A Review of Empirical Studies Concerning the Relationship Between Environmental and Economic Performance

Wagner, Marcus

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What does the evidence tell us?

Marcus Wagner

Lehrstuhl für Umweltmanagement
Universität Lüneburg
Scharnhorststr. 1
D-21335 Lüneburg

Fax: +49-4131-677-2186
csm@uni-lueneburg.de
mwagner@uni-lueneburg.de
www.uni-lueneburg.de/csm/

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Centre for Sustainability Management (CSM) e.V.

Chair of Corporate Environmental Management
University of Lueneburg
Scharnhorststr. 1
D-21335 Lueneburg

Centrum für Nachhaltigkeitsmanagement (CNM) e.V.

Lehrstuhl für Betriebswirtschaftslehre, insbes. Umweltmanagement
Universität Lüneburg
Scharnhorststr. 1
D-21335 Lüneburg

Tel. +49-4131-677-2181
Fax. +49-4131-677-2186
E-mail: csm@uni-lueneburg.de
www.uni-lueneburg.de/csm

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List of Abbreviations

AMEX	American Stock Exchange
BCG	Boston Consulting Group
CEP	Council of Economic Priorities
CERES	Coalition of Environmentally Responsible Economies
CRSP	Centre for Research in Security Prices
EPA	U.S. Environmental Protection Agency
HMIP	Her Majesty's Inspectorate for Pollution
IRRC	Investor Responsibility Research Center
JERU	Jupiter Environmental Research Unit
JIGIT	Jupiter International Green Investment Trust
LSE	London Stock Exchange
NRA	National Rivers Authority
NYSE	New York Stock Exchange
OLS	Ordinary Least Squares
PRP	Potentially Responsible Party
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
SIC	Standard Industry Classification
TRI	Toxic Release Inventory

Introduction[1]

The relationship between environmental and economic performance of firms has now been studied for a considerable period of time. However, no conclusive results have emerged so far, due to several reasons. 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 and 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 (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.

Prior to assessing empirical evidence on the relationship between environmental and economic performance of firms, a possible classification for empirical studies shall presented and theoretical predictions about the relationship are derived. Schaltegger and Synnestvedt (1999) argue that the latter is particularly important since they consider the 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 discussed.

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 their environmental performance (Walley and Whitehead, 1994).[2] At the level of a specific industry, the share of environmental costs in total manufacturing costs might be considerably higher than average (Jaffe *et al.*, 1995, p. 141). Particularly, this might be because 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). It has therefore often been argued that firms in industries with higher environmental compliance costs face a competitive disadvantage. Since 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).

[1] The author wishes to thank for useful comments and discussions Professor Dr Stefan Schaltegger, Dr Frans Berkhout, Dr Frank Figge, Dr Walter Wehrmeyer and the members of the "Measuring Environmental Performance of Industry" project research team as well as Dora Nikolaidou for her patience. Any remaining errors are exclusively the author's.

[2] Environmental performance is the total of a firm's impacts on the natural environment, i.e. its level of total resource consumption and emissions.

Only recently, the notion emerged that improved environmental performance is a potential source for competitive advantage as it can lead to more efficient processes, improvements in productivity, lower costs of compliance and new market opportunities (Porter, 1991; Porter and van der Linde, 1995). Two major reasons underpin this argument. Firstly, 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. But innovations also result in lower production costs e.g. lower input costs due to enhanced resource productivity. Secondly, companies can gain ``first mover advantages'' from selling their new solutions and innovations to other firms (Esty and Porter, 1998). In a dynamic, longer-term perspective, 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 and van der Linde, 1995).

Based on these two contrasting positions two specifications of the direct relationship between environmental performance (measured in terms of resource consumption and emission levels) and economic performance (measured in terms of stock market performance or financial ratios) can be proposed, which were first discussed in Wagner (2000). A first possible specification would be that the relationship between the two is uniformly negative. This reflects the ``traditionalist'' view presented above and is theoretically rooted in neo-classical theory, where pollution abatement measures are predicted to 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). This situation is depicted in Figure 1 below, where high environmental performance (e.g. low normalised emissions and inputs) correspond to low economic performance (i.e. low normalised profitability or market performance) and vice versa.[3]

Generally, economic performance would be required, under the circumstances of Figure 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.

[3] 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 financial ratios or stock-market performance.

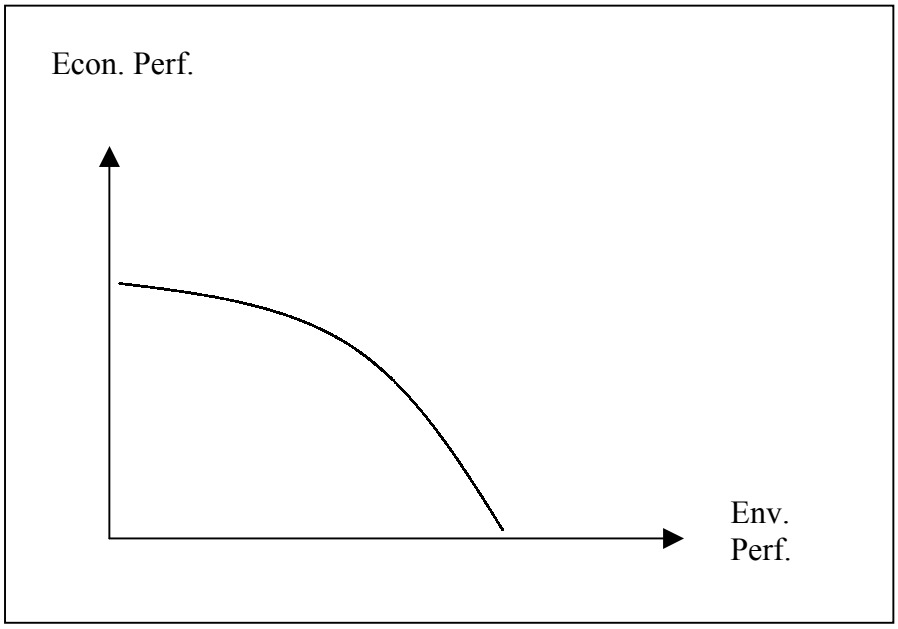

Figure 1: The "traditionalist" view

Instead, under the "revisionist" hypothesis, the shape of the relationship over the whole spectrum of environmental performance would be an inversely U-shaped curve with an optimum point (i.e. a level of environmental performance, where the benefits for economic performance net the costs for achieving this level are maximised over the whole spectrum). The curve (shown in Figure 2) is upward-sloping for firms with environmental performance below the optimum (which is the point where economic performance is maximized). This means that the benefits reaped from increased environmental performance increase continuously for low levels of environmental performance. This curve holds up to a certain point around or slightly above average environmental performance[4]. Beyond this point, the relationship is likely represented by a downward sloping curve (which in a first approximation is considered to be fairly linear). The inversely U-shaped curve with a monotonously decreasing first derivative and a negative second derivative (i.e. an increasing negative marginal impact on economic performance from increasing environmental performance). The part of the curve which lies to the left of its maximum (i.e. the optimum level of environmental performance which corresponds to maximum economic performance) 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 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.[5]

[4] It is an interesting question, 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 thus be discussed in more detail at a later point.

[5] The environmental performance and the economic performance axis are defined as in Footnote 2.

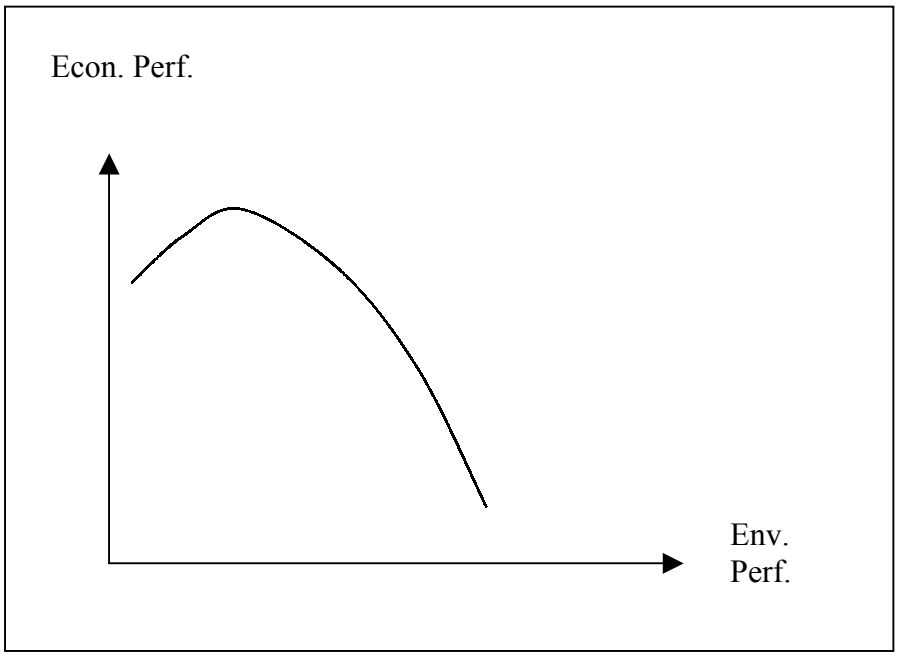

Figure 2: Synthesis of the "traditionalist" and " revisionist" views

The above considerations allow to conclude that approaches in economic theory (particularly standard microeconomic theory and the theoretical reasoning behind the Porter hypothesis) propose the generalised relationship between environmental and economic performance to be either monotonously decreasing (as depicted in Figure 1) or to be an inversely U-shaped (i.e. concave) relationship (as depicted in Figure 2). Following the argument made by Schaltegger and Synnestvedt (1999) a 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 referring to 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. Under such conditions, the optimal level of environmental performance would be the one prescribed by environmental regulations, i.e. compliance without over-compliance.

The theoretical debate on the relationship between environmental and economic performance has certainly been much shaped by the work of Porter (1991) and Porter and van der Linde (1995) formulating the so-called Porter hypothesis which states that stringent regulation (under the condition that it is designed efficiently) can improve competitiveness of firms thus leading to a positive relationship between environmental and economic performance at the firm level. This proposition (also referred to as the "revisionist" view) has been challenged. The critics (which adhere to the "conventional" or "traditionalist" view) predict a negative relationship between environmental and economic performance. The two views represent extremes on a continuum, and more recent theoretical contributions to the discussion on the relationship take a more differentiated view.

Despite of the limitations stated regarding Porter’s hypothesis, the different possible specifications developed before imply different conclusions on the Porter hypothesis for a set of firms in one specific industry (i.e. at the industry level):

(i) A uniformly negative functional relationship would disprove the Porter hypothesis completely, since any improvements in environmental performance would increase

costs and/or reduce sales, thus decreasing profits and essentially economic performance. Assuming that sales are not affected, this would mean that there exist no cost-effective environmental performance improvement measures, which is an unlikely the case, given the ample anecdotal evidence of the contrary that exists (Schmidheiny, 1992; Porter & van der Linde, 1995).

(ii) A inversely U-shaped specification of the functional relationship would again to a degree disprove the Porter hypothesis for firms in one specific industry, since under this specification the hypothesis would only hold for the case of low and below-average environmental performance, i.e. many "low-hanging fruits" from environmental performance improvements in terms of cost-effective or profitable pollution abatement measures would exist. If however a certain level of environmental performance has been achieved, then further improvements would not be profitable or cost-effective any longer, due to increased marginal costs and degreased marginal benefits of environmental performance improvements and pollution abatement.[6]

(iii) Finally, if no correlation at all exists between environmental and economic performance (i.e. if there is no systematic relationship), the Porter Hypothesis would again be disproved, since high economic performance would not be associated in any way to environmental performance.

In summary, the brief theoretical analysis of the relationship between environmental and economic performance has produced two possible specifications, corresponding the "traditionalist", and the "revisionist" view. 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 shall be analysed in detail in the remainder of this paper.

In terms of methodology, empirical studies about the above relationship can be classified broadly into three groups (Day, 1998), (Jaffe *et al.*, 1995). Firstly these are event studies which assess market responses after a positive or negative environmental event and are part of a broader strand of research which assess the response of capital markets on events related to specific firms or industrial sectors (Blacconiere and Northcut, 1997; White, 1996a; Jones and Rubin, 1999; Hamilton *et al.*, 1993; Worrell *et al.*, 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). Thirdly, studies apply multiple regression analysis to assess the influence of different factors (amongst them environmental performance) on firm profitability or conversely, the effect economic performance of firms has on their environmental performance (e.g. Hart and Ahuja, 1996; White, 1996a; Johnson, 1996). Amongst the group of multiple regression studies, a specific type of study adds environmental variables to existing validation models (e.g. on predicting a firm's Beta value)

[6] The empirical and recent theoretical research on the Porter hypothesis strongly points to the possibility that the relationship between environmental and economic performance of firms does not have to be unidirectional, but can be changing from positive to negative or vice versa. Also, a inversely U-shaped functional relationship between environmental and economic performance seems to fit better the empirical results from both, anecdotal evidence of specific firms (which is usually describing high gains and profits) as well as broader statistical studies (which usually do not find strong evidence for high gains and profits across all firms and levels of environmental performance).

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 into different methodological approaches, they 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). Other dimensions to classify studies are the time period covered and whether direct or indirect effects are assessed i.e. more broadly, the research problem and question. These different ways of classifying empirical studies on the relationship between environmental and economic performance illustrate in more detail the difficulty of comparing them amongst each other. 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. Because of this, research problems and questions within each category are to a degree more comparable than across categories.

With regard to the geographical scope of empirical studies, they 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 Toxic Release Inventory mandates standardised emission reporting for a large number of firms in several industries. In the EU, similar analysis using quantitative emission data have 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 and the Dutch ER-1), 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). It then analyses in more detail recent studies published after 1992 and finally will tentatively summarise and evaluate their results.

Early Studies

Very early studies, based on the same data found both significant performance between environmental performance and financial performance as well as no relation between these (e.g. Bragdon & Marlin, 1972; Spicer, 1978 and Chen & Metcalf (1980). All three 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[7]. 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 only reliable source of data on pollution prevention (Cordeiro & Sarkis, 1997). Significant correlation between financial and environmental performance (the latter measured on the basis of 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 this might have been spurious linkage,

[7] 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, 1996).

caused by not controlling for size. In another study using CEP ratings, Ingram and Frazier (1980) also 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 these earliest studies seems to be that no significant clearly positive or negative relationship between environmental and financial performance was found.

The study of Freedman and Jaggi (1982) 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 the indices measuring pollution disclosure and economic performance was found[8]. Mahapatra (1984) compared pollution control expenditures in six industries with average market returns and found negative correlation between environmental and market performance.

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 nominally and risk adjusted. However, Cohen *et al.* (1995) found (as discussed in more detail below) 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. In a later study using a data-set on social performance of consumer products firms published by CEP (Shopping for a Better World), Efle and Fratantuono (1992) found significant positive correlation of firm environmental performance and return on assets, return on investment and return on equity.

Table 1: Summary of results for earlier studies

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 expenditure 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 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 & significant correlation between environmental & economic performance

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

Jaggi & Freedman (1992)	Daily BOD, TSS and pH data, adjusted for firm size and aggrega-ted into an Overall Pollution Index	Net income, return on equity, return on assets, cash flow/equity, cash flow/assets	Economic performance negatively associated in the short-term with pollution performance

Overall, 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 can well be due to methodological problems of these studies, such as unavailability of comparable and meaningful data on environmental performance of firms or small sample sizes. The attention given to the interrelation between environmental and economic performance has increased considerably, however, after the 1992 Earth Summit in Rio. Partly as a result of this, much more comparable data was available since then, thus allowing broader and larger studies on the relationship between environmental and economic performance at the firm level. These are going to be discussed in the following section.

Recent Studies

More recent studies, which avoid some of the limitations of the early research use both, market valuation and profitability measures and can be classified according to the following classification scheme (the name refers to the citation of the study in the reference list 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). 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 the table below 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 & Sarkis (1997) use industry analyst's earnings-per-share forecasts, which are partly based on stock market and historical accounting information. Apart from that, measures that are not based on stock market data or historical accounting data (which both have significant 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 BCG matrix. Although these measures have other limitations, they nevertheless can give additional insights in a firms 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: 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,b)	Financial performance measures can not be used in the context of event studies
Multiple regression studies	Feldman *et al.* (1996) Butz & Plattner (1999) Thomas & Tonks (1999)	Johnson (1996) Hart & Ahuja (1996) Cordeiro & Sarkis (1997)
(Model) portfolio research	Diltz (1993, 1995) White (1995, 1996a)	Cohen *et al.* (1995) Edwards (1998)

Event Studies

Introduction

One particular type of study in the past has focused on market reactions following events of low or high environmental performance. Such events can be product recalls, public disclosure of oil spills, award 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). Event study methodology is based on Efficient Market Theory which holds that the publicly traded share prices include current and expected firm financial performance in the market valuation, based on 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 net present value of the firm as a result of this event (Klassen & McLaughlin, 1996). One limitation of event studies is, that they can only be based on stock market-based company performance data (basically significant differences between actual and expected returns).

Specific Studies

In an earlier event study, Barth *et al.* (1995) 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 Securities Data Corporation databases for 257 firms in four industries (utilities, automobiles, chemicals and appliances) over the period 1989-1993. The industries were chosen for their high concentration of Superfund exposure. Worell *et al.* (1995) in their event study found over the period 1988-93 that the stock market reacted significantly negative on announcements of 58 firms to become more sustainable.

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 $ 4 million. More specifically, 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 indexes. 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) on the legislative events leading to the U.S. Superfund Amendments and Reauthorization Act (SARA) of 1986. Next to 10-K forms 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 to 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 0.1 level, indicating that environmental disclosures in financial and environmental reports, as well as EPA information are 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 and 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 (1996) 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 and energy efficient and sustainable, 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 firms of the 56 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). 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 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 from the estimation period and to adjust for the number of observations in the estimation interval and the difference in effect signing the principles might have on different firms was corrected for.

Using an eleven-day test period the study eventually 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) makes interpretation of these results more difficult, although the results were not due to the response of one firm only.

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 files. Proxying the market portfolio by returns on CRSP value-weighted 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 to estimate market models as White (1996a) 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) are 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 a number of firms in the sample (e.g. the group of firms linked to Exxon and the event and its ten biggest retail competitors). Average abnormal returns were subsequently standardised, using the standard deviation of average abnormal 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 event. No superior stock market performance after the event was found for firms with average environmental performance, however, compared with firms of under-average environmental performance, i.e. a low CEP rating, they had better 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 possibly considerably smaller. Particularly, although firms with above-average environmental performance (as indicated by their CEP rating) showed significantly superior economic performance (i.e. positive average cumulative returns), firms with average or below-average environmental performance, incurring negative average cumulative abnormal returns, did not.

Based on a theoretical model linking environmental management and perceived future financial performance and using event methodology, 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 profits) 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 an 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 (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 return was used as a measure of a firm's financial performance, as the market's assessment of the firm value (based on all publicly available information) is reflected in the equity value of the firm. 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 total market return.A market model was estimated (using OLS regression) for each of the securities (i.e. 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 differences for first-time awards where announcements lead to greater increases in market valuation. However smaller increases were observed for first-time announcements of firms in high-polluting industries, revealing 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 was suggested. 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[9]. 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 to -$0.70 per share.

In summary, significant abnormal returns were therefore found for both, crises and awards, which 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).

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

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 per share). These results seem to be relatively low compared 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.

With regard to past environmental performance, Superfund liability seems to generally be included in the market valuation of firms relatively more consistently than information about future environmental performance (possibly because the high 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 announcement 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. Generally, firms appear to be unable to pass costs on to consumers in higher-polluting industries (automobile manufacturing, steel production and chemical industries) due to industry competition. Only electrical utilities seem to be able to pass on cost due to the highly regulated, monopolistic situation in national energy markets

A recurrent problem, also for the two other types of studies is, that a variety of different measures are used to assess environmental performance. One consequence of this is, that more or less no two studies are similar in their measures (although the large industry scope can be seen rather as different measures supporting each other in terms of results).

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 imply profit increases. Additionally, event studies do not lend themselves easily to assess time series data, are difficult to use for cross-country & inter-industry comparisons, and may be prone to "social amplification" and media impacts of perceived risk stemming from an event. 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.

Table 3: Summary of results for event studies

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 include 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 was first announced
Blacconiere & Northcut (1996)	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	Average abnormal returns for various event windows	Significant cumulative negative excess returns for Exxon (-20% over 90 days)
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 for (-1,1) event window of 0.63% / -0.82%.

(Model) Portfolio Research

Introduction

Research on (model)[10] 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. into only few, usually 2-3 environmental performance categories). The portfolios created in this way can be industry-matched (e.g. each portfolio reflects the same industry structure), 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 performance. Portfolios can cover only one industry, several industries or all industries (e.g. all manufacturing industries). Studies, which evaluate the relationship between environmental and economic performance study, for each portfolio, the average returns, based on accounting profitability or stock market performance measures over all firms and/or over all time periods. The measures adopted to assess economic performance can be risk-adjusted 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. In either case, a weakness of the portfolio approach of classifying environmental performance is that it limits the ability to draw conclusions about the environmental-economic performance relationship over the whole spectrum of environmental performance. This makes it very difficult to establish the specification of the relationship (i.e. whether it is uniformly negative or positive, parabolic or inversely parabolic or neutral). 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 for portfolios of high and low environmental performers, since it only assess average performance across the portfolio and its variation. This however can be a strength in that it allows to establish more clearly systematic differences in economic performance over a larger magnitude of environmental performance.

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 smaller studies, the three most recent and detailed studies shall be discussed in detail and compared in terms of their results.

Specific Studies

The study of Cohen, Fenn, and Naimon (1995) examines the correlation between environmental and financial performance in order to establish whether investing in companies

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

that are environmental leaders in their companies 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 environmental variable (based on the median value of this variable) using all firms listed in the S&P 500, for which values for this variable where available.

Nine variables were used to assess environmental performance of which some were not related to current or past environmental performance, whereas others are likely correlated to the 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) return 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 these financial variables 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. Inter-industry and inter-firm differences in risks and returns in the two portfolios were controlled by matching firms on industry and by including each firm's Beta value in the analysis.

The study 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 five measures of financial and market performance of the two portfolios over three time periods[11] for each of the environmental performance measures introduced above it was 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 of the upper and lower quartiles of firms in each industry, respectively.

The authors conclude 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 prefer choosing firms and industries performing environmentally high in absolute terms.

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

A more disaggregated analysis of the relationship between environmental, operational and market performance (summarised in Table 2) shows however a much more inconclusive pattern of results. This concerns the significance of differences as well as the time pattern of differences.

Broadly it can be found 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). The results for Superfund Sites and TRI emissions also confirm the results of the earlier event study by Hamilton (1995).

Overall, the study by Cohen *et al.* found 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).

Table 4: Disaggregated analysis of the results for the study of Cohen *et al.* (1995)

Environmental Variable	**Significant differences in financial or market performance**
Number of environmental lawsuits (as disclosed in 10-K) per Dollar of revenue	ROA's (and partly ROE) significantly higher for low polluters (all 3 periods), no statistically significant difference in (risk-adjusted and unadjusted) returns to common shareholders
Number of NPL sites where the firm is listed as being a PRP per Dollar of revenue	Total (risk-unadjusted) return to common shareholders significantly higher for low polluters (1987-89), no statistically significant difference in the subsequent periods 1990 and 1991 or ROA's and ROE (in any period)
Dollar value of fines per Dollar of revenue	Firms in the portfolio with high fines consistently express lower values of ROA (in both definitions), ROE and risk-adjusted and unadjusted stock market returns; however these differences are in general not statistically significant
Volume of oil spills (over 10,000 gallons) per Dollar of revenue	Generally ROA's and ROE are significantly lower for firms in the portfolio with high volume of oil spills as is the average of risk-adjusted returns in 1987-89 (not statistically significant) and 1990 (statistically significant)
Volume of chemical spills (exceeding 10,000 pounds)	Average accounting returns (ROA's, ROE) of firms in the portfolio with lower volumes of chemical spills are significantly lower for 1987-89; in the case of ROA with total accumulated depreciation added back this also holds for 1990 and 1991; however, total and

per Dollar of revenue	risk-adjusted total returns are slightly (though not statistically significant) higher for the portfolio of firms with high volumes of chemical spills
Volume of toxic chemical releases (sum of reported 1988 TRI emissions) per Dollar of revenue	Risk-adjusted (though not unadjusted) stock market returns for 1987-89 were significantly lower for the portfolio of high-polluting firms, although most of the difference is due to 1989 when the TRI emissions reported for 1987 was disclosed (differences in return figures for 1987 and 1988 were not statistically significant); ROA's and ROE were in most time periods higher for the portfolio of low-polluting firms, although differences were not statistically significant

Using existing portfolios of investment funds Diltz (1993, quoted in White, 1996) 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 in detail below (White (1996a) which covered approximately the same time period), he concludes however, that his results probably indicates 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 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[12] and the intercept coefficient being the Jensen measure. The study found superior risk-adjusted performance (i.e. investment returns) 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 not statistically significant and considerably smaller than in the case of the portfolio of high-rated firms.

Edwards (1998) carried out one of the rare 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).[13] The environmentally proactive firms were chosen from the JERU Approved List of companies for the JIGIT Ecology Fund.[14] 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. Aspects assessed include the firm's products and services, environmental disclosure by the firm, greenhouse gas and ozone depleting substances emissions, packaging and labelling. Also certain sectors are preferred for the list, such as environmental technology manufacturers, healthcare, telecommunication and IT, and public transport. Also, the firm's environmental management is assessed, based on its environmental policy, environmental management system, the monitoring of its environmental impacts and supplier/contractor auditing as well as energy efficiency improvements, environmental communication with employees and compliance with relevant legislation. Given the thorough assessment procedure, Edwards (1998) takes the view that the JERU assessment is currently " …the most rigorous, comparable and consistent of any such assessments." (Edwards 1998, p. 18). 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, such as the stringency of and approach to regulation) impossible.[15]

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[16] (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

[12] 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 theory.
[13] As will be discussed in the conclusions of this paper, matching is a core problem in portfolio studies. Edwards matches firms only for one year (1995), whilst the criteria matched certainly vary over the years.
[14] JERU stands for Jupiter Environmental Research Unit, whilst JIGIT abbreviates for Jupiter International Green Investment Trust.
[15] However, several of the firms assessed also have significant amounts of operations in other European countries.
[16] All firms included in the study are based in the UK and listed on the London Stock Exchange.

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 (July1996) Company REFS (Really Essential Financial Statistics) publication for the time period 1992 to 1995.[17] 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 best firm not JERU-listed is compared to that of the corresponding JERU listed firm, again using t-tests. Therefore differences in financial performance should 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). Depending on the shape of the profitability curve over the whole range of environmental performance levels it is possible for example that the non-JERU listed firm with the best economic performance is either the one with the next best environmental performance (in the case of a positive linear relationship between environmental and economic performance) or the one with the worst environmental performance (which is possible in the case of a U-shaped curve. Overall, Edwards (1998) 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.[18] In the comparison between firms with highest profitability in both sets, the result is inconclusive however, since in half of the years the listed firms perform better and in the other half the non-listed firms do.[19] As suggested above, the difference in returns in this case are considerably smaller than in the comparisons of the 1st stage. These results support to some degree the proposition that environmentally excellent firms can show above-average economic performance. At least firms are not penalised for their high environmental performance by low financial performance[20].

A more disaggregated analysis of the relationship between environmental performance and profitability for individual industry sectors provides however an equally inconclusive pattern of results, both with regard to the significance of differences as well as their time pattern. In the 'Support Services' sector, which mainly consists of waste companies, data suggests that JERU-listed firms perform above the average values found for other companies at the 1st stage, however the differences in profitability are not statistically significant for almost half of the years (1992-95). For 1992-94 differences in profitability are significant for five of the six t-tests conducted. However, for 1995 differences are not significant for both, ROCE and ROE. The results are even more inconclusive for the second stage since non-listed firms perform financially better (for 1992-95) (non-listed firms have higher profitability than listed

[17] 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. If, this can only refer to half-year results of firms in 1996. Therefore, reported results in this review only refer to 1992-95.

[18] Although possible, no t-test results were reported across the whole data set, nor was the raw data used.

[19] Only two t-tests at the 2nd stage found significant differences, which is partly 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 range between n=16 and n=8 for the 2nd stage of Edwards' 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 raw data is not reported in the publication.

[20] 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.

firms in 29 of 56 direct comparisons). However the small sample size of n=14 makes too broad generalisation of results difficult. This e.g. is even more so for the 'Paper, Packaging and Printing' sector where 4 "green" firms were available. Here in 1992 the JERU-listed firms outperformed the average of the set of non-listed firms, whereas for 1993 the opposite was the case (in 1994 and 1995 both sets of firms performed equally well). When only the most profitable companies are compared, the evidence is even more leaned towards the non-listed firms. The less positive results for the paper and printing sector (e.g. compared to the support services sector) may be explained by the strict and ample environmental regulation the sector, due to its high environmental impact, is exposed to. This is especially the case in the pulp and paper manufacturing industry with its already high share of environmental costs in total production costs (e.g. Jaffe *et al.*, 1995, p. 141). This consideration of sector specific results reveals, that the positive overall results comprise of results of much higher variability at the sector level. In some sectors (e.g. 'Support Services') the relationship between environmental performance and profitability seems to be more positive than in others (e.g. 'Paper, Packaging and Printing'). The small number of firms in each sector however, makes it difficult to generalise results to a general relationship in each sector. Next to Edwards (1998) Kreander *et al.* (2000a) is another example of a portfolio study, which is however based on funds, i.e. portfolios of equities. For funds-based studies, some of the issues are similar as for firm-based portfolio analyses, such as the matching problem. Since common fund performance measures are stock-marked based, some difficulties need to be considered that do not arise when using accounting profitability measures such as ROCE.

The study by Kreander *et al.* (2000a) analyses 40 ethical and 40 non-ethical investment funds from the UK (36), Sweden (22), Germany (8), Netherlands (4), Norway (4), Switzerland (4) & Belgium (2).[21] In the study, ethical funds are defined as funds which employ "non-financial ethical criteria" for selecting the shares they invest in (UK funds used in the study are also classified as ethical/ecological by EIRIS and S&P Micropal). Given that no unified definition of environmental performance exists, such criteria are not necessarily the same as narrow environmental performance criteria. Instead of using an appropriate stock index to benchmark fund performance, the study uses a matched pair approach, based on fund age, country, fund size as well as the investment universe of the fund. Economic performance measures utilised are the risk-adjusted Sharpe, Treynor and Jensen measures, based on weekly price data from Micropal, Datastream, Six, The Unit Trust Yearbook 2000 and the funds themselves. No significant differences were found for any of the (risk-adjusted) performance measure. In addition to that, average weekly returns were not found to be significantly different at the 5% significance level. However, lower levels of risk were found for ethical funds. This is based on the average standard deviation of non-ethical funds which was found to be significantly higher at 5% level. In addition, the research found significantly lower Beta values at 5% level for ethical funds. Although these results are in favour of ethical funds, it needs to be remembered, that fund performance assesses a combination of firm-level performance and fund management performance. Unless the effects of either can be separated, it is very difficult to conclude from studies based on investment funds that they actually reflect a positive relationship between environmental and economic performance at the firm level. Additionally, the use of stock market-based performance measures (for funds as well as firms) has to account for inefficiencies and distortions of stock markets under specific market conditions.

[21] The study is based on earlier research (Kreander *et al.*, 2000b) which does however not utilise a dedicated matched-pair approach and, due to the resulting methodological difficulties, is not discussed.

Table 5: Summary of results for (model) portfolio studies (continued next page)

Study	Data set	Environmental performance measures and data	Economic performance measures and data	Major findings
Diltz (1995)	28 model stock portfolios, 89-91 (14 matched pairs, based on CEP ratings of 159 US firms)	CEP ratings of firms for environment, 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 based on recycling activities, energy sources, waste reduction, environmentally benign products & low levels of non-compliance	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	ROA, ROE, total return to common shareholders (risk-adjusted & risk-unadjusted), based on Compustat data	For the 5 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 signif.)
Edwards (1998)	51 environmentally proactive firms in eight industrial sectors, 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 LSE	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 69% of the comparisons between portfolios of environmentally high-performing firms and other firms, the former perform better. In the comparisons between environmentally high performing firms and best performers among the other firms, only in 46% of the comparisons, the "green" firms perform better, though not in all cases significantly.

Kreander *et al.* (2000)	40 ethical and 40 non-ethical investment funds from the UK (36), Sweden (22), Germany (8), Netherlands (4), Norway (4), Switzerland (4) & Belgium (2)	Ethical funds defined as funds which employ non-financial ethical criteria for selecting the shares they invest in (UK funds also classified as ethical/ ecological by EIRIS & S&P Micropal), matching based on fund age, country, fund size & investment universe of fund	Risk-adjusted Sharpe, Treynor and Jensen measures, based on weekly price data from Micropal, Datastream, Six, The Unit Trust Yearbook 2000 & funds	No significant (sig.) difference for any risk-adjusted performance measure. Average weekly returns not sig. different at 5% level. Lower risk for ethical funds (average value of standard deviation of non-ethical funds is sig. higher at 5% level). Also sig. lower lower ß values at 5% level for ethical funds.

Summary of Results for (Model) Portfolio Research

Overall, (model) portfolio research provides some evidence, that application 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. For example Edwards (1998) found above-average returns for a portfolio of firms that were selected on the basis of a positive screen for their environmental excellence.

Furthermore, above-average returns are the case regardless of whether a portfolio includes the best environmental performer(s) relative to all other firms (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 model portfolios predominantly applied in the case of the above results do often not represent the usual process through 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 with caution be generalised to real-world investment funds. Additionally, the quality of fund management might considerably affect the level of returns and thus cloud any positive relationship between environmental and economic performance (White, 1996).

Comparing in more detail 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.*) 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.

Overall results for both studies were partly consistent and partly not. A more disaggregated analyses revealed considerable variation between industries (Edwards, 1998) and between environmental performance measures (Cohen *et al.*, 1995). Also in both studies, the differences in performance were stronger in the first half of the analysed time period and were decreasing in the second half. Thus although, both studies found some tentative evidence for a positive relationship between environmental and economic performance (measured in terms of historic accounting profitability), they also suggest that important firm-, industry- and country-level variables and factors moderate the relationship, as well as a possible time-dependency of the relationship. This becomes particularly evident, when quantitative results for both studies are compared in more detail.

For Edwards (1998) the average for the 1992-5 period was 14.5% (ROCE) and 5 % (ROE) when comparing environmentally excellent firms with a set of environmentally lower performing firms. Comparing the best financial performers with high environmental

performance and lower environmental performance, the averages for 1992-5 were 0.2% (ROCE) and -2.75% (ROE).

Cohen *et al.* (1995) for two portfolios divided on the basis of TRI emissions find 8.4% higher risk-adjusted returns for the low polluting portfolio for 1989. This finding is significant at the 0.01 level, based on a t-test. For that year, the portfolio of low polluting firms achieves a risk-adjusted return of 32.1%, as compared to 23.7% for the portfolio of firms with higher TRI emissions (based on the median of emissions). For 1990 and 1991, returns on assets are found to be 1.6% higher and -2.8% lower, respectively, for the low polluting portfolio. Both differences are not statistically significant though. The corresponding return on asset values are 33.8% (31.2%) and 35.4% (34.1%) for the portfolio of low polluting and high polluting firms, respectively, for 1990 (1991). The following table summarises these findings. However, in the papers that report the two studies, data provided is insufficient, to directly compare the one variable (return on equity), both have in common. However, as is argued below, the findings of both studies rather contradict each other.

Table 6: Findings on economic performance by study of Cohen *et al.* (1995)

Measure and year	Low polluting portfolio	High polluting portfolio	Significance of difference
Risk-adjusted return, 1989	32.1%	23.7%	Significant at 0.01 level (t-test)
Return on assets, 1990	33.8%	35.4%	Difference not significant
Return on assets, 1991	31.2%	34.1%	Difference not significant

Generally, Cohen *et al.* (1995) find for none of the environmental performance measures they apply that economic performance of low-polluting firms is significantly better in more than half of the direct comparisons (across all environmental performance measures and all years). The highest number of significantly better economic performances over all economic performance measures (ROA in two definitions, ROE, total returns and risk adjusted return) is found for the environmental performance variables litigation (4 out of 15 cases) and volume of chemical spills (5 out of 15 cases). In both of these two cases, return on assets is significantly different for all time periods examined with an average of 10.9% higher returns for low-polluting firms over high-polluting firms for the 1987-91 time period. However, the very similar annual differences on ROA rather indicate co-linearity between the amount of litigation and the volume of chemical spills, since they make it likely, that for both measures the same firms are in the high- and low-polluting portfolios. It seems, that firms are mostly prosecuted for chemical spills, so that litigation and chemical spills are highly correlated. This would explain the almost exactly identical annual differences in ROA for the three study periods (1987-9, 1990, 1991). Return on equity is only in one case significantly different (based on t-tests). This is again for the volume of chemical spills, and in this case low-polluting firms have 3.3% higher returns than high-polluting ones, a finding which is contradicting considerably with the finding of Edwards (1998) who found smaller returns of similar magnitude for low-polluting firms, compared to high-polluting ones (i.e. the sign of returns is reversed). These considerable differences in terms of quantitative results points to the need of more detailed models and research designs which directly incorporate an assessment of, at least, some of these factors.

Generally, as discussed in the introduction, it is a limitation of (model) portfolio-based research that it mainly compares groups of companies, which does not allow an evaluation of the shape of the relationship over the whole spectrum of environmental performance. The 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. A special case of multiple regression-based research is the addition of environmental variables to existing validation models. Empirical studies based on both of these methods are discussed in the following section.

Multiple Regression-based Studies

Introduction

Next to event studies and portfolio studies, multiple-regression-based studies are the third approach to assess the relationship between environmental and economic performance of firms. In its review of recent studies, this chapter covers studies that are using contaminated land liabilities, studies that are predominantly based on TRI emissions (and have consequently all been carried out in the US) or other emissions to air and water (Alanen, 1998), studies based on environmental management activities (Thomas and 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 difficult. 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 study multi-causal models, i.e. networks of interrelated determinants (Oppenheim, 1970, p. 26). They represent advanced, multivariate statistical procedures which are able to assess not only the total 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 needs to take a number of issues, in particular (Oppenheim, 1970, p. 28):

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

In the following, this chapter covers studies that predominantly use emissions or environmental management data to construct measures for environmental performance. This also includes the few multiple regression-based studies (Thomas & Tonks, 1999; Butz & Plattner, 1999) known to have been carried out in Europe so far.

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, publicly-owned treatment work discharges 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 (CAA, CWA. SDWA and TSCA/FIFRA) 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 annual, 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.

Generally, 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 of 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 indicates that fixed costs per spill drive the relationship.

However, there is considerable evidence 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. 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). 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). This shows the considerable variance across industries in the relationship between economic and environmental performance. It is very likely that this variance is resulting, amongst others, from 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).

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[22].

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 (which are assigned SIC codes below 5000) were chosen and that at least four firms per industry (at the four digit 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[23]. 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 performance 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 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 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 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 was indicated by a split sample analysis which found no significant effect on any of the operational and financial performance

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

[23] 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).

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 a subsequent regression study, Cordeiro and Sarkis (1997) aggregate 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 mandatory 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 is aggregated from the plant level TRI data[24]. 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[25]. 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 Commissions (SEC) Disclosure database and are provided by industry analysts of Zacks Investment Co[26]. Firm level controls applied are firm sales (to proxy firm size) and debt-to-equity ratio (to proxy the firms leverage/gearing). Industry level was controlled 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 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. In both regressions (based on industry-adjusted values), firm size and leverage, were included as further independent variables. 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 0.1 and 0.05 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 the same results apply to the non-industry-adjusted values, although the values for the change in proactivism were now clearly not significant any more. Cordeiro and Sarkis conclude, that security analysts systematically anticipate lower earnings-per-share for environmentally proactive firms in the short-term[27],

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

[25] Theoretical concerns against this measure could be mounted however, since firms with higher non-production releases (cet. par.) 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.

[26] Cordeiro and Sarkis 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 an assessment of their relative results not possible. 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.

[27] Cordeiro and Sarkis define short-term somewhat arbitrarily as the period of 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 (and is practically) captured in any of the measures for economic performance of firms commonly adopted.

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 contrast to their (model) portfolio research (Cohen *et al.*, 1995), Konar and Cohen (1997) disaggregate the market valuation of corporate environmental performance and attempt to desegregate firm-specific effects. They decompose the firm market value of a firm into tangible and intangible asset values and find that firms with low environmental performance have lower intangible asset values, with the magnitude of value reductions varying across industries and larger losses accruing to higher-polluting industries. After controlling for other variables (e.g. patents, R&D expenditure, market share or brand reputation) that possibly explain financial performance of firms, they find the average "intangible liability" for a firm to be of about $360m, equalling 8.4% of the replacement value of tangible assets. Thus, a 10% reduction in toxic chemicals emitted would lead to a $31m increase in a firm's market value.

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 decomposition, the study assess 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 that 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. The value of common stock is derived by multiplying end-of-year common stock price and the number of shares outstanding. Market value for preferred shares is estimated through their liquidation value as reported in the firm balance sheets. Replacement value of tangible assets is estimated from balance sheets as the sum of net property, plant and equipment of the firm, cash and short term investments, receivables and inventories. Intangible firm value is calculated as the difference between total market value of the firm (common stock and preferred shares) less the replacement value of its tangible assets. Control variables included in the study are firm market share (proxying for the monopoly power of a firm), industry concentration ratio (4-firm), 3-year firm sales growth rate, debt-to-equity ratio, 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 & 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 a multiple regression equation in several specifications, Komar and Cohen find that independent control variables confirm in sign and significance 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 leverage ratio and tangible assets are related negatively. Accounting for these effects, the used environmental performance measures were found to have 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. Results remain structurally stable under several specifications of the multiple regression equation used.

In a second series of regressions the effect of the environmental performance of a firm on its intangible asset value is assessed, suing the latter as dependent variable. 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 for across all firms is U.S.-$ 362 million, equalling 8.4 % of the studied firm's asset replacement value. Most of this losses 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 under U.S.-$ 1 million.

However, significant industry differences are found regarding these results (and thus the economic significance of negative effects on market valuation from low environmental performance). Loss value (in per cent 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%). In industries such as transportation equipment, food products, electric machinery and non-electric machinery, losses were below 5% of asset replacement value.

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.

Of 297 companies surveyed 291 were quoted on the London Stock Exchange (LSE) and of these 131 replied. Companies covered a range of industries and the average market capitalisation of the companies surveyed was approx. £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.

The size factor was measured in terms of the return on the Hoare-Govett Small Capitalisation Index over the return on the Financial Times All-Share Index, the risk free rate was measured as the Treasury Bill 30-day rate and the market index through the Financial Times All-Share Index. Prior to further analysis, it was established, that the sample of all 291 LSE-listed firms in the pension shareholding scheme (with a Beta close to one and a coefficient on the size factor of about 0.7) was representative of a well-diversified portfolio and that the data set of

the 131 firms who responded to the survey has a similar profile of coefficients, making this responding sample representative of the full sample in terms of the market model parameters.
Overall, the analysis found that the adoption of an environmental policy by firms in an industry with strong pollution record improves 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 is reducing 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 1985-1992, which however 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 which takes 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 found not generally to have significant explanatory power for the existence of (positive or negative) excess returns.
Butz und 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 the four categories ranging from "++" and "+", to "-" and "--", based on a number of quantitative & 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 (the environmental rating was included in the regression by means of three dummy variables). As a result, Butz and Platter find a significant positive regression coefficient for environmental rating (i.e. for the dummy variables), indicating a positive relationship between environmental and economic performance. However, this only holds for a subset of firms in environmentally intensive industries (n=39).[28] 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 include any control variables. This leaves the possibility, that factors other than the environmental rating (but highly correlated with the dummy variables used to operationalise it) could have influenced the Alpha values.
Given that the two 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 two regression studies discussed differ 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 controls such as size factor vs. omission of control variables). However, despite of the differences, there is some similarity in results, in particular the relatively higher influence of environmental aspects in higher-polluting industries.

[28] This result (i.e. high significance for environmentally intensive, i.e. high-polluting industries) was found in both regression studies.

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. 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. is Feldman *et al.* (1996) and is discussed below. 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 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 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[29] and, based on the above model, proposes that the environmental risk of a firm should be positively correlated to the firm's Beta value and share price. 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 then tested in the study through the addition of environmental variables to an existing validation model. To do so, the Beta value 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 the emergence of a 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

[29] 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 1. 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).

that influence firm risk. It 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) and other performance variables at the firm level. These other performance variables are correlation between the return on the market portfolio and firm costs, standard deviation of operating leverage, change of the change in operating incomes, 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. The coefficients for the environmental management and environmental performance variables were however both, positive and significantly different from zero at the 0.01 level. Most non-environmental coefficients were also statistically significant, not so however some of the industry dummy variables. The adjusted coefficient of determination (R-squared) of the model was 0.24.and significant evidence (at the 0.05 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 hypotheses 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 (Feldman *et al.*, 1996).

Before summarising the major findings of multiple regression-based studies, Table 8 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 moderating factors other than environmental performance contribute to the actual 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 8 gives an overview of control variables used and thus allows assessing better the findings of the different studies.

Table 7: Summary of results for selected multiple regression studies (to be read in conjunction with Table 8)

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, based on 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 (econ. perf.) & 1988-89 (env. perf.)	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 & ROS.
Konar & Cohen (1997)	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 pending	Tobin's q (as dependent variable in several specifications) and intangible asset value of firms	Low environmental performance has a Significantly negative intangible asset *value of firms (-8.4% of tangible asset replacement values) 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 (env. perf.), 1993 (econ. perf.)	Change in the sum of TRI releases that are recovered, treated or recycled on-site & releases from remedial actions or catastrophic or similar events	1-year and 5-year industry analyst earnings-per-share growth forecasts from Zacks Investment Co	High environmental performance is found to be significantly negative related to 1-year & 5-year earnings-per-share growth forecasts (based on industry adjusted values).
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 env. perf. 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.

Summary of Results for Multiple Regression-based Studies

Given that no two multiple regression-based studies use identical dependent or independent variables, studies cannot the findings of one another. However, the power of regression models lies in its ability to assess the relative influences of a potentially large array of independent variables on a dependent variable. In this the above studies 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 or other contaminated land liabilities and economic performance, it can be said, that there is generally a strong negative influence of such liabilities on stock market 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. Also, firms with larger contaminated land liabilities possibly pay a higher risk premium on the capital they source on the stock market or from banks, i.e. they pay higher interest rates or shareholders are only prepared to buy shares at a discounted price. However, this is based on only a small number of studies, all of which have been carried out in the U.S. Additionally, studies using such liabilities as measures of environmental performance face the problem, that contaminated land 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 further support for the results of Campbell *et al.* (1996a, 1996b) in that he also finds a negative relationship between the number of Superfund sites and fines and the economic performance of a firm.

A second group of 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). As can be seen from Table 7 above, all three 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, respectively). 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 firm's economic performance, and although principally possible. For example, Cordeiro and Sarkis take not the opportunity to apply the same measures that Hart & Ahuja use, although this could 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 & Sarkis to use at least one of the environmental performance

measures adopted by Hart & Ahuja (1996) in the more recent study, which could in a similar way have addressed the above question of the relative influence of both dimensions.

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 be caused by then-available "low-hanging fruits" 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 cost-effective performance improvements based on an already high level of absolute environmental performance (i.e. a corresponding low level of emissions) given decreasing marginal benefits 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.

When comparing Hart and Ahuja's and Cordeiro and Sarkis's results with the study by Konar and Cohen (1997) 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 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 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.

The study by Johnson (1996) covers (for various types of TRI emissions only) the time period of 1987-92 and 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). which 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 (i.e. return on assets and return on equity).

The 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 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 most often a positive relationship on the economic performance of firms. It can thus be concluded, that

the generally positive relationship found by the latter is only partly supported by Johnson's findings. Differences in the results may be due to the different time periods on which the respective studies were based (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 are those that 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; Thomas & Tonks, 1999).

Overall it can be concluded that there seems to be a certain sensitivity of regression studies 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 overall sensitivity 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 6 illustrates the different dependent and independent variables adopted by selected regression studies.

Table 8: Variables and data sets used in selected multiple regression studies

Study	Dependent variables	Independent variables	Data set
Hart & Ahuja (1996)	ROS, ROA, ROE (1989-1992)	advertising intensity, R&D intensity, capital intensity, leverage, normalised[30] total TRI emissions reductions (1988-89), industry average emission levels	Firms in SIC codes below 5000, n=127
Cordeiro & Sarkis (1997)	1-year & 5-year Industry analyst's 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)	Tobin's q value, firm intangible asset value (1989)	Firm market share, 4-firm concentration ratio, 3-year firm sales growth rate, debt-to-equity ratio, 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 an environmental agency & 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	Change[31] in dept-to-asset ratio, in fixed cost base of operation, in productivity. Change in the coefficient of variation of firm revenue, change in coefficient of variation of firm operating income, change in standard deviation of operating leverage, change in correlation between the return on market portfolio and firm costs and change in the change of operating income, Beta value for the firm during 1980-87, dummy variable for industry membership in a high-polluting industry, average annual change in TRI emissions normalised by capital, EMS rating	Subset of firms listed in the S&P 500 (n=330)

[30] This refers to dividing the total or partial TRI emissions by sales revenue, which accounts for firm size.
[31] Changes refer to the same two time periods as for the dependent variable i.e. 1980-87 and 1988-94.

Conclusions

Introduction

Earlier reviews of literature on the relationship between environmental and economic performance conclude 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 of individual firms from environmental performance improvements/corporate environmentalism, systematic evidence for larger samples of firms across several industries is much more inconclusive. Whereas evidence from earlier studies indicates no significant relationship between environmental and economic performance (Cordeiro & Sarkis, 1997), the 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 whether this is positive or negative.

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 attributed different emphasis under 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). Consistently, studies over a wide range of manufacturing industries 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 evidence of the causal relationship between environmental and economic performance, indicating that bad (good) environmental performance is a actually causing bad (good) economic performance, at least with regard to stock market performance. This, combined with other research that found that market reaction in the form of abnormal returns in turn affects the future environmental performance of a firm[32] points also to the possibility of a circular relationship between environmental and economic performance at the firm level.

Portfolio research (synonymous: screening studies) 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, 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

[32] Konar and Cohen (1997) 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.

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. The generally more negative relationship between environmental performance measured on the basis of contaminated land or hazardous waste clean-up (contingent) liabilities or responsibilities and economic performance measures is probably due to the more certain negative effects of such aspects of environmental performance on economic performance. For contaminated land (clean-up) liabilities or hazardous waste clean-up liabilities, especially liabilities already addressed under current regulations, such as liabilities under the U.S. Superfund regulations, the costs are much more certain.

Evidence from all types of studies supports this, especially event studies and certain multiple-regression studies. 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 under current (more stringent) environmental regulation.

Methodological influences and data constraints

Regarding the different studies analysed in this literature review, 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 of individual firms, as well as of investment funds, there are serious 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 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 expressed above average performance during the telecommunication boom in 2000, which could be erroneously attributed to environmental performance.

Regression analysis allows to carry out "continuous" matching, however 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 lies 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 a 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 e.g. as the 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.*, 2001). 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.

So far there has been no exact reproduction of studies on European firms. Therefore future research could aim at reproducing existing European studies. Beyond this, the review of four studies using different research approaches (portfolio studies vs. regression analysis) allows to formulate a set of criteria which can ensure an improved research design in the future. In particular, studies should

- be based at the site-level, unless aggregation to 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 well as the whole sample; and
- analyse (where necessary) country-level (micro-/macro-economic) influences.

Variability in the relationship between 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 the intrinsically wide variance in the relationship between environmental and economic performance, due to various initiating 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. It is very likely that this variance is mainly resulting from differences in industry regulation (in terms of stringency and regulatory approach), in market structure (i.e. industry structure and demand side) and initiating or inhibiting firm-level factors (e.g. firm size or the type of environmental management pursued). Market structure or industry regulation are often different from country to country, so that country membership or country origin of a company is an important control variable in any cross-national study analysing the relationship between environmental and economic performance. Possibly, further initiating or inhibiting factors of the relationship at the firm level are the processes operated at site level and the production technologies used to operate these processes.

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 dynamic, i.e. 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 (i.e. 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 the environmental performance measures used, the sectors analysed, the 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, i.e. the methodological and the object-related sensitivity of results. One step towards this could be an assessment of the variability between and across methodologies. This could clarify if results differ more within one methodology compared to the average results across methodologies, or whether the average results across methodologies are more different than the variability in results encountered for one specific methodological approach.

Alleys for 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 differential effects within one industry. 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 that 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, 1999; 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). 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 e.g. whether 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 to identify 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, 1996). 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 be as well 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.

An important results from 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 is necessary to focus on individual industries in order to gain a deeper understanding of the forces influencing the relationship between environmental and economic performance. The hypothesis of differential effects in different industries has been addressed in several studies, and both possible forms of the hypothesis have been proposed. Whilst some of the literature suggests that a positive relationship would be strongest and highest in high polluting industries (Hart & Ahuja, 1995) other studies propose that a positive relationship would be strongest for historically clean(er) industries (Klassen & McLaughlin, 1996, p.1203). These opposing hypotheses raise some important research issues. Firstly, this is, how to account for this important moderating factor at the industry level which should consequently be measured in any research, e.g. through a dummy variable in any regression analysis. Membership of a firm to classes of high- or low(er) polluting (i.e. "clean") industries can be defined in various ways, e.g. based on the history (or the lack of history) of environmental crises, accidents or catastrophes in an industry (which

would in a sense proxy for public opinion and perception of that industry). However, past performance history might not adequately reflect the current situation in the industry, based e.g. on the average total pollutant releases per unit of output or per unit of sales[33]. Overall it seems to be more adequate to base classifications on actual, rather than historic performance, since this is probably the measure that is also applied by industry analysts, investors, shareholder and fund managers. One important limitation in this respect is however to account for the existence or possibility of litigation for land contamination (e.g. under the U.S. Superfund legislation).

Next to a possible direct relationship, as analysed in most of the empirical studies discussed above, it may also be possible, that no direct relationship can be detected. It may nevertheless still be possible in this case (but also in the case of a causal relationship existing), that potential explanatory factors simultaneously influence the environmental and economic performance of a firm. In order to analyse this, it is necessary to consider how this simultaneous influence can take place. One way to do so, is a more general model linking 1) moderating/explanatory factors, 2) environmental performance, and 3) economic performance and their interaction as it is shown in Figure 3. The model shows the factors considered most important to cause a certain level of environmental and economic performance.

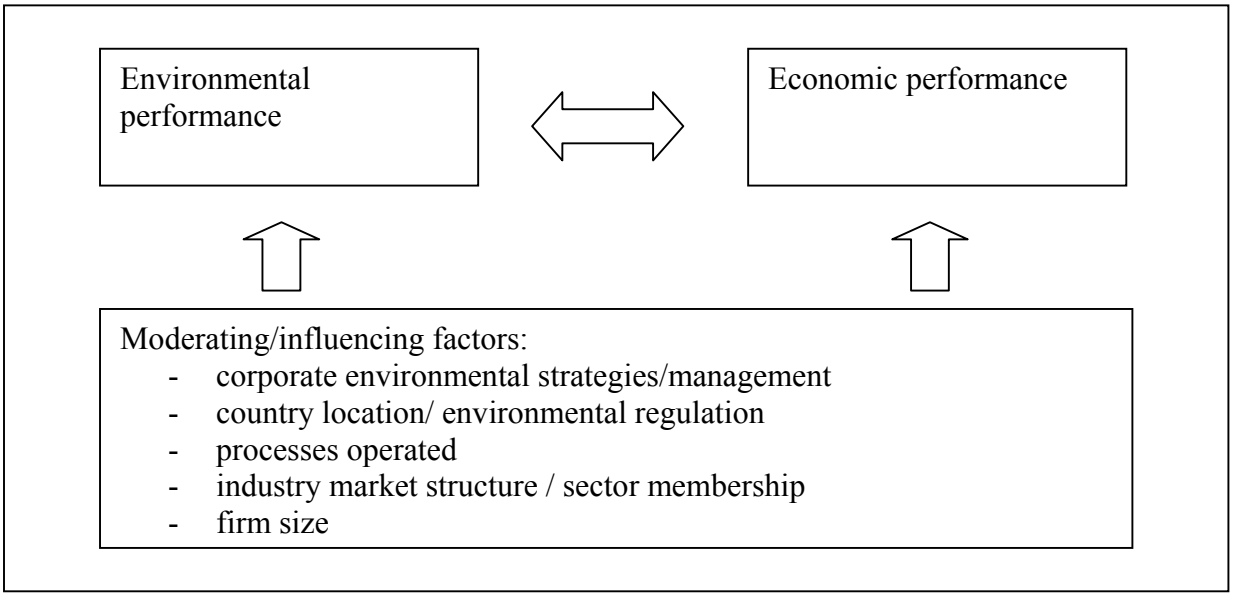

Figure 3: Model for the interaction of environmental and economic performance

In the most general form it should be assumed that each of these factors have a simultaneous influence on environmental and economic performance. However, it may well be possible, that each factor can be considered to have a predominant influence on either environmental or economic performance. As a final thought it is interesting to note that only very 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 to 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 of the field of environmental performance measurement in general (Bennett *et al.*, 1999). 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.

[33] This might for example be the case in the chemicals industry, which as a long history of severe environmental accidents, but mainly as a result of these and subsequent public reaction, has embarked on various programmes (such as e.g. "Responsible Care") to address the environmental challenges posed to the industry.

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