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The Influence of Financial Status on the Safety Performance of Regulated Companies: The Role of Enforcement*

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Abstract

A better understanding of the link between a firm's financial status and its regulated performance can help to improve the design of regulatory regimes and lead to more efficient regulatory structures. To date, however, the literature investigating this link has not considered the role that regulatory enforcement plays in determining how financial status affects performance. This paper analyzes how regulatory enforcement affects the relationship between financial status and the safety performance of regulated firms. It examines a particular form of safety performance, namely, the environmental performance of companies regulated under environmental protection laws. In particular, our study explores this effect in the context of the regulation of water pollution using data on wastewater discharges from U.S. chemical manufacturing facilities for the years 1995 to 2001. The results suggest that enforcement in general can play an important role in shaping the effects of financial status on safety performance.

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1. Introduction

A broad literature examines the effects of corporate financial status on a variety of business management and operating decisions. In many cases, the firms' management and operating decisions are regulated. Relevant contexts include occupational safety, customer safety (relating to, for example, health care and air travel), transport safety (relating to, for example, motor carriers and railroads), and environmental management (see, e.g., Filer & Golbe, 2003; Golbe, 1983; Dionne, Gagné, Gagnon, & Vanasse, 1997; Golbe, 1986; Rose, 1990; Talley & Bossert, 1990; Beard, 1992; Gray & Deily, 1996; Earnhart & Lizal, 2006). Examples of regulated performance standards in the US include workplace health and safety standards (set by the Occupational Safety and Health Administration), safety performance standards for motor vehicles and motor vehicle equipment (set by the National Highway Traffic Safety Administration), performance standards designed to reduce the risk of foodborne illnesses (set by the Department of Agriculture's Food Safety and Inspection Service), and standards for both air emissions and water discharges into the environment (set by the Environmental Protection Agency). An important question is how the firms' financial status affects their performance with respect to these regulations (hereafter "regulated performance").[1] A better understanding of the link between a firm's financial status and its regulated performance can help to improve the design of regulatory regimes protecting workers, customers, transporters, and the environment and lead to more efficient regulatory structures. For example, knowing the types of firms that are more (or less) likely to meet or exceed given safety standards can help regulators design programs to increase compliance and overall safety performance.

Several previous studies examine, both theoretically and empirically, the specific question of how financial status affects the business decisions of firms, including those related to safety or other protective investments or activities. A number of channels through which these effects can arise are suggested in the theoretical literature. For example, due to information asymmetries or other frictions, internally generated funds may cost less than external funds, implying that the amount of internal funds available might affect safety investments or expenditure decisions (Myers & Majluf, 1984; Maynard & Shortle, 2001; Filer & Golbe, 2003; Earnhart & Lizal, 2006). In addition, the possibility that a firm becomes insolvent affects the likelihood that it will be financially responsible for injuries or damages that result from inadequate investments in safety, which in turn affects the firm's investment incentives (Brander & Lewis, 1986; Larson, 1996; Filer & Golbe, 2003). Since both the marginal benefit as well as the marginal cost of investment can be affected, the net effect of potential insolvency on safety investment is theoretically ambiguous (Beard, 1990; Larson, 1996). Reduced solvency can also increase the cost of capital if more solvent firms are able to obtain lower interest rates on bank loans due to lower default risks (Maynard & Shortle, 2001).

In addition to this theoretical literature, a number of studies empirically examine the link from financial status to safety investment or the regulated performance reflecting this investment. Examples of studied contexts include workplace safety (Filer & Golbe, 2003), health care (Beauvais, Wells, Vasey, & DelliFraine, 2007), airline safety (Dionne *et al*., 1997; Golbe, 1986; Rose, 1990; Talley & Bossert, 1990), transport safety (Beard, 1992; Traynor & McCarthy, 1993; Golbe, 1983), and environmental compliance (Gray & Deily, 1996; Maynard & Shortle, 2001; Gray & Shadbegian, 2005; Earnhart & Lizal, 2006; Earnhart & Segerson, 2012).[2]

[1]A related question is how the financial status of firms, including regulated firms, affects their financial performance. See Capon, Farley, and Hoenig (1990) for a review of this literature.

[2]Another set of studies explores the reverse link from environmental performance to financial performance (e.g., Konar & Cohen, 2001; Russo & Fouts, 1997; Khanna & Damon, 1999).

Despite the importance of these regulatory contexts, to date the literature related to the relationship between financial status and safety investment and/or performance has not considered the role that regulatory enforcement plays in determining this relationship. In general, regulators imposing safety standards expend great efforts to induce compliance with these standards through inspections of regulated facilities and enforcement actions against violators.[3] However, for the most part, the literature on the effect of financial status on performance does not consider the role of enforcement. For example, Filer and Golbe (2003) empirically explore the effects of financial status on Occupational Safety and Health Administration (OSHA) violations, while controlling for OSHA inspections, but they do not assess how these inspections influence the effects of financial factors on violations. Thus, in contrast to our study, these authors do not consider the interactions between financial status and enforcement within their empirical analysis.

Likewise, previous literature on the effectiveness of enforcement suggests that enforcement actions have a direct effect on regulated performance (Earnhart, 2004b; Earnhart, 2004c; Earnhart, 2009). In addition, two studies in the literature on regulatory enforcement explore the influence of financial status on the effectiveness of environmental enforcement (Gray & Shadbegian, 2005; Earnhart & Segerson, 2012). However, none of these studies examines the influence of enforcement on the link from financial status to regulated safety performance, which is the focus of our study. Thus, these studies do not examine the total effect of financial status on performance, allowing for both a direct effect and an interaction effect with enforcement. If an interaction effect exists, then empirical studies of how financial status affects regulated safety performance will not generate accurate assessments of this relationship when they fail to account for variation in the extent of enforcement.

The present study contributes to the growing literature on the effects of corporate financial status on business management and operational decisions by analyzing the influence of enforcement conditions on the effects of financial status on regulated performance. We examine this question by examining whether the marginal effects of a firm's financial status on regulated safety performance depend on enforcement conditions.

When assessing the effect of financial status on regulated performance, we consider three prominent dimensions of financial status: [1] solvency (which relates to the potential for bankruptcy), [2] illiquidity (which relates to the cost of accessing funds to cover losses and pay enforcement-related sanctions), and [3] profitability (which can reflect differences in managerial skill and hence differences in total and marginal costs). Previous studies related to financial status typically use a single proxy variable.[4] In addition, we consider both the likelihood of enforcement, as reflected in the likelihood of an inspection, as well as the severity of enforcement, as reflected in the monetary value of imposed sanctions.

We examine the specific regulatory context of U.S. Clean Water Act restrictions imposed on point sources of wastewater discharges. Specifically, we analyze wastewater discharges from U.S. chemical manufacturing facilities subject to effluent limits, using monthly facility-level data over the years 1995 to 2001. To ensure compliance with these limits, federal and state agencies periodically inspect facilities to monitor compliance and collect evidence for enforcement actions, including monetary sanctions (hereafter "sanctions"), taken in response to violations of effluent limits (Wasserman, 1984; Cohen, 1999).

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[3]A large literature explores the effectiveness of monitoring and enforcement efforts (e.g., Scholz & Gray, 1990; Gray & Jones, 1991a, b; Bartel & Thomas, 1985; Viscusi, 1979; Gray & Deily, 1996; Magat & Viscusi, 1990; Laplante & Rilstone, 1996; Helland, 1998a, b; Earnhart, 2004a, b).

[4]In the literature on environmental management and performance, Gray and Deily (1996) include only a financial rate of return measure, yet interpret it as a measure of liquidity; Gray and Shadbegian (2005) include only a financial rate of return measure, yet interpret it both as a measure of liquidity and a measure of solvency; Earnhart and Lizal (2006) consider only profits; Maynard and Shortle (2001) blur together the dimensions of liquidity and solvency when interpreting the effect of profit levels.

The empirical results demonstrate that, in this context, (1) the effect of each financial status dimension depends on at least one of the enforcement components - either its likelihood or its severity, (2) the distinctions across solvency, liquidity, and profitability are important since the financial status dimensions affect regulated performance differently and their effects depend on enforcement conditions differently, (3) the marginal effects of solvency and liquidity depend on the enforcement components collectively based on the conditions found in the studied sample, and (4) marginal effects range across positive and negative values, significantly so in the case of solvency and liquidity (e.g., depending on enforcement conditions, the marginal effect of liquidity is significantly positive or statistically zero).

The remainder of the paper is organized as follows. Section 2 discusses the basic conceptual background that underlies our empirical analysis. Section 3 presents the empirical application to U.S. chemical manufacturing facilities and constructs the econometric model. Section 4 describes the data. Section 5 presents the estimation results. Section 6 concludes.

2. Conceptual Background

The conceptual framework that underlies our empirical analysis is based on the model in Earnhart and Segerson (2012), which models a firm's safety or abatement decisions when faced with a regulatory performance standard. The model considers the role of both financial factors (reflecting solvency, liquidity and managerial skills) and regulatory enforcement factors (probability of inspection and sanctions for violations). Earnhart and Segerson (2012) focus on the efficacy of enforcement. A key theoretical result is that, when a firm faces possible liquidation and bankruptcy constraints, the impacts of marginal changes in enforcement depend on the firm's financial status. The implication is that empirical studies of the effectiveness of enforcement should consider the financial status of the regulated entity, a result that is borne out by the empirical analysis in that paper.

Here, our focus is different. Rather than assessing the effectiveness of enforcement, we focus on the direct relationship between different dimensions of financial status and a firm's regulated performance. In particular, we ask whether ignoring regulatory enforcement leads to biased estimates of this relationship. We probe this question by exploring the marginal impacts of financial status (rather than the marginal impacts of enforcement) with and without consideration of enforcement.

The same theoretical model used in Earnhart and Segerson (2012) to demonstrate the importance of considering financial conditions when studying the effectiveness of enforcement can be used to reveal the following:

> *The effect of a firm's financial status on safety performance depends on the likelihood and severity of enforcement.*

This dependence follows directly from the fact that, when firms face the possibility of illiquidity and/or bankruptcy, the marginal benefit as well as the marginal cost of safety or pollution abatement depend on enforcement factors that determine the probability or magnitude of sanctions and hence the likelihood and payoffs under those possible states.[5] Moreover, the marginal impact of a change in financial status varies across the different dimensions of financial status. These differences imply that, when considering the impact of financial status, it is important to distinguish among these different dimensions. Despite these differences though, in all three cases, the marginal impact is ambiguous in sign; in other words, the marginal impact can be positive, negative or zero, depending on the specific functions and parameter values. This ambiguity stems from the fact that all three dimensions of financial status shift both the marginal benefit of effort and the marginal cost of effort in ways that are ambiguous. Thus, the theoretical model reveals that the ambiguous impact of potential bankruptcy found in the models of Beard (1990) and

[5] See Earnhart and Segerson (2015) for a detailed derivation of this result.

Larson (1996) holds here as well and that this ambiguity extends to other dimensions of financial status, namely, illiquidity and managerial skill. Consequently, empirical analysis must be used to determine both the direction and the magnitude of these influences.

3. Empirical Application and Econometric Approach

Our empirical investigation examines compliance with the effluent limits imposed on point sources of wastewater discharges under the U.S. Clean Water Act. Specifically, we analyze wastewater discharges of total suspended solids (TSS) from EPA-classified "major" chemical manufacturing facilities operating in the US during the years 1995 to 2001. These facilities are a significant source of wastewater discharges, and TSS is one of the five categories of conventional pollutants, which were the focus of Environmental Protection Agency (EPA) control efforts. For this empirical analysis, the dependent variable is the level of environmental performance for facility *i* in time period *t* as measured by the ratio of absolute discharges to facility-specific effluent limits (hereafter the facility's "discharge ratio").

We consider a number of regressors.[6] First, we include three dimensions of financial status: (1) the current ratio (as a measure of solvency), (2) the ratio of year-end liquid assets to total assets (as a measure of liquidity), and (3) the one-year stock return rate (as a measure of profitability and a proxy for managerial skill).

Second, we consider two dimensions of enforcement: likelihood and severity. To capture the likelihood of enforcement, as reflected in the likelihood of an EPA inspection, we use the presence of an EPA inspection conducted at facility *i* in month *t*, where a value of one indicates the presence of at least one EPA inspection. To address the potentially endogeneity of this regressor, we use two-stage least squares regression. We instrument for the EPA inspection measure using the monthly aggregate count of EPA inspections conducted at other similar facilities: major chemical facilities in the same state during the same month as the relevant observation. We divide the aggregate count of inspections by the number of other major chemical facilities operating in each state for the given month, yielding a measure of federal inspections per facility. Since state environmental agencies also monitor regulated facilities, we additionally include the presence of a state inspection conducted at facility *i* in month *t*, where a value of one indicates the presence of at least one state inspection. To address potential endogeneity, we instrument for this factor using the monthly aggregate count of state inspections conducted at other similar facilities in the same state and month, again dividing by the relevant number of other major chemical facilities to yield a measure of state inspections per facility. To capture the severity of enforcement, we use the total monetary value of federal sanctions (in dollars) imposed against other major chemical facilities in the same state and year, adjusted by the number of federal sanctions imposed against other similar facilities. The resulting measure represents the *conditional* average federal sanction amount imposed against other similar facilities.

Third, we control for other regulatory factors that may affect the level of environmental performance (Helland, 1998a; Earnhart, 2004a, b; Nadeau, 1997). To capture regulatory pressure not reflected in the enforcement measures, we include annual budgetary resources expended by state and local agencies (by state), by EPA regional offices (by region), and by the EPA federal office (entire US), all adjusted by the number of manufacturing facilities in each state, region, and country, respectively, for the relevant year. We additionally include EPA regional indicators and season indicators. We also include the following facility-specific permit conditions: (1) the permitted effluent limit (in pounds/day); (2) the limit type [initial or interim versus final]; and (3) an indicator for any modification(s) to the permit after issuance.

Fourth, we control for the following facility-level characteristics (Earnhart, 2004a; Bandyopadhyay &

[6] See Earnhart and Segerson (2012) for a detailed description of the data.

Horowitz, 2006; Gray & Shadbegian, 2005): (1) flow design capacity (as proxied by average flow of wastewater); (2) capacity utilization (as proxied by the ratio of actual wastewater flow to flow design capacity); and (3) industrial sub-sector indicators.

Finally, we control for local community pressure indirectly using certain community characteristics, such as political engagement, as measured by the voter turnout rate (Earnhart, 2004c; Bandyopadhyay & Horowitz, 2006; Hamilton, 1993).[7]

4. Estimation Results

4.1. Description of Results

We estimate three different semi-log models based on three different regressor sets. Model 1 excludes the enforcement regressors along with their interactions with the financial status regressors. Model 2 includes the enforcement regressors while continuing to exclude their interactions with the financial status regressors. Model 3 includes both the enforcement regressors and their interactions with the financial status regressors. By comparing across the three models, we are able to assess the importance of considering enforcement when identifying the effects of financial status on regulated firm performance.

When estimating Model 1, we implement three alternative panel data regression estimators: pooled OLS, fixed effects least squares, and random effects generalized least squares. When estimating Models 2 and 3, we implement three alternative two-stage least squares (2SLS) panel data regression estimators: pooled S2LS, fixed effects 2SLS, and random effects 2SLS (Cameron & Trivedi, 2010). We use an F-test of fixed effects to discern whether the fixed effects estimator dominates the pooled estimator, which is true when the F-test statistic rejects the null hypothesis of no fixed effects. We use the Hausman test of random effects to assess whether the random effects estimates are consistent. If they are, the random effects estimator dominates the fixed effects estimator since the former is more efficient.

In all cases, the F-test for fixed effects statistics reveal that the fixed effects estimator dominates the pooled estimator and the Hausman test for random effects statistics reveal that the random effects estimator dominates the fixed effects estimator. Consequently, we highlight the random effects estimates. Still, we evaluate the fixed effects estimates since they are at least consistent. The two sets of estimation results are similar; in particular, the two sets of estimates relating to financial status and enforcement, including their interactions, are nearly identical. This very strong similarity removes the need to tabulate the fixed effects estimates and, more importantly, implies that our results are robust to the choice of panel data estimator.

When estimating Models 2 and 3, the 2SLS estimators address the potential endogeneity of the inspection-related regressors, including the related interactions in Model 3. Hausman exogeneity test statistics indicate that the use of 2SLS estimators is warranted.[8, 9]

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[7] The list of community characteristics includes the unemployment rate, voter turnout rate, Democratic voting proportion in presidential elections, population density, owner occupied housing proportion, family household proportion, family households with children proportion, male residents proportion, per capita income, chemical-related private earnings proportion, non-white residents proportion, proportion of residents with Bachelor's degree or more, and median age.

[8] For Model 3, which represents a generalization of Model 2, the Hausman exogeneity test statistic for the random effects estimator is 58.96, with a p-value of 0.021. This statistic rejects the null hypothesis of exogeneity.

[9] An assessment of the relevance of our instruments, which are described in Section 3, is available upon request. We are not able to assess statistically the validity of our instruments because the system is exactly identified, i.e., the number of instruments equals the number of potentially endogenous regressors.

Table 1. Random effects estimation of Total Suspended Solids (TSS) discharge ratio (logged)

Model 1: excludes both the enforcement regressors and their interactions with financial status

Model 2: excludes only the interactions between enforcement and financial status

Model 3: includes both the enforcement regressors and their interactions with financial status

Variable [a]	Model 1		Model 2 [b]		Model 3 [b]	
	Coeff	p	Coeff	p	Coeff	p
Financial Status Factors						
Stock Return Rate (lagged)	0.007	0.831	0.011	0.730	0.083	0.150
Current Ratio (lagged)	-0.004	0.864	-0.011	0.649	-0.007	0.885
Liquid Assets / Total Assets (lagged)	-0.083	0.744	0.008	0.976	0.466	0.413
Enforcement Dimensions						
Monthly EPA Inspection			-0.070	0.937	-4.020	0.429
Monthly State Inspection			-0.045	0.754	0.647	0.159
Annual Sanctions on Others / # of Sanctions			5.38 e-09	0.493	6.20 e-08	0.038
Interactions: Stock Return Rate (lagged) □						
EPA Inspections					-1.043	0.826
State Inspections					-0.444	0.273
Sanctions					-9.82 e-08	0.051
Interactions: Current Ratio (lagged) □						
EPA Inspections					1.089	0.711
State Inspections					-0.330	0.263
Sanctions					-3.08 e-08	0.105
Interactions: Liquid Assets / Total Assets (lagged) □						
EPA Inspections					77.470	0.086
State Inspections					-7.914	0.150
Sanctions					9.25 e-08	0.625
Control Factors						
State and Local Budget / # of Manufacturers	-0.722	0.471	-1.554	0.159	-1.962	0.172
EPA Regional Budget / # of Manufacturers	-0.607	0.001	-0.528	0.009	-0.471	0.068
EPA Overall Budget / # of Manufacturers	-0.043	0.000	-0.049	0.000	-0.064	0.000
Monthly Effluent Limit	0.070	0.000	0.087	0.000	0.113	0.000
Initial or Interim Limit Type [c]	0.074	0.307	0.076	0.308	0.140	0.202
Modification to Permit [d]	0.034	0.514	0.032	0.543	0.035	0.628
Winter Season [e]	0.118	0.000	0.119	0.000	0.124	0.000
Spring Season [e]	0.111	0.000	0.113	0.000	0.129	0.000
Summer Season [e]	0.041	0.036	0.041	0.034	0.046	0.033
Flow Capacity	0.029	0.000	0.034	0.000	0.044	0.000
Flow to Flow Capacity	1.806	0.609	1.949	0.583	14.105	0.085
Number of Observations		11,904		11,904		11,904
Adjusted R-squared		0.020		0.022		0.002
F-Test of Fixed Effects [p-value]		60.27 [0.000]		59.38 [0.000]		58.88 [0.000]
Hausman Test: Random Effects [p-value]		0.87 [0.999]		0.47 [0.999]		0.01 [0.999]

[a] All models include the following as regressors: EPA regional indicators, sectoral indicators, and the community characteristics listed in footnote 7. All models also include an inverse Mills ratio that corrects for any potential sample selection bias introduced by the incomplete reporting of wastewater discharges.

[b] The study uses two-stage least squares estimation to estimate Models 2 and 3.

[c] Omitted category = final limit type.

[d] Omitted category = no modification to permit.

[e] Omitted category = autumn season.

Table 1 reports the random effects estimation results.[10] We begin by exploring the results of Model 1, which excludes the enforcement regressors along with their interactions with the financial status regressors. As shown in Table 1, none of the financial status coefficients are statistically significant. Model 2 estimation results support this same conclusion. However, Model 3 estimation results reveal that some of the interaction coefficients are significant. Thus, Model 3 dominates both Models 1 and 2. Consequently, we focus our discussion here on the Model 3 estimates.

Given the inclusion of interactions in Model 3, the coefficients relating to the main effects of the financial variables represent the effect of financial status in the absence of any enforcement threat: zero likelihood of enforcement and zero sanction value. As shown in Table 1, in the absence of enforcement, no financial status factor influences the discharge ratio.

We next assess the interactions between financial status and enforcement. The estimation results suggest the following conclusions. First, the effect of liquidity on the discharge ratio depends on enforcement to some extent. The significantly positive interaction with the likelihood of federal inspections implies that, as a federal inspection becomes more likely, greater liquidity becomes less effective at reducing the discharge ratio. In contrast, the effect of liquidity does not depend on the likelihood of a state inspection or enforcement severity.

The effect of solvency on the discharge ratio also depends on enforcement to some extent. The significantly negative interaction with enforcement severity implies that an increase in severity makes greater solvency more effective at reducing the discharge ratio. In contrast, the insignificant interactions with the likelihood of federal inspections and the likelihood of state inspections imply that the effect of solvency does not depend on federal or state inspections.

The effect of profitability on the discharge ratio depends on enforcement to some extent in a fashion similar to solvency. The significantly negative interaction with enforcement severity implies that an increase in enforcement severity makes greater profitability more effective at reducing the discharge ratio. In contrast, the insignificant interactions with both the likelihood of federal inspections and the likelihood of state inspections imply that the effect of profitability does not depend on federal or state inspections.

Lastly, most of the control factors are statistically significant, supporting the following conclusions. First, as expected, an increase in any of the three budgetary factors lowers the discharge ratio so more money allocated to environmental protection improves the extent of compliance. These effects are statistically significant for the regional and federal budgets. Second, an increase in the effluent limit increases the discharge ratio. Third, discharge ratios fluctuate seasonally. Fourth, discharge ratios are higher for facilities with greater flow capacity, suggesting diseconomies of scale. Fifth, an increase in capacity utilization, as measured by the flow to flow capacity ratio, leads to a higher discharge ratio.

4.2. Assessment of Marginal Effects of Financial Status Factors

To understand the effects of financial status under different enforcement conditions, this sub-section evaluates the marginal effect of each financial status factor – liquidity, solvency, and profitability – on the discharge ratio using the results generated by the random effects estimation of Model 3. Since the

[10] Due to space considerations, we do not report coefficients for community characteristics, EPA regional indicators, and sectoral indicators.

estimation of interaction terms demonstrates that the effect of each financial status factor depends on enforcement, each relevant marginal effect must include both the main effect and the interacted effects, which are evaluated at specific values for the enforcement dimensions. To see the range of impacts, we evaluate these effects in two different ways: (1) using the mean enforcement values, and (2) using the entire distribution of values for the enforcement variables.

Based on the mean enforcement values, the derived marginal effects for profitability, solvency, and liquidity are -0.004, -0.035, and 0.227, respectively. None of these mean-based marginal effects statistically differ from zero at accepted significance levels. (The associated F-test statistics are 0.02, 1.51, and 0.62, respectively, with p-values of 0.879, 0.219, and 0.429.) These results indicate that financial status does not affect the discharge ratio for the "average facility" as identified under average enforcement conditions. Of course, this assessment is incomplete since it considers only the mean enforcement values.

Table 2. Marginal effect of each financial status factor:
Based on enforcement profile of each observation [a]

Percentile (%)	Stock Return Rate			Current Ratio			Liquid / Total Assets		
	Magnitude	Test: Zero Effect		Magnitude	Test: Zero Effect		Magnitude	Test: Zero Effect	
		Statistic	p-value		Statistic	p-value		Statistic	p-value
0 (min)	-1.954	-0.43	0.668	-0.510	-1.57	0.104	-7.448	-1.46	0.144
1	-0.573	-0.70	0.503	-0.340	-1.41	0.159	-7.448	-1.46	0.144
5	-0.361	-0.96	0.338	-0.338	-1.25	0.213	-7.448	-1.46	0.144
10	-0.361	-1.31	0.191	-0.180	-1.58	0.104	-6.930	-1.21	0.225
20	0.044	0.74	0.462	-0.019	-0.41	0.680	0.466	0.82	0.413
30	0.077	1.35	0.177	-0.009	-0.18	0.857	0.466	0.82	0.413
40	0.083	1.44	0.150	-0.007	-0.15	0.885	0.466	0.82	0.413
50	0.083	1.44	0.150	-0.007	-0.14	0.885	0.466	0.82	0.413
60	0.083	1.44	0.150	-0.007	-0.14	0.885	0.466	0.82	0.413
70	0.083	1.44	0.150	-0.007	-0.14	0.885	0.466	0.82	0.413
80	0.083	1.44	0.150	-0.007	-0.14	0.885	0.471	0.84	0.403
90	0.083	1.44	0.150	-0.007	-0.14	0.885	0.503	0.94	0.346
95	0.083	1.44	0.150	-0.007	-0.14	0.885	0.517	0.97	0.330
99	0.083	1.44	0.150	0.579	0.20	0.844	70.021	1.65	0.099
100	0.083	1.44	0.150	1.082	0.37	0.710	78.454	1.75	0.081

[a] Marginal effects are based on the two-stage least squares random effects estimation shown in Table 1 (Model 3).

To understand more fully the influence of enforcement conditions on the effect of financial status, we exploit the heterogeneity of enforcement conditions in the full sample and calculate marginal effects for the entire sample distribution. For each financial status factor, Table 2 reports the key percentiles of the sample distribution: 0 (minimum), 1st, 5th, 95th, 99th, and 100th (maximum), along with the remaining deciles. As shown, the median marginal effect of liquidity is positive, implying that an increase in liquidity leads to a higher discharge ratio, i.e., worse environmental performance. In fact, 90.4 % of the observations display a positive marginal effect. However, the distribution reveals that the marginal effect varies from a minimum of -7.448 to a maximum of 78.45. Table 2 shows that the minimum effect almost significantly lies below zero (p-value of 0.14), while the maximum effect significantly lies above zero (p-value of 0.08). In between the minimum and maximum effects, most of the marginal effects do not significantly differ from zero. However, for the top 1 % of the distribution, the marginal effect proves significantly positive. In general, these empirical results reveal that the effect of liquidity depends on enforcement conditions; in particular, the effect is either statistically zero or significantly positive depending on enforcement conditions. This dependence is consistent with our theoretical results, which show that the sign of the marginal effect of liquidity is ambiguous and depends on enforcement conditions. Thus, analyses that fail to account for the enforcement threat faced by a firm can yield misleading predictions about the effect of liquidity on environmental performance. These points notwithstanding, we acknowledge that our results reveal a dependency on enforcement conditions based on a contrast between the bottom 99 % and the top 1 % of a distribution that offers nearly only statistically insignificant marginal effects.

We next evaluate the marginal effect of solvency across the sample distribution. As shown in Table 2, the median marginal effect is barely negative, implying that an increase in solvency leads to a lower discharge ratio, i.e., better environmental performance. Overall, 99.3 % of the observations display a negative marginal effect. More important, the distribution reveals that the marginal effect ranges from a minimum of – 0.510 to a maximum of 1.082. As shown in Table 2, the minimum effect significantly lies below zero, yet the maximum effect does not significantly lie above zero. In between, many of the marginal effects do not significantly differ from zero. However, the marginal effect lying at the first decile (10^{th} percentile) proves significantly negative, as with the minimum effect. Thus, in the bottom decile of the distribution, the effect of solvency is significantly negative. These empirical results reveal that the effect of solvency depends on enforcement conditions with the effect ranging from negative to zero across the distribution of observation-specific marginal effects.

We finally evaluate the marginal effect of profitability (stock return rate) across the sample distribution. As shown in Table 2, the median marginal effect is positive, as with 84.0 % of the observations. A positive effect implies that greater profitability leads to a higher discharge ratio, i.e., worse environmental performance. Over the sample, the marginal effect ranges from a minimum of −1.954 to a maximum of 0.083. However, neither the minimum nor the maximum marginal effect is significantly different from zero. As shown in Table 2, the minimum effect is clearly insignificant (given a p-value of 0.67), while the maximum effect is only nearly significant (given a p-value of 0.15). In contrast to the first two sets of results, these empirical results reveal that the marginal effect of profitability does not depend on enforcement conditions when the two enforcement components are assessed jointly and the enforcement component values are jointly given by specific observations, i.e., an observation provides both the likelihood and magnitude of enforcement. However, Table 1 clearly reveals that the effect of profitability significantly depends on enforcement severity. Thus, based on consideration of the influence of enforcement conditions individually, but not in combination, even the marginal effect of profitability depends on one of the enforcement components – as severity increases, the marginal effect significantly rises.

4.3. Importance of Including Enforcement and its Interactions with Financial Status

As the final component of analysis, we explore the importance of including the enforcement variables as regressors and more importantly including their interactions with financial status factors. In order to explore this importance, we re-assess the estimation results from Models 1 and 2. First, we reconsider Model 2, which excludes the interactions between individual financial status factors and enforcement dimensions. By excluding these interactions, we force each financial status factor to influence environmental performance independently of enforcement conditions. In this case, the marginal effect of each finance status factor is reflected in the single coefficient associated with each factor, rather than a distribution of marginal effects. For each financial status factor, we then relate this single coefficient to the relevant distribution of marginal effects generated by including interaction terms.

Consider first the marginal effect of liquidity. When we exclude interactions, the marginal effect of liquidity is 0.008. While this magnitude lies within the range established by the specification that includes interactions (see Table 2), this magnitude lies substantially below the median of 0.466, falling at only the 10th percentile. Thus, this magnitude reflects little of the distribution. As important, the marginal effect based on a specification excluding interactions is not statistically significant. In contrast, the upper range of the distribution of marginal effects includes positive magnitudes that are significant. Thus, by excluding interactions, the analysis fails to capture the statistical significance of liquidity within the sample distribution.

Consider next the marginal effect of solvency. When we exclude interactions, the marginal effect of solvency is -0.011. This magnitude lies within the range established by the specification that includes interactions and is reasonably close to the median of -0.007. However, the magnitude falls at only the 24th percentile, again not reflecting much of the distribution. As important, the marginal effect based on a specification excluding interactions is not statistically significant. In contrast, the lower range of the distribution of marginal effects includes statistically negative magnitudes. Thus, by excluding interactions, the analysis fails to capture the statistically negative effect of solvency over some range of the sample distribution.

Lastly, consider the marginal effect of profitability. When we exclude interactions, the marginal effect is 0.011. This magnitude lies within the range established by the specification that includes interactions. Yet the magnitude lies meaningfully below the median of 0.083, falling at only the 19th percentile, thereby, reflecting little of the distribution. The marginal effect based on a specification that excludes interactions is insignificant, similar to the distribution of marginal effects generated by including interactions.

Finally, we reconsider Model 1, which excludes all regressors related to enforcement. Exclusion of all related regressors generates marginal effects dissimilar to those generated by excluding only the interaction terms: -0.083, -0.004, and 0.007, respectively for liquidity, solvency, and profitability. Ignoring enforcement conditions as control factors altogether further distorts the estimated marginal effects for liquidity and profitability. Relative to Model 2, the magnitudes of both the liquidity effect and the profitability effect lie even lower within the distributions generated by Model 3, thereby, reflecting even less of the respective distributions. As important, none of these marginal effects are statistically significant.

Based on this assessment, we conclude that previous studies failing to capture the influence of enforcement conditions on the marginal effects of financial status factors may offer a distorted understanding of the links from financial status to regulated performance, including environmental performance.

5. Conclusion

This study analyzes the influence of enforcement conditions on the effects of financial status on environmental performance. The study considers the effects of three dimensions of corporate financial status: (1) liquidity, (2) solvency, and (3) profitability. The study also considers two dimensions of enforcement: (1) the likelihood of enforcement, as captured by the likelihood of inspections conducted at regulated facilities, and (2) the severity of enforcement, as captured by the size of sanctions imposed on polluting facilities found violating their effluent limits. The study first develops a theoretical model of optimal protection effort (e.g., pollution abatement) in the presence of liquidity and bankruptcy constraints. Then the study uses this model to investigate the effects of financial status on optimal protection effort, and hence, regulated performance, when considering the influence of enforcement conditions on these effects. Finally, the study empirically examines the interactions between financial status and enforcement using data on wastewater discharges (relative to effluent limits) from U.S. chemical manufacturing facilities for the years 1995 to 2001.

Theory suggests that the marginal effects of the three financial status dimensions on regulated performance depend on both enforcement likelihood and enforcement severity and these marginal effects may be positive, negative, or zero. Our empirical results support these predictions by showing that the marginal effects of all three financial status dimensions on environmental performance significantly depend on enforcement conditions even though only three of the nine individual interaction terms are statistically significant. As important, the empirical results reveal that the marginal effect of liquidity varies depending on the values of the enforcement factors shown in the studied sample, with a zero impact in the lower and middle ranges and a significantly positive impact in the upper range. Similarly, the empirical results indicate that the marginal effect of solvency depends on the values of the enforcement factors, running between a significantly negative impact in the lower range and a zero impact in the middle and upper ranges. Lastly, the empirical results indicate that the marginal effect of profitability depends on the value of enforcement severity – as severity increases, the marginal effect significantly rises – but not on the value of enforcement likelihood and not the two components collectively when their values are jointly based on specific observations within in the sample.

We end with a discussion of the policy implications of our empirical results. In the absence of any enforcement threat (i.e., both likelihood and severity equal zero), none of the financial status factors affect environmental performance. While one might hope that greater liquidity, solvency, or profitability improves a facility's compliance with environmental protection laws, only the main effect of solvency proves negative (but insignificantly so), indicating that stronger solvency improves the extent of compliance. In contrast, the main effects of liquidity and profitability are both positive (albeit insignificantly so), indicating that stronger liquidity or profitability actually *undermines* the extent of compliance. Perhaps the presence of enforcement threats might improve the otherwise insignificantly productive effect of solvency and insignificantly unproductive effects of liquidity and profitability. In two cases, an increase in the threat of enforcement improves the effectiveness of greater financial status. Specifically, as evidenced by the significantly negative interaction involving solvency and enforcement severity, an increase in enforcement severity makes greater solvency more effective at improving the extent of compliance. Similarly, as evidenced by the significantly negative interaction involving profitability and enforcement severity, an increase in enforcement severity makes greater profitability more effective at prompting greater compliance. Nevertheless, in one case, an increase in the threat of enforcement exacerbates the otherwise unproductive effect of financial status. Specifically, as evidenced by the significantly positive interaction involving liquidity and enforcement likelihood (when captured by the likelihood of federal inspections), an increase in the likelihood of a federal inspection makes greater liquidity less effective at improving the extent of compliance. Thus, greater enforcement both improves and undermines the productivity of greater financial status.

Finally, we assess the generalizability of our analytical results. We shape our theoretical model to explore environmental performance given the regulatory context of our empirical analysis. Fortunately, our theoretical model applies as well to the effect of a performance standard in other regulatory contexts, such as workplace safety, consumer product safety, and transportation safety. We admit that the results from our empirical analysis of regulated environmental performance need not generalize to other regulatory contexts. Still, both the theoretical and empirical analysis presented here suggest that failure to consider the role of enforcement could lead to incorrect conclusions about the impact of financial status on regulated performance.

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