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The Market Valuation of Environmental Capital Expenditures by Pulp and Paper Companies

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ABSTRACT: The objective of this study is to examine the market valuation of environmental capital expenditure investment related to pollution abatement in the pulp and paper industry. The total environmental capital expenditure of $8.7 billion by our sample firms during 1989–2000 supports the focus on this industry. In order to be capitalized, an asset should be associated with future economic benefits. The existing environmental literature suggests that investors condition their evaluation of the future economic benefits arising from environmental capital expenditure on an assessment of the firms' environmental performance. This literature predicts the emergence of two environmental stereotypes: low-polluting firms that overcomply with existing environmental regulations, and high-polluting firms that just meet minimal environmental requirements. Our valuation evidence indicates that there are incremental economic benefits associated with environmental capital expenditure investment by low-polluting firms but not high-polluting firms. We also find that investors use environmental performance information to assess unbooked environmental liabilities, which we interpret to represent the future abatement spending obligations of high-polluting firms in the pulp and paper industry. We estimate average unbooked liabilities of $560 million for high-polluting firms, or 16.6 percent of market capitalization.

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I. INTRODUCTION

Compliance with stringent environmental regulations can significantly increase production costs in polluting industries such as pulp and paper, chemical, steel, and utilities (Joshi et. al. 2001). The magnitude of the costs to comply with environmental regulations is such that securities regulators and accounting academics are calling for increased accounting disclosure and standardized measurement of corporate environmental activities (Barth et. al. 1997; Beets and Souther 1999).

The capitalization of environmental capital expenditure investments (hereafter ECE) related to pollution abatement is controversial. Existing accounting standards (FASB 1989, 1990) require capitalizing such expenditures due to the long-lived nature of pollution abatement facilities. However, some critics question the capitalization of abatement outlays, since such expenditures result in no incremental increase in future economic benefits (CICA 1993). Consider, for example, the classic issue of asbestos removal costs. Critics would argue that such outlays should be expensed as repairs rather than capitalized as betterments. Supporters of existing accounting standards argue that abatement costs represent additional costs of previously anticipated benefits from the related capital asset and invoke the concept of matching to support capitalization. This controversy remains unresolved in the fixed assets literature. In contrast, there is a clear consensus that site remediation costs should be expensed since there are no incremental future economic benefits.

We look to the environmental economics literature for guidance on whether future incremental economic benefits exist when firms incur abatement outlays. Traditional economic theory suggests that firms should meet only the minimal environmental standards prescribed by law and will be reluctant to spend more than necessary (McCain 1978). However, the recent environmental economics literature offers several explanations as to why firms may choose to overcomply with existing environmental regulations. Potential incremental benefits associated with overcompliance include the creation of ''green goodwill'' (Arora and Gangopadhyay 1995), incentives to innovate (Porter and van der Linde 1995) and raising rivals' costs (Salop and Scheffman 1983, 1987). Low-polluting firms enjoy the above benefits whereas the minimum compliance abatement expenditures of high-polluting firms represent the costs of environmental externalities now imposed on firms' shareholders. In effect, high-polluting firms incur pollution abatement outlays with no incremental return.

We examine the market valuation of environmental capital expenditures conditional on the firm's environmental performance. Based on the claimed benefits for overcompliance, we hypothesize that the market positively values ECE investments for low-polluting firms; the market assigns a value of zero to the ECE investments of high-polluting firms; and finally, the market assesses the existence of unbooked environmental liabilities (future abatement spending obligations) for high-polluting firms. Our results are consistent with our predictions.

We explore the above research questions for a single industry, pulp and paper, because a single industry setting offers a number of advantages. First, the pulp and paper industry in the U.S. is well known for its water and air pollution (see Magat and Viscusi 1990) and has faced ever more stringent emission standards since the 1970s. Second, environmental performance measures such as toxic release emissions are better specified and measurable within a single industry, because the various types of emissions are more homogenous.[1] Finally, our empirical valuation model places restrictions on coefficient estimates that are more likely to be satisfied when pooling across firms in a single industry.

Our findings have implications for a number of important constituents. In order to be capitalized, an asset should be associated with future economic benefits. Thus, our study provides information on the representational faithfulness of an accounting amount, ECE (Barth et al. 2001). Our valuation evidence suggests that there are incremental economic benefits associated with the ECE investments of low-, but not high-polluting firms in the pulp and paper industry. This finding is useful to the FASB if they reconsider the issue of whether to capitalize ECE.[2] Second, to management, investors, and to SEC enforcement staff who assess MD&A disclosure compliance, our study provides evidence of unbooked environmental liabilities for high-polluting firms and a methodology for ranking firms by environmental performance. The magnitude of future capital spending obligations related to proposed environmental legislation is a specific MD&A disclosure requirement. Third, our evidence is of interest to providers of assurance of firm environmental reports. Our methodology for reliably ranking pulp and paper firms in terms of environmental performance suggests that such performance measures are suitable for audit, thus deterring "greenwashing" in firm environmental reports (Beets and Souther 1999).[3]

The remainder of the paper is organized as follows. In the second section, we briefly describe the pulp and paper industry regulatory setting, review the relevant literature and develop our hypotheses. In the third section, we present the econometric model, followed by a description of our data in the fourth section. Finally, we present our empirical results in the fifth section, and our sixth section contains the summary and conclusion.

II. REGULATORY SETTING, LITERATURE REVIEW, AND HYPOTHESIS DEVELOPMENT

Regulatory Setting

A prominent feature of environmental regulations in the pulp and paper industry is that effluent guidelines are established within the variations of Best Available Technology (BAT), defined typically as the average effluent quality calculated over the top 50 percent of mills at any given point in time. Thus, firms with the best environmental performance effectively set the environmental standards and thereby dictate the evolution of future environmental regulations, hence future ECE spending for the rest of the industry. This regulatory setting provides support for the existence of two types of firms in the pulp and paper industry, low- and high-polluting firms. High-polluting firms have latent environmental liabilities as a result of future capital spending obligations to comply with ever more stringent environmental regulations. Environmental regulations pertaining to the pulp and paper industry have become increasingly stringent since the 1970s. According to an industry

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[1] There is increasing evidence that corporate environmental performance indicators may be industry-specific. The results of Campbell et al. (1998) suggest that environmental risk exposure is captured by the number of Superfund sites in the chemical industry, but not in the pulp and paper industry. Cormier and Magnan (1997) find that water-based environmental performance measures capture future environmental liabilities for firms in the pulp and paper industry, but not for firms in the chemical and oil industry. Thus, studies using inter-industry samples may be limited in power when compared to single-industry studies.

[2] As a necessary caveat, our valuation relevance evidence is not sufficient for accounting policy deliberation because standard setters consider other purposes of accounting information besides valuation relevance. Additionally, our evidence does not purport to measure all of the costs and benefits that a standard setter must consider when setting standards (Holthausen and Watts 2001).

[3] While external verification of environmental reports is not currently required in the U.S., many corporations voluntarily elect to undergo external environmental examination and verification (Beets and Souther 1999, 134).

survey,[4] total industry ECE spending in 2000 constant dollars since 1970 has been $26.5 billion, of which $15 billion was spent prior to the period we examine, 1989–2000. While firm-specific ECE spending data are not publicly available prior to 1989, we assume that our sample low-polluting firms outspent high-polluting firms in the 1970s and 1980s in order to obtain their best environmental performance status in our sample period. The regulatory setting in the pulp and paper industry is dynamic as future discharge standards are set according to BAT. The U.S. Environmental Protection Agency (EPA) implemented a comprehensive set of stringent water discharge and air emission standards for the pulp and paper industry in November 1997, called the ''Cluster Rule.'' The EPA estimated that high-polluting firms in the industry needed to invest approximately $1.8 billion in environmental capital expenditures by November 2001, in order to comply with these new emission standards (EPA 1997). The EPA is currently contemplating a new set of water regulations to follow the ''Cluster Rule'' (PPWRC 2000). This setting allows low-polluting firms to pursue a ''raising rivals' cost'' strategy by continued ECE spending.

The nature of latent environmental liabilities faced by high-polluting firms differs from the liability to remediate existing contamination because the former represent spending to abate future pollution. Accountants do not accrue abatement-related capital spending commitments on the balance sheet until the cash expenditure occurs. Nonetheless, the magnitude of future capital spending obligations is of interest to the SEC with respect to enforcement of required MD&A disclosures. Item 303 of SEC Regulation S-K requires companies to discuss in their MD&A the impact of proposed environmental legislation on future operations and financial conditions (Cole 1991). Our study provides a methodology for reliably ranking pulp and paper firms in terms of environmental performance that may be beneficial to SEC enforcement staff when monitoring disclosure compliance.

Accounting Literature

Existing accounting research has examined how capital markets combine accounting information with ''other information'' for firm valuation. For example, Ittner and Larcker (1998) examine whether the release of customer satisfaction measures provides information to the market beyond what is captured in current financial statements. They find customer satisfaction measures to be economically relevant, even though they are only partially reflected in current accounting earnings and book values. Similarly, Barth et al. (1998) find the pricing multiples on book value and net income in a valuation model depend on a firm's financial health as measured by bond ratings. Consistent with these arguments, Barth and McNichols (1994) and Hughes (2000) employ nonfinancial pollution measures (number of Superfund sites and sulfur dioxide emissions, respectively) to show that such measures capture the exposure of high-polluting firms to future environmental liabilities. We view relative environmental performance data to be a forward-looking nonfinancial measure that has the potential to augment the information in current accounting earnings and book values. We examine the market valuation of environmental capital spending conditional on relative corporate environmental performance, while at the same time allowing for unbooked environmental liabilities.[5]

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[4] The National Council For Air and Stream Improvement (2002).

[5] Johnson (1995) uses valuation methodology to explore, across a number of industries, whether the market valuation of ECE is conditional on relative environmental performance. However, Johnson (1995) does not control for environmental liabilities. Furthermore, her estimated valuation coefficient on a dollar of ECE investment for firms with above-average toxic releases is negative, an estimate we argue should be lower bounded at 0.

Environmental Economics Literature

The environmental literature provides support for the argument that the value of a dollar of current ECE depends on the firm's environmental performance. Specifically, the literature suggests that firms have incentives to take a proactive approach to managing environmental impacts, with the benefits of overcompliance arising from a number of sources.

Arora and Gangopadhyay (1995) provide an explanation for overcompliance within the context of a duopoly game. In their setting, two rival firms face a segmented market with each choosing an emission (pollution control) technology and a price for its product. They show that one firm will choose to spend more on emission technology to become a low-polluting firm to attract and retain environmentally conscious consumers who are willing to pay a premium for the products made by a superior environmental performer (the notion of ''green goodwill''). Although it is difficult for pulp and paper firms to derive a price premium from a homogenous product such as pulp and paper, low-polluting firms are better positioned to secure long-term contracts with customers who practice ''green'' supply-chain management (Walton et al. 1998). This is consistent with anecdotal evidence in the financial press.[6]

Porter and van der Linde (1995) argue that environmental regulations can trigger innovations that will improve corporate operational efficiency by the substitution of less costly materials, by better utilization of materials in the process, or by converting waste into more valuable forms. In addition, best environmental performers enjoy early-mover advantages by tapping into the international market that is moving rapidly toward valuing low-pollution and energy-efficient products. King and Lenox (2001) report empirical evidence consistent with Porter and van der Linde (1995) in this respect. In particular, they report that ''greener'' firms have lower inventory levels compared to the industry average. This evidence is consistent with the complementary effect that pollution reduction has on operational efficiencies.[7]

Another economic benefit of maintaining superior environmental performance is to raise rivals' costs. Salop and Scheffman (1987) derive a general model in which a dominant firm can choose a cost-raising action that will affect the costs of all firms in the industry, and cite environmental standards as one example. The dominant firm can use incremental ECE spending to convince the regulators that more stringent environmental standards are economically achievable. The BAT standard-setting process previously discussed will force high-polluting firms to spend more on ECE in order to comply with more stringent environmental standards, thus leading to higher costs. Higher costs in the Salop and Scheffman (1987) model lead to an upward shift to the left in the industry supply curve, which in turn results in an increase in the market-clearing price. They show that a sufficient condition for this cost-raising strategy to be profitable for the dominant firm is that the price increase exceeds the increase in average cost for the dominant firm, i.e., the dominant firms will enjoy a higher profit margin.[8]

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[6] The ''green goodwill'' argument is consistent with anecdotal evidence published in the financial press. See *Globe & Mail* (1994).

[7] Weyerhaeuser, one of our sample firms, installed elemental chlorine-free bleaching technologies several years before it was required by the ''Cluster Rule.'' The company stated, ''We installed them mostly because our customers required that we have these kinds of advanced processes in place to meet their requirements.'' The company indicated that the new technologies have ''improved the product quality and reduced costs associated with operating the facility'' (Canning 1998).

[8] The pulp and paper industry is oligopolistic (the four-firm sales concentration ratio in our sample is 47.0 percent). This offers support for the existence of dominant firms as required by Salop and Scheffman's (1987) model. According to their model, high-polluting firms will not benefit from the cost-raising action if the resulting increase in industry price is less than the increase in the average cost of high-polluting firms.

To summarize, the environmental economics literature is unambiguous in claiming that economic benefits arise from overcompliance. In our industry setting, no single benefit is likely to be the sole explanation for overcompliance. Our valuation model evidence pertaining to these claimed benefits is indirect in nature. While our descriptive statistics offer some direct evidence in support of the claimed benefits, we do not attempt to discriminate between these theories as a rationale for overcompliance. Rather, we rely on the common insight from all three theories that economic benefits accrue only to firms with superior environmental performance. This key insight lends support to our empirical design that conditions the investors' assessment of ECE on environmental performance.

Hypothesis Development

The claimed benefits to overcompliance in the environmental economics literature lead to the following two hypotheses (in alternate form):

H1: The market positively values ECE investment for low-polluting firms.

H2: The market assigns a value of zero to the ECE investment of high-polluting firms.

The basic intuition underlying H1 is that incremental ECE spending by low-polluting firms may generate economic benefits (''green goodwill,'' incentives to innovate and raising rivals' costs). High-polluting firms do not enjoy these benefits. Instead, their minimum compliance abatement expenditures represent the costs of environmental externalities (pollution) now imposed on firm shareholders (in effect, a capital outlay with no incremental return).

Our third hypothesis flows naturally from the above two. Low-polluting firms create value for shareholders when they incur abatement expenditures. Thus, they do not face obligations to incur future abatement expenditures with no incremental return to shareholders. High-polluting firms, in contrast, face unbooked liabilities to incur future abatement spending as emission standards get tougher. From the perspective of shareholders, these represent economic liabilities in terms of commitments to incur future capital outlays with no associated incremental return. This suggests the following hypothesis:

H3: The market assesses the existence of unbooked liabilities (future abatement spending obligations) for high-polluting firms.

III. ECONOMETRIC MODEL

In order to test the above hypotheses, we need a measure of the theoretical construct, relative environmental performance. We develop nonfinancial pollution indicators to measure environmental performance, which we then use to classify firms as low- versus high-polluting. We adopt two alternative measures for relative environmental performance (EP), both based on data publicly available from the EPA. Our primary measure, EP_{TRI}, uses data from the EPA's Toxic Release Inventory (TRI) about the release and transfer of toxic chemicals from manufacturing facilities. TRI is the sum of all chemicals (in pounds) released to air, water, and land in a particular year. Following Konar and Cohen (1997), we calculate EP_{TRI} by deflating aggregate TRI by cost of goods sold to obtain a measure of emissions relative to production output. This measure identifies the object of regulatory scrutiny, namely, the firms' pollution relative to their production scale. As a control for measurement error in this proxy, we also employ an additional environmental performance measure, EP_{BOD}, which is based on Biological Oxygen Demand (BOD). Existing literature in environmental economics uses BOD as a reliable indicator of water pollution for the pulp and paper industry (Magat and Viscusi 1990). The BOD data are available from the EPA's Permit Compliance System that tracks permit issuance, permit limits, and actual emissions pertaining to facilities. BOD data are available in the Permit Compliance System only on a mill-by-mill basis along with mill discharge limits. We calculate EP_{BOD} as the ratio of the sum of the BOD discharges across the firm's mills divided by the sum of the mill BOD discharge limits.[9]

We adopt EP_{TRI} as the basis for our primary environmental performance proxy because EP_{TRI} reflects environmental performance in all media (water, air, and solid waste disposal) and thus is compatible with our ECE measure, which captures spending in all three areas. Moreover, complete EP_{TRI} data are available whereas the EP_{BOD} data are somewhat more limited. In order to classify firms as low- and high-polluting, we partition the sample at the median EP_{TRI} (EP_{BOD}) for that year. We then create an indicator variable, *POLLUTE,* and set this variable to 1 for high-polluting firms.[10]

To investigate whether the market uses environmental performance information to assess the return on ECE investments, we begin with a modified version of the Ohlson (1995) valuation model. In light of prior studies that document the existence of unbooked environmental liabilities (Barth and McNichols 1994; Cormier et al. 1993; Cormier and Magnan 1997; Hughes 2000), we argue that the market uses environmental performance indicators as other information that predicts future negative abnormal earnings beyond a knowledge of current abnormal earnings, i.e.,

$$V = \alpha_0 + \alpha_1 \, BV + \alpha_2 \, AE + \alpha_3 \, POLLUTE + \varepsilon \tag{1}$$

where:

V = market value of common equity in million dollars, measured three months after the firm's fiscal year end;
BV = book value of common equity in million dollars;
AE = abnormal earnings to common defined as earnings to common equity less an assumed cost of capital based on the CAPM times beginning-of-period book value of common equity, in million dollars;[11]
$POLLUTE$ = an indicator variable assuming the value of 1 for high-polluting firms, and 0 otherwise; and
ε = error term.

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[9] This measure is structurally similar to the pollution performance index used in Cormier et. al. (1993) and Cormier and Magnan (1997), although they use total mill water flow-through (not always available in the EPA's Permit Compliance System database) as a weighting factor to aggregate across mills.

[10] To validate that our *POLLUTE* labeling captures the underlying construct of interest, relative environmental performance, we examine the number of environmental violations and prosecutions of 11 of our sample firms (five low-polluting and six high-polluting) covered in the Corporate Environmental Profiles Database developed by the Investor Responsibility and Research Center. We find that the five low-polluting firms had an average of 27 environmental violations and prosecutions during the 1992 to 2000 period, while the high-polluting firms had an average of 55 environmental violations and prosecutions during the same period. Thus, firms that we label high-polluting do have a higher propensity of noncompliance with environmental regulations. Using a randomization test (Noreen 1989), the difference between 55 and 27 is statistically significant at the 0.0074 level (one-tailed).

[11] The cost of equity capital is based on the CAPM ($k_e = R_F + \beta[E(R_M) - R_F]$) with β estimated using 60 months of historical return data and updated annually, R_F equal to 4.5 percent, and the market price of risk ($[E(R_M) - R_F]$) equal to 6.5 percent. For support for these estimates, see Siegel (1999). Our results are not affected when we vary R_F and the market price of risk between 3 to 5 percent and 6 to 8 percent, respectively.

We then modify Equation (1) based on the assumption that current period capital expenditures predict future abnormal earnings beyond a knowledge of current abnormal earnings if they represent positive NPV projects.[12] We decompose total current period capital expenditure into environmental capital spending (*ECE*) and nonenvironmental spending (*NECE*). The interaction between *ECE* and *POLLUTE* tests whether, as suggested by theory, investors value *ECE* investments conditional on the firm's environmental performance. As a control, we add a similar interaction term between *NECE* and *POLLUTE,* however, there should be no significant interaction between *NECE* and *POLLUTE* unless *POLLUTE* is simply proxying for other confounding variables. Our primary empirical model is therefore:

$$\begin{aligned} V = \beta_0 + \beta_1\, ABV + \beta_2\, ECE + \beta_3\, ECE{*}POLLUTE + \beta_4\, NECE \\ + \beta_5\, NECE{*}POLLUTE + \beta_6\, AE + \beta_7{*}POLLUTE + \upsilon \end{aligned} \tag{2}$$

where:

ABV = adjusted book value of common equity equal to book value of common equity (*BV*) minus current period capital expenditure (*ECE* + *NECE*), in million dollars;
ECE = current period (undepreciated) environmental capital expenditure, in million dollars;[13]
NECE = current period (undepreciated) nonenvironmental capital expenditure, in million dollars;
υ = error term; and

all remaining terms are as previously defined.

In terms of this model, our coefficient tests are as follows:

$\beta_2 > 0$ (a test of H1)
$\beta_2 + \beta_3 = 0$ (a test of H2)
$\beta_7 < 0$ (a test of H3)

In Equation (2), β_2 represents the valuation coefficient on a dollar of *ECE* investment for low-polluting firms, which is predicted to exceed 0 by H1; furthermore, $\beta_2 + \beta_3$ represents the valuation coefficient on a dollar of *ECE* investment for high-polluting firms, which is predicted to be 0 by H2. Finally, β_7 tests whether high-polluting firms have unbooked environmental liabilities as predicted by H3. An additional coefficient test is as follows:

$$\beta_2 > 1.$$

[12] Feltham and Ohlson (1996) provide theoretical support for the notion that current capital spending can explain goodwill beyond current abnormal earnings. Their accounting-based valuation model implies that the valuation coefficient on current capital investment isolated from book value is 0 if there is no incremental cash return (see Feltham and Ohlson 1996, 213). We prefer, for the sake of simplicity, to state our primary econometric equation in terms of Ohlson (1995).

[13] We discuss issues related to depreciation of current period *ECE* and *NECE* and cumulative *ECE* in the "Robustness Checks" subsection.

Absent measurement error in our environmental performance proxies, ECE investments should have a valuation coefficient that exceeds unity in our empirical valuation model, for low-polluting firms. Since measurement error typically biases slope coefficients toward 0, we prefer to report coefficient tests for β_2 against the benchmark of both 0 and unity. In order to consider the sensitivity of our results to the unscaled form of our primary econometric model (Equation (2)), we repeat the analysis after scaling all items (other than *POLLUTE*) by the number of common shares outstanding (Barth and Clinch 2001).

IV. SAMPLE DATA

Our sample consists of U.S. pulp and paper companies for which environmental performance, stock price, and disclosed environmental capital expenditure (*ECE*) data are available during the period 1989–2000. A joint search of *Lockwood-Post's Directory of Pulp and Paper and Allied Trades* (1996) and the Compact Disclosure USA database generates 45 public companies listed in the U.S. with pulp and paper mills.[14] By examining 10-Ks, we eliminated 16 of the 45 firms that have only limited operations in the pulp and paper sectors, resulting in our final sample of 29 "pure play" pulp and paper companies. These companies disclosed ECE spending sometime during the 1989–2000 period, yielding a sample of 256 firm-year ECE disclosures.[15] The total ECE spending by these companies over the sample period is \$8.71 billion, which represents about 81 percent of the total industry ECE spending, according to the industry survey (referred to earlier).[16] This gives us reasonable confidence that our sample is representative of the industry. *TRI* data are available for each of the 256 firm-years but BOD data are only available for 183 firm-years.

Panel A of Table 1 presents distributional statistics for variables in our regression models. The sample is broadly distributed along all dimensions. The average annual *ECE* of our sample firms during the 1989 to 2000 period is \$34.39 million with annual *ECE* spending ranging from \$0.15 million to \$190 million. Similarly, the average annual *NECE* is \$318.6 million with annual *NECE* ranging from \$0.3 million to \$1.39 billion. The mean *ECE* is 9.77 percent of the mean total capital expenditure (*ECE* + *NECE*) over the sample period. In terms of environmental performance, the average annual EP_{TRI} measure is 2.039 (i.e., 2.039 pounds of toxic release per \$1,000 of cost of goods sold) and the average annual EP_{BOD} measure is 0.449 (i.e., 44.9 percent of limit). The annual EP_{TRI} measures range from a low of 0.019 to a high of 14.210 while the EP_{BOD} measures range from 0.068 to 1.021.[17] For both measures, lower values represent better environmental performance. Panel B of Table 1 presents a Pearson correlation matrix after scaling all variables we use in regression models, other than EP_{TRI} and $EP_{BOD,}$ by common shares

[14] We use the 1996 *Lockwood-Post Directory* in order to generate as large a sample as possible. The pulp and paper industry has gone through some significant consolidations in the late 1990s.

[15] There are only 13 firm-years for which firms were in operation but failed to disclose *ECE* spending in either their annual report or 10-K. Since there is no indication whether the nondisclosure arises because the firms did not make *ECE* expenditures or because they decided not to make the required disclosure, we treat these 13 observations two ways. Our primary analysis treats these 13 observations as missing observations. Alternatively, when we treat these 13 observations as indicating no environmental capital expenditures, the conclusions are unaffected.

[16] The survey indicates that the total industry *ECE* over the same period is about \$10.765 billion. The primary reason that the total *ECE* spending of our sample firms is less than 100 percent of the total reported *ECE* spending by the pulp and paper industry is that we restrict our sample to "pure play" public companies, whereas the survey includes *ECE* spending by private as well as public firms with operations in the industry.

[17] A review of the *BOD* data indicates that this particular sample firm had a very large *BOD* emission in July 1990 that far exceeded the discharge limit. The company was back in compliance in 1991 with an EP_{BOD} measure of 0.706. Nonetheless, this EP_{BOD} measure is still significant higher than the average EP_{BOD} of 0.523 for our sample firms in 1991.

TABLE 1
Descriptive Statistics for a Sample of Pulp and Paper Companies from the Period 1989–2000[a]

Panel A: Distributional Statistics

Measure[b]	Mean	Standard Deviation	Median	Minimum	Maximum
V	3,367.470	5,215.976	1,639.722	15.600	3,7680.330
BV	1,897.917	2,052.237	1,469.450	−71.100	1,3386.000
ABV	1,544.921	1,784.379	1,067.360	−90.800	1,2034.000
ECE	34.390	36.387	23.000	0.150	190.000
$NECE$	318.605	299.893	232.319	0.300	1,392.000
AE	−14.922	245.236	−14.199	−847.800	1,339.240
EP_{TRI}	2.039	1.936	1.447	0.019	14.210
EP_{BOD}	0.449	0.167	0.439	0.068	1.021

Panel B: Pearson Correlation Matrix—All Variables (other than *EP*) Scaled by the Number of Common Shares Outstanding

	V/CS	ABV/CS	ECE/CS	$NECE/CS$	AE/CS	EP_{TRI}	EP_{BOD}
V/CS	1.000						
ABV/CS	0.433***	1.000					
ECE/CS	0.367***	0.244***	1.000				
$NECE/CS$	0.504***	0.421***	0.310***	1.000			
AE/CS	0.358***	0.084*	0.118*	0.164***	1.000		
EP_{TRI}	−0.220***	−0.138*	−0.084	−0.105*	−0.079	1.000	
EP_{BOD}	−0.243	−0.251***	−0.042	−0.013	−0.088**	0.200***	1.000

(*continued on next page*)

TABLE 1 (continued)

Panel C: Median Measures for the Sample Partitioned on the Basis of Environmental Performance (*POLLUTE*)

	Overall Sample (n = 256 firm-years)			1989–1994 (n = 140 firm-years)			1995–2000 (n = 116 firm-years)		
Measure	**Low-Polluting Firms *POLLUTE* = 0**	**High-Polluting Firms *POLLUTE* = 1**	**Mann Whitney p-value**	**Low-Polluting Firms *POLLUTE* = 0**	**High-Polluting Firms *POLLUTE* = 1**	**Mann Whitney p-value**	**Low-Polluting Firms *POLLUTE* = 0**	**High-Polluting Firms *POLLUTE* = 1**	**Mann Whitney p-value**
V	2,350.297	1,345.874	0.007	1,654.185	1,174.173	0.125	2,966.294	1,595.000	0.005
BV	1,615.100	1,186.169	0.039	1,486.900	1,071.295	0.439	2,092.650	1,265.917	0.023
ABV	1,196.805	893.325	0.029	1,082.360	831.500	0.109	1,865.100	1,162.649	0.023
ECE	23.350	20.845	0.449	26.000	22.850	0.331	20.720	16.500	0.142
NECE	264.500	217.300	0.326	261.200	222.950	0.500	264.500	223.335	0.357
AE	−11.936	−15.030	0.555	−26.804	−22.402	0.378	7.478	−2.448	0.042
Leverage	0.933	0.592	0.052	0.935	0.599	0.048	0.927	0.614	0.051
Asset Age	0.541	0.442	0.161	0.448	0.451	0.807	0.552	0.488	0.128
Liquidity	0.114	0.087	0.146	0.082	0.072	0.646	0.133	0.098	0.081
EP_{TRI}	0.947	2.180	<0.001	1.032	2.407	<0.001	0.670	1.777	<0.001
EP_{BOD}	0.397	0.462	0.015	0.423	0.499	0.021	0.382	0.413	0.353
ECE/CGS	0.0367	0.0650	0.0014	0.0746	0.0854	0.0440	0.0253	0.0442	0.0042

*, **, *** Significant at the 10 percent, 5 percent, and 1 percent levels, respectively.

[a] The distributional statistics (Panel A) and correlations (Panel B) are based on the 256 firm-years for which *ECE* and *TRI* data are available for all measures except EP_{BOD}, which is based on the 183 firm-years for which *ECE* and *BOD* data are available.

[b] Variable definitions: *V* is the market value of the firm's common equity (in $millions); *BV* is the firm's book value of common equity (in $millions); *ABV* is the firm's adjusted book value of common equity (in $millions) equal to *BV* minus current period capital expenditure (*ECE* + *NECE*); *ECE* and *NECE* are the firm's current period environmental and nonenvironmental capital expenditures (in $millions), respectively; *AE* is the firm's abnormal earnings (in $millions) defined as earnings to common equity less an assumed cost of capital based on the CAPM times the book value of common equity; EP_{TRI} is the firm's environmental performance measure in terms of toxic release inventory (TRI) defined as pounds of TRI per thousand dollar cost of goods sold (*CGS*); EP_{BOD} is the firm's environmental performance measure in terms of biological oxygen demand (BOD) defined as BOD discharge relative to discharge limits; *POLLUTE* is the firm's relative environmental performance measure set equal to 0 for firm-years with below the median EP_{TRI} in a given year and equal to 1 otherwise; *Leverage* is the ratio of long-term debt to equity; *age* of capital equipment is the ratio of net capital equipment to gross capital equipment; and *Liquidity* is the ratio of cash flow from operations to sales.

outstanding. The overlap among the independent variables is modest, with no pair-wise correlation exceeding 0.5.[18]

Panel C of Table 1 presents descriptive statistics when we classify the sample firms as low-polluting and high-polluting firms. We present the descriptive statistics for two subperiods, 1989–1994 (corresponding to cyclical downturn years) and 1995–2000 (corresponding to recovery years) as well as for the overall sample period. For the overall period, the median EP_{TRI} for high-polluting firms is 2.18 pounds per thousand dollars of cost of goods sold, versus a corresponding metric of 0.947 for low-polluting firms. The median EP_{BOD} measure is 46.2 percent of permit limits, compared to 39.7 percent, for high- versus low-polluting firms.

Further, when dollar ECE is scaled by cost of goods sold, low-polluting firms spend less on ECE than their high-polluting rivals: for the 1989–2000 period, annual ECE for high-polluting firms averaged 6.5 percent of cost of goods sold (*CGS*), compared to 3.7 percent for low-polluting firms. For the years 1999 and 2000, when most of the ECE spending in response to the ''Cluster Rule'' occurred, the (untabulated) median *ECE*/*CGS* of high-polluting firms more than doubled in 1999 relative to 1998 from 2.10 percent to 4.48 percent, and then increased by a further 50 percent in 2000 relative to 1999 to 6.87 percent (more than triple the 1998 level). In contrast, the median (untabulated) *ECE*/*CGS* for low-polluting firms declined in both years to historical lows (the figures are 1.50 percent in 1998, 1.44 percent in 1999, and 1.40 percent in 2000). Thus, it seems that low-polluting firms force up the *ECE* spending of their rivals as environmental regulations change, while at the same time continuing to spend in anticipation of the next round of regulatory change. This pattern is consistent with cost raising argument of Salop and Scheffman (1987) outlined in Section II.

Focusing on the overall period suggests that low-polluting firms are larger ($p = 0.007$ for market capitalization and 0.029 for book value of common equity adjusted for current period capital expenditures, ABV). These differences are statistically significant in the 1995–2000 subperiod, but not in the 1989–1994 subperiod. The trends involving profitability (*AE*) are of particular interest. For the 1989–1994 period, median abnormal earnings are negative, reflecting a cyclical downturn facing the industry, and the difference in profitability across the two groups is not significant. For the 1995–2000 period, low-polluting firms are more profitable and more liquid, consistent with benefits to overcompliance suggested by theory. In addition, low-polluting firms have higher financial leverage. We discuss the implications for our primary inferences of the differences in firm characteristics (size, leverage, profitability, and liquidity) across low- and high-polluting firms in the ''Robustness Checks'' subsection of the paper.

The year-by-year EP_{TRI} and EP_{BOD} data (untabulated) demonstrates that on average, the environmental performance of our sample firms is improving over the sample period, consistent with continuous ECE spending over time. For instance, the mean EP_{TRI} changes from 3.777 in 1989 to 1.644 in 2000. Similarly, we see a significant improvement in the mean EP_{BOD} from 0.568 in 1989 to 0.376 in 2000. This implies that we must assess the relative environmental performance of our sample firms year by year. As discussed in Section III, we create an indicator variable for environmental performance by partitioning our sample firms into low- and high-polluting groups based on the median EP_{TRI} (EP_{BOD}) measure. It turns out that this partitioning is quite stable over the 12-year study period: the average rank correlations for adjacent years are 0.868 and 0.798 for the EP_{TRI} and EP_{BOD}

[18] The Spearman rank correlations (untabulated) are very similar to those reported in Table 1.

measures, respectively. Using EP_{TRI} partitioning, we find only three instances in which firms changed group during the 12 years, with two firms moving from the high-polluting to the low-polluting group (one in 1991 and one 1992) and one moving from the low-polluting group to the high-polluting group (in 1991). One possible reason why we do not see significant variation in group membership is that it is difficult for a high-polluting firm to catch up in a short period of time. High-polluting firms must spend considerable resources to improve *EP* measures for all their mills in order to improve firm-wide environmental performance. In addition, as indicated by Panel C of Table 1, low-polluting firms continue to spend to maintain their superior environmental performance status, making it more difficult for high-polluting firms to catch up.

V. RESULTS

In order to test our hypotheses, we initially run the valuation model (Equation (2)) on the pooled sample of firm-year observations using a pooled GLS technique. In a cross-sectional time-series sample such as ours, the OLS assumption that all observations are independent can lead to misspecification due to serial correlation of the error terms for observations from the same company. The pooled GLS technique allows for cross-sectional heteroscedasticity and serial correlation and provides a better specification by using within-company correlation coefficients as estimates of the autoregressive parameters for each cross-sectional unit. The technique uses estimated autoregressive parameters to transform the observations and obtain more efficient estimators. Since we have unbalanced panel data, we apply the pooled GLS technique for unbalanced panel data as described in Baltagi (1995) and in Baltagi and Chang (1994). For this analysis, we run both an unscaled version of the model, a version scaled by common shares (Barth and Clinch 2001), and rank regressions.

While GLS corrects for autocorrelation and heteroscedasticity, it does not correct for cross-sectional correlations in the residuals. Thus, given the problem of cross-sectional correlation inherent in a pooled cross-sectional regression (Bernard 1987), we also run annual regressions using OLS and report cross-temporal t-statistics for the average coefficients. Finally, we report the results of analyses designed to address various robustness concerns.

Pooled Regression Results

Panel A of Table 2 contains GLS results for Equation (2) (unscaled and scaled) based on the pooled sample of 256 firm-years for which TRI data are available.[19] The significance levels reported below the coefficients for this and subsequent tables are two-tailed, as some of these coefficients are not of primary research interest. For the primary coefficient tests, reported p-values are one-tailed whenever we have directional predictions. Results are consistent with all three hypotheses. Regarding H1, the estimated coefficient on *ECE* (β_2) is 2.706, reliably exceeding both zero ($p = 0.006$) and unity ($p = 0.057$). Thus, the market positively values *ECE* investment for low-polluting firms, as predicted by H1. Turning next to H2, the valuation multiple attached to a dollar of current period *ECE* for high-polluting firms ($\beta_2 + \beta_3$) is 0.479 (2.706–2.227), an estimate which is as predicted statistically

[19] As previously discussed, the EP_{TRI} measure is remarkably stable over the 12-year study period, with only three firms changing partition. To address potential concerns regarding the effect these three firms might have on the results, we initially repeat the analysis after dropping them from the sample, finding the results to be qualitatively unaffected. In addition, we repeat the analysis after measuring *POLLUTE* with two-year lagged EP_{TRI}, given there is a two-year reporting lag between filing and publication of TRI data. Consistent with the stability of partition membership, our results remain unchanged.

TABLE 2

Pooled GLS Regression Estimates of the Market Valuation Model for a Sample of Pulp and Paper Companies from the Period 1989–2000[a]

Panel A: Environmental Performance (*POLLUTE*) Based on Toxic Release Inventory (EP_{TRI}), n = 256 firm-years

Model	Inter	*ABV* (+)	*ECE* (+)	*ECE*POLLUTE* (−)	*NECE* (+)	*NECE*POLLUTE* (?)	*AE* (+)	*POLLUTE* (−)	Adj. R^2
Unscaled	−124.843	1.242	2.706	−2.227	3.439	−0.543	1.850	−560.441	0.775
	(0.713)	(<0.001)	(0.011)	(0.030)	(<0.001)	(0.372)	(<0.001)	(0.005)	
Scaled	−24.149	0.969	2.549	−2.483	3.017	−0.458	1.734	−14.058	0.795
	(0.147)	(<0.001)	(0.019)	(0.038)	(<0.001)	(0.379)	(<0.001)	(<0.001)	

Primary Coefficient Tests

Unscaled Model Test	p-value	Scaled Model Test	p-value
$\beta_2 > 0$	0.006	$\delta_2 > 0$	0.010
$\beta_2 > 1$	0.057	$\delta_2 > 1$	0.079
$\beta_2 + \beta_3 = 0$	0.354	$\delta_2 + \delta_3 = 0$	0.429
$\beta_7 < 0$	0.003	$\delta_7 < 0$	<0.001

Panel B: Environmental Performance (*POLLUTE*) Based on Biological Oxygen Demand (EP_{BOD}), n = 183 firm-years

Model	Inter	*ABV* (+)	*ECE* (+)	*ECE*POLLUTE* (−)	*NECE* (+)	*NECE*POLLUTE* (?)	*AE* (+)	*POLLUTE* (−)	Adj. R^2
Unscaled	485.715	1.197	2.605	−2.273	3.108	−1.069	1.774	−1230.539	0.723
	(0.319)	(<0.001)	(0.026)	(0.038)	(<0.001)	(0.289)	(<0.001)	(0.018)	
Scaled	−57.377	0.956	2.001	−2.472	3.657	−0.720	2.219	−12.599	0.794
	(0.343)	(<0.001)	(0.004)	(0.002)	(<0.001)	(0.243)	(<0.001)	(0.028)	

(*continued on next page*)

TABLE 2 (continued)

Primary Coefficient Tests

Unscaled Model: Test	Unscaled Model: p-value	Scaled Model: Test	Scaled Model: p-value
$\beta_2 > 0$	0.013	$\delta_2 > 0$	0.002
$\beta_2 > 1$	0.087	$\delta_2 > 1$	0.093
$\beta_2 + \beta_3 = 0$	0.259	$\delta_2 + \delta_3 = 0$	0.695
$\beta_7 < 0$	0.009	$\delta_7 < 0$	0.014

Panel C: Rank Regression Results[b]

Model	Inter	*ABV* (+)	*ECE* (+)	*ECE*POLLUTE* (−)	*NECE* (+)	*NECE*POLLUTE* (?)	*AE* (+)	*POLLUTE* (−)	Adj. R^2
EP_{TRI}	−0.028	0.640	0.296	−0.213	0.384	−0.091	0.081	−0.174	0.899
	(0.195)	(<0.001)	(0.024)	(0.029)	(<0.001)	(0.395)	(<0.001)	(0.016)	
EP_{BOD}	0.019	0.637	0.290	−0.198	0.335	−0.127	0.083	−0.107	0.897
	(0.267)	(<0.001)	(0.021)	(0.038)	(<0.001)	(0.281)	(<0.001)	(0.025)	

Primary Coefficient Tests

Model with EP_{TRI}: Test	Model with EP_{TRI}: p-value	Model with EP_{BOD}: Test	Model with EP_{BOD}: p-value
$\beta_2 > 0$	0.0132	$\beta_2 > 0$	0.011
$\beta_2 + \beta_3 = 0$	0.326	$\beta_2 + \beta_3 = 0$	0.249
$\beta_7 < 0$	0.008	$\beta_7 < 0$	0.013

[a] Two-tailed p-values are reported in parentheses for the hypothesis that the coefficient is equal to 0. For the primary coefficient tests, reported p-values are one-tailed whenever we have directional predictions.

[b] For the rank regression models (Panel C), all variables except *POLLUTE* (i.e., *V*, *ABV*, *AE*, *NECE*, and *ECE*) are ranked from smallest to largest within each year and then scaled to fit between 0 and 1 by dividing by the number of firm-year observations for the given year. *POLLUTE* remains a (0, 1) variable as described above, based alternatively on toxic release inventory (EP_{TRI}) and biological oxygen demand (EP_{BOD}) (Model EP_{TRI} and Model EP_{BOD}, respectively).

The unscaled and scaled models are $V = \beta_0 + \beta_1 ABV + \beta_2 ECE + \beta_3 ECE * POLLUTE + \beta_4 NECE + \beta_5 NECE * POLLUTE + \beta_6 AE + \beta_7 POLLUTE + \upsilon$ and $V/CS = \delta_0/CS + \delta_1 ABV/CS + \delta_2 ECE/CS + \delta_3 ECE/CS * POLLUTE + \delta_4 NECE/CS + \delta_5 NECE/CS * POLLUTE + \delta_6 AE/CS + \delta_7 POLLUTE + \tau$.

Variable definitions: *V* is the market value of the firm's common equity (in \$millions); *ABV* is the firm's adjusted book value of common equity (in \$millions) equal to the firm's book value of common equity minus current period capital expenditure (*ECE* + *NECE*); *ECE* and *NECE* are the firm's current period environmental and nonenvironmental capital expenditures (in \$millions), respectively; *AE* is the firm's abnormal earnings (in \$millions) defined as earnings to common equity less an assumed cost of capital based on the CAPM times the book value of common equity; *POLLUTE* is the firm's relative environmental performance measure set equal to 0 for firm-years with below the median EP_{TRI} in a given year and equal to 1 otherwise; and *CS* is the number of common shares outstanding. *POLLUTE* is based alternatively on toxic release inventory (EP_{TRI}) and biological oxygen demand (EP_{BOD}).

insignificant from 0 ($p = 0.354$). In regard to H3, the negative and significant ($p = 0.003$) estimate of β_7 implies that, on average, the market assesses the existence of unbooked liabilities for high-polluting firms, as predicted by H3. The coefficient estimate of −560.441 implies an average unbooked liability of $560.441 million for high-polluting firms, or 16.6 percent of market capitalization. The average estimates of unbooked environmental liabilities are 28.6 percent and 16.3 percent of market capitalization, respectively, in Barth and McNichols (1994) and Hughes (2000). The results for the scaled model, reported in Panel A of Table 2, are consistent with the unscaled analysis. Specifically, all four coefficients tests are consistent with the predictions of H1–H3.[20]

Given the potential for measurement error for our choice of EP measures, we establish that our results are qualitatively similar using an alternate *POLLUTE* indicator variable based on EP_{BOD}.[21] Panel B of Table 2 reports the analysis for the full model (Equation (2), unscaled and scaled) based on a pooled sample of 183 firm-years with ECE and BOD data using GLS. All coefficient tests are consistent with the predictions of H1–H3, for both the unscaled and scaled models. Specifically, the market positively values ECE investment for low- but not high-polluting firms, and assesses the existence of unbooked liabilities for high-polluting firms.

As a control, Panels A and B of Table 2 report the results of tests of an interaction between *NECE* and *POLLUTE*. For the unscaled model where *POLLUTE* is based on EP_{TRI}, Panel A indicates that for low-polluting firms the estimated coefficient on a dollar of *NECE* is 3.439 ($p < 0.001$). Furthermore, the estimated coefficient on the interaction between *NECE* and *POLLUTE* is insignificantly different from zero ($p = 0.372$, two-tailed). Thus, we infer that *POLLUTE* is not simply proxying for other confounding variables, as low- and high-polluting firms experience the same multiplier on a dollar of *NECE*.

As a further control for the choice of deflator, we estimate model (2) in ranks and report the results in Table 2, Panel C. Specifically, we rank each variable except *POLLUTE* (i.e., *V, ABV, NECE, ECE,* and *AE*) from smallest to largest within each year and then scale it to fit between 0 and 1 by dividing by the number of firm-year observations for the given year. For example, for the 27 firms with observations in 1994, the firms are first sorted by *V* within that year, ranked from 1 to 27 and then the rankings divided by 27 giving values between $1/27 = 0.037$ (smallest) and $27/27 = 1.000$ (largest). We follow an analogous procedure for each of the other variables. *POLLUTE* remains a (0,1) variable as described in Section III, based alternatively on toxic release inventory (EP_{TRI}) and biological oxygen demand (EP_{BOD}). The results for the three primary coefficient tests remain the same. The coefficient test ($\beta_2 > 1$) is not meaningful in rank regressions.

Annual Regression Results

Table 3 presents mean coefficient values re-estimating the valuation model (equation (2)) using OLS for each of the twelve years of our sample period (1989–2000) and then

[20] Our inferences are unchanged when we repeat the analysis reported in Panel A of Table 2 after scaling all items (other than *POLLUTE*) in Equation (2) by the book value of equity as opposed to the number of common shares outstanding. Details are available from the authors upon request.

[21] As Barth and McNichols (1994) point out, the bias in estimated slope coefficients depends on the measurement error in included variables and the correlation between that measurement error and relevant omitted variables. Since the correlation structure and the omitted variables are unknown, we adopt the simple strategy of an alternate *EP* measure. We view EP_{BOD} as an instrumental variable correlated with EP_{TRI} but uncorrelated with the measurement error in EP_{TRI} (for support, see Greene 2000, 370). If the estimated slope coefficients are similar with an alternate EP measure, this makes a stronger case that such results are not driven by bias due to measurement error.

TABLE 3
Mean Coefficient Estimates for the Annual Market Valuation of 256 Firm-Year Observations over the Period 1989–2000[a]

$$V_{it} = \beta_0 + \beta_1 ABV_{it} + \beta_2 ECE_{it} + \beta_3 ECE_{it}{*}POLLUTE_{it} + \beta_4 NECE_{it} + \beta_5 NECE_{it}{*}POLLUTE_{it} + \beta_6 AE_{it} + \beta_7 POLLUTE_{it} + \upsilon$$

	ABV (+)	*ECE* (+)	*ECE* POLLUTE* (−)	*NECE* (+)	*NECE* POLLUTE* (?)	*AE* (+)	*POLLUTE* (−)
Mean Coefficient	1.269***	2.249***	−1.912***	3.728***	−0.408	2.591***	−468.511**
No. of coefficients > 0	12	11	1	12	5	12	2
No. of |t-Statistics| > 1.645	10	10	9	10	2	10	9
Abarbanell and Bernard t-statistic[b]	5.711	3.829	−4.025	5.244	−1.445	4.142	−2.596
Z_1 (Aboody and Lev)[c]	8.082	7.103	−6.471	7.240	−0.980	8.007	−6.023
Z_2 (Aboody and Lev)[c]	7.206	5.343	−5.605	10.370	−0.997	5.828	−5.507

Primary Coefficient Tests[d]	**p-value A and B t-statistic**	**p-value Z_1**	**p-value Z_2**
$\beta_2 > 0$	<0.001	<0.001	<0.001
$\beta_2 > 1$	0.017	<0.001	0.002
$\beta_2 + \beta_3 = 0$	0.488	0.226	0.416
$\beta_7 < 0$	0.005	<0.001	<0.001

, * Significant at the 5 percent and 1 percent levels, respectively, based on the Abarbanell and Bernard t-statistic.

[a] The analyses are based on the 256 firm-years with *ECE* and *TRI* data (1989 (16), 1990 (21), 1991 (24), 1992 (24), 1993 (28), 1994 (27), 1995 (24), 1996 (20), 1997 (21), 1998 (20), 1999 (19), and 2000 (12)).

[b] The Abarbenell/Bernard t-statistic adjusts for the estimated first-order autocorrelation in the independent variables over the sample period by adjusting standard errors using the following factor: $\{[(1+\varphi)/(1-\varphi)] - [2\varphi(1-\varphi^n)/n(1-\varphi)^2]\}^{1/2}$ where n is the number of years and φ is the estimated first-order autocorrelation in the yearly coefficients (Abarbanell and Bernard 2000).

[c] The Z_1 statistic, which assumes residual independence, is $(1/n^{1/2})\Sigma(t_i/\{k_i/k_i - 2\}^{1/2})$ where t_i is the t-statistic for year *n*, k_i is the degrees of freedom, and n is the number of years (7). The Z_2 statistic is: mean t-statistic/(standard deviation of t-statistics/$\{n - 1\}^{1/2}$) (Aboody and Lev 1998; Healy et. al. 1987; White 1984).

[d] For the primary coefficient tests, reported p-values are one-tailed whenever we have directional predictions.

Variable definitions: *V* is the market value of the firm's common equity (in $millions); *ABV* is the firm's adjusted book value of common equity (in $millions) equal to book value minus current period capital expenditure (*ECE* and *NECE*); *ECE* and *NECE* are the firm's current period environmental and nonenvironmental capital expenditures (in $millions), respectively; *AE* is the firm's abnormal earnings (in $millions) defined as earnings to common equity less an assumed cost of capital based on the CAPM times the book value of common equity; and *POLLUTE* is the firm's relative environmental performance propensity measure set equal to 0 for firm-years in the low EP_{TRI} partition (firms with below the median EP_{TRI} in a given year) and equal to 1 for firm-years in the high EP_{TRI} partition.

averaging across the years. We determine annual t-statistics based on White's (1984) consistent covariance matrix. The average coefficient values are similar to those for the pooled analysis presented in Panel A of Table 2. The estimated *ECE* coefficient (β_2) is positive in 11 of the 12 years with |t-statistics| > 1.65 in ten of the 12 years, the *ECE**POLLUTE* interaction term coefficients are negative in 11 years with |t-statistics| > 1.65 in nine years, and the estimates of β_7 are negative in ten years with |t-statistics| > 1.65 in nine years.

In order to test for the statistical significance of the mean coefficients, we consider several approaches. Following Abarbanell and Bernard (2000), we calculate the standard error from the distribution of yearly coefficients and then make an adjustment for serial correlation in the coefficients.[22] To supplement this measure, we also calculate the two Z-statistics (Z_1 and Z_2) employed by Aboody and Lev (1998) and Healy et al. (1987).[23] For the primary coefficient tests, reported p-values are one-tailed whenever we have directional predictions.

Once again, all four primary coefficient tests are consistent with the predictions of H1–H3. Regarding H1, the mean coefficient on *ECE* for low-polluting firms (β_2) is 2.249, reliably exceeding both 0 and unity for the Abarbenell and Bernard t-stat and the Z_1 and Z_2 statistics ($p \leq 0.017$). Turning next to H2, the estimate of $\beta_2 + \beta_3$ for high-polluting firms is 0.337 (2.249–1.912), an estimate which is statistically insignificant from 0 (p = 0.488, 0.226, and 0.412 for the Abarbenell and Bernard t-statistic, Z_1, and Z_2, respectively). In regard to H3, the negative and significant estimate of β_7, −468.511, is reliably less than 0 ($p \leq 0.005$ for the Abarbenell and Bernard t-statistic, Z_1, and Z_2) and suggests that unbooked environmental liabilities exist for high-polluting firms. Thus, the results from the annual regressions reinforce conclusions drawn from the pooled regressions.

Robustness Checks

We perform a number of sensitivity analyses to ensure that our main results are robust and not subject to model misspecification and measurement error. Possible causes of concern for model misspecification include potential confounds due to omitted variables, the impact of observations with negative abnormal earnings, and the use of a dichotomous *POLLUTE* proxy for relative environmental performance. In order to further address potential measurement error, we also examine the impact of cumulative *ECE* to incorporate difference in firm depreciation policy. We discuss each robustness check below.

Potential Confounds

As indicated in Section IV, low- and high-polluting firms differ in their firm characteristics (leverage and size for the overall 1989–2000 period: leverage, liquidity, profitability, and size, for the 1995–2000 subperiod), and the differences represent potential confounds to our main empirical analysis. The pooled and annual analyses presented above show that our results are unlikely to have been driven by factors other than environmental performance. Specifically, it is unlikely that differences between low- and high-polluting firms would be reflected in the *ECE*-related coefficients but not the *NECE*-related coefficients if,

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22 The Abarbenell/Bernard t-statistic adjusts for the estimated first-order autocorrelation in the independent variables over the sample period by adjusting standard errors using the following factor: $\{[(1 + \varphi)/(1 - \varphi)] - [2\varphi(1 - \varphi^n)/n(1 - \varphi)^2]\}^{1/2}$ where n is the number of years and φ is the estimated first-order autocorrelation in the yearly coefficients. As noted by Abarbanell and Bernard, this adjustment factor assumes that the serial correlation is first-order autoregressive.

23 The Z_1 statistic, which assumes residual independence, is $(1/n^{1/2}) \sum_{i=1}^{n} (t_i/\{k_i/k_i - 2\}^{1/2})$ where t_i is the White's t-statistic for year *n*, k_i are the degrees of freedom, and *n* is the number of years (12). The Z_2 statistic is: mean t-statistic/(standard deviation of t-statistics/$\{n - 1\}^{1/2}$). See White (1984) for further support.

in fact, *POLLUTE* simply represents an omitted confounding variable. We present additional evidence regarding the role of potential confounds by modifying Equation (2) to allow all model coefficients to vary across the environmental performance subsets:

$$\begin{aligned} V = {} & \eta_0 + \eta_1 ABV + \eta_2 \mathrm{ECE} + \eta_3 NECE + \eta_4 AE + \eta_5 POLLUTE \\ & + \eta_6 ABV{*}POLLUTE + \eta_7\, \mathrm{ECE}{*}POLLUTE + \eta_8\, NECE{*}POLLUTE \\ & + \eta_9\, AE{*}POLLUTE + \pi \end{aligned} \tag{3}$$

where all terms are previously defined.

The results of this analysis, reported in Table 4, are consistent with the results from preceding analyses on the four primary coefficient tests. Specifically, the coefficient on ECE for low-polluting firms is positive and reliably exceeds both 0 ($p = 0.012$) and unity ($p = 0.095$); the coefficient on ECE for high-polluting firms ($\eta_2 + \eta_7$) is statistically indistinguishable from 0 ($p = 0.424$); and the estimate of η_5 is reliably less than 0 ($p = 0.007$). However, of more immediate interest, with the exception of *ECE*POLLUTE*, none of the interaction terms are significant. The p-values on *ABV*POLLUTE, NECE*POLLUTE,* and

TABLE 4
Pooled GLS Regression Estimates for the Extended Market Valuation Model for 256 Firm-Year Observations from the Period 1989–2000[a]

$$\begin{aligned} V = {} & \eta_0 + \eta_1 ABV + \eta_2 ECE + \eta_3 NECE + \eta_4 AE + \eta_5 POLLUTE + \eta_6 ABV{*}POLLUTE \\ & + \eta_7 ECE{*}POLLUTE + \eta_8 NECE{*}POLLUTE + \eta_9 AE{*}POLLUTE + \pi \end{aligned}$$

Intercept	*ABV* (+)	*ECE* (+)	*NECE* (+)	*AE* (+)	*POLLUTE* (−)
−170.979	1.142	2.366	4.994	1.749	−739.677
(0.298)	(<0.001)	(0.023)	(0.006)	(0.005)	(0.014)

*ABV*POLLUTE*	*ECE*POLLUTE*	*NECE*POLLUTE*	*AE*POLLUTE*
(?)	(−)	(?)	(?)
−0.0332	−2.211	−0.677	−0.751
(0.394)	(0.025)	(0.490)	(0.303)

Primary Coefficient Tests	p-value
$\eta_2 > 0$	0.012
$\eta_2 > 1$	0.095
$\eta_2 + \eta_7 = 0$	0.424
$\eta_5 < 0$	0.424

[a] Two-tailed p-values are reported in parentheses for the hypothesis that the coefficient is equal to 0. For the primary coefficient tests, reported p-values are one-tailed whenever we have directional predictions.

Variable definitions: *V* is the market value of the firm's common equity (in \$millions); *ABV* is the firm's adjusted book value of common equity (in \$millions) equal to book value minus current period capital expenditure (*ECE* + *NECE*); *ECE* and *NECE* are the firm's current period environmental and nonenvironmental capital expenditures (in \$millions), respectively; *AE* is the firm's abnormal earnings (in \$millions) defined as earnings to common equity less an assumed cost of capital based on the CAPM times the book value of common equity; and *POLLUTE* is the firm's relative environmental performance measure set equal to 0 for firm-years in the low EP_{TRI} partition (firms with below the median EP_{TRI} in a given year) and equal to 1 for firm-years in the high EP_{TRI} partition.

*AE*POLLUTE* estimates are 0.394, 0.490, and 0.303, respectively. Further, the results of F-tests (untabulated) reject the null hypothesis that the coefficients for the high-polluting group are equal to 0 for all but *ECE*. Thus, the only estimated coefficient that differs between the low- and high-polluting groups is that on *ECE*, which reinforces the argument that it is unlikely our results are being driven by omitted variables correlated with *POLLUTE*.[24]

Assessing the Impact of Negative Abnormal Earnings

Given the large number of firm-year observations with negative abnormal earnings, we modify Equation (2) to allow for different coefficients for firm-years with negative abnormal earnings. Since persistence may differ across negative and positive abnormal earnings, restricting the coefficient to be the same across the two groups potentially results in model misspecification. Panel A of Table 5 reports the results for Equation (2) for the 105 firm-years when *AE* is positive. Three of the four coefficient tests are consistent with the prediction of H1–H3. In Panel B of Table 5, for the 151 firm-years when *AE* is negative, three of the four coefficient tests again are consistent with the predictions of H1–H3, but the results regarding H1 are mixed. Specifically, the coefficient on *ECE*, 1.729, reliably exceeds 0 ($p = 0.025$) but does not reliably exceed unity ($p = 0.203$). Nonetheless, our results lead us to conclude that the main inferences regarding of H1–H3 are not driven by this potential source of model misspecification.[25]

Using a Continuous Measure to Capture Relative Environmental Performance

We repeat the estimation of Equation (2) using a continuous measure, EP_{TRI}, instead of a dummy variable, *POLLUTE,* to capture relative environmental performance. A continuous *EP* measure implies that low-polluting firms also have unbooked environmental liabilities. This is inconsistent with theory and intuition. Nonetheless, our results (untabulated) are qualitatively equivalent to those reported in Panel A of Table 2 when *POLLUTE* is replaced with a continuous measure, EP_{TRI}, in Equation (2). Specifically, all four coefficient tests again are consistent with the predictions of H1–H3.

Depreciation and Cumulative ECE

The analysis presented above implicitly assumes that 100 percent of current period capital expenditures are included in book value of common equity at year-end. Clearly, however, the firm will depreciate these expenditures over the useful life of the project, including an appropriate portion in the year of outlay. In addition, the analysis does not isolate the undepreciated ECE from previous years that is also part of year-end book value. Ideally, we would like to base our analysis on only the undepreciated current period ECE plus book value of prior years' undepreciated ECE.

Unfortunately, our sample firms do not disclose a separate depreciation schedule for *ECE* or a separate account for undepreciated ECE. To address these issues, we estimate a year-by-year depreciation rate for each of our sample firms based on the reported gross and net capital asset account balances, assuming that net increases occur at the midpoint of the year. Although an average of the rates that the firm applies to various assets is unlikely to

[24] As a further check for potential confounds, we repeat the estimation of Equation (2) by employing a fixed-effects model allowing the intercept to vary by firm, and second including the firm characteristics *Leverage, Asset Age,* and *Liquidity* as additional variables. Both of these approaches yield results almost identical to those reported in Panel A of Table 2.

[25] Our main inferences are also unaffected when we separately estimate Equation (2) for the two subperiods, 1989–1994 and 1995–2000, referred to in Panel C of Table 1.

TABLE 5
Pooled GLS Regression Estimates of the Market Valuation Model for a Sample of Pulp and Paper Companies from the Period 1989–2000 Partitioned on the Basis of Abnormal Earnings (*AE*)[a]

Panel A: Firm-years with *AE* > 0, n = 105

Intercept	*ABV*	*ECE*	*ECE* POLLUTE*	*NECE*	*NECE* POLLUTE*	*AE*	*POLLUTE*	Adj. R^2
−116.937	1.305	2.463	−2.307	4.365	−0.263	5.802	−525.831	0.825
(0.250)	(<0.001)	(0.037)	(0.049)	(0.014)	(0.375)	(<0.001)	(0.008)	

Primary Coefficient Tests	p-value
$\beta_2 > 0$	0.019
$\beta_2 > 1$	0.107
$\beta_2 + \beta_3 = 0$	0.401
$\beta_7 < 0$	0.004

Panel B: Firm-years with *AE* < 0, n = 151

Intercept	*ABV*	*ECE*	*ECE* POLLUTE*	*NECE*	*NECE* POLLUTE*	*AE*	*POLLUTE*	Adj. R^2
−129.812	1.403	1.729	−1.761	3.190	−0.222	1.692	−428.482	0.867
(0.258)	(<0.001)	(0.049)	(0.030)	(<0.001)	(0.408)	(0.036)	(0.046)	

Primary Coefficient Tests	p-value
$\beta_2 > 0$	0.025
$\beta_2 > 1$	0.203
$\beta_2 + \beta_3 = 0$	0.581
$\beta_7 < 0$	0.023

[a] Two-tailed p-values are reported in parentheses for the hypothesis that the coefficient is equal to 0. For the primary coefficient tests, reported p-values are one-tailed whenever we have directional predictions.

$V = \beta_0 + \beta_1 ABV + \beta_2\ ECE + \beta_3\ ECE{*}POLLUTE + \beta_4\ NECE + \beta_5\ NECE{*}POLLUTE + \beta_6\ AE\ \beta_7\ POLLUTE + \upsilon$.

Variable definitions: *V* is the market value of the firm's common equity (in $millions); *ABV* is the firm's adjusted book value of common equity (in $millions) equal to the firm's book value of common equity minus current period capital expenditure (*ECE* + *NECE*); *ECE* and *NECE* are the firm's current period environmental and nonenvironmental capital expenditures (in $millions), respectively; *AE* is the firm's abnormal earnings (in $millions) defined as earnings to common equity less an assumed cost of capital based on the CAPM times the book value of common equity; and *POLLUTE* is the firm's relative environmental performance measure set equal to 0 for firm-years with below the median EP_{TRI} in a given year and equal to 1 otherwise.

be appropriate for any specific class of assets, this estimate appears to be the best available given the limited disclosures.

First, we repeat the analysis after applying the estimated depreciation rates to both current period *ECE* and *NECE*. The pooled GLS results for Equation (2), with *ECE* and *NECE* now measured as the estimated undepreciated current period *ECE* and *NECE,* and *ABV* measured as book value of common equity net of undepreciated current period *ECE* and *NECE* (untabulated), indicate that our conclusions are robust to this adjustment. We find that the coefficient on *ECE* for low-polluting firms reliably exceeds 0 ($p = 0.022$) and unity ($p = 0.065$), while the coefficient on *ECE* for high-polluting firms is not statistically distinguishable from 0 ($p = 0.305$). In addition, the negative and significant estimate of β_7 is reliably less than 0 ($p < 0.001$). Thus, these results are consistent with the predictions of H1–H3.

Second, for the 15 firms with complete ECE data for the eight-year period (1992–1999), we determine the balance of cumulative undepreciated *ECE* made from 1992 up until the end of each of 1997, 1998, and 1999, based on the estimated depreciation rates. We then pool the 1997–1999 data (45 firm-years) and estimate the pooled GLS model (Equation (2)) with the *ECE* variable measured as the estimated cumulative undepreciated *ECE* in book value at the end of each of the relevant years. *ABV* is measured as book value of common equity at year-end net of the estimated cumulative undepreciated *ECE* balance and the undepreciated current period *NECE*. Again, the results (untabulated) are consistent with the previous analysis and are consistent with the predictions of H1–H3. Specifically, we find that the coefficient on *ECE* for low-polluting firms reliably exceeds 0 ($p = 0.001$) and unity ($p = 0.022$), while the coefficient on *ECE* for high-polluting firms is not statistically distinguishable from 0 ($p = 0.249$). We also find the estimate of β_7 is negative and reliably less than 0 ($p = 0.003$).

Pooling across years, the weighted average annual depreciation rates are 7.8 percent and 7.2 percent for low- and high-polluting firms, respectively. The difference is statistically indistinguishable from 0 (Mann-Whitey $p = 0.559$). This finding, together with the above sensitivity analyses, allows us to conclude that measurement error with respect to depreciation and cumulative *ECE* is not driving our results.

VI. SUMMARY AND CONCLUSIONS

The objective of this study is to examine the market valuation of environmental capital expenditure investment related to pollution abatement in the pulp and paper industry. Our total sample *ECE* spending of \$8.7 billion during 1989–2000 supports the focus on this industry. In order to be capitalized, an asset should be associated with future economic benefits. The existing environmental literature suggests that investors condition their evaluation of the future economic benefits arising from ECE on an assessment of the firms' environmental performance. This literature predicts the emergence of two environmental stereotypes: low-polluting firms that overcomply with existing environmental regulations, and minimal compliance high-polluting firms. Using the median emission data to partition firms, our valuation evidence indicates that there are incremental economic benefits associated with ECE investment by low- but not high-polluting firms. This finding may be useful to the FASB if they reconsider the issue of whether to capitalize ECE.

We also find that investors use environmental performance information to assess unbooked environmental liabilities, which we interpret to represent the future abatement spending obligations of high-polluting firms in the pulp and paper industry. We estimate average unbooked liabilities of \$560 million for high-polluting firms, or 16.6 percent of market capitalization. These estimates are consistent with the corresponding estimates of

28.8 percent and 16.3 percent of market capitalization, made by Barth and McNichols (1994) and Hughes (2000), respectively, for the industries which they examine. These findings are beneficial to SEC enforcement staff, because they indicate which types of firms face unfavorable capital spending obligations arising from impending environmental legislation. Finally, our methodology for reliably ranking pulp and paper firms in terms of environmental performance measures suggests that such performance measures are suitable for audit, which is of interest to providers of assurance of firm environmental reports.

We stress several limitations regarding our study. First, we provide indirect capital market evidence of the claimed benefits to voluntary environmental overcompliance, suggested by theory and by practitioners. We demonstrate greater profitability of low-polluting relative to high-polluting firms in the later years (1995–2000) of our sample. However, we leave it to future research to conclusively demonstrate more direct evidence and to discriminate between the various theories of overcompliance. Second, while our results are robust to a variety of robustness checks, the reader should be aware of the potential for measurement error in our proxies. For example, we could only approximate the depreciation rate that our sample firms used for our current and cumulative ECE. Third, a maintained but not directly tested assumption is that the label ''low polluting'' captures a deliberate strategic choice on the part of such firms to benefit from overcompliance as suggested by economic theory. While we find this assumption plausible given the regulatory setting, whereby low-polluting firms dictate the environmental spending of high-polluting firms, and have attempted to eliminate plausible rival explanations, we do not test this assumption explicitly. Fourth, any self-selection bias not controlled for in our tests potentially confounds inferences. The fact that the high-polluting dummy variable interacts as predicted with environmental capital expenditures, but is insignificant when interacted with nonenvironmental capital expenditures, leads us to conclude that correlated omitted variables are not driving our results. This adds credence to our measure of latent environmental liabilities estimated with this categorical variable. Finally, our results are confined to a single industry. A useful avenue for future research would be to explore whether our ECE findings generalize to other industries.

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