The Relationship between Pollution Control Record and Financial Indicators Revisited
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Comments

The Relationship Between Pollution Control Record and Financial Indicators Revisited

Kung H. Chen and Richard W. Metcalf

A RECENT study [Spicer, 1978] highlighted the responsiveness of firms to corporate social responsibility and important financial indicators in stock investment decisions. That study purported to test the relationship of pollution indices to five financial indicators. The five financial indicators used were: (1) profitability, as measured by the ratio of income available to common stock equity; (2) size, as measured by the total assets; (3) total risk, as measured by the standard deviation of periodic stock return; (4) systematic risk, as measured by individual security contribution to portfolio risk, represented by a portfolio index (Standard and Poor's Composite Price Index); and (5) price/earnings ratio.

Directional hypotheses were tested. Through non-parametric testing procedures, Spicer concludes that there is evidence substantiating existence of a moderate to strong association between the investment value of a company's common shares and its social performance record:

> Specifically, it was found that, for a sample drawn from the pulp and paper industry, companies with better pollution-control records tend to have higher profitability, larger size, lower total risk, lower systematic risk and higher price/earnings ratios than companies with poorer pollution-control records [Spicer, 1978, p. 109].

Unfortunately, the result is still not as strong as expressed in Spicer's statement. The purpose of this paper is to show (1) that the evidence is not as definitive as Spicer indicated, and (2) that the evidence rests on spurious relationships created through one or more intervening variables. The reported significant associations might not have been observed had the effect of intervening variables been controlled (or adjusted). An outline on constructing a model, based upon statistical relationships, is presented to facilitate discussion. This is followed by an analysis of the relationship among variables included in Spicer's study.

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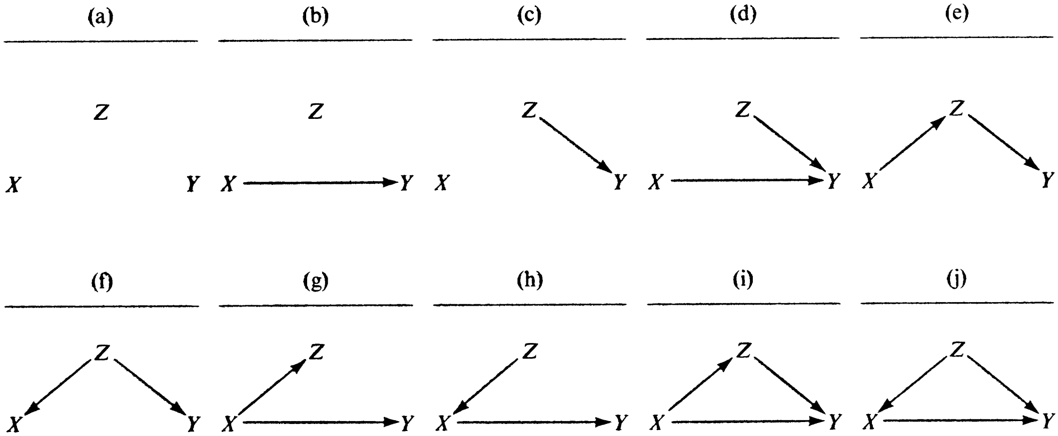
FIGURE 1

POSSIBLE CAUSAL RELATIONSHIP AMONG X, Y, AND Z, TAKING Y AS THE DEPENDENT VARIABLE AND NO TWO-WAY RELATIONSHIPS ALLOWED



Source: Adapted from Blalock [1960, p. 339].

CORRELATION AND SPURIOUS RELATIONSHIP

Existence of a significant coefficient of correlation between two variables X and Y, for example, often serves as evidence of an association between X and Y and warrants the use of X as a predictor of Y's magnitude. Furthermore, if supported by theory, X can be regarded as a cause of Y.[1] In any empirical study, conclusions and further references are valid, however, *only* if the relationship is not spurious. A significant association created through a spurious empirical relationship is meaningless in testing predictability.

Relationships Among Variables

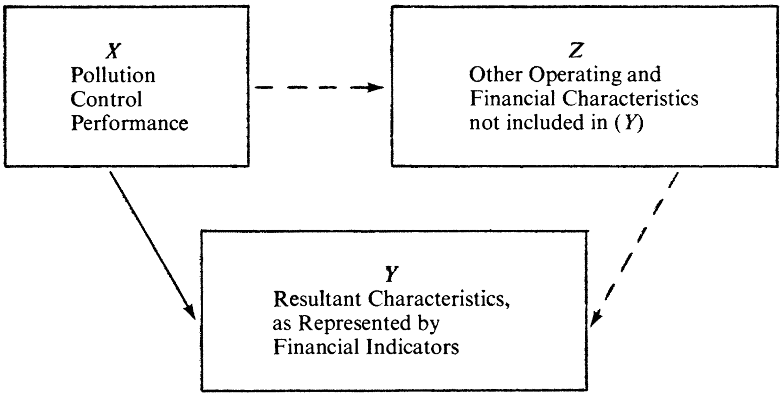
Observed relationships among variables can be genuine or spurious. A spurious relationship between two variables X and Y exists if a third variable Z causes, either directly or indirectly, both X and Y and there is no direct relationship between X and Y. To clarify relationships among variables, consider the cases of three variables.[2] Let Y be the dependent variable or the variable whose value is of ultimate interest in the investigation, and let X and Z be the variables whose relationships with Y are the focus of the study. Figure 1 exemplifies possible relationships among these variables. A directional arrow denotes existence of direct effect from one variable to the other. Lack of a directional arrow between two variables indicates that any relationship between the variables shown

[1] Statisticians carefully point out that correlation analysis cannot be used directly to establish causality because of the fact that correlations merely measure covariation or the degree to which several variables vary together. In employing correlation analysis, a researcher is, at least implicitly, assuming the existence of casual relationships among variables being correlated. As Blalock points out, one of the basic aims of any science is to establish causal relations. "Regardless of one's philosophical reservations concerning the notions of cause and effect, it is extremely difficult to think theoretically in any other terms" [Blalock, 1960, p. 337].

[2] Similar analyses can be made for cases with more than three variables. Readers interested in detailed discussions on general cases are referred to works by Blalock [1962, 1964, 1968] and Simon [1957].

FIGURE 2

SPICER'S MODEL OF RELATIONSHIPS AMONG POLLUTION CONTROL INDICES, FINANCIAL INDICATORS, AND OTHER VARIABLES



in a correlation analysis is spurious.[3] Using the variables included in the Spicer study, X is one of the pollution control indices, Y is one of the financial indicators, and Z can be either one of the financial indicators not designated as Y or a variable that was not included, even though it should have been. In diagram (a), no relationship exists between any pair of variables X, Y, and Z, whereas (b) indicates that X has a direct effect on Y. Other variables, as represented by Z, have only random effects on both X and Y. The relationship represented in (f) is that both X and Y are affected by Z *and* any relationship shown between X and Y is spurious even though it reflects the common effect of Z on both X and Y. The three-arrow diagrams (i) and (j) indicate that both variables X and Z have direct effects on the variable Y, whereas one of the variables X and Z also has direct effects on the other variable.

Clarification of Relationships

In the discussion and conclusion in the Spicer paper, it is implied that the relationships between a firm's performance on pollution control X and its financial indicators Y are one or more of those depicted by diagrams (b), (d), (g), (h), (i), and (j); diagrams excluded are those that indicate no relationship between X and Y.[4] These relationships can be summarized as in Figure 2. Possible relationships, represented by the dotted lines, may or may not exist. It seems that based on the Spicer's discussions, none of the dotted lines are assumed to exist since he did not indicate the possible existence of any variable having the characteristics of Z.

(1) *Correlation Coefficients and Relationships Among Variables*

With this clarification of possible relationships among variables, the next question is which model depicted in Figure 1 best describes the true relationship among X, Y, and Z? To distinguish among various models, it is necessary to examine the relative magnitudes of the

[3] Two-way arrows are excluded in these diagrams. Through a careful selection of events in a time sequence, the effect can be placed in one direction or the other but not mutually effected simultaneously.

[4] Conceivably, (e) and (f) can be included also. However, the relationship between X and Y in these two diagrams is spurious, by definition.

correlation coefficients among pairs of variables. For the first three, (a), (b), and (c) models, the magnitudes of correlation coefficients among variables dictate which model represents the relationships among variables. In (d), both X and Z have effects on Y, while there is no direct relationship between X and Z. Since X and Z are independent, Z is a disturbing factor (from the point of view of the relationship between X and Y). A control[5] of the variations in Z reduces random variations in Y with respect to the variations in X and makes the relationship between X and Y most distinct. Control of variations in Z increases the magnitude of correlation between X and Y. If the control is achieved, through adjusting for the effects of Z on X and Y, then it is expected that the partial correlation $\rho_{XY.Z}$ will be greater than the zero-order correlations ρ_{XY}.

In cases (e) and (f), control of variations in Z weakens the relationship between X and Y. In fact, if Z is the background factor that affects both X and Y, *and* if the relationship between X and Y is spurious, the control of Z causes the relationship between X and Y to approach zero. Similar results can be expected between Y and Z in (g) and (h), if variations of X are controlled. In (i) and (j), control of an independent variable does not weaken the relationship between Y and the other independent variable to the extent that no relationship exists. This is because X has a direct effect on Y in (i), for example, and control of variations in Z will not weaken significantly the relationship between X and Y. If control of variations in Z weakens the relationship between X and Y to the extent that a significant relationship between X and Y no longer exists, then the appropriate model is not (i), rather, it should be (e).[6]

(2) *Regression Coefficients and Relationships Among Variables*

Examinations of the magnitudes of correlation coefficients among variables help to ascertain relationships among variables. One should take care, however, in distinguishing relationships such as those represented by (e) and (g) or by (f) and (h). In these models a common background factor affects the other independent variable and this may or may not directly affect Y. As an example, relationships depicted in cases (f) and (h) are quite distinct. In (h), the variable X has a direct effect on Y, while the relationship between X and Y in (f) is spurious, even though both have Z as a common background factor. In both of these cases, the control of variations in Z weakens the relationships between X and Y. Such a control may reduce the effect of X on Y to the extent that significant relationships between X and Y in (f) and (h) no longer exist. In the case of (h), such inference is incorrect.

To avoid reaching an erroneous conclusion from observing correlation coefficients among pairs of variables in ascertaining the model that depicts the true relationships, it is necessary also to compare regression coefficients. A control of variations in the common factor may cause a significant correlation coefficient to become statistically insignificant, whereas the significant relationship in

[5] To control the effect of a third variable on two or more variables that are of interest in an investigation, it is ideal to investigate the relation between two variables within categories of the third variable. The large sample required usually renders such a procedure impractical. The term "control" referred to here and in the remainder of the paper is a control through partial correlation. Partial correlation "controls" by adjusting values of the other variables through considering the scores of the third (control) variable.

[6] A detailed discussion of these analyses is presented by Blalock, especially in Blalock [1960, pp. 329–343].

regression coefficients is not affected. This occurs even if a direct relationship were to exist between the dependent and independent variables. In this case, both the partial correlation coefficient $\rho_{XY.Z}$ and the regression coefficient $\beta_{XY.Z}$ approach zero in (f), *whereas* only the partial correlation coefficient $\rho_{XY.Z}$ approaches zero in (h) (Blalock, 1968, pp. 175–6).

A Further Analysis of Association Between Pollution Control Indices and Financial Indicators

Validity of Spicer Study

Spicer applies two different tests to data from 1968 to 1973. Financial variables of this period are averaged over three overlapping periods: 1968–73, 1969–71, and 1971–73. Two pollution indices, one based on percentage of productive capacity adequately controlled and the other on percentage of mills adequately controlled, are constructed for the years 1970 and 1972. Twelve test statistics are reported for each financial variable. In each case, detailed levels of significance at which the null hypothesis of no correlation between the performance on pollution control and the financial indicators can be rejected are reported.

The results reported in the Spicer study were examined using .05 as the level for testing significance.[7] Our examination reveals that Spicer's conclusion "that . . . companies with better pollution-control records tend to have higher profitability, larger size, lower total risk, lower systematic risk and higher price/earnings ratios than companies with poorer pollution-control records" (p. 109) is far from justified. At the .05 level of significance, such a conclusion can be drawn only for three of the five financial variables: profitability, size, and price/earnings ratios. The result of tests of significant association between pollution control record and total risk and between pollution control record and systematic risk indicates that observed evidence is not significantly different from random variations, except in two cases (out of 24). The null hypothesis would be rejected even less often if a more stringent significance level (say, .01) were used.

Pollution Control and Profitability

In assessing the results of the empirical tests, consider this fundamental question: Is it logical to expect the performance on pollution control to have significant effects on profitability of operations, size of the firms, variations of periodic returns on stock investments, extent of price variations that can be explained by market factors, and price/earnings ratios? A test of association is meaningless unless the answer for each of the related variables to the pollution control indices is affirmative. Conceivably, performance in pollution control can have effects on security prices. This effect will be reflected in the measures of total risk, systematic risk, and price/earnings ratio. It is difficult to see, however, why a firm's pollution control record would have positive, significant effects on the result of operations and size of the firm.

Typically, management is reluctant to incur expenditures for pollution abatement on the ground that these additional expenditures would reduce the reported earnings in financial statements. Yet this is the basis for the measure of profitability used by Spicer. Economically, a firm with

[7] It is not clear what level of significance should be used in assessing the results reported. Labovitz [1968] suggests 11 criteria that should be considered by researchers in selecting the level of significance for testing hypotheses. The .05 level of significance was used in the table because Spicer seemed, more or less, to suggest this level of significance in his discussions [Spicer, 1978, pp. 105 and 108].

high earnings is more likely to incur pollution abatement costs than one with low earnings. Although such a relationship yields a significant association between pollution control record and profitability, the relationship is meaningless for the purpose of Spicer's study—to provide empirical evidence on the importance of disclosing a company's social performance record. A positive conclusion for the research question addressed can be drawn only if an improvement in pollution control leads to better profitability of the firm. Spicer's reported evidence did not show the temporal sequence of better pollution control leading to a higher profit.

Size Effect

The same relationship expected between pollution control record and profitability should also exist between pollution control record and size of operation. It hardly seems possible for the result of controlling pollution to have a positive effect on the size of operation. Rather, with the visibility of larger firms[8] and the severe effects of pollution from large operations on the environment, a large firm tends to do more, either voluntarily or involuntarily, on pollution control.

Size of operation, moreover, may have a significant effect on the other four financial indicators included in Spicer's study. Supporting this idea is a study investigating the relationship between various accounting and market-based measures (Beaver *et al.*, 1970), which found that market-based risk measures correlated negatively with asset size, as measured by the firm's total assets. Exactly the same relationship between these variables is expected to exist in the data reported in the Spicer study. The results show that the pollution indices have positive associations with size of firm, whereas the same indices have negative associations with the market-based risk measures. In other words, size may be a background factor that causes significant association between pollution control indices and each of the other four financial indicators. Referring to Figure 1, such a relationship is represented by diagrams (f), (h), and (j), with Z denoting size, X denoting a pollution control index, and Y denoting one of the other four financial indicators included in the study. Conceivably, diagram (d) may also represent the relationship. In (d), both size and pollution control have significant effects on the financial indicators, whereas no significant relationship exists between pollution control index and size—a situation rejected on the basis of strong association between these two variables reported by Spicer [1978, pp. 105–108].

Replicating the Study

Further analyses are needed to separate models (f) and (h). These analyses require use of product-moment correlations between size and other financial indicators. Since these data are not available in Spicer (1978), the procedures described in the Spicer paper were followed to obtain financial variables. To ensure that these data conform with those reported by Spicer, the Spearman rank-order correlation tests were made. With minor differences in magnitudes of correlation coefficients, the results in the levels of significance are essentially the same as obtained by Spicer [1978, pp. 105–107].

Spicer used non-parametric statistics because he was concerned that the data might not satisfy the strict assumptions

[8] Evidence of the effect of firm size on managerial behavior was reported recently. It was found that the single most important factor explaining managerial behavior with regard to the proposed general price level adjustments of the Financial Accounting Standards Board is firm size [Watts and Zimmerman, 1978, p. 131].

underlying the parametric statistics. Yet, parametric tests are needed to determine the relationships among these variables. There is extremely strong evidence—both mathematical and empirical—that parametric tests are very robust under violation of assumptions (see, *e.g.*, Boneau [1960], Lord [1953], Anderson [1961], and Baker *et al.* [1966]). As a test on suitability of the product-moment correlation coefficients for further analyses in this study, hypotheses were tested using the product-moment correlation coefficients.

Comparison of the coefficients and levels of significance between those from the Spearman rank-order correlation procedure and those from product-moment correlation procedure reveals almost identical results. These results agree with Boneau's finding on the effect of violating the normality assumption [Boneau, 1960, p. 62].

Visualizing the Relationships

To determine whether the size variable, Z, is a background factor for the significant association between pollution indices, X, and one of the other four financial indicators, Y, either variations in Z need to be controlled or the effects of variations of Z on the other two variables need to be adjusted. If Z is a dominant background factor for the other two variables, then the adjustment of the effects of Z on X and Y causes the partial correlation $\rho_{XY.Z}$ to approach zero. If the relationship is like the one depicted in diagrams (b) or (d), then the observed significant association between X and Y remains even though variations in Z are held constant statistically. Table 1 reports the result of tests of association between pollution indices and financial indicators, holding the effects of size variations constant. Compare these results with those reported in Spicer [1978]. The results indicate that the conclusion of a moderate to strong association between pollution control record and financial indicators *is not justified.* At the .05 level of significance, the null hypothesis of no relationship between a pollution index and a financial indicator cannot be rejected in any case; only four out of a total of 24 cases can be rejected if the level of significance is increased to .10. This is true when the effect of size on these two variables was adjusted. Consequently, it is highly improbable that either (b) or (d) represents the relationship among the pollution indices, size of operation, and one of the other four financial indicators. Our analyses suggest that the relationships among these variables is as described in Figure 3. Relationships represented by the dotted lines in Figure 3 may or may not exist. If the line between X and Y does not, in fact, exist, then the relationship is depicted by (f); if the line between Z and Y does not exist while the directed arrow between X and Y exists, then the relationship is represented by (h); if both dotted lines exist, then the relationship is the one described by (j).

If the relationship is (h) or (j), then a control for Z weakens the correlation between X and Y *but* does not affect the expected value of the regression coefficient between X and Y, to the extent that it becomes insignificant. If the relationship is (f), a control for Z will weaken both the correlation coefficient and the regression coefficient [Blalock, 1968, pp. 175–76]. Thus, there is a means to discriminate between these relationships. Table 2 reports the results of regressing the other four financial indicators, taken one at a time, on a pollution index and on size. Both the regression coefficients and their corresponding t-value are reported in the table. With only one exception, the regression coefficients are not

FIGURE 3

RELATIONSHIP AMONG SIZE, POLLUTION CONTROL AND OTHER FINANCIAL CHARACTERISTICS AS SUGGESTED BY THE DATA USED IN SPICER [1978]

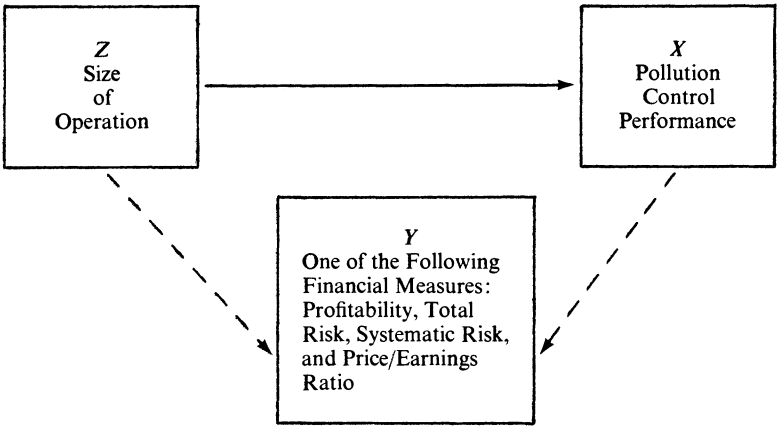


TABLE 1

COEFFICIENTS OF PARTIAL CORRELATIONS OF POLLUTION INDICES AND TOTAL RISK, SYSTEMATIC RISK, AND PRICE/EARNINGS RATIO WITH SIZE CONTROLLED*

	6 Years (1968–73)		*3 Years (1969–71)*		*3 Years (1971–73)*	
	Productive Capacity (1970)	*Mills (1970)*	*Productive Capacity (1970)*	*Mills (1970)*	*Productive Capacity (1972)*	*Mills (1972)*
Profitability	0.1578 (0.273)	0.0715 (0.393)	0.0897 (0.366)	0.1470 (0.287)	0.4108** (0.057)	0.3809** (0.073)
Total Risk	0.0916 (0.363)	0.0715 (0.393)	−0.1650 (0.263)	0.1864 (0.237)	−0.0773 (0.388)	−0.1585 (0.279)
Systematic Risk	−0.1580 (0.272)	−0.1787 (0.246)	0.1904 (0.232)	0.2910 (0.129)	−0.3866** (0.070)	−0.3832** (0.071)
P/E Ratio	−0.0208 (0.468)	0.0390 (0.441)	0.0539 (0.419)	0.1250 (0.316)	−0.2123 (0.215)	−0.2105 (0.217)

* Coefficients of partial correlation are reported in the table; the corresponding levels of significance are reported in parentheses directly below.

** Significant at the 0.10 level of significance.

TABLE 2

REGRESSION COEFFICIENT OF THE INDEPENDENT VARIABLE POLLUTION INDEX WHEN SIZE IS INCLUDED*

	6 Years (1968–73)		*3 Years (1969–71)*		*3 Years (1971–73)*	
Dependent Variable	*Productive Capacity (1970)*	*Mills (1970)*	*Productive Capacity (1970)*	*Mills (1970)*	*Productive Capacity (1972)*	*Mills (1972)*
Profitability	0.1543 (0.43)	0.2749 (0.89)	0.0625 (0.19)	0.1697 (0.55)	0.3876 (1.67)	0.2730 (1.00)
Total Risk	0.1458 (0.41)	0.0894 (0.31)	−0.1861 (0.55)	0.21133 (0.74)	−0.0789 (0.30)	−0.1690 (0.60)
Systematic Risk	−0.1724 (0.46)	−0.2189 (0.67)	0.2583 (0.78)	0.3312 (1.19)	−0.3990 (1.56)	−0.41313 (1.55)
P/E Ratio	0.0392 (0.24)	0.0363 (0.25)	0.1061 (0.76)	0.0976 (0.78)	−0.1186 (0.81)	0.89129 (5.85)

* Beta coefficients are reported in the table. The number in parentheses is the corresponding t value for the regression coefficient in the same cell.

significantly different from zero. The argument that X has a direct effect on Y, mediates the effect of Z on Y, or completely contains the effect of Z on Y, is not substantiated. The appropriate relationship is the one represented by (f), in that size is an explanatory variable for both pollution control and financial indicators.

An examination of data over time gives additional evidence of the spurious relationship between pollution indices and financial indicators. Although Spicer found statistically significant association at the .05 level on three out of the five measures with the 1970 pollution control indices, the same results are not obtained when 1972 pollution control indices were correlated with financial data of a later period. Spicer reasoned that the difference resulted from substantial improvements in pollution control between 1970 and 1972. Although the general levels of pollution control of the companies studied have improved, not all companies have the same pollution record. The rank correlation of pollution indices between 1970 and 1972 shows that the null hypothesis of no correlation can be rejected at the .01 level of significance. Furthermore, the ranges of variation in these two years do not have substantial differences. It can be expected that if the variations in pollution indices have a legitimate relationship with the financial indicators, the same results would be obtained in data of the two time periods. Pollution indices in both 1970 and 1972 vary over wide ranges. The fact that the associations of pollution indices with the financial indicators in the second time period (1971–73) are not significant suggests that the significant association observed in the first time period (1969–71) might result from the effects of other variables.

CONCLUSION

Further analyses of the data used in Spicer (1978) indicate that the moderate-to-strong associations between pollution control record and financial indicators are spurious due to *at least* one common background variable—size. This result is in direct conflict with Spicer's conclusions. It is highly improbable that the data suggest the importance of the disclosure of corporate social responsibility performance.

By no means is size the only possible background factor. Several other variables (financial and economic) are known to affect the financial indicators included in Spicer's study. A clearer picture would have been provided were effects of other background factors considered in Spicer's analysis.

The result of this study should not be interpreted as evidence that investors are indifferent in regard to corporate social performance. An investor's primary concern is return on his investment, and a concern for pollution control is relevant to the extent that failure to have adequate pollution control endangers earnings of the firm. As long as a firm has a satisfactory performance on pollution control, there is no reason for investors to be concerned. Any negative effect of pollution control performance on financial indicators is, perhaps, confined to firms with poor pollution control records.

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