# Does it *Really* Pay to be Green?
# An Empirical Study of Firm Environmental and Financial Performance

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Previous empirical work suggests that profitable firms tend to have high environmental performance, but questions persist about the nature of the relationship. Does stronger environmental performance really lead to better financial performance or is the observed relationship the outcome of some other underlying firm attribute? Does it pay to have clean running facilities or to have facilities in relatively clean industries? To explore these questions, we analyze 652 U.S. manufacturing firms over the time period 1987 to 1996. While we find evidence of an association between lower pollution and higher financial valuation, we find that a firm's fixed characteristics and strategic position might cause this association.

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Scholars had long assumed that investments to protect the natural environment provided few financial benefits to firms.  In the last 20 years, however, a growing number of researchers have challenged this assumption.  In the field of industry ecology, scholars argue that there are situations where beyond compliance behavior by firms is a win-win for both the environment and the firm (Nelson 1994; Panayotou and Zinnes 1994; Esty and Porter 1998; Reinhardt 1999).  Scholars now suggest that firms may be both "green and competitive" (Porter and van der Linde 1995; Reinhardt 1999). Qualitative research has identified numerous examples of profitable pollution prevention opportunities (Denton 1994; Deutsch 1998; Graedel and Allenby 1995; Porter and van der Linde 1995; King 1995).  Many scholars now argue that discretionary improvements in environmental performance often provide financial benefit (e.g. Hart 1997).

In response, a growing empirical literature has applied econometric techniques to test the "pays to be green" hypothesis. Several studies provide evidence that higher environmental performance is associated with better financial performance, but these early studies often lacked the longitudinal data needed to fully test the relationship. Several years of data are needed if one wants to rule out rival explanations for the apparent association or show that environmental improvement *causes* financial gain. Furthermore, the empirical literature does not clarify whether the apparent association is generated by a firm's choice to operate in cleaner industries or to operate cleaner facilities. Existing research cannot answer whether it pays to be green or whether it pays to operate in green industries.

In this paper, we review and comment on the empirical "pays to be green" literature. We discuss how a firm's stable attributes and strategic position may jointly cause both lower pollution levels and better financial performance, and thereby create the appearance of a direct relationship between the two. For example, innovative firms may have both lower emissions levels and greater profits. Alternatively, managers may choose to improve their firm's environmental performance when they have an especially profitable year.

To help distinguish the effect of pollution reduction from other underlying factors, we adopt empirical methods that account for unmeasured firm attributes. Furthermore, to differentiate between pollution reduction and divestiture of operations in dirtier industries, we separate environmental performance into two constructs: (1) relative performance within one's industries, and (2) the average performance of the industries in which one chooses to operate. We analyze 652 U.S. manufacturing firms over the time period 1987 to 1996. We find evidence of a real association between lower pollution and higher financial performance. We also show that a firm's environmental performance relative to its industry is associated with higher financial performance. However, we cannot show conclusively that a firm's choice to operate in cleaner industries is associated with better financial performance, nor can we prove the direction of the observed relationships. Thus, our research provides support for a connection between some means of pollution reduction and financial performance, but it also suggests that the connection should be viewed with caution.

## Evidence to Date

Proponents of a causal link between environmental and financial performance argue that pollution reduction provides future cost savings by increasing efficiency, reducing compliance costs, and minimizing future liabilities (Porter and van der Linde 1995; Reinhardt 1999). Porter and van der Linde (1995) theorize that opportunities for profitable pollution reduction exist because managers often lack the experience and skill to understand the full cost of pollution (Jaffe, Peterson et al. 1995). Hart (1997) proposes that excess returns (i.e., profits above the industry average) result from differences in the underlying fixed characteristics of firms and industries. Managers may possess unique resources or capabilities that allow them to employ profitable strategies that are difficult to imitate.

Using a variety of measures (See Tables 1 & 2), much of the empirical "pays to be green" literature has supported the proposed positive relationship between pollution reduction and financial gain by relying on correlative studies of environmental and financial performance. A series of studies conducted by the Council on Economic Priorities (CEP) in the 1970s found that expenditures on pollution control were significantly correlated with financial performance among a sample of pulp and paper firms (Bragdon and Marlin 1972; Spicer 1978).[i] More recently, Russo and Fouts (1997) found a significant positive correlation between various financial returns and an index of environmental performance developed by the Council on Economic Priorities. Dowell and colleagues (2000) found that firms that adopt a single, stringent environmental standard worldwide have higher market valuation (Tobin's q) than firms that do not adopt such standards.

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Insert Table 1 about here

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In the finance literature, a number of studies have examined the market returns of portfolios of environmentally friendly firms. Cohen and colleagues (1995) used several measures of environmental performance derived from U.S. EPA databases to construct two industry-balanced portfolios of firms.  They found no penalty for investing in the green portfolio and a positive return to green investing.  Similarly, White (1996) found a significantly higher risk-adjusted return for a portfolio of green firms using the CEP ratings of environmental performance.[ii]

To the extent that one cares merely about correlation and little about causation, these correlative studies are informative.  Market analysts, for example, increasingly gather environmental performance data as an indicator of future capital market returns (Kiernan 1998).  For their purposes, it matters little whether environmental performance leads to financial performance or simply provides an indicator of firms that have high financial performance.

From the perspective of corporate managers and policy analysts, however, the distinction is critical.  The prescription that often follows from the "pays to be green" literature is that managers should make investments to lower their firm's environmental

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impact (Hart and Ahuja 1996). To fully demonstrate that it "pays to be green", research must demonstrate that environmental improvements produce financial gain.

Event studies are one means of demonstrating that greening indeed causes financial gain. Such studies look at the relative changes in stock price following some environmental event. By isolating a single environmental event within a narrow time frame, event studies control for important differences among firms that cannot be observed. The limitation with event studies is that they often study the effect of events that are only partially environmental in nature. Klassen and McLaughlin (1996), White (1996), Karpoff and colleagues (1998), and Jones and Rubin (1999) study the effect of published reports of events and awards on firm valuation and find a relationship between the valence of the event (positive or negative) and the resulting change in market valuation. Blacconiere and Patten (1994) estimate that Union Carbide lost $1 billion in market capitalization, or 28%, following the Bhopal chemical accident in 1984. Muoghalu and colleagues (1990) found that firms named in lawsuits concerning improper disposal of hazardous waste suffered significant losses in capital market value. Each of these events has environmental elements, but they also are affected by other firm attributes. King and Baerwald (1998) argue the size, market power, and unique firm characteristics influence how events are reported and interpreted. A firm with good public relations may be able to put a positive spin on negative news. A firm that possesses good legal resources may better forestall lawsuits.

Some event studies seek to avoid these problems by using the annual release of toxic emission data through the U.S. EPA's Toxic Release Inventory (TRI) program as the "event". Hamilton (1995), Konar and Cohen (1997), and Khanna and colleagues

(1998) all find that polluting firms lost market value in a one-day window following the release of TRI information. These important studies still may suffer from construct validity however. Given the complexity of analyzing TRI data, it seems possible that same day stock price movements probably reflect contemporaneously reported pollution rankings. These rankings are strongly affected by firm size and industry choice and thus the stock market effect may be the result of temporary bad press rather than a real change in perception of a firm's long-term value. Perhaps for this reason, these TRI event studies showed only weak and inconsistent evidence in a 5-day window following the TRI data release.

Another way to account for unobserved firm differences is to use standard regression techniques to evaluate the effect of *changes* in pollution on *changes* in financial performance. This in essence is the approach used in a widely cited study by Hart and Ahuja (1996). They show that changes in pollution (emission per sales dollar) predate changes in financial performance. While an important advance in the literature, their measure of environmental performance conflates reduction of pollution at current operations and divestiture of dirty operations, making it difficult to interpret the meaning of their study. Is it that it pays to be green or does it pay to operate in clean industries?

This issue underscores a larger debate within the strategy literature on the source of returns in excess of investments of similar risk (Rumelt 1991; McGahan & Porter 1997). The industrial organization literature out of economics suggests that excess returns result from differences in the underlying structure of industries. According to this logic, greener industries may have higher returns than dirtier industries because of lower compliance and regulatory costs. In contrast, the resource-based

view of strategic management suggests that individual firm capabilities may lead to

excess returns when they are difficult to imitate, not substitutable, rare, and valuable

(Barney 1986; Wernerfelt 1984).  According to this view, superior ability to manage

environmental problems relative to others in your industry may lead to higher returns.

Much of the empirical "pays to be green" literature uses strategy resource-based logic

to justify a relationship between environmental and financial performance.

Unfortunately, they fail to disentangle the effects of industry choice from the effects of

variance in environmental strategies amongst firms in the same industry.


## An Empirical Approach

In the following sections, we analyze whether it really "pays to be green" using a

methodology that allows us to explore whether unmeasured firm and industry

characteristics may explain the observed link between environmental and financial

performance.  We also use a measure of environmental performance that untangles the

effect of a firm's relative performance within its industries and the average performance

of the industries in which it chooses to be.

We create a sample of publicly traded U.S. manufacturing firms during the period

1987-1996 by combining the U.S. EPA's Toxic Release Inventory (TRI) with facility data

from Dun & Bradstreet and corporate data from Standard & Poor's Compustat

database.   The U.S. EPA started the TRI in 1987 to track emissions of over two

hundred toxic chemicals from U.S. manufacturing firms.  Facilities must complete

annual TRI reports if they manufacture or process 25,000 pounds (or about 11,340

kilograms), use more than 10,000 pounds of any listed chemical during a calendar year,

and employ ten or more full-time people.  To be in our sample, a firm must have at least one facility that meets these requirements and be among the public corporations listed in the Compustat database.  Matching the two sets, we created an unbalanced sample of 652 firms constituting 4483 firm-year observations for the years 1987 to 1996. [iii]

## *Measures*

**Financial Performance**. The dependent variable for our analysis is financial performance as reflected by Tobin's q. Tobin's q measures the market valuation of a firm relative to the replacement costs of tangible assets (Lindenberg & Ross, 1981). Essentially, it reflects what cash flows the market thinks a firm will provide per dollar invested in assets.  It should be higher if future cash flows are expected to be greater or if they are expected to be less risky.   In accordance with more recent "pays to be green" studies, we use a simplified measure of Tobin's q (Dowell, Hart, & Yeung 2000). We calculate *Tobin's q* 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.[iv]  All financial data were obtained from the Compustat database.  .

**Environmental Performance.**  Previous research has measured the environmental performance of a firm as the degree to which that firm emits toxic pollution given its size (Hart & Ahuja 1996).  We create a similar measure (*Total Emissions*) by calculating the log of total facility emissions of toxic chemicals . Unfortunately, the meaning of this variable is ambiguous because it confounds pollution that results from industry positioning with pollution that results from poor environmental management.  Consequently, we form two additional variables to separate the effect of

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environmental management from the effect of industry positioning. *Relative Emissions* measures the firm's ability to manage and reduce its pollution by comparing the degree to which a firm's facilities are more or less polluting than other facilities in the same industry (measured by 4 digit SIC code and adjusted for differences in size). *Industry Emissions* measures the degree to which a firm tends to operate in industries where production entails pollution. If a firm operates in industries where the average facility has higher emissions, this variable will have a larger value. Please refer to the Appendix for a detailed description of the construction of these variables.

**Controls.** We include a number of measures commonly used in the analysis of financial performance as controls. These measures include 1) the company's size (*Firm Size*) calculated as the log of the company's assets, 2) the capital intensity of a firm (*Capital Intensity*) calculated by dividing capital expenditures by sales, 3) the annual growth of the firm (*Growth*) calculated as the percentage change in sales, 4) the degree to which the firm is leveraged (*Leverage*) divided as the ratio of its debt to assets, and 5) the R&D intensity (*R&D Intensity*) calculated by dividing research & development expenses by total assets.

In addition, we control for the stringency of the regulatory environment in which the firm operates (*Regulatory Stringency*). Environmental regulation varies across regions and imposes greater (or lesser) penalties for pollution from facilities operating in those regions. We measure a state's regulatory stringency by calculating the inverse of the log of toxic emissions divided by total employees in four main polluting industries – chemicals, petroleum, pulp & paper, and materials processing (Meyer 1995). The logic for this measure is that higher regulation leads to lower emissions per employee (for

these industries) and thus increases the inverse of this ratio (*Regulatory Stringency*).

For each firm, we create a measure of the average regulation it faces by calculating the

weighted-average of the regulatory stringency for all the states in which the firm

operates.

To create an alternative measure of the degree to which the different facilities in

our sample are regulated, we count the number of performance criteria with which each

facility must comply (*i.e.*, the number of permits issued to a facility). Under the U.S.

Clean Water Act, regulators may impose limits on water flow, suspended solids, and

chemical concentration. Although guidelines exist for administering the law, substantial

discretionary power remains.  We created an alternative measure of regulatory

stringency, *Permits*, by summing the number of federal permits and then dividing by

firm size.

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Insert Table 3 about here

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## Results

Previous studies have found that pollution precedes poor financial performance

by one or more years (Hart & Ahuja, 1996).  To test these findings, we use least-

squares regression analysis to find a linear relationship between our independent

variables and the firm's <u>future</u> *Tobin's q* (See Table 4).[v]  Because firms may differ in

ways that we do not capture with our independent variables, we include dummy

variables that allow each firm to have a different constant value.  This is often called a

"fixed effects" analysis because it reduces the possibility that a firm's fixed attributes

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confounds the analysis. In essence, this fixed-effect regression requires that *changes* in independent variables (rather than their baseline level) be associated with changes in dependent variables.

Consistent with much of the "pays to be green" literature, we find that *Total Emissions* are associated with superior financial performance even when controlling for firm fixed effects (Model 1). Thus, we provide evidence that environmental performance is associated with financial performance rather than the observed relationship being the outcome of some other underlying firm attribute.

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Insert Table 4 about here

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As discussed earlier, evidence of such a relationship still leaves many unanswered questions. Does it pay to have clean running facilities, or to have facilities in relatively clean industries? To better account for these differences, we separate *Total Emissions* into two parts that reflect a firm's tendency to operate in polluting industries (*Industry Emissions*) and its tendency to operate dirtier facilities within these industries (*Relative Emissions*). In Model 2, the significant and negative coefficient for *Relative Emissions* indicates that firms with lower emissions in their industries tend to experience higher financial performance in the subsequent year. The lack of significance for the coefficient for *Industry Emissions* means that we cannot conclude that firms that operate in cleaner industries have higher financial performance.

One problem with fixed effects analysis is that it can do its job too well. By eliminating the effect of all firm attributes that are relatively constant, the fixed effect

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may obscure evidence that a fixed attribute is actually important.  If firms do not frequently change industry, and thus industry position is relatively constant, we might miss the financial effect of industry choice.  To check this, we use an alternative specification called random effects.  While this method continues to reduce the effect of fixed firm attributes, it assumes that these are normally distributed.  This method suggests that firms that operate in cleaner industries (*Industry Emissions*) have higher financial performance.

What might explain the difference between Model 3 and Model 2?  One possibility is that few firms in our sample actually move across industries and thus the fixed effects analysis removes the effect of industry position.  Another possibility is that firms benefit from being in cleaner industries, but not from *moving* to cleaner industries. Perhaps such movement entails costs that reduce a firm's valuation or signals some difficulty or problem.  It is important to note that in our particular case, statistical tests suggest that the fixed effects and not random effects analysis should carry more credence.[vi]

Finally, we still have not considered the effect of causality.  Which way does the relationship run?  Do more profitable firms invest more in environmental performance or does environmental performance lead to profit?  In Model 4, we present one method for answering this question.  To reduce the effect of a previous profitable year, we include the previous year's Tobin's q in the regression.[vii]  Unfortunately, this analysis does not provide reliable evidence that firms with lower emissions in their industries (*Relative Emissions*) tend to experience higher financial performance.  Thus, while we find evidence of an association between reduced emissions and profit, we can not say with

confidence which way the relationship runs. We again find no evidence that the cleanliness of the industries in which the firm has facilities (*Industry Emissions)* is associated with higher market valuation when we control for firm fixed effects.

The above analysis is illustrative of what we found throughout our analysis. Using different forms of models and different methods for measuring our variables, we often found an association between environmental and financial performance. However, we also found that variations in model specification, sample, and measurement method could reduce the significance of this effect below accepted thresholds (although it never reversed in sign). We have presented the most careful and complete specification of our analyses.

## Conclusions

In this paper, we further explore whether it "pays to be green". We use longitudinal data and statistical methods that reduce the potential for unobserved differences among firms to create a misleading association between environmental and financial performance. We also test to see whether pollution reduction causes financial gain. Table 5 presents a summary of these results. We find evidence of an association between pollution reduction and financial gain, but we cannot prove the direction of causality. We also show that firms in cleaner industries have higher Tobin's q, but we are unable to rule out possible confounding effects from fixed firm attributes. Moreover, we cannot show that firms that move to cleaner industries improve their financial performance.

Our research provides both additional support for the "pays to be green" hypothesis and suggests caution in interpreting its implications. Much of the variance in our study is attributed to firm level differences. Better understanding of these differences might provide a richer understanding of profitable environmental improvement. It may be that it pays to reduce pollution be certain means and not others. Alternatively, it may be that only firms with certain attributes can profitably reduce their pollution.

Additional research is needed to explore how underlying firm characteristics affect the relationship between relative environmental performance and financial performance. The relationship between underlying capabilities and environmental management is likely to be complex and contingent. Environmental management and other capabilities may prove to be complementarities. Depending on industrial conditions, different bundles of capabilities may be important. Our research suggests that firm attributes and different strategies for environmental improvement may moderate the apparent link. It suggests that "*When* does it pay to be green" may be a more important question than "does it pay to be green".

# References

Barney, J. 1986. Strategic factor markets: Expectations, luck, and business strategy. *Management Science.* 32(10): 1231-1241.

Blacconiere, W. G. and D. M. Patten. 1994.  Environmental disclosures, regulatory costs, and changes in firm value.  *Journal of Accounting and Economics.* 8: 357-77.

Bragdon, J.H. and J. Marlin. 1972. Is pollution profitable? *Risk Management.* 19(4).

Chen, K. and R.W. Metcalf. 1980. The relationship between pollution control records and financial indicators revisited. *Accounting Review.* 55:168-180.

Cohen, M., S. Fenn, and J. Naimon. 1995. Environmental and financial performance: Are they related? *Working paper*, Vanderbilt University.

Denton, K. 1994. *Enviro-Management:  How Smart Companies Turn Environmental Costs into Profits.* Boston: Prentice Hall.

Deutsch, C. H. 1998. For Wall Street, increasing evidence that green begets green. *The New York Times.* July 19, 1998.

Dowell, G., S. Hart, and B. Yeung. 2000. Do corporate global environmental standards create or destroy value? *Management Science.*  46(8):1059-1074.

Esty, D. and M. Porter. 1998.  Industrial ecology and competitiveness: strategic implications for the firm.  *Journal of Industrial Ecology.* 2(1):35-43.

Graedel, T. E., and Allenby, B. R. 1995. *Industrial Ecology.* Englewood, NJ: Prentice Hall.

Hamilton, J. 1995. Pollution as news: Media and stock market reactions to the toxic release inventory data.  *Journal of Environmental Economics and Management.* 28:98-113.

Hart, S. and G. Ahuja. 1996. Does it pay to be green? An empirical examination of the relationship between emission reduction and firm performance. *Business Strategy and the Environment.* 5:30-37.

Hart, S. 1997. Beyond greening: Strategies for a sustainable world. *Harvard Business Review.* 75(1): 66.

Jaffe, A. B., S. R. Peterson, et al. (1995). "Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us?" *Journal of Economic Literature* 33: 132-163.

Jones, K. and P. Rubin. 1999. Effects of harmful environmental events on reputations of firms. *Working paper*, Emory University.

Karpoff, J., J. Lott, and G. Rankine. 1998. Environmental violations, legal penalties, and reputation costs. *Working paper*, Social Science Research Network.

King, A. 1995. Innovation from differentiation: Pollution control departments and innovation in the printed circuit industry. *IEEE Transactions on Engineering Management.* 42(3): 270-277.

King, A. and Baerwald, S. 1998. Greening arguments: Opportunities for the strategic management of public opinion. In *Better Environmental Decisions: Strategies for Governments, Businesses and Communities* edited by K. Sexton et. al. Washington, D.C.: Island Press.

King, A. and M. Lenox. 2000. Industry self-regulation without sanctions: The chemical industry's Responsible Care Program. *Academy of Management Journal, 43(4):* 698-716.

Khanna, M., W. R. Quimio, et al. (1998). "Toxic Release Information: A Policy Tool for Environmental Protection." *Journal of Environmental Economics and Management* 36: 243-266.

Kiernan, M. 1998. The eco-efficiency revolution. *Investment Horizon.* April: 68-70.

Klassen, R. and C. McLaughlin. 1996. The impact of environmental management on firm performance. *Management Science.* 42:1199-1214.

Konar, S. and M. Cohen (1997). "Information as Regulation: the Effect of Community Right to Know Laws on Toxic Emissions." *Journal of Environmental Economics and Management* 32: 109-124.

Lindenberg, E. and S. Ross. 1981. Tobin's q ratio and industrial organization. *Journal of Business.* 54(1):1-32.

McGahan, A. and M. Porter. 1997. How much does industry matter, really? *Strategic Management Journal.* July: 5-30.

Meyer, S. 1995. The economic impact of environmental regulation. *Journal of Environmental Law & Practice.* 3(2): 4-15.

Muoghalu, M., H. D. Robinson, and J. Glascock. 1990. Hazardous waste lawsuits, stockholder returns, and deterrence. *Southern Economic Journal.* 57:357-370.

Nehrt, C. 1996. Timing and intensity of environmental investments. *Strategic Management Journal.* 17: 535-547.

Nelson, K.  1994.  Finding and implementing projects that reduce waste. In *Industrial Ecology and Global Change* edited by Socolow et al..  New York: Cambridge University Press.

Panayotou, T. and C. Zinnes.  1994.  Free-lunch economics for industrial ecologists. In *Industrial Ecology and Global Change* edited by Socolow et al..  New York: Cambridge University Press.

Porter, M. and C. van der Linde. 1995. Green and competitive. *Harvard Business Review*.  September-October 1995: 121-134.

Reinhardt, F. 1999. Market failure and the environmental policies of firms. *Journal of Industrial Ecology*. 3(1): 9-21.

Rumelt, R. 1991. How much does industry matter? *Strategic Management Journal*.12: 167-185.

Russo, M. and P. Fouts. 1997.  A resource-based perspective on corporate environmental performance and profitability.  *Academy of Management Journal*. 40: 534-559.

Spicer, B.H. 1978. Investors, corporate social performance, and informational disclosure: An empirical study. *Accounting Review*. 53: 94-103.

Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management Journal*. 9:441-454.

White, M. 1995.  The performance of environmental mutual funds in the United States and Germany: Is there economic hope for 'green' investors?  *Research in Corporate Social Performance and Policy Supplement*. 1:325-346.

White, M. 1996.  Corporate environmental performance and shareholder value. *Working paper*, University of Virginia.

## Appendix - Environmental Performance Measures

To correct for differences in toxicity between emitted chemicals, we follow King & Lenox (2000) and weight each chemical by its toxicity using the "reportable quantities" (RQ) database in the CERCLA statute. We construct aggregate releases for a given facility in a given year ($E_{it}$) by summing the weighted releases of the 246 chemicals that have been consistently a part of the TRI database.

$$E_{it} = \sum_{\forall c} w_c e_{cit} \tag{1}$$

where $E_{it}$ is aggregate emissions for facility $i$ in year $t$, $w_c$ is the toxicity weight for chemical $c$ in year $t$, and $e_{ci}$ is the pounds of emissions of chemical $c$.

Following King & Lenox (2000), we measure relative environmental performance at the facility level by estimating production function relationship between facility size and aggregate toxic emissions for each 4-digit Standard Industrial Classification (SIC) code within each year using standard OLS regression. The relative environmental performance of a facility ($RE_{it}$) is given by the standardized residual, or deviation, between observed and predicted emissions given the facility's size and industry sector. We must use employees to measure facility size because we have no measure of production units or sales at the facility level. Thus, if a facility emits more than predicted given its size and SIC code, it will have a positive residual and a positive score for environmental impact. We estimate a production function for each industry.

$$E_{it} = e^{\alpha_{jt}} \, s_{it}^{\beta_{1jt}} \, s_{it}^{\ln(s)^* \beta_{2jt}} \, e^{\varepsilon_{jt}} \tag{2}$$

$$\ln E_{it} = \alpha_{jt} + \beta_{1jt} (\ln s_{it}) + \beta_{2jt} (\ln s_{it})^2 + \varepsilon_{jt} \tag{3}$$

$$RE_{it} = e^{(\ln E_{it} - \ln E^*_{it})} \tag{4}$$

where $E^*_{it}$ is predicted emissions for facility $i$ in year $t$, $s_{it}$ is facility size, and $\alpha_{jt}, \beta_{1jt}$, and $\beta_{2jt}$ are the estimated coefficients for sector $j$ in year $t$.

To create a firm-level measure of relative environmental performance, we calculate the weighted-average of the facility-level scores.  We weighted the scores by the percentage of total production that each facility represented for the company.

$$Relative\ Emissions_{nt} = \text{Log} \sum_{\forall i \text{ in } n} (s_{it}/s_{nt}) RE_{it} \qquad (5)$$

where $s_{it}$ is facility $i$ size in year $t$, and $s_{nt}$ is firm size.

With the above data in hand, we can differentiate performance within an industry (*Relative Emissions*) from the degree to which a firm chooses to operate in dirty or clean industries (*Industry Emissions*).  We calculated the dirtiness of the sector as the total emissions for the sector divided by the total number of employees in the sector, i.e., emissions per employee.  We create our firm-level measure (*Industry Emissions*) of the firm's tendency to operate in dirty or clean industry sectors by aggregating the dirtiness of the sectors in which a company owns a facility.  In performing this aggregation, we use a weighted-average, using the percentage of the company's total production in each sector for weights.

$$IE_{nt} = \ln\left(\sum_{\forall i \text{ in } n} (s_{it}/s_{nt}) E_{jt}\right) \qquad (6)$$
$$E_{jt} = \sum_{\forall i \text{ in } j} E_{it}$$

where $IE_{nt}$ is weighted industry emissions for firm $n$ in year $t$, and $E_{jt}$ is total toxicity-weighted emissions per employee for industry $j$ in year $t$.

**TABLE 1**
**Measures of Corporate Financial Performance Used**
**in 'Pays to be Green' Scholarship**

| Measure | Description | Examples |
|---|---|---|
| Tobin's q | Firm market valuation over replacement value of assets | Dowell et. al. (2000) |
| Return on Assets | The ratio of income to total assets | Hart & Ahuja (1996), Russo & Fouts (1997) |
| Return on Equity | The ratio of income to firm equity | Hart & Ahuja (1996), Russo & Fouts (1997) |
| Return on Investment | The ratio of operating income to book value of assets. | Hart & Ahuja (1996), Russo & Fouts (1997) |

**TABLE 2**
**Measures of Corporate Environmental Performance Used**
**in 'Pays to be Green' Scholarship**

| Measure | Examples |
|---|---|
| Capital Expenditures on pollution control technology | Spicer (1978), Nehrt (1996) |
| Emissions of toxic chemicals (typical source: TRI) | Hamilton (1995), Hart & Ahuja (1996) |
| Spills and other plant accidents | Karpoff et. al. (1998) |
| Lawsuits concerning improper disposal of hazardous waste | Muoghalu et. al. (1990) |
| Rewards or other recognition for superior environmental performance | Klassen & McLaughlin (1996) |
| Participation in Environmental Management Standards | White (1996), Dowell et. al. (2000) |
| Rankings of superior environmental performers (e.g. CEP) | White (1996), Russo & Fouts (1997) |

## TABLE 3a
## Descriptive Statistics

| Variable | Description | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Tobin's q | Firm market valuation over replacement value of assets | 1.58 | 0.94 | 0.28 | 12.67 |
| Total Emissions | Log of total emissions of facilities | 5.82 | 3.28 | 0.00 | 13.76 |
| Relative Emissions | Average relative emissions of facilities based on sector and size (in employees) | 0.21 | 0.77 | -7.08 | 9.41 |
| Industry Emissions | Average total emissions per employee of sectors in which the firm operates | 0.22 | 0.50 | -1.80 | 1.62 |
| Firm Size | Natural log of firm assets | 6.27 | 1.94 | 0.76 | 12.52 |
| Capital Intensity | Capital expenditures over sales | 0.07 | 0.06 | 0.00 | 1.19 |
| Growth | Percent change in sales | 0.12 | 0.44 | -0.91 | 13.36 |
| R&D Intensity | Research and development outlays over firm assets | 0.04 | 0.04 | 0.00 | 1.03 |
| Leverage | The ratio of debt to firm assets | 0.18 | 0.16 | 0.00 | 1.93 |
| Regulatory Stringency | The regulatory stringency of the states the firm operates | 0.51 | 0.84 | 0.00 | 7.01 |
| Permits | The number of firm CWA and RCRA permits over firm size | 0.49 | 0.74 | 0.00 | 5.95 |

Note: $n = 4483$

## TABLE 3b
## Correlations

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Tobin's q | 1.00 | | | | | | | | | | |
| 2. Total Emissions | -0.12 * | 1.00 | | | | | | | | | |
| 3. Relative Emissions | -0.04 | 0.46 * | 1.00 | | | | | | | | |
| 4. Industry Emissions | -0.09 * | 0.38 * | -0.08 * | 1.00 | | | | | | | |
| 5. Firm Size | -0.02 | 0.49 * | 0.09 * | 0.05 | 1.00 | | | | | | |
| 6. Capital Intensity | 0.17 * | -0.01 | -0.03 | 0.03 | 0.11 * | 1.00 | | | | | |
| 7. Growth | 0.14 * | -0.05 * | -0.03 | -0.01 | -0.06 * | 0.05 * | 1.00 | | | | |
| 8. R&D Intensity | 0.28 * | -0.15 * | -0.07 * | 0.00 | -0.05 | 0.17 * | 0.04 | 1.00 | | | |
| 9. Leverage | -0.19 * | 0.09 * | 0.06 * | -0.01 | 0.07 * | -0.02 | 0.01 | -0.23 * | 1.00 | | |
| 10. Regulatory Stringency | 0.00 | 0.30 * | 0.05 * | 0.13 * | 0.22 * | 0.13 * | -0.03 | -0.09 * | 0.09 * | 1.00 | |
| 11. Permits | -0.11 * | 0.55 * | 0.10 * | 0.07 * | 0.48 * | -0.01 | -0.06 * | -0.15 * | 0.06 * | 0.27 * | 1.00 |

Note: $n = 4483$, * $p < 0.001$

**TABLE 4**
**Estimates of Future Financial Performance (*Tobin's q $_{t+1}$*)**
**1987-1996**

| *Method:* | Fixed Effects | Fixed Effects | Random Effects | IV & Fixed Effects |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| **Total Emissions** | **-0.021 \*\*** <br> **(0.008)** | | | |
| **Relative Emissions** | | **-0.036 \*** <br> **(0.018)** | **-0.029 +** <br> **(0.017)** | **-0.032** <br> **(0.021)** |
| **Industry Emissions** | | **-0.027** <br> **(0.049)** | **-0.076 \*** <br> **(0.037)** | **-0.083** <br> **(0.021)** |
| *Controls* | | | | |
| Firm Size | -0.219 \*\*\* <br> (0.030) | -0.219 \*\*\* <br> (0.030) | -0.034 \* <br> (0.014) | -0.238 \*\*\* <br> (0.057) |
| Capital Intensity | -0.420 \* <br> (0.198) | -0.416 \* <br> (0.198) | -0.147 <br> (0.187) | -1.645 \*\*\* <br> (0.222) |
| Growth | 0.053 \* <br> (0.022) | 0.053 \* <br> (0.023) | 0.068 \*\* <br> (0.022) | -0.036 <br> (0.022) |
| R&D Intensity | 3.429 \*\*\* <br> (0.535) | 3.377 \*\*\* <br> (0.535) | 5.062 \*\*\* <br> (0.408) | 1.094 <br> (0.577) |
| Leverage | -0.153 <br> (0.101) | -0.152 <br> (0.101) | -0.330 \*\*\* <br> (0.090) | 0.149 <br> (0.110) |
| Regulatory Stringency | 0.108 <br> (0.071) | 0.111 <br> (0.071) | 0.080 \* <br> (0.032) | 0.035 <br> (0.107) |
| Permits | -0.061 <br> (0.045) | -0.069 <br> (0.045) | -0.060 + <br> (0.032) | -0.090 <br> (0.054) |
| *Tobin's q* | | | | -0.321 \*\*\* <br> (0.101) |
| n | 4483 | 4483 | 4483 | 3130 [a] |
| Number of Firms | 652 | 652 | 652 | 544 |
| F Stat | 24.36 \*\*\* | 22.80 \*\*\* | | |
| $\chi^2$ Stat | | | 505.30 \*\*\* | 255.09 \*\*\* |
| Adj. $R^2$ | 0.667 | 0.667 | 0.714 | 0.756 |

[a] The sample is slightly smaller due to the inclusion of lagged instruments.
Firm and year dummies are included but not presented in all models.
Standard errors are in parenthesis.
[+] $p < 0.10$, \* $p < 0.05$, \*\* $p < 0.01$, \*\*\* $p < 0.001$ (two-tailed test)

**TABLE 5**
**Summary of Findings**

| Variable | Description | Result |
| --- | --- | --- |
| Total Emissions | Log of total emissions of facilities | Associated with financial performance but direction of the relationship uncertain. |
| Relative Emissions | Emissions relative to other facilities of similar sector and size | Associated with financial performance but direction of the relationship uncertain. |
| Industry Emissions | Emissions per employee for the sectors in which the firm operates | Apparent but possibly spurious association with financial performance. Direction of effect uncertain. |

# Endnotes

[i] Interestingly, a follow-up study by Chen and Metcalf (1980) found that the effect disappeared when the analysis corrected for differences in size.

[ii] In contrast, White (1995) found that a group of six mutual funds that employed environmentally responsible screens performed *worse* than the S&P 500 in both nominal and risk-adjusted terms. White resolved the contradiction between the two findings by concluding that environmental performance and financial performance are indeed correlated but managers of environmentally oriented mutual funds are less skilled than managers of other funds.

[iii] Such a sample is often referred to as a panel or longitudinal data set since we have multiple observations of the same entity over time.

[iv] We did not use the more complicated measure of *Tobin's q* as proposed by Lindenberg & Ross (1981) because past research in this domain has found little qualitative difference between this measure and the simplified version used in this analysis (Dowell, Hart, & Yeung, 1998). We chose to use *Tobin's q* rather than accounting measures of financial performance, such as return on assets (ROA) or return on sales (ROS), because *Tobin's q* reflects expected future gains.

[v] OLS is a technique for estimating the parameters of a mathematical model by minimizing the square of the difference between actual data and the predicted model.

[vi] Performing a Hausman test on the random effects model suggests that a random-effects specification is recommended over a fixed-effects specification.

[vii] Estimating the model with a lagged dependent variable increases the likelihood of serial correlation. We use an instrumental variables approach to correct for this potential problem. The lagged values of the exogenous regressors are used as instruments. These regressors have the desirable property that they will not be correlated with the error but will be correlated with the lagged value of the dependent variable (Kennedy 1993).