Green to Gold?

An Empirical Study of the Relationship between Firm Environmental and Financial Performance

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Abstract

Previous empirical work suggests that poor firm environmental performance is negatively associated with firm financial performance. A common measure of firm environmental performance is emissions of toxic chemicals, typically taken from the EPA’s Toxic Release Inventory (TRI). However, TRI emissions do not accurately represent the actual health risks posed by these emissions as they do not take into account factors such as chemical toxicity and exposure. Therefore, the relationship between risk-adjusted emissions and firm financial performance is unknown. To explore this issue and others, this paper analyzes 148 US manufacturing firms over the time period 2000 – 2003. Once I control for time-consistent firm-level features, I find evidence of a negative association between risk-adjusted emissions and firm financial performance across a variety of specifications. More generally, I provide consistent statistical evidence that environmental performance does impact firm financial performance.
I. Introduction

The empirical question examined in this paper concerns the extent to which a firm’s environmental performance is valued (if at all) in the marketplace. Although previous research in the “pays-to-be-green” literature has documented a negative correlation between poor environmental performance and firm financial performance, the former is generally proxied by aggregate firm emissions as reported in the EPA’s Toxic Release Inventory (TRI).¹

However, aggregate firm TRI emissions is not necessarily a good metric for environmental performance because mass emissions of toxic chemicals are not representative of the public health impacts associated with those emissions. In particular, chemicals have widely varying degrees of toxicity, move through the environment in different manners, and impact various population segments differently. To the extent the market values TRI emissions due to the risks posed to public health, risk-adjusted emissions should provide a better proxy for firm environmental performance.

In order to address the relationship between risk-adjusted emissions and firm financial performance, this study utilizes the EPA Office of Pollution Prevention and Toxics’ Risk-Screening Environmental Indicators (RSEI) model. The RSEI model provides a mechanism for assessing the relative impacts of releases of toxic chemicals using a risk-related perspective. This paper utilizes two measures of environmental performance that are adjusted for relative health risks. In particular, this paper uses a firm’s “hazard score” and “relative risk score.” The former weights TRI releases by chemical toxicity, while the latter accounts for not only chemical toxicity but also exposure modeling and population estimates as well.

The substantial part of the analysis in this paper relies on the use of these risk-adjusted TRI emissions as measures of firm environmental performance. In particular, the unique contribution of this paper is to expand upon previous work in the “pays-to-be-green” literature by examining the association between firm financial performance and TRI emissions adjusted for their relative human health risks.

The final measure of environmental performance is total firm TRI emissions (measured in pounds), where TRI emissions are not adjusted for their relative health

¹ Facilities must annually report emissions (in pounds) for approximately 600 toxic chemicals to EPA
risks. This measure is included to see if we can replicate previous findings in the literature of a negative association between TRI emissions and firm financial performance, using an updated data set.

All measures of environmental performance used in this paper are at the firm level. As data for environmental performance is originally obtained at the facility level, I assigned individual facilities to parent corporations and aggregated facility-level environmental performance measures to obtain a firm-level measure of environmental performance. Finally, the reader should note that each of these firm-level environmental performance measures is scaled by firm sales in each study year for use in regression analysis.

These three different measures of environmental performance are examined in the context of three models for how the market may account for environmental performance. In particular, the first model considers the level of firm environmental performance. Since stock prices should only change when new information is released, a model that examines stock prices as a function of yearly levels of pollution represents a naïve view of how investors may account for environmental performance. This model basically assumes that investors ignore previous year’s information in evaluating the relationship between environmental performance and firm value. In reality, one would expect that investors utilize a more sophisticated approach in accounting for environmental performance, perhaps by looking at changes in environmental performance or by comparing a firm’s environmental performance to an “expected” value. The other two models account for these more realistic scenarios by examining 1) annual changes in a firm’s environmental performance, and 2) the environmental performance for a firm relative to what one would expect given its size and the industry in which it operates.

This paper analyzes 148 US manufacturing firms over the time period 2000–2003. Ultimately, once I control for time-consistent firm-level features I find that environmental performance measures generally matter across all three of these models. Thus, my findings suggest that the market does take into account a pollution impact measure that reflects human health risks, rather than just aggregate emissions. Moreover, I provide evidence that environmental performance affects firm financial performance, and, in particular, firm market valuation.
The remainder of this paper is organized as follows: Section II briefly reviews some of the literature on the relationship between firm environmental performance and financial performance. Section III discusses the study methodology and Section IV highlights the firm financial and environmental performance data. Section V summarizes the empirical approach of the study while Section VI presents the results of the analysis. Finally, Section VII offers some concluding thoughts.

II. Previous Research

Much of the “pays-to-be-green” literature has supported the proposed positive relationship between pollution reduction and financial gain through correlative studies of environmental and financial performance. The Council on Economic Priorities (CEP) conducted a series of studies in the 1970s that found that expenditures on pollution control were significantly correlated with financial performance among a sample of pulp and paper firms. More recently, Russo and Fouts (1997) found a significant positive association between firm financial returns and an index of environmental performance developed by the CEP. In the finance literature a number of studies have examined the market returns of stock portfolios of environmentally friendly firms. In particular, Cohen, Fenn and Naimon (1995) constructed “industry balanced” portfolios of poor environmental firms and environmental leaders in each industry, and found that stock market performance of the environmental leaders equaled or exceeded that of the environmental laggards over the time period 1987-1990. Similarly, White (1996) found a significantly higher risk-adjusted return for a portfolio of “green” firms using the CEP environmental performance ratings.

These correlative studies are informative but fail to shed light on the issue of causality. To the extent one only cares about environmental performance as an indicator of future capital market returns, it matters little whether environmental performance directly leads to financial performance or whether it is just an indicator of firms that have

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2 Spicer (1978) as cited in King and Lenox (2001)  
3 As cited in King and Lenox (2001)  
4 As cited in Konar and Cohen (2001)  
5 As cited in King and Lenox (2001)  
6 King and Lenox (2001)
strong financial performance. However, as King and Lenox (2001) argue, this distinction is critical for managers. The recommendation that often falls out of the “pays-to-be-green” literature is for managers to invest in decreasing their firm’s environmental impact. If environmental performance really matters research must demonstrate that environmental improvements produce financial gain.

Event studies are one means of addressing the issue of causality. Such studies examine the relative changes in stock price following an environmental event; by isolating a single environmental event within a narrow time frame event studies control for important, unobserved differences among firms. For example, Klassen and McLaughlin (1996) found that firms experienced significant negative, abnormal returns in the wake of bad environmental news, such as an oil spill, and experienced significant positive returns following receipt of environmental awards. Similar results for environmental event studies were reported by Karpoff, Lott and Rankine (1999). Blacconiere and Patten (1994) estimated that Union Carbide lost $1 billion in market capitalization (about 28%), following the Bhopal accident in 1984. Muoghalu et al. (1990) found that firms named in lawsuits related to improper disposal of hazardous wastes were subject to significant decreases in market value.

Such event study methodologies demonstrate that 1) news of high levels of toxic emissions results in significant abnormal returns, and that 2) firms with strong environmental management practices have better stock price returns than firms with poor practices after a major environmental disaster. However, the limitation with event studies is that they may study the effect of events that are only partially environmental in nature without taking into account how each is affected by other firm attributes. Size, market power, and other unique firm characteristics may influence how events are reported and interpreted. For example, a firm with superior public relations may be able to put a positive spin on negative environmental news, and a firm that possesses

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7 ibid
8 ibid
9 ibid
10 As cited in Konar and Cohen (2001)
11 As cited in Konar and Cohen (2001)
12 As cited in King and Lenox (2001)
13 As cited in King and Lenox (2001)
15 King and Lenox (2001)
16 King and Baerwald (1998) as cited in King and Lenox (2001)
good legal resources may be able to better prevent lawsuits from being brought against the firm.\textsuperscript{17}

Some studies have tried to correct for this problem by using the release of toxic emission data through EPA’s TRI program as the event. For example, Hamilton (1995) found that a large sample of publicly traded firms experienced significant abnormal, negative returns on the day that the TRI was first announced in 1989.\textsuperscript{18} However, it is hard to tell if this effect was the result of temporary bad press or a fundamental change in perception of a firm’s long-term value.\textsuperscript{19}

Finally, some studies employ standard regression techniques to examine the relationship between firm environmental and financial performance. Konar and Cohen (2001), for example, compare the environmental and financial performance of manufacturing firms in the S&P 500, where environmental performance is proxied by aggregate firm TRI emissions and financial performance is represented by Tobin’s $q$. After controlling for variables thought to influence firm-level financial performance, the authors find that TRI emissions have a statistically significant, negative effect on firm market valuation.\textsuperscript{20} This study expands upon Konar and Cohen’s work by including environmental performance measures where TRI emissions are adjusted for relative health risks.

### III. Methodology

I created a sample of publicly traded US manufacturing firms from the period 2000-2003 using EPA facility TRI data, EPA data linking facilities to parent corporations, and corporate financial data from Standard & Poor’s Compustat database. The EPA started the TRI in 1987 to track emissions of more than 200 toxic chemicals from US manufacturing firms. Today facilities with 10 or more full-time employees must report chemical releases if they either 1) manufacture or process over 25,000 pounds of a designated chemical or designated chemical category, or 2) use more than 10,000 pounds of any designated chemical or category during the course of a calendar

\textsuperscript{17} King and Lenox (2001)
\textsuperscript{18} As cited in Konar and Cohen (2001)
\textsuperscript{19} King and Lenox (2001)
\textsuperscript{20} Konar and Cohen (2001)
To be in the sample for this paper, a firm must have at least one facility that meets these requirements and for which TRI data is available from the EPA. Additionally, a firm must be among the public corporations listed in Standard & Poor’s Compustat database for which nearly full financial information can be compiled. By matching these requirements I created a sample of 148 firms constituting 573 firm-year observations for the years 2000 through 2003.

In order to calculate the environmental performance measures for each firm (to combine with firm financial information obtained from Compustat) it was necessary to first assign facilities to parent corporations. This was initially accomplished using data obtained from EPA. Facilities that could not be assigned to parent corporations based on EPA data (due to the fact that EPA did not provide this information), were referenced against a dataset provided by Dr. Michael Lenox, of the Fuqua School of Business at Duke University, to determine if any of these facilities could be assigned to corporations in the study sample. This procedure resulted in the inclusion of a moderate number of additional facilities in each of the study years that could be assigned to parent corporations (and which otherwise would have been excluded from the analysis). As data for all of the environmental performance measures utilized in this study exist at the facility level, it was necessary to aggregate these measures to the firm level once facilities were assigned to parent corporations.

The reader should note that firm financial data obtained from Compustat are matched with firm environmental performance measures from the previous year in order to account for the lag from when TRI emissions occur and when they are eventually compiled and made available to the public and the regulated community. For example, in order to make a full observation, firm environmental performance measures for the year 2000 are compiled and subsequently combined with firm financial information from 2001, and so forth. Therefore, while data for environmental performance cover the time period 2000-2003, data related to firm financials cover the time period 2001-2004.

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21 EPA. The Emergency Planning and Community Right-to-Know Act: Section 313 Release and Other Waste Management Reporting Requirements.
22 Such a sample is generally referred to as a panel or longitudinal data set as there are multiple observations of the same entity over time.
Although the sample is not perfectly representative of the US manufacturing universe, it nevertheless consists of many of the largest firms in the US from diverse lines of business. Figure 1 shows the distribution of firms for the most prevalent industries in the study sample, where industries are categorized by two-digit SIC code. Table 1 provides a brief description of each of these SIC codes.

IV. Firm Financial and Environmental Performance Data

Financial Performance

The dependent variable employed in this analysis is firm financial performance, as reflected by the log of Tobin’s $q$. Tobin’s $q$ measures the market value of a firm relative to the replacement costs of its tangible assets. More generally, it represents what cash flows the market thinks a firm will provide per dollar invested in assets.\textsuperscript{24} It should be greater if future cash flows are expected to be larger or if they are expected to have less risk associated with them.\textsuperscript{25} Following King and Lenox (2001), this paper employs a simplified measure of Tobin’s $q$ which is calculated by dividing the sum of firm equity value, book value of long-term debt, and net current liabilities by the book value of total assets.\textsuperscript{26} The firm equity value is obtained by multiplying the year-end price of the common stock by the number of shares outstanding. Net current liabilities are found by subtracting current assets from current liabilities. The book value of long-term debt and total assets is taken directly from Compustat.

Controls

A number of measures commonly used in the analysis of financial performance are included as controls (Table 2). These measures are generally thought to influence firm market value directly, as well as indirectly through profitability.\textsuperscript{27} In particular, the following are included as control variables: sales growth, R&D intensity, firm size, age of firm assets, capital intensity, firm financial leverage, and industry dummy variables at the two-digit SIC code for the firm. These control variables are discussed in more detail below:

\textsuperscript{24} King and Lenox (2001)
\textsuperscript{25} ibid
\textsuperscript{26} ibid
\textsuperscript{27} Konar and Cohen (2001)
Sales growth – In this study sales growth (Sales Growth) is calculated as the annual percentage change in sales for a particular firm-year observation.

R&D intensity – This study utilizes the log of R&D intensity (R&D Intensity), where R&D intensity is calculated by dividing firm research and development expenses by total assets. It should be noted that data for firm R&D expenditures in Compustat is somewhat limited. To prevent dropping a significant number of observations for which data on R&D expenditures was missing, firms in industries for which a mean value for R&D expenditures could be calculated were assigned this mean value whenever possible. Firm-year observations that could not be assigned a mean industry value were dropped from the sample.

Firm size – The log of company assets is used to control for differences in firm size (Firm Size).

Age of firm assets – The log of the age of firm assets (Age of Assets) is used to control for the fact that firms with older equipment and technology may be less efficient and therefore less profitable than firms with newer technology.28 The age of firm assets is obtained by dividing the value of the property, plant and equipment of the firm (net of accumulated depreciation) by the gross value of property, plant and equipment.29

Capital intensity – The capital intensity of a firm (Capital Intensity) is calculated by dividing capital expenditures by sales.

Firm financial leverage – The degree to which a firm is leveraged (Leverage) is measured by its debt ratio, or the ratio of the firm’s total liabilities to its total assets.

Industry SIC dummy variables – Industry-wide effects on the market value of the firm are controlled for by including two-digit, SIC industry dummy variables. This controls for the possibility that a heavily polluting industry will require larger capital expenditures on pollution control equipment.30 In such a scenario one would expect a lower Tobin’s $q$ due to the fact that these expenditures will increase the replacement value of capital, but not firm market value.

Two important, yet omitted control variables are market share and advertising intensity. I was unable to control for firm market share because this variable because is not available through Compustat. It is important to note, though, that ideally one should control for this variable as firms with higher market shares have been found to have higher $q$ values.31 I was unable to include advertising intensity because data on firm

28 ibid
29 ibid
30 ibid
advertising expenditures in Compustat were scarce and the sample size would have been severely restricted. Ideally, one would control for this variable as well; advertising expenditures can lead to product differentiation and consumer loyalty. A number of studies have found a significant positive relationship between firm-level advertising expenditures and profitability.

Environmental Performance

Three measures of firm environmental performance are examined independently (Table 2). It is important to note that each of these measures, Total Emissions, Hazard Score and Relative Risk Score, are scaled by firm sales to account for differences in production. The first measure of environmental performance (Total Emissions) is total annual firm TRI emissions, measured in pounds. This measure is included to see if I can replicate previous findings in the literature of a negative correlation between firm TRI emissions and firm financial performance, using an updated data set. Data regarding annual pounds of facility TRI emissions were obtained from the EPA and subsequently aggregated to the firm level. As was mentioned previously, facilities must report pounds of TRI emissions for approximately 600 toxic chemicals. Reporting of toxic emissions is required by the Community Right to Know Law of 1986.

The other two measures of environmental performance make use of the EPA Office of Pollution Prevention and Toxics’ Risk-Screening Environmental Indicators (RSEI) model. The RSEI model provides a mechanism for assessing the relative impacts of releases of toxic chemicals using a risk-related perspective. This is a useful tool because chemicals have widely varying degrees of toxicity, move through the environment in different manners, and can impact different population segments with different degrees of severity. Therefore, pounds of TRI emissions is not necessarily a good metric for firm environmental performance because this measure does not provide information regarding the public health risks associated with these emissions. Although the RSEI model is by no means perfect, it is an attempt to more accurately represent the health risks posed by firm emissions.

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32 Konar and Cohen (2001)
34 The limitations of the RSEI model are addressed in the Appendix
The second measure of firm environmental performance (Hazard Score) can be thought of as a partially risk-adjusted emissions measure. In particular, this environmental performance measure weights facility emissions by the toxicity of the chemicals released, but does not include any exposure modeling or population estimates. As the RSEI model reports “hazard score” values at the facility level, these values must be aggregated to parent corporations as before in order to obtain a firm-level measure of environmental performance.

The final measure of firm environmental performance (Relative Risk Score) can be thought of as a fully risk-adjusted emissions measure. In particular, this measure expands upon Hazard Score by including exposure modeling and population estimates. A “relative risk score” is calculated for each chemical release from a facility and is the product of the chemical’s toxicity weight (the relative toxicity of the chemical per pound), the surrogate dose and the exposed population. The surrogate dose is found by combining exposure and chemical release volumes with physicochemical properties and site-specific characteristics to estimate an ambient concentration in the environmental medium of concern. The ambient media concentration is then combined with standard human exposure assumptions (both for adults and children) to estimate the magnitude of the dose.

The surrogate dose is determined for air releases, for example, by using a dispersion model over a grid of 101km x 101km around a facility. The surrogate dose is defined as the amount of a chemical to which a person in each 1km x 1km square of the grid would be exposed. The population in each square is determined by extrapolation between the 1990 and 2000 census databases. The “relative risk score” for a chemical release is calculated over all individuals in each 1km x 1km square. Therefore, the total “relative risk score” for a particular release is additive over all of the squares in the grid around the facility, and the “relative risk score” for a facility is additive over all of the “relative risk scores” for each chemical release in a year. As before, since “relative risk

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36 ibid
37 ibid
38 ibid
score” data are at the facility level, it is necessary to aggregate these values to parent corporations.

V. Empirical Approach

The three measures of environmental performance are examined in the context of three models for how the market may account for environmental performance (Table 3). In the “naïve” model (Levels) the key independent variable of interest is a firm’s level of environmental performance as represented by either Total Emissions, Hazard Score or Relative Risk Score. In reality, however, we would expect that investors utilize a more sophisticated approach in accounting for environmental performance, perhaps by examining changes in firm environmental performance or by comparing firm environmental performance to an “expected” value. The last two models are included to account for such scenarios.

In particular, in the second model (Changes) the key independent variable of interest is the annual change in a firm’s environmental performance, where the change in performance is captured by the change in Total Emissions, Hazard Score or Relative Risk Score. In the third model (Relative Performance) the key independent variable of interest is a firm’s deviation from its expected environmental performance given its size and the industry in which it operates. Using standard regression techniques I create “expected” values for firm environmental performance measures (as represented by Total Emissions, Hazard Score and Relative Risk Score), based on a firm’s size and its two-digit SIC code. The key independent variable of interest, therefore, is the difference between this “expected” level of environmental performance and a firm’s actual level of performance.

The reader should note that in the Relative Performance model, ideally the analysis should be performed at the facility level rather than the firm level. In particular, it is problematic to create an “expected” level of firm environmental performance based on two-digit SIC codes. Although a two-digit SIC code categorization may provide a good indication of the industry in which a firm conducts most of its operations, it does not capture all of the industries in which a firm may operate.

A potential way to avoid this problem would be to calculate the relative environmental performance of a facility as the deviation between observed and predicted
emissions, given the facility’s size (based on employees) and industry sector. It is much easier to define the particular industry segment of a facility than for a firm. To create a firm-level measure of relative environmental performance, one could calculate the weighted-average of the facility level scores, where the facility scores are weighted by the percentage of total production that each facility represents for the company.39 Ideally, this paper would have followed such a methodology but the necessary data were not available for the study years.

This paper employs two regression techniques, Ordinary Least Squares (OLS) and fixed effects, to find a linear relationship between the independent variables and a firm’s Tobin’s $q$. A fixed effects analysis allows me to control for omitted variables that differ between firms but which remain relatively constant over time. It essentially utilizes dummy variables that allow each firm to have a different constant value, as firms may differ in ways that are not captured by the independent variables.

VI. Results

Consistent with much of the “pays-to-be-green” literature, I find that aggregate firm TRI emissions (Total Emissions) are negatively correlated with financial performance (Table 4, Column 1) using OLS. Additionally, I find that environmental performance measures in which TRI emissions are adjusted for their relative health risks (Hazard Score and Relative Risk Score) are also negatively associated with financial performance (Table 4, Columns 2 & 3). In each case the coefficient for environmental performance is highly significant. However, in model 2 (Changes) and model 3 (Relative Performance) none of the environmental performance measures are significant (though they do have the expected sign).40 Consequently, although I do provide some evidence that environmental performance matters, both in terms of the level of emissions as well as the health risks associated with these emissions, it seems to matter in a somewhat myopic way. In particular, there is no evidence that changes in environmental performance or deviations between a firm’s observed and expected environmental performance matter. This is not the result one would necessarily expect.

39 King and Lenox (2001)
40 In the interest of brevity these results are not presented
I resolve this issue by using a fixed effects analysis. In particular, I again find a negative correlation between \textit{Total Emissions} and firm financial performance (Table 5, Column 1). Additionally, I find a negative correlation between changes in \textit{Total Emissions} and firm financial performance in model 2, though the effect is not significant (Table 5, Column 2). Finally, I also find a negative correlation between a firm’s deviation from its “expected” \textit{Total Emissions} and its financial performance (Table 5, Column 3). Thus, I am able to provide some evidence that firm emissions (unadjusted for their relative health risks) are negatively associated with a firm’s financial performance.

More importantly, two additional findings come out of the fixed effects analysis. The first is that environmental performance measures where TRI emissions \textit{are} adjusted for their relative health risks are negatively correlated with firm financial performance as well (Table 6, Rows 4-9). In particular, \textit{Hazard Score}, the change in \textit{Hazard Score} and a firm’s deviation from its “expected” \textit{Hazard Score} are all negatively associated with firm financial performance and are all significant. Additionally, \textit{Relative Risk Score}, the change in \textit{Relative Risk Score} and a firm’s deviation from its “expected” \textit{Relative Risk Score} are all negatively associated with firm financial performance, and two of the three are significant. These results suggest that the market \textit{does} take into account a pollution impact measure that reflects public health risks, rather than just aggregate TRI emissions.

The other significant finding that comes out of the fixed effects analysis is that when I control for time-consistent, firm-level characteristics, measures of environmental performance generally matter across all three models. Table 6 summarizes the effects of each of the environmental performance measures (on firm financial performance) for each of the three models. As one would expect that investors should be more concerned with changes in firm environmental performance or with observed environmental performance relative to “expected” performance, it is comforting that environmental performance measures are generally significant (or close to significant) for model 2 (\textit{Changes}) and model 3 (\textit{Relative Performance}).

Using OLS environmental performance measures are only significant for model 1 (\textit{Levels}). However, as fixed effects is the more appropriate regression technique, I
provide consistent statistical evidence across all three models that environmental performance does impact firm financial performance.

**VII. Summary and Conclusions**

In this paper, I explore further the relationship between firm environmental performance and financial performance. In particular, the objectives of this study are threefold: 1) to see if I can replicate previous findings in the literature of a negative association between TRI emissions and firm financial performance; 2) to examine the relationship between firm financial performance and TRI emissions adjusted for their relative health risks; and 3) to see if I can provide consistent evidence of a relationship between firm environmental and financial performance across a variety of specifications. In order to address these objectives I analyze three measures of environmental performance across three different models for how the market may account for environmental performance. I employ a panel dataset consisting mostly of US firms from the manufacturing sector from the time period 2000 to 2003.

Ultimately, I am able to replicate the negative association between TRI emissions (*Total Emissions*) and firm financial performance (Table 4, Column 1 & Table 5, Column 1). Moreover, once I employ a fixed effects analysis to reduce the potential for unobserved differences among firms to confound the results, I find that nearly all environmental performance measures have a statistically significant, negative impact on firm financial performance across all three models (Table 6). Therefore, I provide consistent statistical evidence that environmental performance matters.

A key finding is that the market does, in fact, take into account a pollution impact measure that reflects public health risks, rather than just aggregate TRI emissions (Table 6, Rows 4-9). This is an interesting result because much of the literature to date has focused simply on the quantity of air emissions of toxic chemicals. Despite the fact that TRI emissions data are much more widespread and readily available, it appears that the market is somehow able to capture the public health risks associated with these emissions. This is a comforting finding. If the market did not value such risk-adjusted emissions, then firms would have an incentive to only reduce the overall quantity of emissions without regard to risk. One can imagine a situation where a firm may lower its
overall emissions through a change in its inputs or production processes, but in so doing release more dangerous chemicals that have adverse health impacts to the surrounding community.

Although scholars had long assumed that investments to protect the natural environment provided few financial benefits to firms, in the last 20 years a growing number of researchers have challenged this assumption.\textsuperscript{41} In fact, many scholars now argue it is possible for firms to be both “green” and competitive.\textsuperscript{42} Though this research provides support for the “pays-to-be-green” hypothesis, the findings should be interpreted cautiously. In particular, I am not yet able to make any statements about the relative effect of the three environmental performance measures. Future research should seek to quantify the relationship between a pound of emissions and a unit of a firm’s \textit{Hazard Score} and \textit{Relative Risk Score}. A key question to be addressed here is the extent to which the environmental performance measures yield consistent economic results (as opposed to consistent statistical results).

Additionally, it is a challenge to draw on this study’s results to make specific policy recommendations for managers. A better understanding of firm-level differences would help yield a better understanding of the opportunities for profitable environmental improvement. It could be the case that it only pays for firms to reduce pollution by certain means and not others. Additionally, it may be the case that only firms with certain attributes can profitably reduce pollution.\textsuperscript{43}

\textsuperscript{41} King and Lenox (2001)
\textsuperscript{42} ibid
\textsuperscript{43} ibid
Figure 1. Distribution of Select Firms by Two-Digit SIC Code

Table 1. Industry SIC Codes

<table>
<thead>
<tr>
<th>Two-Digit SIC Code</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIC 13</td>
<td>Oil and gas extraction</td>
</tr>
<tr>
<td>SIC 20</td>
<td>Food products</td>
</tr>
<tr>
<td>SIC 26</td>
<td>Paper and allied products</td>
</tr>
<tr>
<td>SIC 28</td>
<td>Chemicals and allied products</td>
</tr>
<tr>
<td>SIC 29</td>
<td>Petroleum refining and related industries</td>
</tr>
<tr>
<td>SIC 30</td>
<td>Rubber and miscellaneous plastics products</td>
</tr>
<tr>
<td>SIC 33</td>
<td>Primary metal industries</td>
</tr>
<tr>
<td>SIC 34</td>
<td>Fabricated metal products (except machinery and transportation equipment)</td>
</tr>
<tr>
<td>SIC 35</td>
<td>Industrial and commercial machinery, and computer equipment</td>
</tr>
<tr>
<td>SIC 36</td>
<td>Electronic and other electrical equipment and components (except computer)</td>
</tr>
<tr>
<td>SIC 37</td>
<td>Transportation equipment</td>
</tr>
<tr>
<td>SIC 38</td>
<td>Measuring, analyzing and controlling instruments (including photographic and medical equipment)</td>
</tr>
</tbody>
</table>
Table 2. Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobin's q</td>
<td>Log of firm market valuation over replacement value of assets</td>
<td>0.26</td>
<td>0.68</td>
<td>-2.5</td>
<td>2.22</td>
<td>572</td>
</tr>
<tr>
<td>Sales Growth</td>
<td>1 year percentage change in sales</td>
<td>7.09</td>
<td>21.83</td>
<td>-56.58</td>
<td>235.73</td>
<td>573</td>
</tr>
<tr>
<td>R&amp;D Intensity</td>
<td>Log of research and development outlays over firm assets</td>
<td>-3.71</td>
<td>1.21</td>
<td>-7.91</td>
<td>-0.07</td>
<td>568</td>
</tr>
<tr>
<td>Firm Size</td>
<td>Log of firm assets</td>
<td>9.03</td>
<td>1.09</td>
<td>6.61</td>
<td>12.18</td>
<td>573</td>
</tr>
<tr>
<td>Age of Assets</td>
<td>Log of age of plant assets (PPE net / PPE gross)</td>
<td>-0.73</td>
<td>0.21</td>
<td>-1.48</td>
<td>-0.06</td>
<td>573</td>
</tr>
<tr>
<td>Capital Intensity</td>
<td>Log of capital expenditures over sales (in $ millions)</td>
<td>-3.14</td>
<td>0.71</td>
<td>-5.19</td>
<td>-0.21</td>
<td>573</td>
</tr>
<tr>
<td>Leverage</td>
<td>Ratio of total liabilities to total assets</td>
<td>0.6</td>
<td>0.19</td>
<td>0.1</td>
<td>1.21</td>
<td>573</td>
</tr>
<tr>
<td>Environmental Performance</td>
<td>Log of total firm emissions over firm sales (in $ millions)</td>
<td>4.96</td>
<td>2.41</td>
<td>-5.34</td>
<td>11.63</td>
<td>573</td>
</tr>
<tr>
<td>Hazard Score</td>
<td>Log of firm Hazard Score over firm sales (in $ millions)</td>
<td>11.9</td>
<td>4.29</td>
<td>-0.72</td>
<td>20.38</td>
<td>565</td>
</tr>
<tr>
<td>Relative Risk Score</td>
<td>Log of firm Relative Risk Score over firm sales (in $ millions)</td>
<td>-1.5</td>
<td>3.49</td>
<td>-16.29</td>
<td>6.36</td>
<td>565</td>
</tr>
</tbody>
</table>

Table 3. Three Models for How the Market Accounts for Firm Environmental Performance

<table>
<thead>
<tr>
<th>Environmental Performance Measure</th>
<th>Model 1 (Levels)</th>
<th>Model 2 (Changes)</th>
<th>Model 3 (Relative Performance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Emissions</td>
<td>Total Emissions</td>
<td>Δ Total Emissions</td>
<td>Total Emissions (deviation from expected value)</td>
</tr>
<tr>
<td>Hazard Score</td>
<td>Δ Hazard Score</td>
<td>Hazard Score (deviation from expected value)</td>
<td></td>
</tr>
<tr>
<td>Relative Risk Score</td>
<td>Δ Relative Risk Score</td>
<td>Relative Risk Score (deviation from expected value)</td>
<td></td>
</tr>
</tbody>
</table>
## Table 4. Variables Affecting Financial Performance (Tobin’s $q$)  
- OLS, Model 1

<table>
<thead>
<tr>
<th></th>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td>1 (Levels)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Environmental performance**
- Total Emissions: $-0.052^{***}$  (.013)
- Hazard Score: $-0.034^{***}$  (.007)
- Relative Risk Score: $-0.034^{***}$  (.008)

**Controls**
- Sales Growth: $0.0025^{**}$  (.0013)  
  $0.0027^{**}$  (.0013)  
  $0.0026^{**}$  (.0013)
- R&D Intensity: $0.026$  (.027)  
  $0.012$  (.027)  
  $0.016$  (.026)
- Firm Size: $0.002$  (.025)  
  $-0.007$  (.025)  
  $-0.005$  (.025)
- Age of Assets: $0.21$  (.132)  
  $0.222^{*}$  (.132)  
  $0.247^{*}$  (.135)
- Capital Intensity: $0.11^{**}$  (.044)  
  $0.08^{*}$  (.043)  
  $0.101^{**}$  (.045)
- Leverage: $-1.35^{***}$  (.168)  
  $-1.38^{***}$  (.169)  
  $-1.32^{***}$  (.172)

<table>
<thead>
<tr>
<th>n</th>
<th>568</th>
<th>560 +</th>
<th>560 +</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>.44</td>
<td>.45</td>
<td>.44</td>
</tr>
</tbody>
</table>

Note: SIC industry dummy variables are included but not presented. Standard errors are in parentheses.  
+ The sample is slightly smaller because RSEI cannot model the emissions of some facilities. Therefore, these facilities drop out of the sample.  
* significant at 10% level, ** significant at 5% level, *** significant at 1% level
Table 5. Variables Affecting Financial Performance (Tobin’s $q$)  
- Fixed Effects, Total Emissions

<table>
<thead>
<tr>
<th></th>
<th>Column 1 (Levels)</th>
<th>Column 2 (Changes)</th>
<th>Column 3 (Relative Performance)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td>Fixed effects</td>
<td>Fixed effects</td>
<td>Fixed effects</td>
</tr>
<tr>
<td><strong>Environmental performance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Emissions</td>
<td>-.077 ***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.021)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ Total Emissions</td>
<td>-.012</td>
<td>-.012</td>
<td>-0.057 ***</td>
</tr>
<tr>
<td>(0.023)</td>
<td></td>
<td>(0.023)</td>
<td>(.008)</td>
</tr>
<tr>
<td>Total Emissions (observed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Emissions (expected)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Controls</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales Growth</td>
<td>.0029 ***</td>
<td>.0051 ***</td>
<td>0.0025 ***</td>
</tr>
<tr>
<td>(0.006)</td>
<td>(.009)</td>
<td>(0.006)</td>
<td></td>
</tr>
<tr>
<td>R&amp;D Intensity</td>
<td>-.037</td>
<td>-.160 ***</td>
<td>-.043</td>
</tr>
<tr>
<td>(0.032)</td>
<td>(.041)</td>
<td>(0.042)</td>
<td></td>
</tr>
<tr>
<td>Firm Size</td>
<td>-.559 ***</td>
<td>-.597 ***</td>
<td>a</td>
</tr>
<tr>
<td>(0.074)</td>
<td>(.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of Assets</td>
<td>-.215</td>
<td>-1.311 ***</td>
<td>-0.32 *</td>
</tr>
<tr>
<td>(0.188)</td>
<td>(.241)</td>
<td>(.188)</td>
<td></td>
</tr>
<tr>
<td>Capital Intensity</td>
<td>.055</td>
<td>-.092 *</td>
<td>.055</td>
</tr>
<tr>
<td>(0.043)</td>
<td>(.052)</td>
<td>(.043)</td>
<td></td>
</tr>
<tr>
<td>Leverage</td>
<td>-.493 **</td>
<td>-.034</td>
<td>-.469 **</td>
</tr>
<tr>
<td>(0.194)</td>
<td>(.263)</td>
<td>(.194)</td>
<td></td>
</tr>
</tbody>
</table>

n 568 422 + 568  
Number of firms 146 146 146  
F stat 8.09 12.77 7.45  
R² .20 .37 .18

Note: SIC industry dummy variables are included but not presented. Standard errors are in parentheses. + The sample is slightly smaller because of the inclusion of lagged instruments. 

a Firm size is dropped from the regression as it is used to help predict “expected” environmental performance

* significant at 10% level, ** significant at 5% level, *** significant at 1% level
### Table 6. Summary of Effects of Environmental Performance Measures on Firm Financial Performance (Tobin’s q) - Fixed Effects

<table>
<thead>
<tr>
<th>Environmental performance measure</th>
<th>Fixed effects (Levels)</th>
<th>Fixed effects (Changes)</th>
<th>Fixed effects (Relative Performance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Emissions</td>
<td>-.077 ***</td>
<td>-.012</td>
<td>-.057 ***</td>
</tr>
<tr>
<td>(Expected value)</td>
<td>(.021)</td>
<td>(.023)</td>
<td>(.008)</td>
</tr>
<tr>
<td>Δ Total Emissions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Emissions (deviation from expected value)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazard Score</td>
<td>-.034 ***</td>
<td>-.017 *</td>
<td>-.015 ***</td>
</tr>
<tr>
<td>(Expected value)</td>
<td>(.012)</td>
<td>(.01)</td>
<td>(.002)</td>
</tr>
<tr>
<td>Δ Hazard Score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazard Score (deviation from expected value)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Risk Score</td>
<td>-.031 ***</td>
<td>-.014</td>
<td>-.024 ***</td>
</tr>
<tr>
<td>(Expected value)</td>
<td>(.011)</td>
<td>(.01)</td>
<td>(.004)</td>
</tr>
<tr>
<td>Δ Relative Risk Score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Risk Score (deviation from expected value)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: SIC industry dummy variables are included but not presented. Additionally, all regressions control for sales growth, R&D intensity, age of firm assets, capital intensity and leverage. Models 1 and 2 control for firm size as well. In Model 3 firm size is used to help calculate “expected” performance and is therefore dropped from the final regression. For the purpose of brevity coefficients for all these variables are not presented. Standard errors are in parentheses.

* significant at 10% level, ** significant at 5% level, *** significant at 1% level
Appendix. Limitations of the RSEI Model

The RSEI model is a screening tool that provides a risk-related perspective in assessing the relative impacts of releases of toxic chemicals. Risk-related results are modeled for releases and transfers to air and water. While RSEI facilitates risk-related comparison for different chemical releases, the reader should note that it does not provide a quantitative assessment of risk and is not designed as a substitute for more comprehensive, site-specific risk assessments. Additionally, there are a number of important considerations associated with each component of the model; the most important of which are described below.

- **Chemical releases**: RSEI utilizes facility-reported TRI data, some of which is known to contain reporting errors, to construct risk-adjusted emission scores. There are some releases in the TRI data that are likely erroneous but are still included because facilities have not submitted corrected reporting forms. Some of these releases may be associated with large risk-related impacts.

- **Imprecise data submitted by facilities**: For chemicals other than persistent and bio-accumulative toxics (PBTs), firms can choose to report a range of pounds released rather than the precise quantity, as long as the release is less than 1,000 pounds. In such cases, the EPA takes the midpoint of the range to calculate RSEI scores. Therefore, if the chemicals in question have large toxicity weights the facility’s risk-adjusted score could be substantially impacted.

- **Toxicity**: RSEI employs a Chronic Human Health model that only addresses chronic human toxicity (cancer and non-cancer effects) associated with long-term exposure and does not address acute human toxicity or environmental toxicity. In its estimation of reference doses and reference concentrations for non-cancer effects RSEI

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45 For the purpose of brevity not all considerations are presented here. For a more detailed description see the User’s Manual section of the RSEI CD, Version 2.1.3, September 2005.
47 Political Economy Research Institute, Corporate Toxics Information Project.
48 ibid
incorporates uncertainty factors which are reflected in toxicity weights based upon these values.  

Additionally, in some cases related chemicals are grouped together for TRI reporting purposes rather than being reported individually. In these instances, the RSEI model assigns a toxicity weight to the group as a whole although the toxicity of individual compounds within the group may vary. Therefore, depending on which compounds are released by the facility and which compound is used as the basis for the RSEI toxicity weight, the resulting RSEI score may overstate or understate true risks.

Finally, it should be noted that only 429 of the 612 chemicals and chemical categories in the TRI database have been assigned toxicity weights by EPA; the chemicals which have not yet been assigned a toxicity weight are not included in calculating RSEI scores. If these omitted chemicals are highly toxic, or if they represent a substantial fraction of the releases at a facility, their omission could substantially understate risk-related scores.

- **Exposure**: RSEI only estimates exposure levels; it does not yield actual exposure amounts. The model employs generic assumptions in certain instances related to such factors as stack heights, stack diameters, and exit gas velocities when facility-specific information is missing. Insofar as the actual values for these variables differ from those used in EPA’s calculations, the final risk-related scores will be affected. Finally, as was previously mentioned, risk-related results are only modeled for releases to air and water.

- **Population**: Population values incorporated in the model are estimated based on linear interpolations at the block level between the 1990 and 2000 U.S. Census dates, and on extrapolations back to 1988 and forward to 2002. Drinking water populations are estimated within the model by using the total drinking water populations associated with individual downstream water intakes.

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50 ibid
51 Political Economy Research Institute, Corporate Toxics Information Project.
52 ibid
53 ibid
54 ibid
56 ibid
57 ibid
58 ibid
- *Geographical limits of modeled dispersion*: The RSEI air-release model only accounts for impacts within an area that extends 50 kilometers in each direction from a facility. In the case of facilities with tall stacks, high exit velocities, and strong prevailing winds, there are likely to be impacts beyond this modeled area that are not included in the model.\(^5^9\) This problem may be most pertinent in the case of electric utilities.\(^6^0\)

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\(^5^9\) Political Economy Research Institute, Corporate Toxics Information Project.

\(^6^0\) ibid
References


Dowell, Glenn; Hart, Stuart and Yeung, Bernard. Do Corporate Global Environmental Standards Create or Destroy Market Value? Management Science, Volume 46, Number 8. 2000


White, Mark. *Corporate Environmental Performance and Shareholder Value*. University of Virginia Online Scholarship Initiative. [online].
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