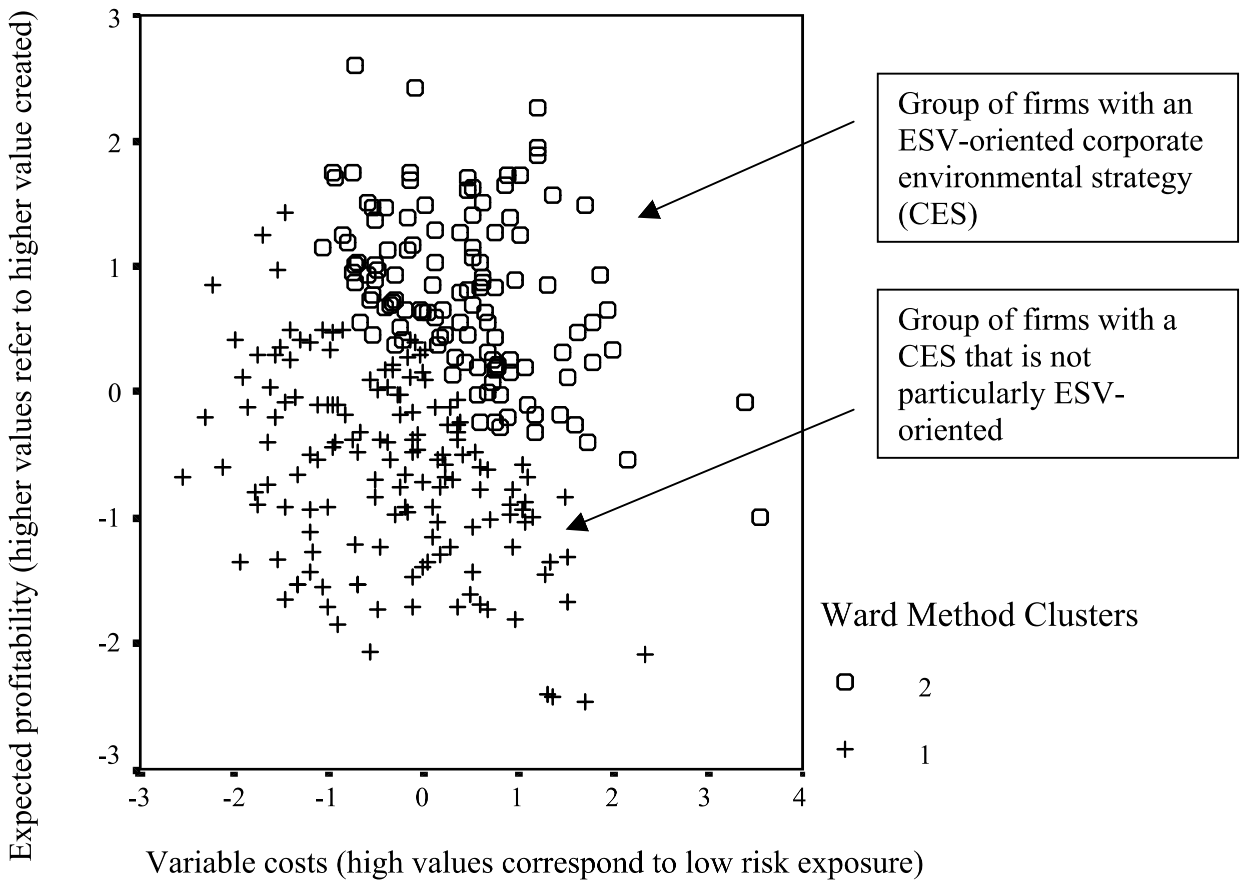

Figure 5.1: Solution of the cluster analysis for Environmental Shareholder Value factors

Using the same cluster analysis method as described above, a cluster analysis was also carried out based on the eight individual items used in the factor analysis for Environmental Shareholder Value. Other than for the factors, the items can be differently correlated amongst each other, which makes a cluster analysis using the Ward procedure less appropriate due to unequal weight of items in the cluster analysis. However, the results can be compared, providing an indication to the degree of sensitivity between them, which has been done in Table 5.11 below. As can be seen, in both cases, the 2-Cluster solution, which emerged as the optimal solution, is overlapping to a very high degree. This validates the results.

Table 5.11: Crosstabulation of factor-based and item-based solutions of cluster analysis

Cluster solution Ward method (factor-based)	**Cluster solution Ward method (item-based)**		**Total**
	1 (not ESV-oriented)	2 (ESV-oriented)	
1 (not ESV-oriented)	137	16	153
2 (ESV-oriented)	16	107	123
Total	153	123	276

The results found in the cluster analysis are validated in two ways. Firstly, the resulting scatterplot shown in Figure 5.1 is analysed to ascertain that any emerging patterns fit with the theory behind Environmental Shareholder Value. From the scatterplot it can be seen that there is very good agreement of the cluster solution with the theory. A separation line can be imagined running from the top left to the bottom right of the scatterplot. Such a diagonal separation line is also what can be expected from the theory behind Environmental Shareholder Value. The quadrant in the top right of Figure 5.1 in this would be a "win-win quadrant" where firms simultaneously achieve above average expected profits/value creation and above average risk reduction. The two quadrants in the top left and the bottom right of the scatter plot are each cut in half by the imagined separation line.

The upper triangles of these two quadrants are those where trade-offs are positive. This means, that firms are above average on one factor, but at the "price" of being below average on the other factor. However, the degree to which they are below average on this second factor is relatively less than the degree to which firms are above average on the other factor.

In the lower triangles of the two quadrants, the opposite is the case, i.e. trade-offs are negative. This means that firms pay a relatively higher "price" (in terms of being below average) on one factor for being above average on the other factor. Finally, the quadrant in the bottom left represents those firms, which are below average on both factors. From these considerations it can be seen, that the cluster analysis separates well between the group of firms whose corporate environmental strategies are found empirically to either create value or to reduce risk (or both) and the group of firms whose strategies are either not creating much value or are not reducing much their risk, or even worse, do not contribute to either.

Secondly, to validate the cluster solution derived, t-tests were carried out on those items of the questionnaire battery that were not used in the factor and cluster analyses. According to Hair *et al.* (1998) this validation procedure assesses criterion validity (also called predictive validity), which is the "ability of clusters to show the expected differences on a variable not used to form the clusters. (Hair *et al.* 1998, p. 470)". Here this would mean that for the remaining ESV items included in the survey (highlighted in grey in Tables 5.12 and 5.13 below), values should be significantly higher (based on e.g. t-tests or non-parametric Mann-Whitney tests) for the cluster of ESV-oriented firms (cluster 2). This analysis is summarized in Tables 5.12 and 5.13 below. As would be expected from theory, mean scores on each item were significantly higher for the cases allocated to cluster 2, i.e. for those firms with a high ESV orientation of their corporate environmental strategies.

Table 5.12: Group statistics for t-tests

Variable name	**Ward Cluster**	**N**	**Mean**	**Std. Dev.**	**Std. Error Mean**
Through eco-products or eco-marketing we can achieve above-average market prices for our current products	1	153	-0.4703	0.6012	0.04860
	2	123	0.5938	0.7557	0.06814
Eco-products or eco-marketing help us to charge above-average market prices for possible future products	1	153	-0.4031	0.7201	0.05822
	2	122	0.5033	0.7092	0.06421
Environmental management helps us to have lower costs for our processes	1	153	-0.2566	0.0294	0.08322
	2	123	0.3369	0.8467	0.07634
Eco-products or eco-marketing help us to sell more of our current products	1	153	-0.4865	0.6108	0.04938
	2	123	0.5990	0.7021	0.06330
Environmental management in our company leads to lower capital investments for our current processes	1	153	-0.4179	0.6067	0.04905
	2	123	0.4966	0.6974	0.06288
Environmental management in our company helps us to utilize better existing equipment	1	153	-0.4045	0.8089	0.06540
	2	123	0.4878	0.6999	0.06311
Environmental management in our company helps us to create a competitive advantage that is difficult to imitate	1	153	-0.4995	0.7695	0.06221
	2	123	0.5872	0.7816	0.07048
Environmental management helps our company to better predict its costs	1	153	-0.4239	0.8922	0.07213
	2	123	0.4830	0.7929	0.07149
Through environmental management the proportion of variable costs in our company is higher	1	153	-0.2827	0.8687	0.07023
	2	123	0.3527	0.6838	0.06166
Environmental management helps our company to extend the operational life of our production equipment	1	152	-0.2828	0.7407	0.06008
	2	123	0.3299	0.7471	0.06736
Environmental management helps our company to better predict its future investments	1	153	-0.3807	0.7878	0.06369
	2	123	0.4655	0.7489	0.06752
Environmental management helps our company to extend the operational life of our products	1	153	-0.3791	0.6792	0.05491
	2	123	0.4458	0.7043	0.06351
Through its environmental management our company can defer investments to a later point in time	1	153	-0.2351	0.6782	0.05483
	2	123	0.2836	0.6466	0.05830

Table 5.13: Independent samples test (equal variances assumed/not assumed as appropriate; Table continued on next page)

Item variable	**Equal variances**[81]	**Levene's Test for Equality of Variances**		**t-test for Equality of Means**			**Statistics**	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Through eco-products or eco-marketing we can achieve above-average market prices for our current products	A	5.814	0.017	-13.03	274	<0.001	-1.0641	0.08167
	N			-12.72	229.951	<0.001	-1.0641	0.08369
Eco-products or eco-marketing help us to charge above-average market prices for possible future products	A	0.510	0.476	-10.44	273	<0.001	-0.9064	0.08682
	N			-10.46	261.201	<0.001	-0.9064	0.08667
Environmental management helps us to have lower costs for our processes	A	8.685	0.003	-5.146	274	<0.001	-0.5936	0.1153
	N			-5.256	273.848	<0.001	-0.5936	0.1129
Eco-products or eco-marketing help us to sell more of our current products	A	2.252	0.135	-13.73	274	<0.001	-1.0855	0.07908
	N			-13.52	243.338	<0.001	-1.0855	0.08029
Environmental management in our company leads to lower capital investments for our current processes	A	3.524	0.062	-11.64	274	<0.001	-0.9145	0.07856
	N			-11.47	243.329	<0.001	-0.9145	0.07975
Environmental management in our company helps us to utilize better existing equipment	A	2.301	0.130	-9.666	274	<0.001	-0.8923	0.09232
	N			-9.818	272.494	<0.001	-0.8923	0.09088

[81] A: assumed, N: not assumed

Environmental management in our company helps us to create a competitive advantage that is difficult to imitate	A	0.517	0.473	-11.58	274	<0.001	-1.0867	0.09384
	N			-11.56	259.651	<0.001	-1.0867	0.09400
Environmental management helps our company to better predict its costs	A	2.087	0.150	-8.816	274	<0.001	-0.9069	0.1029
	N			-8.930	271.224	<0.001	-0.9069	0.1016
Through environmental management the proportion of variable costs in our company is higher	A	10.550	0.001	-6.626	274	<0.001	-0.6353	0.09588
	N			-6.798	273.890	<0.001	-0.6353	0.09346
Environmental management helps our company to extend the operational life of our production equipment	A	<0.001	0.983	-6.795	273	<0.001	-0.6128	0.09018
	N			-6.789	260.247	<0.001	-0.6128	0.09026
Environmental management helps our company to better predict its future investments	A	2.260	0.134	-9.067	274	<0.001	-0.8463	0.09334
	N			-9.117	266.406	<0.001	-0.8463	0.09282
Environmental management helps our company to extend the operational life of our products	A	0.029	0.864	-9.865	274	<0.001	-0.8250	0.08362
	N			-9.826	257.221	<0.001	-0.8250	0.08395
Through its environmental management our company can defer investments to a later point in time	A	1.399	0.238	-6.448	274	<0.001	-0.5187	0.08045
	N			-6.482	266.130	<0.001	-0.5187	0.08003

The two (successful) validation steps described are important, since the items based on the ESV framework are used for the first time in empirical research, and it is thus necessary to ascertain, that they distinguish well between different corporate environmental strategies. Since they do, it was possible to identify a cluster of firms with high ESV orientation and one with low ESV orientation in the data and to validate these.

5.2.4 Empirical identification and measurement of dimensions of environmental competitiveness

As discussed in the introduction to the core concepts of this research in Chapter 1.3, environmental competitiveness (i.e. that part of overall profitability or competitiveness of a firm which can actually be influenced by environmental management activities) is an important yet difficult-to-measure construct. Therefore, the most feasible way seems to be the use of self-assessment by firms, based on a number of items. Hence, for this research, environmental competitiveness was measured by means of a battery of items, for which the survey questionnaire asked about the degree to which environmental management activities (over the last three years) were beneficial for a number of corporate goals. Answers were provided on a 5-point Likert scale ranging from "very negative" via "neutral" to "very positive". A factor analysis (PCA) was carried out on the data collected on the item battery. This resulted in three factors with Eigenvalues above 1, explaining 40.6%, 9.7% and 9.1% of the overall variance, respectively (see Table 5.14 below).[82]

[82] Eigenvalues are mathematically solutions to a set of equations underlying a factor analysis. If an Eigenvalue is greater than 1, this signifies, that the corresponding factor explains more variance, than the individual items of which it is composed. Conversely, an Eigenvalue below 1 signifies, that the corresponding factor explains less variance than the items which constitute it. In this latter case, the Eigenvalue criterion in factor analyses requires that these factors are not to be used in the analysis, and that consequently, only factors with Eigenvalues greater than unity are considered.

Table 5.14: Variance explained by factors in environmental competitiveness factor analysis

Component / Factor	**Initial Eigenvalues and Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.440	40.253	40.253	3.519	21.992	21.992
2	1.542	9.637	49.889	3.338	20.865	42.857
3	1.457	9.104	58.993	2.582	16.136	58.993
4	0.988	6.178	65.171			
5	0.776	4.851	70.022			
6	0.755	4.720	74.742			
7	0.608	3.797	78.539			
8	0.558	3.485	82.024			
9	0.497	3.108	85.132			
10	0.490	3.059	88.191			
11	0.425	2.654	90.845			
12	0.386	2.412	93.257			
13	0.341	2.129	95.387			
14	0.299	1.866	97.253			
15	0.242	1.512	98.765			
16	0.198	1.235	100.000			

Extraction Method: Principal Component Analysis.

The percentage values provided in the three columns under the heading "Initial Eigenvalues and Extraction Sums of Squared Loadings" for each factor refer to the share of the total variance which is explained by the respective factor. The variance explained indicates how much of the variability encountered in the total of the initial variables is explained by the respective factor (Backhaus *et al.* 2000, p. 308). For example, the second factor explains approx. 9.7% of the total variation in the data, whereas the third factor explains a further 9.1% of the variability encountered in the data. Overall, approx. 59% of the total variation encountered in the data is explained by the three factors extracted, with the first factor alone explaining 40.3%. Table 5.15 provides the factor loadings for each item on each of the three factors with Eigenvalues greater than unity. These factor loadings form the basis for interpreting the factors with regard to their meaning.

Table 5.15: Rotated component matrix for environmental competitiveness factor analysis[83]

Item	Components		
Environmental activities have a positive effect on	1	2	3
Competitive advantage	0.663	0.267	0.155
Corporate image	0.484	0.616	0.125
Product image	0.649	0.336	0.225
Sales	0.842	0.162	0.175
Market share	0.803	0.135	0.236
New market opportunities	0.768	0.198	0.05192
Short term profit	0.164	0.04573	0.75
Long term profit	0.373	0.277	0.662
Cost savings	-0.004784	0.196	0.759
Productivity	0.207	0.154	0.698
Improved insurance conditions	0.136	0.475	0.325
Better access to bank loans	0.286	0.386	0.349
Owner/shareholder satisfaction	0.129	0.765	0.178
Management satisfaction	0.212	0.836	0.102
Worker satisfaction	0.135	0.737	0.154
Recruitment and staff retention	0.301	0.591	0.08328

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 6 iterations. Only grey-shaded cells are taken into account in the interpretation of the factors.

As can be seen, items having high loadings on the first factor are competitive advantage, product image, sales, market share and new market opportunities. Therefore, the underlying factor was labeled "market-oriented environmental competitiveness" since it predominantly relates to the market- and product-related benefits of a company's environmental activities. As can be seen from Table 5.14, this factor explains 40.3% of the variance encountered in the data.

The items with high loadings on the second factor are corporate image, owner/shareholder satisfaction, management satisfaction, worker satisfaction and recruitment and staff retention.

[83] The KMO measure for the factor analysis was 0.881, which is a sufficiently high value. In addition to this, the individual KMO measures based on the anti-image correlations on the main diagonal of the anti-image correlation matrix were all above 0.8. Therefore the correlation matrix of the data set is considered suitable for carrying out a factor analysis on the data set.

Therefore, this factor was labeled "internally-oriented environmental competitiveness" since it mainly refers to internally-oriented satisfaction and company image benefits from a company's environmental activities (based on a specific corporate environmental strategy). Table 5.14 shows that the second factor explains 9.7% of the total variance encountered in the data.

On the third factor identified in Table 5.15, the items short-term and long-term profits, cost savings and productivity have high factor loadings. These predominantly refer to productive and allocative efficiency of a company and the factor was therefore labeled "efficiency-oriented environmental competitiveness". It explains 9.1% of the variance encountered in the data.

For two of the items in Table 5.15, namely "improved insurance conditions" and " better access to bank loans", factor loadings were below 0.5 for all three factors identified above with Eigenvalues above unity. These were therefore excluded from the interpretation of the three factors. Looking at the two items excluded, it becomes clear however, that these potentially represent a fourth factor, since both are linked to the financial exposure of a company due to its level of environmental risk and it was therefore decided to interpret these two items as a fourth factor labeled "risk-related environmental competitiveness".[84] For further analyses indices were calculated, based on the factors identified, since this allowed to calculate a fourth index taking into account the two items which could not be assigned to a factor during the factor analysis. As will be seen later, this is justified since the correlation between a factor and its corresponding index was in all cases very high, and since the correlation of the additional fourth index (which was constructed for the two items not allocated to any factor) with the index scores based on the three other factors identified were relatively lower than correlations with their respective indices (see Table 5.18 below).

Prior to index calculation, in order to assess the reliability of the indices, the internal consistency for each index was analysed based on the Cronbach coefficient (Cronbach's Alpha). This coefficient can take values between zero and one and empirical values above 0.8 are usually considered acceptable (Schumann 1999, p. 42). For all four indices, Cronbach's Alpha was above 0.8 or just slightly below, and for none of the indices it could be increased by excluding an item. The only exception with regard to the Alpha was the index for risk-related environmental competitiveness with an Alpha of just below 0.6. It was decided to nevertheless include this index in the subsequent regression analyses, but to treat results cautiously. The remaining three indices (which essentially represent tests for the underlying "unobservable" factors identified by the factor analysis, see Schumann (1999)) are considered

[84] An initial PCA on the German firms surveyed only supports this view, since there, the excluded items represent an additional, fourth factor. Therefore, inclusion of this fourth factor seemed to be justified.

to be reliable and from this point of view fully usable in the analysis to follow. Table 5.16 provides a summary of the reliability analysis results for the four indices.

Table 5.16: Reliability analysis (Cronbach's Alpha) for environmental competitiveness indices

Index (based on corresponding factor from factor analysis/PCA)	**N of Cases**	**Number of items**	**Alpha**	**Standardized item Alpha**
Environmental competitiveness index 1 (based on Factor 1: "market-related environmental competitiveness")	284	5	0.8412	0.8472
Environmental competitiveness index 2 (based on Factor 2: "internally-related environmental competitiveness")	281	5	0.8301	0.8309
Environmental competitiveness index 3 (based on Factor 3: "efficiency-related environmental competitiveness")	280	4	0.7714	0.7884
Environmental competitiveness index 4 (based on the two items not linked to above factors: "risk-related environmental competitiveness")	277	2	0.5819	0.6134

Indices were calculated separately for the above three factors, and the remaining two items, based on the relevant item scores of each case. Missing values for a case on a specific item were omitted. It was found that the distribution of index values is slightly right-skewed (i.e. firms perceive that their environmental activities had generally a positive effect of the different items reflecting business performance dimensions). For the third environmental competitiveness factor (efficiency-related environmental competitiveness), the distribution was widest (i.e. more firms perceived a negative influence of their activities on this factor). The highest mean was found for the second factor (internally-related environmental competitiveness), i.e. here, on average, firms saw the strongest positive influence of their environmental management activities. The following Table 5.17 summarises descriptive statistics for the four indices.

Table 5.17: Descriptive statistics for environmental competitiveness indices

Index	Number of valid cases	Mean	Standard Deviation
Market-related environmental competitiveness	289	3.25	0.42
Internally-related environmental competitiveness	290	3.49	0.48
Efficiency-related environmental competitiveness	288	3.14	0.51
Risk-related environmental competitiveness	284	3.2	0.44

The index score values calculated are based on non-standardised environmental competitiveness items, but that this is not considered problematic here, since in the regressions, the possibility of sector-specific or country-specific differences in environmental competitiveness will be accounted for through sector dummy variables. However, the PCAs were based on standardised variables (according to the method proposed by Aragon-Corea (1998) for standardization), since otherwise different sector and country mean values could have distorted the PCA results. Nevertheless, the results based on standardized and unstandardised items differed only marginally, and in particular, the relevant items for each factor did not change.

As Table 5.18 shows, the correlation between the environmental competitiveness variables and the corresponding factor scores is very high, which further supports the use of the indices (since essentially they do not differ much from their corresponding factor scores).

Table 5.18: Correlations between environmental competitiveness indices and factor scores

Factor scores	**Statistics**	**Index score for market-related env. comp. (Factor 1)**	**Index score for inter-nally-related env. comp. (Factor 2)**	**Index score for efficiency-related env. comp. (Factor 3)**	**Index score for two unassigned items**
Regression-based factor score for market-related env. comp. (Factor 1)	Correlation	***0.874***	0.320	0.196	0.214
	Sig. (2-sided)	0.0001	0.0001	0.001	0.0001
	N	268	268	268	268
Regression-based factor score for internally-related env. comp. (Factor 2)	Correlation	0.254	***0.865***	0.200	0.477
	Sig. (2-sided)	0.0001	0.0001	0.001	0.0001
	N	268	268	268	268
Regression-based factor score for efficiency-related env. comp. (Factor 3)	Correlation	0.203	0.165	***0.866***	0.370
	Sig. (2-sided)	0.001	0.007	0.0001	0.0001
	N	268	268	268	268

Bold and italicized: Correlation is significant at the 1% level (2-tailed). Regression-based factor scores are calculated based on all items included in the factor analysis. Factor loadings are used as regression coefficients.

All correlations are significant at the 1% level, except that between the factor score 3 and the environmental competitiveness index 2, which is however significant at the 10% level. Also, it can be seen, that for the fourth index score (right column of Table 5.18), which was constructed for the two items not assigned to any factor, its correlations with all three factors identified were relatively lower than those of these factors with their corresponding index. This confirms the intuition, that the fourth index measures an additional dimension and should therefore be included in the subsequent analyses.

To sum up, factor analysis resulted in identification of four dimensions of environmental competitiveness along which firms can position themselves. These relate to market benefits, satisfaction and reputation benefits, efficiency gains and risk reduction, respectively. For each of these dimensions, an index score could be calculated for each of the firms in the data set.

5.2.5 Empirical identification and measurement of environmental performance

The empirical measurement of environmental performance as described in Chapter 5.1 included assessment by firms of the reduction of their environmental impact in a number of environmental performance dimensions shown in the first column of Table 5.19 below over the period of 1998-2000. Table 5.19 shows the correlation of the individual variables (each of them standardized for different sector and country means according to the method proposed by Aragon-Corea (1998)) with the overall index. As can be seen, in all cases the correlation is positive and highly significant (at the 1% level) which strongly suggests that the index is a good overall measure for all environmental performance dimensions. Also the correlation of the index and all individual variables with standardised overall business performance is reported (which is insignificant in all cases). Cronbach's Alpha for the index is 0.8521. Descriptive statistics for all independent variables used in the second empirical analysis can be found in the Appendix at the end of this thesis (separately for German and British firms).

Table 5.19: List of variables for index calculation and correlation to index variables

Individual variable	**Pearson Correlation**	**Environmental impact reduction index**	**Standardised overall business performance**
Reduction in use of water	Correlation	***0.649***	-0.012
	Observations	230	204
Reduction in use of energy	Correlation	***0.603***	0.041
	Observations	236	210
Reduction in non- renewable resource use	Correlation	***0.604***	-0.082
	Observations	186	169
Reduction in use of toxic inputs	Correlation	***0.589***	-0.011
	Observations	182	161
Reduction of solid waste	Correlation	***0.575***	0.009
	Observations	228	204
Reduction of soil contamination	Correlation	***0.673***	-0.060
	Observations	148	134
Reduction in waste water emissions	Correlation	***0.650***	-0.021
	Observations	225	203
Reduction in emissions to air	Correlation	***0.675***	0.049
	Observations	223	201
Reduction of noise	Correlation	***0.646***	0.063
	Observations	214	195
Reduction of smell/odour emissions	Correlation	***0.610***	0.025
	Observations	172	155
Reduction of landscape damage	Correlation	***0.656***	-0.015
	Observations	151	137
Reduction in the risk of severe accidents	Correlation	***0.662***	-0.023
	Observations	212	194
Standardised overall business performance	Correlation	0.020	***1.000***
	Observations	234	267

Bold and italicized: Correlation is significant at the 1% level (2-tailed). For the regression analysis, the environmental impact reduction index was transformed so it only takes positive values by adding the lowest value it takes in the data set to the values for all other cases.

5.3 Results

5.3.1 Introduction and overview

In this section, the results of analysing of the hypothesis H2 on the influence of corporate environmental strategies on the relationship between environmental performance and environmental competitiveness in the manufacturing sector in Germany and the UK, as formulated in Chapter 3, will be presented. This hypothesis and the two derived sub-hypotheses H2.1 and H2.2 are tested (separately for the two sets of firms with and without value-oriented corporate environmental strategies) based on regression equation in Chapter 5.1.5. Regressions were carried out separately for the four different environmental competitiveness factors identified above and were subsequently compared with regard to the contents of the hypotheses H2.1 and H2.2, thereby testing these hypotheses. Results will be discussed further in 5.3.2.

The two strategy clusters derived in 5.2 were found to be not significantly associated to firm size, industry sector membership and country location (see Wagner 2002) which means, that the two subsets of firms defined on the basis of the above cluster analysis are not significantly different in terms of the sector membership, country location and firm size profiles of the firms included. Therefore, standard OLS regression is appropriate.

Overall, four separate regression models were estimated (one for each dependent variable, i.e. one of the dimensions of environmental competitiveness, as represented by the corresponding indices and their scores for the individual firms in the data set), using OLS regression as estimation procedure.[85] Each of these models was estimated separately for the set of firms with a value-oriented corporate environmental strategy (i.e. those firms belonging to the cluster CES=2 in Figure 5.1 above) and those firms that do not pursue a specifically value-oriented corporate environmental strategy (i.e. those firms assigned to the cluster CES=1 in Figure 5.1 above). Tables 5.20 to 5.23 summarise the results for the four different regression models estimated (separately for firms with value-oriented CES and with no specific value orientation).

[85] Further information on the data set for the second empirical analysis is available from the author by mailing to mwagner@gmx.co.uk. However, the firm level data used here are based on a survey in which participating firms were guaranteed confidentiality and it is therefore not possible to supply data directly for further analyses to third parties. The possiblity to estimate different specifications with the data and programs used via remote electronic data processing may however be feasible but needs to be assessed on a case-by-case basis.

Table 5.20: Results for market-related environmental competitiveness as dependent variable

Subset of firms with:	**Value-oriented CES**		**Not specifically value-oriented CES**	
Equation variables:	Coef.	Std. Dev.	Coef.	Std. Dev.
Intercept	***2.120***	0.334	***3.067***	0.248
Country	*0.194*	0.104	**0.201**	0.080
Firm size	0.007690	0.010	0.143	0.107
Square of firm size	-0.0000514	0.0000734	-0.01467	0.023
Food and tobacco	-0.213	0.211	0.08491	0.149
Textile products	-0.111	0.202	0.05017	0.168
Pulp and paper products	0.05629	0.450	-0.369	0.235
Printing and publishing	-0.159	0.225	-0.128	0.139
Energy, oil and nuclear fuels	No observations		0.216	0.387
Chemicals and fibres	-0.164	0.216	-0.01193	0.152
Rubber and plastic products	-0.130	0.345	0.04933	0.213
Non-ferrous mineral products	-0.212	0.196	-0.246	0.185
Machines and equipment	***-0.695***	0.190	-0.006142	0.164
Electrical and optical products	***-0.456***	0.171	-0.01495	0.154
Transport products	-0.224	0.195	-0.008946	0.148
Other manufacturing products	-0.188	0.200	0.04628	0.164
Firm legal status	-0.006107	0.102	-0.009586	0.082
Firm age	-0.01156	0.048	0.002218	0.039
Overall business performance	*0.07309*	0.043	0.01811	0.034
Market development	***0.218***	0.054	-0.005996	0.034
Considering EMS implementation	*0.306*	0.179	0.05810	0.150
EMS implementation in progress	-0.05141	0.148	0.155	0.111
EMS implemented	0.123	0.123	0.119	0.100
Environmental impact reduction index	*0.424*	0.239	-0.206	0.155
Square of environmental impact reduction index	-0.06709	0.066	0.04830	0.042
Number of observations	94		112	
R-squared	0.492		0.262	
F statistic	***2.988***		1.301	

Bold and italicised figures mean significance at the 1% level, bold figures mean significance at 5% level, and italicised figures mean significance at the 10% level

Table 5.21: Results for internally related environmental competitiveness as dependent variable

Subset of firms with:	**Value-oriented CES**		**Not specifically value-oriented CES**	
Equation variables:	Coef.	Std. Dev.	Coef.	Std. Dev.
Intercept	***2.278***	0.327	***2.696***	0.308
Country	0.02629	0.101	-0.06481	0.099
Firm size	-0.00370	0.010	*0.249*	0.133
Square of firm size	0.0000015	0.00007182	-0.03996	0.028
Food and tobacco	-0.210	0.207	0.128	0.185
Textile products	-0.02636	0.198	0.07529	0.208
Pulp and paper products	0.05833	0.441	-0.427	0.292
Printing and publishing	-0.194	0.220	0.01955	0.172
Energy, oil and nuclear fuels	No observations		-0.394	0.480
Chemicals and fibres	0.02996	0.211	0.08528	0.189
Rubber and plastic products	-0.241	0.338	0.09927	0.264
Non-ferrous mineral products	-0.192	0.192	*-0.401*	0.230
Machines and equipment	**-0.409**	0.186	-0.04577	0.204
Electrical and optical products	-0.154	0.168	-0.06448	0.191
Transport products	-0.04559	0.191	0.01325	0.183
Other manufacturing products	-0.07168	0.196	0.168	0.204
Firm legal status	0.02606	0.100	0.05516	0.102
Firm age	-0.01596	0.047	0.04766	0.048
Overall business performance	0.05098	0.042	0.008389	0.042
Market development	**0.130**	0.053	-0.003334	0.043
Considering EMS implementation	0.206	0.175	0.259	0.186
EMS implementation in progress	0.06091	0.145	0.229	0.138
EMS implemented	**0.307**	0.120	**0.266**	0.124
Environmental impact reduction index	**0.832**	0.234	0.292	0.192
Square of environmental impact reduction index	***-0.176***	0.065	-0.07293	0.052
Number of observations	94		112	
R-squared	0.498		0.287	
F statistic	***3.061***		*1.474*	

Bold and italicised figures mean significance at the 1% level, bold figures mean significance at 5% level, and italicised figures mean significance at the 10% level

Table 5.22: Results for efficiency-related environmental competitiveness as dependent variable

Subset of firms with:	**Value-oriented CES**		**Not specifically value-oriented CES**	
Equation variables:	Coef.	Std. Dev.	Coef.	Std. Dev.
Intercept	***1.850***	0.378	***2.813***	0.360
Country	0.07744	0.117	0.002937	0.116
Firm size	0.002046	0.012	0.141	0.155
Square of firm size	-0.00000023	0.00008313	-0.01690	0.033
Food and tobacco	-0.09541	0.240	0.300	0.216
Textile products	0.02511	0.229	0.142	0.243
Pulp and paper products	0.116	0.510	0.02177	0.341
Printing and publishing	-0.228	0.255	0.06449	0.201
Energy, oil and nuclear fuels	No observations		-0.830	0.561
Chemicals and fibres	0.130	0.244	0.04771	0.221
Rubber and plastic products	0.344	0.391	0.181	0.308
Non-ferrous mineral products	0.08419	0.222	-0.308	0.269
Machines and equipment	**-0.462**	0.215	0.04343	0.238
Electrical and optical products	0.001784	0.194	0.227	0.223
Transport products	0.298	0.221	0.06953	0.214
Other manufacturing products	-0.03680	0.227	0.280	0.238
Firm legal status	*-0.194*	0.115	**-0.272**	0.119
Firm age	-0.000719	0.055	-0.04849	0.057
Overall business performance	**0.132**	0.048	0.06709	0.049
Market development	*0.119*	0.061	-0.01526	0.050
Considering EMS implementation	0.03135	0.202	0.03505	0.217
EMS implementation in progress	-0.07307	0.168	0.235	0.161
EMS implemented	0.126	0.139	0.09701	0.145
Environmental impact reduction index	*0.501*	0.270	0.109	0.224
Square of environ-mental impact reduction index	-0.07865	0.075	-0.01458	0.061
Number of observations	94		112	
R-squared	0.461		0.252	
F statistic	***2.642***		1.234	

Bold and italicised figures mean significance at the 1% level, bold figures mean significance at 5% level, and italicised figures mean significance at the 10% level

Table 5.23: Results for risk-related environmental competitiveness as dependent variable

Subset of firms with:	**Value-oriented CES**		**Not specifically value-oriented CES**	
Equation variables:	Coef.	Std. Dev.	Coef.	Std. Dev.
Intercept	***2.196***	0.340	***2.629***	0.259
Country	0.04993	0.105	-0.004030	0.083
Firm size	*-0.01953*	0.010	-0.01850	0.112
Square of firm size	**0.0001507**	0.00007466	0.01632	0.024
Food and tobacco	-0.113	0.216	0.199	0.155
Textile products	0.01798	0.206	-0.132	0.175
Pulp and paper products	-0.346	0.457	**-0.565**	0.245
Printing and publishing	-0.245	0.229	-0.01242	0.145
Energy, oil and nuclear fuels	No obser-vations		0.006383	0.402
Chemicals and fibres	-0.353	0.219	0.09695	0.158
Rubber and plastic products	-0.399	0.350	0.02225	0.221
Non-ferrous mineral products	0.04246	0.199	*-0.336*	0.195
Machines and equipment	-0.308	0.193	-0.137	0.181
Electrical and optical products	-0.143	0.174	0.08239	0.161
Transport products	0.06158	0.202	0.150	0.154
Other manufacturing products	0.169	0.204	0.07667	0.172
Firm legal status	-0.05665	0.104	-0.118	0.086
Firm age	-0.01712	0.049	0.06297	0.041
Overall business performance	0.07119	0.044	0.03963	0.035
Market development	**0.144**	0.055	0.01974	0.036
Considering EMS implementation	0.291	0.182	-0.124	0.156
EMS implementation in progress	0.08612	0.152	0.180	0.116
EMS implemented	0.06174	0.125	0.08454	0.108
Environmental impact reduction index score	*0.471*	0.242	0.02614	0.167
Square of environmental impact reduction index score	-0.08808	0.067	0.002467	0.047
Number of observations	94		112	
R-squared	0.390		0.304	
Fstatistic	**1.945**		*1.582*	

Bold and italicised figures mean significance at the 1% level, bold figures mean significance at 5% level, and italicised figures mean significance at the 10% level

5.3.2 Results for market-related environmental competitiveness

For the first environmental competitiveness index referring to market- and product-related benefits through environmental management, the regression is overall significant for the set of firms with a value-oriented CES, but insignificant for the set of firms without a specific value orientation.

A significant positive country effect is found for both subsets of firms, but no further significant effect (other than a highly significant intercept term, which, however, only models the joint effect of all omitted dummy variables, i.e. those which were used as reference) was found for the set of firms without a specifically value-oriented CES.

For the set of firms with a value-oriented CES a significant positive effect of market development as well as a significant negative effects for the machines and equipment sector and the electrical and optical products sector are found. All these effects are significant at the 5% level and below (see Table 5.20), except for the country variable in the set of firms with a value-oriented CES, which was only significant at the 10% level.

Furthermore, a significant positive effect of considering EMS implementation (relative to not implementing an EMS) and of overall business performance is found (for the subset of firms with a value-oriented CES) which is significant at the 10% level. In addition to this, a significant positive effect (at the 10% level) is found for the environmental impact reduction index (but not its square) in the subset of firms with a value-oriented CES.

The positive country effect means that UK firms have significantly higher market- and product-related benefits than firms located in Germany in both subsets of the data. Similarly, firms in the "machines and equipment" and the "electrical and optical products" sectors have significantly lower benefits, compared with the reference sector "metal products". The significant positive coefficient for market development means that the more positive the change in the market of the main product of the firm is sold into in the last three years, the higher are the product- and market-related benefits for firms with a value-oriented CES. The positive and significant coefficient for the environmental impact reduction index means that high environmental performance improvements during 1998 to 2000 have a significant positive influence on market- and product-related benefits from environmental management for the period from 1998 to 2000. This means, that there is evidence that firms with a value-oriented CES are able to simultaneously improve their environmental and economic performance, whereas firms without a specific value orientation are not achieving simultaneous improvements (i.e. the environmental impact reduction index is insignificant for the subset of firms with no specific value orientation in their CES). The same applies to firms considering implementation of an EMS since they have significantly heightened product- and market-related benefits relative to firms who have not implemented an EMS and are also not considering implementing an EMS. Finally, overall business performance seems to have a small positive effect on the level of product- and market-related benefits for firms with a value-oriented CES, but not for firms without, i.e. more profitable firms have higher such market-related benefits.

5.3.3 Results for internally-related environmental competitiveness

For the second environmental competitiveness index referring to satisfaction- and company image-related benefits through environmental management, the overall model was found to be significant for both subsets of firms, i.e. the null hypothesis of all coefficients simultaneously being zero was rejected based on the F statistic. For the subset of firms with no specific value-orientation, firm size has a significant positive effect at the 10% level. Concerning sectoral influences, the machines and equipment sector as a significant negative effect (at the 5% level) in the subset of firms with a value-oriented CES and the non-ferrous mineral products sector has a negative effect (significant at the 10% level) in the subset of firms without a value-oriented CES.

As for the first index a significant positive effect of market development was found (at the 5% level) for the subset of firms with a value-oriented CES. Furthermore, for both subsets of firms, a significant positive effect of an EMS being implemented on internally-related environmental competitiveness is found. In both subsets of the data set, this effect is significant at the 5% level.

Finally, in the subset of firms with a value-oriented CES, the environmental impact reduction index was found to have a significant positive coefficient (at the 5% level) and the square of the index was found to have a significant negative coefficient (at the 1% level). No significant influence of the index was found in the estimation for the subset of firms without a specific value-orientation in their corporate environmental strategy and management.

The negative sector effects found mean that firms in the "machines and equipment" sector (for firms with a value-oriented CES) and in the "non-ferrous mineral products" sector (for firms with a CES without specific value orientation) have significantly lower reputation and satisfaction-related benefits, compared with the reference sector "metal products". The significant positive coefficient for market development (for the value-oriented subset) means that the more positive the change in the market the main product of the firm is sold into in the last three years, the higher are the satisfaction and reputation-related benefits. The positive and significant coefficient for firm size in the subset of firms not specifically value-oriented means that the larger a firm, the higher are its benefits with regard to internally-related environmental competitiveness. The same applies, for both subsets, to implementation of an EMS, i.e. relative to not having implemented an EMS; full implementation of an EMS significantly increases a firm's internally-related environmental competitiveness. Finally, reduction of environmental impacts only has a significant positive influence on internally-related environmental competitiveness for firms with a value-oriented corporate environmental strategy. This again means, that there is evidence that firms with a value-oriented CES are able to simultaneously improve their environmental and economic performance (with regard to the environmental competitiveness dimension related to reputation and firm-internal satisfaction), whereas firms without a specific value orientation are not achieving simultaneous improvements (i.e. their environmental performance improvements are not in a significant way related to their environmental competitiveness). The significant negative coefficient for the square of the environmental impact reduction index for the subset of value-oriented firms means that the marginal effect of environmental performance improvements on internally-related environmental competitiveness is always positive, but of decreasing magnitude (as was ascertained by analysing the frequency distribution of the environmental impact reduction index). This means that the maximum value of the dependent variable is reached at the maximum value of environmental performance in the data set. This shape of the relationship is identical with the shape of the first part of the inversely U-shaped curve discussed in the theoretical analysis of the relationship between environmental and economic performance in Chapter 2.1.2 (Figure 2.1).

5.3.4 Results for efficiency-related environmental competitiveness

For the third dimension of environmental competitiveness, relating to efficiency, only the model estimated for the subset of firms with a value-oriented CES was overall significant (at the 1% level). For this model, the dummy for the "machines and equipment" sector was negative and significant at the 5% level. Furthermore, for the value-oriented subset, overall business performance has a positive and significant influence (at the 5% level) as has market development and the environmental impact reduction index (both at the 10% level). The only variable significant for both subsets of firms is firm legal status, which has a negative influence at the 10% (for the value-oriented subset) and 5% levels, respectively.

The negative effect of the "machines and equipment" sector, as well as the positive effects of overall business performance and market development on efficiency-related environmental competitiveness can be interpreted as before under 5.3.2 and 5.3.3. The significant negative coefficient of firm legal status in both subsets analysed means that firms under sole proprietorship have significantly lower levels of efficiency-related environmental competitiveness, compared with firms that are not under sole proprietorship. Finally, the positive and significant coefficient for the environmental impact reduction index for the subset of value-oriented firms, taken together with the insignificant coefficient in the other subset means again, that firms with a value-oriented CES are able to simultaneously improve environmental and economic performance (in the sense that a reduction of environmental impact implies significantly higher efficiency-related environmental competitiveness). On the other hand, for firms with no specific value orientation, no significant influence of environmental performance (in terms of environmental impact reductions) on economic performance can be identified.

5.3.5 Results for risk-related environmental competitiveness

For the fourth dimension of environmental competitiveness relating to environmental risk and its influence on financial conditions, both models estimated (for the subset of firms with a value-oriented CES, as well as for the subset of firms without specific value orientation) were overall significant (at the 5% and 10% levels, respectively).

For the subset of value-oriented firms, firm size was found to have a negative effect, which was significant at the 10% level. In addition to that, the square of firm size was found to be positive and significant at the 5% level. Furthermore, market development was found to have a positive and significant influence at the 5% level. Finally, the environmental impact reduction index was again found to have a significant positive influence at the 10% level.

For the subset of firms with no specific value orientation, environmental impact reduction did not have any significant influence on the dependent variable, neither in the linear, nor in the squared term. However, the dummy variables for the “pulp and paper products” sector and the “non-ferrous mineral products” sector were both found to have negative coefficients significant at the 5% and 10% levels, respectively.

The negative effect of the “pulp and paper products” and “non-ferrous mineral products” sectors, as well as the positive effect of market development on risk-related environmental competitiveness can be interpreted as before under 5.3.2, 5.3.3 and 5.3.4, respectively. The significant negative coefficient of firm size and the positive coefficient of the square of firm size in the value oriented subset means, that firm size has a non-linear relationship with risk-related environmental competitiveness. Analysing the coefficients together with the frequency distribution of firm size for the set of firms with value-oriented CES reveals that firm size has initially a negative influence on risk-related environmental competitiveness, which is however decreasing with increasing firm size (i.e. the marginal negative effect of firm size is decreasing). The value of firm size that maximises the negative influence on risk-related competitiveness is around a value of sixty-six thousand employees, which is not the highest all firm size value in the subset of value-oriented firms. Therefore, beyond this value, the negative effect of firm size is less severe (i.e. the slope of the curve is positive) and around a value of around 133,000 employees (i.e. for very large firms), the effect of firm size on risk-related environmental competitiveness becomes positive. However, this concerns only one firm included in the regression analysis. Therefore, in first approximation, firm size has a negative effect on risk-related competitiveness.

Finally, the positive and significant coefficient for the environmental impact reduction index for the subset of value-oriented firms, taken together with the insignificant coefficient in the other subset, means (as for the other three dimensions) that firms with a value-oriented CES are able to simultaneously improve environmental and economic performance (in the sense that a reduction of environmental impact implies significantly higher risk-related environmental competitiveness). The insignificance of the squared index variable here means, that the positive influence is not of diminishing magnitude, i.e. the marginal effect is constant. On the other hand, for firms with no specific value orientation, no significant influence of environmental performance (in terms of environmental impact reductions) on economic performance can be identified, which, however, also means that these firms are not directly penalised for their missing value orientation.

5.3.6 Results for additional variables: market growth, legal status, overall profit, firm age

In addition to the control variables already included in the first part of the research, market growth rate, firms' legal status and overall profitability were included as additional control variables.

As explained in Chapter 4.2, market development is considered to be a potentially very important influence, and given that no sub-sector information was available for the cross-industry data set analysed during the second empirical, the influence of differences in market development was addressed in terms of a firm-specific measure of market growth on a 5-point scale. This variable measures the development in the market firms mainly sell into on a scale from "The market has decreased significantly" (which was considered to represent decreasing sales for the firm) to “The market has increased significantly” (which was considered to reflect high sales growth for the firm). As Tables 5.20 to 5.23 show, the market development variable was positive and significant for all four environmental competitiveness dimensions, but only for the subset of firms with a value-oriented CES. The regression coefficients are 0.218 (1% level) for market-related, 0.130 (5% level) for internally-related, 0.119 (10% level) for efficiency-related and 0.144 (5% level) for risk-related environmental competitiveness, respectively. This means that a one-unit change in the level of market development increases the level of market-related environmental competitiveness about twice as much as the other three dimensions of environmental competitiveness. This is as expected (in terms of both, the magnitude as well as the significance level of the coefficient) since market-related environmental competitiveness is the dimension most closely related to market aspects. However it also means, that the other dimensions of environmental competitiveness are positively influenced by the market growth rate. This confirms the generally positive influence of market growth on economic performance found in other studies (Russo & Fouts 1997), but also differentiates this influence in that a positive influence of market development could not be identified for firms, which have no specific value orientation.

Nguyen Van *et al.* (2000) have argued for inclusion of control variables for firm age and firms’ legal structure. Therefore a measure for firm age and a binary dummy variable distinguishing between sole proprietorship and a firm being part of a larger company was included in the regressions. Firm age was found not to have any significant effect in any of the regressions for both subsets of firms. Firm legal form was found to have a significant influence only on efficiency-related environmental competitiveness. This effect was negative and significant for both subsets of firms. It was slightly weaker in the subset of value-oriented firms (-0.194, 10% level) compared with the other subset (-0.272, 5% level). Generally the effect means, that firms under sole proprietorship have significantly lower levels of efficiency-oriented environmental competitiveness. One possible explanation for this observation could be that firms not under sole proprietorship (which have more limited liability, and are usually more affected by capital markets since they have higher levels of debt finance) have stronger pressure to maximize shareholder value, which in turn could lead to a higher efficiency orientation.

Finally, a measure of firms’ overall profitability (measured on a 5-point scale ranging from “Gross profits well in excess of expenditure” to “Highly loss-making”) was included in the regressions and found to be positive and significant for efficiency-related (0.132, 5% level) and market-related (0.07, 10% level) environmental competitiveness, but only for the subset of firms with a value-oriented CES. For the subset of firms without a specific value orientation, overall profitability was insignificant in all regressions. One explanation for the significant positive effect of overall profitability on efficiency-related (and partly also on market-related) environmental competitiveness could be that efficiency-oriented environmental investments are usually made under good economic conditions, whereas in times of economic crisis firms tend to reduce the overall level of investments. If the often-made assumption holds, that environmental investments have lower rates of return and longer payback periods than other investments, then the former should be cut first during economic downturns, and thus a positive relationship should be found. Another reason why environmental investments could be reduced first during economic crises is the reduced managerial attention for environmental issues in times of economic downturn. This could lead to a situation where profitable environmental investments remain unidentified and are thus not carried out, whereas general investments considered essential for a firm's survival still are.

6. Conclusions and Recommendations

In the following, Chapter 6.1 will draw **joint conclusions** based on the results reported in Chapters 4.3 and 5.3, **for both empirical analyses** of the research and **link these to theory and the literature reviewed** in Chapter 2, based on the hypotheses developed in Chapter 3.

6.1 Conclusions

6.1.1 Conclusions for the first empirical analysis

Based on the results presented in Chapter 4.3, 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 performance. Overall the **results confirm the inversely U-shaped relationship between environmental and economic performance** formulated in hypothesis H1 in Chapter 2.1.2 and Chapter 3 **for the output-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 found for financial leverage in terms of the debt-to-equity ratio in the most appropriate models (fixed effects for the output-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. This increases the confidence, which can be put into the basic model specification in terms of the dependent and independent variables.

Otherwise, the results seem to reflect (at least to some degree) the underlying theoretical debate about the influence of gearing on firms' costs of capital. As pointed out in Chapter 3, Hay and Morris (1991) suggest at least five different phases in thinking about leverage and its effect on firms capital costs and profitability. Their analysis suggests that it is very difficult to meaningfully interpret the coefficient of the debt-to-equity ratio beyond its function as a control variable in the regression analyses reported in this thesis. Therefore the gearing/debt-to-equity ratio, as well as the asset turnover ratio (for which similar arguments hold) should 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 first 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 **in the first analysis 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. Another argument here is, that the use of different production technologies only allows lower production outputs and therefore does not allow to benefit 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 Chapter 4.3, 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, also firms located in Italy and the Netherlands perform relatively better than firms located in Germany in the relevant model (pooled model).

6.1.2 Conclusions for the second empirical analysis

The key research question of the second empirical analysis was whether the choice of a value-oriented corporate environmental strategy (CES) has a significant effect on the relationship between environmental and economic performance at the level of the firm. Different to the analysis in the first empirical analysis, in the second analysis a set of novel measures for environmental competitiveness is used to address the criticisms raised by Lankoski (2000).[86] The value orientation of corporate environmental strategy is measured **based on the item battery** developed **for Environmental Shareholder Value**, and **two** underlying **factors** could be **identified** using factor analysis (i.e. Principal Component Analysis). **These** were expected profitability (essentially referring to the value created by a firm) and a factor reflecting risk reduction based mainly on variable costs. These two factors **fit well with theoretical reasoning**, which proposes that analysis of environmental management activities from an economic point of view should be carried out in terms of the expected value (i.e. the mean) of returns of such activities as well as the risk (i.e. the variance) attached to these returns (Reinhardt 1999). Using the above two factors, cluster analysis was applied to identify two very different strategy orientations, one representing a high degree of value orientation of CES and the other one a comparatively much lower degree. This fits very well with the reasoning behind the Environmental Shareholder Value concept (Schaltegger & Figge 1998; 1999; 2000) and was furthermore validated with additional data in two validation analyses.

The **resulting two strategy clusters** were found to be **not significantly associated with firm size, industry sector membership and country location** (Wagner 2002) which means, that the two subsets of firms defined on the basis of whether or not a firm pursued a value-oriented CES are not significantly different in terms of the sector membership, country location and firm size profiles of the firms included.[87] **Therefore**, the **two portfolios of firms analysed**

[86] Lankoski (2000) criticises that any causal effect of environmental performance on overall economic performance is likely small and thus difficult to detect with common measures of (overall) economic performance.

[87] The fact, that no significant differences exist between the two clusters identified with regard to firms' country location, industry sector membership and firms' size is a necessary, but likely not sufficient condition for a unique development path for operational environmental strategies and it strongly makes the case for the argu-

and compared **can be considered** as two portfolios **matched for industry membership, country location and firm size**.

The hypothesis H2 (derived from the research question formulated in Chapter 3) regarding the influence of strategy orientation on the relationship between environmental and economic performance was tested with regressions of the specification provided in Chapter 5.1.5.

The main result was, that **for** all four regressions carried out on the subset of **firms with a value-oriented CES**, the **environmental impact reduction index** was **found to have a significant and positive influence on the four different environmental competitiveness dimensions (market-, internally-, efficiency- and risk-related environmental competitiveness)**. Opposed to this, **for** all four regressions carried out on the subset of **firms with no specific value-orientation** in their corporate environmental strategy, **no significant influence of the environmental impact reduction index on any of the four environmental competitiveness dimensions** analysed **was found**. Therefore, that the two derived **sub-hypotheses H2.1 and H2.2 could** both **not be falsified**, i.e. both cannot be rejected based on the results **and therefore need to be accepted for the time being**. This means, that **for firms pursuing a value-oriented corporate environmental strategy environmental performance has a significant positive relationship with all four dimensions of environmental competitiveness** (as the specific component of economic performance which can be influenced by environmental management activities), **after controlling for other relevant influences** on environmental competitiveness. In addition to that, **for firms not pursuing a value-oriented corporate environmental strategy, environmental performance has no significant relationship with any of the four dimensions of environmental competitiveness**, after controlling for other relevant influences. This **stresses the importance of internal factors influencing the relationship between environmental and economic performance** over external factors.

6.1.3 Comparison of results for the two empirical analyses

6.1.3.1 Introduction

Generally, as far as possible the control variables of the first empirical analysis of this research should as well be included during the second empirical analysis in order to evaluate, to which degree results are affected by methodological choices. The main methodological difference between the first and the second analysis of the research is that the first analysis is based on indirect measurement (i.e. the environmental and economic performance of firms are

ment, that internal factors shape strategy choices much more than external ones, which is one possible explanation for the insignificance of many external factors in the analyses carried out in the first empirical analysis.

based on some independent third-party assessment), whereas the second analysis is based on some kind of direct measurement (i.e. firms are carrying out some form of self-assessment). Direct measurement is potentially more affected by strategic behaviour on the side of firms, and therefore a **comparison of the results for identical or very similar control variables can provide an indication for methodological influences**, especially a stronger bias from strategic response behaviour for direct measurement.

6.1.3.2 Firm size

The **expectation based on theory was that smaller firms are not expected to have significantly lower or higher average levels of environmental competitiveness/economic performance** than larger firms, for all or at least most (independent) dimensions of environmental competitiveness/economic performance. As can be seen from Tables 4.21 to 4.23, 4.24 to 4.26 and 5.20 to 5.23, only for ROS in the first empirical analysis for the pooled model (which is however not the most suitable specification) firm size was found to have a significant influence. Also, firm size had a significant effect on risk-related (for the subset of value-oriented firms) and on internally-related (for the subset of firms without specific value orientation) environmental competitiveness. This means that for 75% of the regressions estimated during the second empirical analysis, no significant influence could be identified and that no significant effect could be identified in the most appropriate specifications of the regression models for the first empirical analysis. Therefore, **theoretical expectations are confirmed**.
In the second empirical analysis, firm size initially has a detrimental effect on risk-related environmental competitiveness for small firm sizes, which is however reversed for very large firm sizes (because of the positive and significant effect of the square of firm size). Hence the relationship between firm size and risk-related environmental competitiveness for the subset of value-oriented firms is represented by U-shaped curve. For the subset of firms without specific value orientation, firm size is found to have a positive and significant effect on internally-related environmental competitiveness. Since the square of firm size is not significant, the relationship between firm size and internally-related environmental competitiveness for the set of firms without specific value orientation is represented by a linear or logarithmic curve.

6.1.3.3 Sector membership and market development

The **expectation based on theory was that environmental competitiveness/economic performance varies significantly across sectors**, i.e. there are significant differences for all or at least some dimensions of environmental competitiveness/economic performance. There is

some evidence in the data to support this expectation, in that **some of the sector dummy variables were found to have a significant influence on different dimensions of environmental competitiveness**. These influences are summarised in Table 6.1, which also shows that **for the large majority of sectors, differences are insignificant**, as was the case for the paper industry sub-sectors in the first empirical analysis. What can be seen from the table is that all significant influences (relative to the metal products sector) are negative, i.e. that generally, firms in the metal products sector have relatively high (average) scores on the different environmental competitiveness dimensions. There are only two sectors, "machines and equipment" (for the subset of firms with a value-oriented CES) and "non-ferrous mineral products" (for the subset of firms without specific value orientation) where significant differrences occur for more than one environmental competitiveness dimension. For two other sectors ("pulp and paper products" and "electrical and optical products") significant differences are found for one environmental competitiveness dimension only. Therefore the **results of the second empirical analysis are similar** (though not directly comparable) **to those of the first analysis**, where sub-sector effects were linked to only one specific sub-sector. In the second analysis, the **sector effects are mainly related to few specific sectors** and when evaluating this, it has to be taken into account that the number of sectors in the second analysis is larger than that of the four sub-sectors of the first empirical analysis.

Table 6.1: Significant sector influences on dimensions on environmental competitiveness

Environmental competitiveness dimension	**Sector which has a significant influence**	**Direction, magnitude & significance level of influence**	**Subset of firms**
Market-related	Machines & equipment	-0.695 (1% level)	Value-oriented CES
	Electrical & optical	-0.456 (1% level)	Value-oriented CES
Internally-related	Machines & equipment	-0.409 (1% level)	Value-oriented CES
	Non-ferrous mineral products	-0.401 (10% level)	No value orientation
Efficiency-related	Machines & equipment	-0.462 (5% level)	Value-oriented CES
Risk-related	Pulp & paper products	-0.565 (5% level)	No value orientation
	Non-ferrous mineral products	-0.336 (10% level)	No value orientation

Note: all influences relative to metal products sector as reference group for the other dummy variables

6.1.3.4 Country location

During the first empirical analysis it was found that a **significant positive effect of firm location in the UK** exists **for all three economic performance measures** (ROCE, ROS and ROE) in the pooled model (which was however less appropriate in the case of the output-based environmental performance index). These **findings for the first part are partly confirmed for the second empirical analysis**. Only for market-related environmental competitiveness, in both subsets the country dummy variable was found to be positive and significant (0.194 (10% level) for subset of firms with a value-oriented CES and 0.201 (5% level) for the data set of firms with no specific value orientation). This means that for 75% of the regressions estimated in the second analysis, no significant influence could be identified. The positive country effect observed means that **UK firms have significantly higher market and product-related benefits than firms located in Germany** with the effect being of almost identical magnitude in both subsets of the data. Possible explanations for the significant effect of the UK country variable are a potentially stronger market orientation in the UK, and the potentially better conditions for "green" marketing in the UK, where the level of environmental awareness in the general public is likely lower than in Germany, given the established high levels of environmental awareness in Germany, see e.g. Preisendörfer (1996) and thus claims of environmental excellence by firms are likely less scrutinized by the public.

6.1.3.5 Environmental management systems

The analysis concerning EMS could only be included during the second analysis, since only there, data on EMS implementation was available. However, Wagner (2003) analyses the data set used in the first empirical analysis with regard to influences of EMS certification. Even though EMS implementation is relatively highly correlated with EMS certification (since EMS certification implies EMS implementation) EMS certification is a problematic variable (see e.g. Wagner (2003) on this issue) and was therefore excluded from the first empirical analysis, so that EMS influences were only analysed in the second empirical analysis.

The **expectation** for the second empirical analysis analysing the EBEB data set **is that firms with an implemented EMS** or EMS implementation in progress **have better environmental competitiveness** than firms that have not implemented an EMS for all or at least most of the four dimensions of environmental competitiveness identified empirically. However, this should only be the case, if a firm has a strong value orientation of its CES, since only in this case an EMS assists in implementing value-oriented environmental management at an operational level (Schaltegger & Synnestvedt 2002; Schaltegger & Figge 2000).

As explained earlier, instead of using an ordinal variable to represent the 4-point scale ranking, three dummy variables were included for the four possible states of EMS implementation, for which data was gathered. This specification was confirmed by the fact that only some coefficients for these dummy variables were found to be significant, and that usually, coefficients were not found to have proportionally increasing or decreasing values, as would be necessary for using one ordinal variable.

As can be seen from Tables 5.20 to 5.23 above, **influences of EMS implementation were significant only for market-related environmental competitiveness and for internally-related environmental competitiveness**. In the former case the dummy variable for "considering EMS implementation" was found to have a positive influence (0.306) at the 10% level, but only for the subset of value-oriented firms. This means that relative to no EMS being implemented, considering EMS implementation increases market-related environmental competitiveness by 0.306 units, everything else being equal.

For internally-related environmental competitiveness, the dummy variable for "EMS implemented" was found to have a significant positive influence at the 5% level for both subsets of firms. For the subset of firms with a value-oriented CES, this means that relative to no EMS being implemented, full EMS implementation increases internally-related environmental competitiveness by 0.307 units. One possible explanation for this significant influence could be that full EMS implementation (but not considering EMS implementation) improves internal motivation and satisfaction and institutionalizes a continuous improvement philosophy, which then has a positive influence on work satisfaction and company image.

However, this was not only the case for value-oriented firms, but also for firms with no specific value orientation in their CES. **For** them, EMS implementation was also found to have a significant positive effect on **internally-oriented environmental competitiveness**, with a roughly similar magnitude of the influence (0.266 (at the 5% level) versus 0.307 (at the 5% level) for the value-oriented subset). This means that **the effect of EMS implementation does not differ** between the two sets of firms, **i.e.** that **satisfaction and company image are improved regardless of the type of CES adopted** by the firm.

The significant effect of considering EMS implementation on market-related environmental competitiveness is more difficult to interpret. If considering EMS implementation is made public by the company, then this could have already a positive effect if the market anticipates future performance improvements resulting from this. On the other hand, publicising such considerations is only rationale for a company if it already has the true intent to implement an

EMS. **For market-oriented environmental competitiveness**, the **results** are **as expected in that EMS implementation is only significant for the value-oriented firms**.

For efficiency-related environmental competitiveness and risk-related environmental competitiveness as dependent variables, no significant influence was found for any of the three dummy variables referring to EMS implementation. This means that the expectation, that EMS implementation would mainly influence environmental competitiveness (in its different dimensions) if a firm has a value oriented CES was not supported much by the findings.

Rather it seems, that EMS implementation in itself does not have a strongly differentiating function, compared to environmental performance, where there is clearly a very different influence on environmental competitiveness depending on whether the subset of firms with a value-oriented CES is considered or the set of firms, which have no specifically value-oriented CES.

6.1.3.6 Comparison of results with regard to the overall research question

Comparing the results for the two empirical analyses with regard to the overall research question and the hypotheses formulated in Chapter 3, a relatively clear and consistent picture emerges. Firstly, **if an outputs-based environmental performance index is considered**, in one environmentally intensive sector, **a predominantly negative relationship between environmental and economic performance is found**. If, for the same sector, the relationship is analysed **on the basis of an inputs-based environmental index**, then **no significant relationship emerges**, i.e. there is no significant positive or negative effect. This is consistent with the theoretical proposition, that end-of-pipe environmental protection (which is essentially captured in a outputs-based environmental index) has a more negative impact on economic performance than integrated pollution prevention (which is captured with an inputs-oriented environmental performance index). Finally, once different strategy orientations of firms in terms of the degree of value orientation of their corporate environmental strategies (CES) are taken into account, as expected, **for firms with a value-oriented CES a predominantly positive relationship between environmental and economic performance emerges**. In this, the **signs of** the coefficients of **the linear and the squared term of the environmental** impact reduction **index** used are **as expected for the theoretically-derived inversely U-shaped relationship** between environmental and economic performance, even though the squared term is not always significant. **For a set of matched firms with no specifically value oriented CES, no significant relationship between environmental and economic performance** is found, as was in the first empirical analysis of the research for the inputs-based index. Therefore, **firms with no specifically value-oriented CES as well as firms in environmentally intensive sectors** (due to their sector's characteristics) seem to **face more difficulties when attempting to bring about a positive relationship between environmental and economic performance**. Integrated pollution prevention seems to be one possibility to at least avoid a strongly negative relationship between environmental and economic performance in an environmentally intensive sector. Across the whole economy (i.e. a whole set of sectors in the manufacturing industry), **firms that actively pursue a value-oriented CES** seem to be **most likely to achieve a positive relationship** between environmental and economic performance. Opposed to this, **firms, which do not actively pursue such a strategy,** seem to be **less likely to bring about such a positive relationship**.

Overall, this research therefore shows, that **depending on the specific conditions, it is possible to find a predominantly positive, a mainly neutral, i.e. insignificant, or a predominantly negative relationship between environmental and economic performance/environmental competitiveness**. This also implies, that both theoretically derived conceptions of the relationship, the "traditionalist" as well as the "revisionist" views have their merits, but under different conditions. In some cases, a predominantly negative relationship is more likely, lending support to the "traditionalist" view, whereas in others, the "revisionist" view captures better the situation, even to the extent that to a large degree a positive relationship is possible. This also explains, why the empirical literature reviewed yields inconclusive results, since it usually does not consider in much detail the specific conditions.

One **key factor for a positive relationship** seems to be **strategy choice by the firm**. One **key factor for a negative relationship** seems to be **sector membership of a firm**. A negative relationship can however still be influenced by the type of environmental management approach a firm chooses (e.g. end-of-pipe versus integrated pollution prevention), or by pursuit of a value oriented CES. Also, even if a firm is not in an environmentally intensive industry sector, it may still not be able to achieve a positive interaction between environmental and economic performance, if it is not actively pursuing an appropriate CES aimed at bringing about a positive relationship between environmental and economic performance. This would mean, that a set of firms without a specific value orientation likely only achieves a neutral, i.e. insignificant relationship. Also, it seems that for firms in particularly environmentally intensive industry sectors, a neutral relationship may be the best to hope for, i.e. for them even when pursuing a value-oriented CES, it may prove to be too difficult, to achieve a positive interaction, given their sector's characteristics.

6.2 Recommendations

The important question is of course at this point, what the findings of the whole investigation (including the literature review, theoretical analysis and both empirical analyses) imply for the relationship between environmental and economic performance. For a start, the hypothesis H1, that "environmental performance has either a uniformly negative or an inversely U-shaped influence on economic performance, after controlling for firm-level, industry-level, and country-level/location-related influences on economic performance" and that "it is also possible, that no significant relationship exists empirically, if the influence of environmental performance on economic performance is very small", could be confirmed. It was found, that for environmentally intensive sectors alone, the relationship tends to be negative, whereas in multi-sector samples it is likely inversely U-shaped. Depending on circumstantial factors, it is possible that no significant relationship between environmental and economic performance exists in less extreme situations (e.g. if in a multi-sector sample, firms have no specifically value-oriented CES, or if in environmentally intensive industries, firms pursue predominantly integrated environmental protection activities, which have relatively high value orientation).
Given that the effect of environmental performance as an influence on economic performance is likely small (as suggested by the empirical literature as well as the theoretical analysis), in the second empirical analysis, **more direct measures** capturing the relationship between environmental and economic performance were utilized by **separating "environmental competitiveness"** components **from** the **overall economic performance** of a firm. Simultaneously, the influence of a value-oriented corporate environmental strategy on the relationship between environmental and economic performance was assessed in the second empirical analysis.
Based on this, the hypothesis H2 that "there is an influence of corporate environmental strategy choice on the relationship between environmental competitiveness and environmental performance, after controlling for firm-, industry- and country-level influences in that the choice of a value-oriented type of corporate environmental strategy or management leads to a more positive relationship between environmental performance and environmental competitiveness" could be confirmed.
This was achieved by confirming the two derived sub-hypotheses of H2. Firstly, this was the sub-hypothesis H2.1 that for firms pursuing a value-oriented corporate environmental strategy environmental performance has a significant positive component in an overall inversely U-shaped relationship with environmental competitiveness, after controlling for other relevant influences on environmental competitiveness. Secondly, it was the sub-hypothesis H2.2 that for firms not pursuing a value-oriented corporate environmental strategy, environmental per-

formance should have no significant or a significant negative relationship with environmental competitiveness, after controlling for other relevant influences.

Overall, these results of the research reported in this thesis provide important insights in the relationship between environmental and economic performance and the influence of strategy choice. These insights form a basis for formulate recommendations for managers and policy makers. For example, the **influence of firm size on economic performance** seems to be **of** much **lesser importance**, than initially expected for this research. The implication of this for policy makers would be, that they should not be too much concerned with this parameter.

With regard to country effects, there is **little evidence in the results that a strong country effect on economic performance exists**, i.e. that for example the costs of environmental regulation necessarily increase in countries (in this case Germany) with more stringent regulation. Thus any reduction of competitiveness through stringent environmental regulation seems to be small relative to other (random) influences on the economic performance of firms or is compensated by other country-related influences. **These results** render support and may **encourage policy makers to continue aiming at stringent, yet** at the same time also economically **efficient environmental regulation**, since there is little empirical evidence for a loss of competitiveness on the side of firms, but theoretical and empirical support for the environmental effectiveness of stringent (yet efficient) environmental regulation. This situation may become even more favourable in a more dynamic analysis (allowing for innovation), which could also reveal innovation-inducing (and thus potentially competitiveness-enhancing) effects of stringent regulation (assuming again that regulation is efficiently designed). This concept, captured in the so-called Porter hypothesis is difficult to test empirically, but some evidence for its validity exists for specific industries and circumstances (Albrecht 1998). An important qualification is that environmentally intensive sectors may still be disadvantaged.

Concerning the question whether there is an indication for methodological influences, especially because of a potentially stronger bias from direct measurement in the second empirical analysis of the research, comparison of results for the key control variables (country location, market development/(sub-)sector membership and firm size reveals that some **differences** exist **between the results of the first and the second empirical analysis** carried out during the research presented here. However, these are **not very pronounced**, e.g. country and firm size effects are only rarely found in both analyses, and sector and sub-sector influences are very much confined to one to two specific sub-sectors and sectors. Therefore, some methodological influence can be found in the results, but this is not considered to be strong enough to constitute a serious bias. Also, it has to be kept in mind, that the first analysis focused on one specific sector, and that the second analysis used a more direct measure of that part of a firm's competitiveness and profitability, which is actually influenced by its environmental management activities and corporate environmental strategy. The use of a more direct measure in the second empirical analysis came however at the price of having to use a multi-sector sample (since this was a basic survey requirement). Therefore direct comparison between the two analyses is only possible to some degree (even though the same key control variables were used in both analyses), since the paper manufacturing industry represents only a very minor proportion in the sample of firms analysed in the second empirical analysis. Nevertheless, having raised the issue of methodological influences as one of the outcomes of the literature review, it seemed necessary and appropriate to address this issue, as far as possible, with the data at hand. As a last point, **possible directions of future research** on the topic of this thesis shall be discussed and recommendations made for this.

Recommendations regarding the relationship of environmental performance and economic performance (i.e. short-term profitability and longer-term (environmental) competitiveness) should **take into account the theory and empirical findings of the field of industrial economics and industrial organisation** to fully assess relevance and attributability of the observed relationship. In this, the traditional analysis of the overall empirical relationship between market structure and economic performance, which attempts to identify significant empirical links between the structural constraints within which firms operate and the economic performance they are able to generate (Hay & Morris 1991) could be expanded by considerations of the influence of environmental performance. The **framework provided in industrial economics could here be used to a larger degree** than has been done so far **as a basis for future research**. An analysis of environmental management activities by firms and the influence of strategy choice on the relationship between environmental and economic performance could also **take into account issues raised by the concept of the active firm** (Hay & Morris 1991) and evaluate the consequences of revised predictions about firm behaviour and objectives in this respect. The concept of the active firm (taking the traditional industrial economics and industrial organization framework as its starting point) proposes that firms actively attempt to modify market structure (e.g. in reducing competition or in developing new markets), which therefore becomes endogenous and dependent on the economic performance (and possibly also environmental performance) of a firm. In this framework, firms actively control the allocation of their funds and in doing so alter demand and supply conditions. Investments (e.g. in plant and equipment) and expenditures (e.g. in R&D) for example determine how the cost structure develops over time. Furthermore, investments (e.g. in advertising or R&D) might influence consumer preferences that partly determine demand conditions (Hay & Morris 1991). Depending on the market structure in their industry, firms can earn excess profits, at least for some time, which exceed the minimum profits required for the firm to survive. The concept of the active firm can therefore form a basis for analysing in more detail the **causes for a specific empirical relationship between environmental and economic performance** of firms. The results of the empirical analysis of the Environmental Shareholder Value concept (Schaltegger & Figge 1998; 1999; 2000) show that firms can actively influence the relationship between environmental and economic performance by choosing a specific corporate environmental strategy (CES). Other possibilities of influencing the relationship by means of product differentiation (Porter 1985; Shaked & Sutton 1987; Reinhardt 1999; Alanen 1998), changing the market structure (Bain 1951; Schwartzman 1959; Collins & Preston 1968; 1969) or technology choice such as the choice between end-of-pipe and integrated environmental protection (Twiss & Goodridge 1989) could in future research be analysed based on the concept of the active firm.

Whilst this thesis provides insights into the relationship between environmental and economic performance and the influence of strategy choice, due to data limitations, it develops a predominantly static picture of what determines the relationship between environmental and economic performance. Future research should expand this in analysing in more detail **dynamic aspects of the relationship**. One such dynamic aspect may be the proposition made by the Porter hypothesis that stringent, but effective environmental regulations can induce innovatory activity at the firm level, which not only achieves the required high environmental standards, but also increases competitiveness of firms and industries in those countries which have adopted stringent regulation (Porter 1991; Porter & van der Linde 1995; Esty & Porter 1998). Methodologically, such analysis likely requires much larger data sets and longer time periods.

Also, the impact of different strategic orientations on firms' environmental and economic performance is of key importance (see e.g. the findings of this research in the second empirical analysis, or Wagner 2001) and should be researched further in particular concerning the **interaction of business strategies and corporate environmental strategies** and their relationship to firms' environmental and economic performance (see e.g. Porter & van der Linde 1995; Schmidheiny & BCSD 1992). In most analyses to date, the "fit" between corporate environmental and business strategies is implicitly assumed and taken as given. However, this may not always be the case in reality, and the implications of this for the influence of CES on the relationship between environmental and economic performance should be a focus of future research in the field, but was unfortunately beyond the scope of the research reported here.

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Appendix

Table A.1: Descriptive Statistics for second empirical analysis for German set of firms

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Overall business performance	145	1.00	5.00	3.6966	0.8686
Market development	158	1.00	5.00	3.0190	1.0676
Firm legal status	162	0.00	1.00	.5802	0.4950
Firm age	156	0.00	6.51	3.6480	1.0986
Food and tobacco	166	0.00	1.00	.1265	0.3334
Textile products	166	0.00	1.00	0.08434	0.2787
Pulp and paper products	166	0.00	1.00	0.02410	0.1538
Printing and publishing	166	0.00	1.00	0.07831	0.2695
Energy, oil and nuclear fuels	166	0.00	1.00	0.006024	0.07762
Chemicals and fibres	166	0.00	1.00	0.05422	0.2271
Rubber and plastic products	166	0.00	1.00	0.04819	0.2148
Non-ferrous mineral products	166	0.00	1.00	0.06024	0.2387
Machines and equipment	166	0.00	1.00	0.1386	0.3465
Electrical and optical products	166	0.00	1.00	0.1205	0.3265
Transport products	166	0.00	1.00	0.07831	0.2695
Other manufacturing products	166	0.00	1.00	0.06024	0.2387
Firm size	160	0.03	23.00	0.6595	2.2317
Considering EMS implementation	164	0.00	1.00	0.04878	0.2161
EMS implementation in progress	164	0.00	1.00	0.1220	0.3282
EMS implemented	164	0.00	1.00	0.3354	0.4736
Environmental impact reduction index score	145	0.05	4.20	1.6000	0.7158

Table A.2: Descriptive Statistics for second empirical analysis for UK set of firms

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Overall business performance	122	1.00	5.00	3.5246	1.2413
Market development	134	1.00	5.00	3.1493	1.0001
Firm legal status	131	0.00	1.00	0.3588	0.4815
Firm age	122	0.69	5.17	3.7784	0.8493
Food and tobacco	135	0.00	1.00	0.04444	0.2068
Textile products	135	0.00	1.00	0.05926	0.2370
Pulp and paper products	135	0.00	1.00	0.02222	0.1480
Printing and publishing	135	0.00	1.00	0.1037	0.3060
Energy, oil and nuclear fuels	135	0.00	1.00	0.02222	0.1480
Chemicals and fibres	135	0.00	1.00	0.1407	0.3490
Rubber and plastic products	135	0.00	1.00	0.03704	0.1896
Non-ferrous mineral products	135	0.00	1.00	0.05185	0.2226
Machines and equipment	135	0.00	1.00	0.08889	0.2856
Electrical and optical products	135	0.00	1.00	0.09630	0.2961
Transport products	135	0.00	1.00	0.08148	0.2746
Other manufacturing products	135	0.00	1.00	0.08148	0.2746
Firm size	133	0.02	155.00	2.5982	15.7371
Considering EMS implementation	134	0.00	1.00	0.1418	0.3501
EMS implementation in progress	134	0.00	1.00	0.2388	0.4280
EMS implemented	134	0.00	1.00	0.3060	0.4625
Environmental impact reduction index score	116	0.01	3.50	1.6000	0.7433