Down the Tubes:
Financial Distress, Bankruptcy, and Industrial Water Pollution

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Abstract

How do firms' efforts to prevent harm to third parties change as they approach, enter, and then exit bankruptcy? To help answer this, I investigate a panel of roughly 350 US firms, all of which declare bankruptcy and are regulated under the Clean Water Act (CWA) for pollutants they release into public waterways. As these firms approach bankruptcy, the rate at which they release pollutants beyond their permitted limit increases by 50%. Once firms file for bankruptcy, their compliance dramatically improves, returning to a baseline from well before they filed for bankruptcy. I explore mechanisms that may explain this pattern and conclude that the most likely causes are a nexus of moral hazard problems and financing frictions affecting thinly capitalized firms. These findings lend support to a range of policy interventions, such as changes in the priority of bankruptcy claims, that can help to alleviate moral hazard problems for thinly capitalized firms. Furthermore, the dramatic compliance improvements that occur after firms file for bankruptcy point to a less-recognized role of corporate bankruptcy in helping to prevent public harms that can occur as a result of firms operating while in significant financial distress. This suggests an added public benefit to bankruptcy policies that encourage firms to file for bankruptcy early, and an added detriment to policies and practices that seek to delay firms' resolution of financial distress.

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1 Introduction

Financial distress is widely recognized as creating distortions in firms that can lead them to operate less efficiently, thus destroying value of the firm and its assets. Heavily indebted firms may have difficulty obtaining financing for value-enhancing investments (Myers, 1977), and may encounter greater divergence of interests between shareholders and creditors (Jensen and Meckling, 1976). Bankruptcy and similar restructuring proceedings can potentially preserve the value of a firm's assets by resolving this financial distress and either reorganizing the firm with a more stable capital structure, or transferring the firm's assets to new owners that will be able to make more productive use of them.

Firms in financial distress are not, however, merely at risk of squandering the private value of their assets; they also may be at heightened risk of externalizing harms to third parties or to the general public (see, e.g. Shavell, 1986). Furthermore, while there has been extensive scholarship that examines ways that bankruptcy preserves the value of privately owned assets, there has been little consideration of the ways in which the bankruptcy process may play an important role in preventing harms to the broader public.

This article aims to fill that gap both conceptually and empirically. In particular, to the best of my knowledge, this is the first article to examine a large number of firms that go bankrupt and to examine how the harm externalizing behavior of those firms changes as they approach, enter, and then exit bankruptcy. To accomplish this, I consider a set of roughly 350 firms that are both regulated under the Clean Water Act (CWA) and that file for bankruptcy.[1] For each facility owned by such a firm, I build a control group by matching it to five similar facilities owned by firms that do not go bankrupt. I use a series of analyses similar to a difference in differences approach[2] to examine how firms' compliance changes as they approach, enter, and exit bankruptcy. I show that the closer these firms get to filing for bankruptcy, the more likely they are to release pollutants into public waterways that exceed their

[1] In theory, one could perform similar investigations of firms that engage in private restructurings. Unfortunately, in practice, there is only one firm that has engaged in such a restructuring for which I can track both pre- and post-restructuring CWA compliance.

[2] I discuss these formulations in more detail in Section 5. The primary way that they deviate from a formal differences in differences analysis is that when analyzing pre-bankruptcy changes in compliance, there is no single "treatment date" at which firms that will eventually declare bankruptcy are marked in their fate. Nevertheless, I show that firms in the treatment and control groups follow parallel trends more than four years prior to bankruptcy, whereas after this point, on average, firms that eventually declare bankruptcy begin to deteriorate in their compliance.

permitted limits. In particular, as firms approach bankruptcy, their likelihood of violating their permitted pollutant limits increases roughly 50% compared to their baseline compliance level from four or more years prior to their bankruptcies. For what I term "serious" violations, where firms exceed their permit limits by 100% or more, violation rates increase by roughly 75% in the two years preceding bankruptcy. Pollutant releases of the type that I study have been linked to increased mortality in nearby populations (Hendryx et al., 2012), making these results of significant concern.

After measuring these results for specific firms that go through bankruptcy, I then generalize the analyses to broader contexts. For instance, I show that firms with so-called "junk" or "non-investment grade" debt, even if they do not go bankrupt, violate CWA permit requirements at significantly higher rates than other firms. I also show that industry groups (based on SIC2 classifications) that are in financial distress (based on the number of industry-wide bankruptcy filings), also have higher rates of CWA permit violations, and that the elevated violation level subsides after the financial distress subsidies.

Nevertheless, despite these environmental problems associated with firms in financial distress, I show that the substantial deterioration of compliance pre-bankruptcy dramatically reverses itself after firms file for bankruptcy. After filing, firms quickly return to levels of compliance comparable to what they maintained four years or more prior to filing for bankruptcy. For firms that ultimately reorganize, I show that the improved compliance persists after they emerge from bankruptcy, suggesting that it is not merely an aspect of the bankruptcy process itself, such as oversight of the firms by judges, that drives the improved performance.

For firms that liquidate some or all of their assets, I show that their facilities tend to be bought by corporations that operate the facilities with substantially lower rates of regulatory violations. In some of these instances, I find direct evidence of the new owners investing money in improving facilities' equipment in ways that reduce environmental externalities. For instance, after ND Otam bought a wood pulp manufacturing facility from bankrupt Red Shield Acquisition Corporation, the new owner undertook "repair and maintenance work that had been deferred by previous owners, including repairs and upgrades to the ... ash handling system, fuel handling system, fuel distribution and combustion

systems."[3] Similarly, after Noble Americas purchased an ethanol production plant from bankrupt New Energy Corp, Noble converted the plant from running on coal power to natural gas power, as well as making other environmental control upgrades such as installing new regenerative thermal oxidizers for handling waste products.[4] Thus, the bankruptcy process also plays a constructive role in transferring ownership of assets to new corporations that can operate them in ways that better protect the public interest.

Next, I investigate what mechanisms may explain the pre-bankruptcy deterioration in environmental compliance and the post-bankruptcy improvements in compliance. Although firms file for bankruptcy for a variety of reasons, the fact that shareholders rarely receive value in bankruptcies (Bharath et al., 2010; Kim, 2018) suggests that in general, firms that file are thinly capitalized and financially distressed. On account of this, firms near bankruptcy may face a range of moral hazard problems where key decision-makers in the firms do not bear the full costs of externalized harms, such as from pollution. These stem from limited liability protections for firm owners (Shavell, 1986), bankruptcy rules which give secured creditors priority over many fines and penalties for pollution violations (Posner, 1976; LoPucki, 1996), and limits on the personal wealth of managers that can prevent them from being able to pay the full costs of harms they cause (Arlen and Carney, 1992).[5] Firms near bankruptcy may also face a series of finance frictions such as debt overhang that make it difficult for firms to fund the personnel and equipment needed to maintain compliance, even if doing so would enhance firm value (Myers, 1977).

After a firm files for bankruptcy, however, both the moral hazard and the finance frictions are substantially improved. Bankruptcy law provides a series of tools, such as a stay on collection of pre-petition debts as well as Debtor in Possession (DIP) finance that can help to allay finance frictions (Ayotte and Skeel, 2013). In fact, some of the motions for DIP finance for firms in my sample explicitly mention the funding as being necessary in order to fund environmental compliance.[6] Moral hazard concerns

[3] State of Maine Department of Environmental Protection, Departmental Findings of Fact and Order New Source Review, ND OTM LLC, available https://www.maine.gov/dep/ftp/AIR/licenses/titlev/A0180NSR13A.pdf

[4] "South Bend, Indiana, Ethanol Plant on Line Again," by Ann Bailey, Ethanol Producer Magazine, September 1, 2015.

[5] Some managers may nevertheless maintain incentives to fully comply with regulations due to their risk aversion or fear of criminal penalties. Yet, as (Arlen and Carney, 1992) show, these risks are not sufficient to deter all managers, hence their finding of heightened securities fraud committed by managers of firms near bankruptcy.

[6] For instance, Vanguard Natural Resources notes in its motion for DIP finance that "[a]s is typical in its industry, Vanguard's businesses are cash intensive, with significant daily costs to ... maintain the safety of its operations, and fulfill environmental and other regulatory

are also substantially alleviated through a series of provisions of bankruptcy law. For instance, a firm's creditors will frequently become its owners after a bankruptcy. Thus, thinly capitalized pre-bankruptcy equity holders with little left to lose are replaced post-bankruptcy with new equity holders who have much greater value in the firm's equity to lose should it accrue significant new environmental liability. Relatedly, the bankruptcy code grants a higher administrative priority to claims for environmental penalties assessed post-bankruptcy, whereas most pre-bankruptcy penalties will be low priority, general unsecured claims. This creates further incentives for creditors to exert their control during the bankruptcy process to ensure firms' environmental compliance.

Lending some credence to these hypotheses of moral hazard and finance frictions, I find evidence that the firms whose compliance deteriorated the most in the leadup to bankruptcy were firms that were most under capitalized and firms that were the most short on cash. I also find that firms that were most under-capitalized and shortest on cash improve most after filing for bankruptcy, although here, the relationship is statistically significant only when measuring the relationship between pre-bankruptcy cash constraints and post-bankruptcy compliance improvements.

Beyond these explanations relating to moral hazard and finance frictions, I examine other possible explanations for changes in environmental compliance before and after firms file for bankruptcy. For instance, I examine whether the pre-bankruptcy deterioration in compliance might be due simply to the fact that poorly managed firms are both more likely to go through bankruptcy and more likely to fail to comply with environmental regulations. Similarly, I investigate whether improvements in compliance post-bankruptcy might be attributable to reductions in firm output, direct supervision of firms by a bankruptcy judge, or changes in enforcement intensity by environmental regulators. Although I do not rule out the possibility that these and other factors may be relevant in particular instances, I present evidence that they do not appear to be the primary drivers of the changes in environmental compliance I observe pre- and post-bankruptcy.

The findings in this investigation have implications for several areas of policy. First, these findings help to cast the role of bankruptcy in a new light, as an important process that helps to prevent harms

requirements." In re Vanguard Natural Resource, Case No. 17-30560, Motion for DIP Finance, filed February 2, 2017. See also, for instance, Peabody Energy Corporation, et al., Case No. 16-42529, Motion for DIP Finance, filed April 13, 2016, and In re Venoco, Inc., et al., Case No. 16-10655, Motion for DIP Finance, filed March 18, 2016, both citing a need for DIP finance to maintain environmental compliance.

to the public that can come from firms in financial distress. In turn, this shows how bankruptcy law, and the public resources spent to support it, benefits the public interest directly, rather than merely serving as a way to maximize private value.

Stemming from this view of bankruptcy law, the findings in this investigation lend support to a series of reforms aimed at encouraging financially distressed firms to resolve their financial distress sooner rather than later. Policies to promote this include lowering costs and complexity of bankruptcy for small corporations (Lawless, 2020) and altering the tax implications of debt writedowns in order to promote out-of-court debt renegotiation (Campello et al., 2019; Donaldson et al., 2022).[7] Conversely, Buccola (2022) examines an array of aggressive strategies firms may use to delay filing for bankruptcy while failing to fully address their underlying financial distress.[8] The results here suggest that judges should view such delaying strategies with skepticism, especially given that they often already require strained readings of existing contract terms.

Second, the finding that regulatory compliance deteriorates so sharply in the leadup to bankruptcy emphasizes the importance of policy changes aimed at reducing moral hazard for firms near insolvency. These changes include, for instance, increasing the priority of bankruptcy claims for externalized harms (LoPucki, 1994; Ohlrogge, 2022), more robust provisions to recover funds in bankruptcy via fraudulent transfer provisions (Macey and Salovaara, 2019), and increased use of bonding and insurance requirements (Boomhower, 2019). To the extent that high financial leverage increases the likelihood that firms will encounter financial distress, the results here also provide reason to question policies, such as the favorable tax treatment of debt versus equity finance, that encourage leverage.

Third, these findings have implications for regulatory enforcement policy. For instance, many regulatory agencies, under so-called "ability to pay" guidelines, reduce penalties imposed on financially precarious firms out of concern that forcing a firm into bankruptcy may impose negative externalities such as job losses.[9] The results here show that if a firm is so financially precarious that imposing a

[7] See also Donaldson et al. (2022) for additional suggestions for encouraging firms to resolve financial distress sooner, via either restructuring or bankruptcy.

[8] These include, for instance, efforts to enable a firm that has already encumbered its assets with liens to "prime" those liens and thus take out new secured debt, giving a lifeline to firms for which no new unsecured lenders would be willing to loan. Yet, without a writedown of the firm's original debt, the result may simply be a firm with an even more highly leveraged and unstable capital structure.

[9] For the version of these guidelines most pertinent to NPDES enforcement, see "Interim Clean Water Act Settlement Penalty Policy," March 1, 1995, Environmental Protection Agency, available https://www.epa.gov/sites/default/files/documents/cwapol.pdf. For a review of such policies across many enforcement areas, see Atkinson (2022).

regulatory penalty would push it into bankruptcy, then there is a significant danger that the firm's continued operation will impose significant externalities. As such, these results cast further doubt on the advisability of many "ability to pay" enforcement policies.[10] The empirical results of this investigation, coupled with supplemental analyses that I perform, also suggest that in many instances, increasing inspections and regulatory scrutiny of firms in financial distress will be a cost-effective use of regulatory resources.

The remainder of this article proceeds as follows. Section 2 reviews prior research. Section 3 discusses what compliance with the NPDES permits requires, what motivates firms to comply with those permits, and why compliance may change as firms approach, enter, and exit bankruptcy. Section 4 discusses the data I use and Section 5 presents the main empirical analyses and results. Section 6 discusses policy implications. Section 7 concludes, and the Appendix presents supplemental analyses.

2 Prior Research

Much of the foundational analysis of the potential moral hazard and finance frictions facing the equity holders, creditors, and managers of firms near bankruptcy was set out by a series of papers including Shavell (1986), Posner (1976), Jensen and Meckling (1976), Myers (1977), and Arlen and Carney (1992). Following these, a series of papers argued that the theoretical concerns raised in earlier articles were pressing problems that needed to be addressed in policy. These included Hansmann and Kraakman (1991), Bebchuk and Fried (1995) and LoPucki (1996). A wave of more skeptical papers followed, arguing that much of the evidence in earlier work was either anecdotal or hypothetical, and that it was unlikely that theoretical incentive problems would cause many practical harms. These later papers included work by White (1998), Schwarcz (1999), and Listokin (2008), who remarked that "reports of the death of liability are greatly exaggerated" and that future empirical research "may well show that ... causes of the death of liability, such as under-capitalization are ... empirically irrelevant." Beard (1990) expressed skepticism of another sort, showing theoretically that in some instances, owners

[10] For a thorough discussion of ability to pay policies that addresses other criticisms, see Atkinson (2022). For a counterpoint though, see Earnhart and Segerson (2012) who argue that in at least some situations, increasing regulatory penalties for firms in financial distress can be counterproductive.

of a firm near insolvency might have incentives to take too much care to prevent harms to third parties. Beard's insight was that for a firm sufficiently near insolvency, money spent to prevent harms may come largely out of creditors' recoveries in bankruptcy, whereas equity holders may disproportionally benefit from a reduced likelihood that penalties for harms wipe out equity's remaining stake.

Despite the lively theoretical and policy debate, there is, as one recent review of the literature noted, "little empirical evidence on the size or pervasiveness of changes in investment risk-taking when a firm approaches financial distress" (Gilje, 2016). Much of the reason for this is that creditors are generally able to use tools such as loan covenants to constrain these problems, a point that Jensen and Meckling (1976) themselves make, and which has been validated empirically (Smith and Warner, 1979; Barclay and Smith, 1995; Guedes and Opler, 1996). Nevertheless, Eisdorfer (2008) presents some empirical evidence that creditors of firms near insolvency are harmed by excessively risky investments, while Gilje (2016) presents empirical evidence that suggests the opposite.[11] Adler and Capkun (2019) show that firms increase their use of secured credit as they approach bankruptcy, potentially harming unsecured or involuntary creditors. Arlen and Carney (1992) show that conflicts between managers and shareholders increase in the leadup to bankruptcy, taking the form of increased incidence of securities fraud.

A recent review of the empirical literature on debt overhang and associated finance frictions concluded that there has also been little evidence of the impact of debt overhang on firms, in large part because creditors and equity holders are generally able to negotiate and restructure obligations to avoid inefficiencies (Wittry, 2021). Nevertheless, recent papers such as Giroud et al. (2012), Sautner and Vladimirov (2018), Wittry (2021), and Liebersohn et al. (2022) are starting to develop evidence of situations where it is more difficult than normal for creditors and equity holders to resolve the problems of debt overhang, and thus where it may have a greater effect.

While these prior studies are informative, none present direct empirical evidence for whether risk-taking incentives or finance frictions operate to increase harms to third parties, such as through increased environmental violations. To my knowledge, only two prior studies directly investigate whether

[11] A related strain of literature looks at financial institutions. Gan (2004) provides evidence of risk-shifting by thrifts in response to the Texas real estate collapse, something which is made possible by government insurance of these institutions that does not fully adjust to their riskiness (Merton, 1977). By contrast, Gorton and Rosen (1995) and Becker and Ivashina (2015) present evidence they view as inconsistent with risk-shifting in their studies of banks and insurance companies, respectively.

firms that are closer to insolvency or bankruptcy become more likely to externalize harms to third parties. The first of these studies is by Feinstein (1989), who examines whether nuclear power plants have increased safety violations as their credit ratings deteriorate. Feinstein (1989) finds no evidence of this, but an important caveat is that the power plants in question are required by regulation to maintain high levels of insurance,[12] with risk-sensitive pricing (Dubin and Rothwell, 1989). This can act as a powerful constraint on moral hazard problems of undercapitalized firms. The other study is Hartzmark and Shue (2023), which was developed at a similar time as this study and publicly released shortly before it. Hartzmark and Shue (2023) find that firms in the bottom decile of Altman Z-scores (which are developed to predict the probability of bankruptcy or default) release more greenhouse gasses than firms with higher Z-scores. This present study therefore can be seen as a complement to the findings in Hartzmark and Shue (2023), while adding innovations such as demonstrating the potential for bankruptcy to resolve externalized harms stemming from financial distress.

A number of other studies look at whether other financial metrics, such as profitability, correlate with harms firms externalize to third parties. Because the key theoretical predictors of increased harm to third parties relate specifically to solvency, rather than other financial metrics, many of these other investigations offer only indirect insights into the questions at hand in this investigation. These other studies include (Dionne et al., 1997) and Rose-Ackerman (1991), which both look at profitability, Earnhart and Segerson (2012) which examines the ratio of current assets to current liabilities, Thomas et al. (2022) which looks at firms that just barely meet analyst earnings forecasts, and Xu and Kim (2022), which looks at the frequency that company 10-Ks contain "constraining" words such as "required," "obligations," or "imposed."[13]

Overall, this paper contributes to the above literature in several ways. First and most importantly, to the best of my knowledge, this is the first empirical paper to examine the potential for the bankruptcy process to play a constructive role in reducing firms' negative externalities by resolving capital structure problems that lead to moral hazard and finance frictions. Second, to the best of my knowledge, this is the first empirical paper to directly document an increase in firms externalizing harms to third parties as

[12]This insurance was mandated by the Price-Anderson Act of 1957, 42 U.S.C. §2210.

[13]Xu and Kim (2022) also complements this analysis by looking at the 2004 American Jobs Creation Act (AJCA) which reduced taxes on repatriated income and thus gave some companies an increased supply of liquid funds.

they approach bankruptcy. This focus on proximity to bankruptcy provides a much more direct measure of the conditions apt to cause moral hazard and finance frictions, as compared to prior literature that has generally used rough proxies such as profitability.[14] As such, it may help to explain why prior literature has reached mixed results when examining relations between financial status and negative externalities.[15] Third, as described more in depth below, by observing firms both before and after they file for bankruptcy, I am able to overcome identification challenges in many earlier papers, such as the possibility that poorly managed firms may both be more likely to deteriorate financially and more likely to fail to comply with environmental regulations. This helps to bolster evidence that financial distress and the approach towards bankruptcy has a causal impact on firm environmental compliance.[16]

A related area of research examines the impact of policy interventions that affect the moral hazard problems faced by creditors and shareholders of firms near insolvency. Ohlrogge (2022) shows that when a Seventh Circuit court decision effectively raised the priority of environmental claims in bankruptcy, creditors began writing loan covenants that allowed them to more strictly monitor borrowers' environmental performance, and that those borrowers began adopting safer environmental practices. Boomhower (2019) shows that when the state of Texas adopted new requirements for oil and gas producers to either post bonds or purchase risk-priced insurance to cover environmental costs in the event of bankruptcy, firms either improved their environmental compliance or went out of business, transferring production to entities with safer environmental records. Finally, Akey and Appel (2021) show that when a Supreme Court ruling restricted the ability of environmental regulators to pursue claims against parent corporations of an insolvent subsidiary, thus effectively strengthening limited liability, environmental performance of affected firms deteriorated. The results of this investigation show more directly how large the deterioration of compliance for firms near bankruptcy can be, and thus add further weight in support of the policy recommendations advanced by the authors of these prior articles.

[14]The exception is Hartzmark and Shue (2023), which through the use of Z-scores much more directly captures proximity to insolvency.

[15]For instance, contrast Rose (1990) finding that less profitable airlines experience more safety violations, Golbe (1986), finding no relationship between airline profitability and safety violations, and Earnhart and Segerson (2012), finding no significant relationship between violations of environmental regulations and firms' ratios of current assets to current liabilities.

[16]Hartzmark and Shue (2023) also are able to overcome many identification challenges by conducting variations on their analyses that use Z-scores for other firms in a given firm's industry as a proxy for a firm's own Z-score.

Finally, this paper contributes to a new but growing literature, including Ellias (2022), Sautner and Vladimirov (2018), Baghai et al. (2021) and Graham et al. (2022) that examine the ways that financial distress and bankruptcy impact the operation of businesses. In particular, each of these recent studies looks at how firms' ability to attract and retain employees are impacted by bankruptcy or financial distress. This present study differs in two key respects. First, it focuses on a different outcome, environmental compliance rather than employment, and in so doing helps to illustrate the potential negative consequences of employment difficulties experienced by firms near bankruptcy that some of the earlier literature points to. Secondly, unlike the prior literature (Ellias, 2022; Graham et al., 2022) that shows harms from the bankruptcy process in the form of firms' reduced ability to attract and retain employees, this study shows that there are also important benefits in the form of improved compliance. While these results may seem at odds with each other in whether they view the bankruptcy process as constructive or destructive, they need not be. Both the findings here and those in these prior papers support policies that encourage firms to quickly file for bankruptcy when they are in financial distress, and then to quickly resolve the bankruptcy proceedings when they occur.

3 Determinants of Compliance

3.1 What Does CWA Compliance Require?

Among its many provisions, the Clean Water Act (CWA) of 1972[17] requires that any point source of pollutants that discharges into certain types of public waterways[18] obtain a permit under the National Pollutant Discharge Elimination System (NPDES). NPDES permits set limits for the quantity or concentration of discharges of specific pollutants. The limits on an individual permit must conform with both industry-wide requirements set by the national EPA as well any stricter criteria established by states for the protection of particular bodies of water.[19] In general, the EPA industry-wide limits are set based on an allowable amount of pollution per unit of production, so facilities with larger productive capac-

[17] 33 U.S.C. §1251 et seq. (1972)

[18] U.S. Code 33 (2006) § 1342. Terms such as "discharge," "pollutant," and "point source" are subject to significant interpretative issues. For an overview, see, e.g., McCall (2017).

[19] McCall (2017), see also *E.I. DuPont de Nemours & Co. v. Train*, 430 U.S. 112 (1977).

ity will be allowed to release more pollutants than smaller facilities.[20] Limits are also based on what is technologically and economically feasible for the pollutants used in particular industries.[21] Once a limit is set, however, regulated entities are free to choose the technology they find most appropriate to comply with the limit.

Companies take a range of actions in order to comply with NPDES permit requirements. These actions include recycling chemicals used in production rather than releasing them, and favoring less toxic chemicals (which will have more lenient discharge limits) rather than more toxic ones in their production. Facilities regulated under NPDES permits also use technologies such as membrane filtration, carbon absorption, chemical oxidation, coagulation and sedimentation ponds, and many other techniques (Earnhart and Glicksman, 2011).

Furthermore, although there is variation among companies, a great many take compliance with the Clean Water Act seriously. One of the richest sources of information on this is Earnhart and Glicksman (2011), who conduct extensive surveys and other investigations of 97 chemical manufacturing facilities regulated under NPDES permits. Earnhart and Glicksman (2011) find, for instance, that the average facility devoted 10% of its employees to wastewater management, and the median devoted 3%. Facilities conducted an average of six (median of one) internal environmental audits per year to assess their compliance procedures. In addition, seventy-eight percent of facilities employed external consultants to assist with their environmental compliance.

Taken together, these results reveal two important facts. First, at least for financially healthy firms, there appear to be strong incentives to comply at least relatively well with NPDES permit requirements. Second, because of the degree of resources devoted to compliance, a financially distressed firm could accrue, at least in the short term, substantial savings by reducing those compliance expenditures.

3.2 Motivations for Environmental Compliance

In order to understand why compliance may break down pre-bankruptcy, and why it might improve post-bankruptcy, it is important to understand what motivates firm owners, managers, and creditors

[20] NPDES Permit Writers' Manual, Chapter 5, Environmental Protection Agency, September 2010. Available https://www.epa.gov/sites/default/files/2015-09/documents/pwm_chapt_05.pdf.

[21] 33 U.S.C. §1311.

to expend resources to comply with NPDES permit requirements. The conceptual discussions in this section also will set the foundation for empirical tests in subsequent sections that seek to pinpoint, as much as possible, which sets of factors best explain changes in firms' pre- and post-bankruptcy environmental compliance.

3.2.1 Legal Motivations for Compliance

Government monitoring and enforcement is conducted by both state and federal regulators, although state officials generally take the most active role. Regulators gain information about facilities' compliance through several mechanisms. First, facilities are required to self-monitor and report on their releases of each pollutant governed by their NPDES permit. In addition, regulators conduct inspections of facilities, examining both their pollution control technology, their monitoring equipment, and their records relating to compliance.[22]

If regulators detect permit violations, either through on-site inspections, self-reporting, or both, they may invoke a variety of sanctions. These range from informal enforcements, which generally take the form of letters warning a facility to improve compliance, to formal enforcement actions, in which regulators can impose monetary penalties and require firms to upgrade their equipment and compliance procedures. For more serious violations, environmental regulators can refer cases to the department of justice (or state attorneys general) for civil or criminal enforcement (McCall, 2017). Although the targets of these cases are usually the firms themselves, managers and lower level employees can also be criminally prosecuted for knowing violations of the Clean Water Act and its permitting requirements, including for knowingly submitting false reporting information or tampering with monitoring equipment.[23]

Often, the fines for regulatory violations are relatively small, with the primary cost to violators simply being the requirement to upgrade equipment and treatment procedures. For instance, unless a case is referred to the DOJ or comparable state prosecutors, the maximum administrative penalty

[22] In the set of firms that I observe, facilities are inspected on average 0.42 times per year, or equivalently, roughly once every 2.4 years. If I consider all forms of official enforcement conduct with regulators, thus combining both inspections and enforcement actions, then facilities receive an average of 0.74 contacts per year, or equivalently, one contact every 1.3 years.

[23] The EPA publishes annual lists of major criminal enforcement actions, which periodically include jail terms and personal fines for managers of firms that have violated the Clean Water Act. See for example the 2016 listing, available https://www.epa.gov/enforcement/2016-major-criminal-cases.

that can be assessed is roughly $300,000 (in 2022 dollars).[24] While this may be a significant sum for a small or mid-sized facility, it may be nearly immaterial for larger operations. Facilities with multiple violations may be assessed higher total amounts, but the dollar values are still relatively small. For instance, over the past 20 years, there have been an average of only 18 facilities per year that receive total administrative fines in a year above $1 million dollars.

Nevertheless, where cases are referred for civil prosecution, penalties can be significantly larger. To take an example from the companies in the sample I analyze, Alpha Natural Resources, a large coal mining company, was found to have failed "to properly operate existing treatment systems, install adequate treatment systems, and implement appropriate water handling and management plans." On account of this, roughly one year before it filed for bankruptcy, Alpha signed a consent decree agreeing to pay $27.5 million in civil penalties and to spend an estimated $200 million on upgrading its compliance equipment and systems in order to ensure it better met its NPDES permit requirements.[25] Another way that penalties can be more significant is regulators can revoke a facility's NPDES permit, [26] which could effectively force it to cease its operations.

Many firms regulated under NPDES permits are also subject to requirements under other environmental laws. For instance, a firm that releases an unsafe amount of toxic chemicals into waterways and thereby contaminates a lake or groundwater supply may face substantial cleanup obligations under laws such as the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), or other such statutes. As discussed in Ohlrogge (2022), the costs of cleanup under these statutes can easily range into the tens or hundreds of millions of dollars, and can thus provide significant additional deterrence incentives.

The final formal legal enforcement mechanism comes in the form of suits by private citizens or organizations. The Clean Water Act authorizes such "citizen suits" to enforce its requirements. Where successful, these suits generally result in settlements in which a given company agrees to upgrade its equipment and procedures to ensure future compliance with its NPDES permit, and a set of penalties if the company fails to abide by the promised improvements. Attorneys fees are generally awarded as

[24] 40 C.F.R. §19.4
[25] https://archive.epa.gov/epapages/newsroom_archive/newsreleases/54efd06d18fe451985257c92006b4692.html
[26] 40 CFR § 122.41(f).

part of these suits, and civil penalties can also be assessed (McCall, 2017).

3.2.2 Additional Motivations for Compliance

Beyond these formal legal mechanisms, however, many other mechanisms also operate to induce firms to comply, or at least make efforts to comply, with their NPDES permits. Reputational interests may be a motivator for at least some firms and managers. In addition to seeking to avoid the negative impact of a large scandal, many firms take proactive steps to cultivate an image as good environmental stewards. Earnhart and Glicksman (2011) report, for instance, that 90% of the chemical manufacturers they surveyed reported taking steps to communicate with the public regarding their environmental compliance. These steps included, for instance, advertising, press releases, focus groups, and other measures. Gunningham et al. (2005) conduct extensive interviews with managers of chemical and electroplating plants regulated under the Clean Water Act, and find that they worry that if they develop a reputation for violating environmental regulations, then members of the community will oppose future efforts by the firms to obtain new permits for expanded operations or to renew permits on their existing operations. Gunningham et al. (2005) also report significant indirect reputational pressure, in which firms that sell products to other companies are pressured by their customers to maintain good environmental records, lest violations reflect poorly on the companies who ultimately purchase their products.[27] Finally, Lel (2023) finds reputational damages for CEOs and directors of companies with significant environmental lapses, although in general the effects are limited to more recent time periods and firms with significant commitments to social responsibility.

Gunningham et al. (2005) report many other less formal ways that regulations motivate compliance. For instance, roughly half of the managers they surveyed reported feeling a moral obligation to comply with regulations, thus looking to regulations for normative guidance. Many other managers simply used regulations as a template for setting corporate policy without any apparent effort to estimate the costs and benefits of compliance which would be key inputs into certain models of decisionmaking

[27] Of course, not all firms will be equally motivated by reputational concerns in all situations and time periods. Thus, for instance, Karpoff et al. (2005) find that when press accounts emerge of allegations that public firms have violated environmental laws, firms tend to suffer drops in market capitalization that closely match the size of the penalties they receive, thus suggesting little role for reputational harms. Nevertheless, Karpoff et al. (2005) do not account for the fact that regulatory penalties often occur a substantial amount of time after the underlying behavior is first announced. Thus, it could be that a re-analysis of the data in Karpoff et al. (2005) would show that market reactions were significantly larger than the discounted expected future value of penalties.

(Becker, 1968).

3.3 Breakdowns in Compliance Pre-Bankruptcy

One reason compliance may deteriorate pre-bankruptcy is due to a series of moral hazard problems affecting thinly capitalized firms, a condition that will apply to a large number, even if not all, firms that are soon to file for bankruptcy.[28] These moral hazard problems can lead owners, creditors, and managers of thinly capitalized firms to not pay the full costs associated with their actions.

For firm owners, the key driver is limited liability, which caps losses to owners at the current value of their equity. For a sufficiently distressed firm, the owners may find themselves in a "last period" situation in which they believe that if they do not divert resources away from environmental compliance and towards other business exigencies, then the firm, or at least their equity stake in it, will not survive. In this case, the prospect of potential future environmental penalties or losses to a firm's reputation may pose very little deterrent to equity holders (Shavell, 1986). As a firm's financial condition deteriorates, owners may retain their ethical desires to comply with regulations, but those desires may be tempered if owners believe that full regulatory compliance will come at the cost of losing their entire stake in the company, rather than just reducing its profitability. This may be particularly true given that reductions in regulatory compliance will often simply increase the probability of environmental harm, rather than guarantee that it will occur.

In general, a firm's creditors have incentives to constrain inefficient risk-taking, (Jensen and Meckling, 1976), and reducing expenditures on environmental compliance may in many instances represent such an inefficient risk. Creditors can influence borrowers by writing covenants governing environmental compliance (Ohlrogge, 2022), by refusing to continue to lend to firms whose environmental compliance deteriorates, or by a host of less formal mechanisms, such as discussions between lenders and borrowers. Yet, secured creditors enjoy priority over many environmental penalties, potentially leading to reduced incentives on their part to constrain harms (Posner, 1976; LoPucki, 1996). Unsecured creditors do have somewhat greater incentives to monitor firms' environmental compliance,

[28] Research by Bharath et al. (2010); Kim (2018) and others shows that equity holders rarely retain value in bankruptcies, thus suggesting that by the time of bankruptcy, equity value has dropped to zero, and that often equity value will be close to zero in the leadup to bankruptcy.

although even these are less than they would be if environmental penalties had priority over both secured and unsecured claims. In general, however, unsecured creditors rarely have the kinds of strong covenant clauses as do secured creditors of the type examined by Ohlrogge (2022). Thus, the primary way an unsecured creditor could exert influence would simply be by refusing to lend more funds to a borrower whose compliance has deteriorated.

Firm managers can face fines or even imprisonment for knowing or reckless violations of environmental laws, which often gives them significant incentives to ensure compliance, particularly when coupled with the risk-aversion that many people exhibit. Nevertheless, as I show below for firms in my sample, top managers frequently do not retain their jobs following a bankruptcy filing. Thus, these officers may believe they are in a "last period" situation in which they must divert resources from environmental compliance and towards more exigent corporate needs in order to prevent an imminent failure of their firm and loss of their jobs. Arlen and Carney (1992) have previously documented that this last period situation can induce managers to commit securities fraud at substantially elevated levels, despite the fact that doing so exposes those managers to significant risks of financial penalties and imprisonment.

The factors that limit the extent to which key decision makers in a firm will be required to pay for the costs of regulatory violations may be further exacerbated by regulatory guidelines that can reduce penalty amounts for firms in precarious financial positions based on their perceived "ability to pay." (Atkinson, 2022). These guidelines may in particular dampen creditor incentives to monitor, since if regulators are reluctant to allow fines to push a firm into bankruptcy there is a lower chance those fines will directly impact creditor recoveries.

Alongside these moral hazard concerns, financial frictions such as debt overhang may make it difficult for firms to fund the personnel and equipment needed to maintain compliance, even if doing so would be profitable for the firm (Myers, 1977). As explained in Myers (1977), debt overhang occurs where a firm has limited equity value left and its debt is worth meaningfully less than its face value, due to the risk of default. In this situation, equity holders may not have an incentive to invest new money in the firm, because some of the extra value they contribute will simply go to increasing the value of

the firm's debt.[29] Finally, new creditors will not want to lend, for the same reasons, unless they are able to obtain priority above the firm's existing creditors.[30]

In many respects, the finance frictions and moral hazard problems are linked. For instance, if equity holders were not shielded by limited liability from the full penalties for regulatory violations, those equity holders would have a greater incentive to finance cost-effective investments in equipment or personnel to reduce the likelihood of regulatory violations.[31] If secured creditors did not enjoy priority over costs for pre-bankruptcy regulatory violations, they would have a stronger incentive to defer collecting on interest payments, if such collecting impeded environmental compliance.[32] Furthermore, the decision to continue operating a company that cannot afford environmental compliance measures, rather than declaring bankruptcy and restructuring sooner, may itself be viewed as a product of moral hazard.

Firms that are close to bankruptcy may face greater operational stresses as they struggle to meet increasingly urgent demands from creditors, satisfy reluctant suppliers, attempt to find new customers, and retain key employees who may seek to leave for a more stable employer. These challenges of managing a firm in financial distress could divert managerial attention and firm resources away from compliance, leading to increased regulatory violations. Many of these effects, however, are largely a manifestation of the moral hazard and finance frictions discussed above. In particular, if a firm diverts employee resources away from compliance tasks and towards other projects, rather than expending the funds needed to hire and retain personnel to maintain environmental compliance, then that would presumably be due to some combination of finance frictions and moral hazards.

At the same time, firms near bankruptcy may find it more difficult and expensive to attract and retain key employees (Sautner and Vladimirov, 2018; Baghai et al., 2021). If employees could immediately and costlessly transfer to a new employer, then working for a firm in significant financial peril would be

[29] If new equity investors are given a sufficiently large share of the corporation's ownership, then there may still be terms under which they find a new investment profitable. But, doing so would come at the expense of existing equity holders, who would be giving up some of the option value of their equity holdings, and thus existing equity holders may not agree to such a transaction.

[30] In frictionless bargaining settings, it is of course possible in such a situation to reach an agreement between a firm's creditors, equity holders, and potentially new investors, that would resolve these issues to the benefit of all. For instance, existing creditors can write down a portion of their claim, potentially in exchange for a grant of a new equity interest. Yet, in many practical situations, the realities of bargaining frictions and information asymmetries can make such negotiations difficult or impossible.

[31] I thank Barry Adler for helpful discussions on this point.

[32] Without the priority of secured creditors over environmental penalties, secured creditors would also be more willing to allow new creditors to invest at a higher priority than them.

less of a concern to them. Yet, because of the "employment frictions" associated with transferring to new jobs, it can be rational for employees to be reluctant to work for firms in significant financial peril. An increased difficulty hiring and retaining employees could also therefore impact a firms' environmental compliance, even in the absence of more traditional financial frictions.

3.4 Improvements in Compliance Post-Bankruptcy

After a firm files for bankruptcy, problems of moral hazard and finance frictions are substantially improved. Bankruptcy law imposes a stay on collection of pre-bankruptcy debts that can free up cash flow to invest more in personnel or equipment to boost environmental compliance.[33] Furthermore, many firms obtain Debtor in Possession (DIP) finance, providing more liquid funds that can be used to pay for the personnel and equipment needed to comply with environmental regulations. In fact, as described in the introduction, for some of the firms in my sample, the motions seeking approval for DIP finance specifically mention that the funding is needed to pay for environmental regulation compliance costs. This DIP finance in turn is frequently made possible by mechanisms of bankruptcy law that circumvent the problems of debt overhang that deter investment pre-bankruptcy (Ayotte and Skeel, 2013).[34] Bankruptcy provisions such as the ability to sell assets free and clear of existing encumberances also help to resolve finance frictions and improve liquidity for firms that file for bankruptcy (Ayotte and Skeel, 2013).

Concerns with moral hazard are likewise improved upon filing for bankruptcy. A pre-bankruptcy firm will be controlled by equity holders who may have little left to lose. After bankruptcy, control shifts towards creditors who generally will be the residual claimants and who will still have much value they could lose. Furthermore, while most liability for pre-bankruptcy environmental violations will be low priority, unsecured claims in a bankruptcy, liability incurred for violations after the bankruptcy will take on a higher administrative priority.[35] Lenders with a stronger incentive to ensure compliance post-

[33] Secured creditors may still be owed some payments as "adequate protection" on their property interests in the estate (11 U.S.C. §361). Yet, even here, if the value of creditors collateral has depreciated below the loan amount, then creditors' rights to adequate assurance will tend to be lower than their pre-bankruptcy payment rights. Furthermore, to the extent that a firm has unencumbered assets, secured creditors' adequate assurance may be provided by granting new liens on unencumbered assets, thus obviating the need to make cash payments at all.

[34] In particular, for instance, the ability to bifurcate an undersecured pre-bankruptcy claim, the ability to prime existing liens, the ability to sell assets free and clear of existing liens, and the limitation of pre-bankruptcy liens application to property acquired after a bankruptcy filing all can help to promote liquidity from DIP finance (Ayotte and Skeel, 2013).

[35] Secured creditors still rank higher in claim priority than administrative claims. Nevertheless, in order for a plan of reorganization to be

bankruptcy may do so by more strictly enforcing loan covenants and other control rights that allow them to supervise borrowers' environmental compliance.[36]

Firms often replace top management around the time they file for bankruptcy,[37] which might also help to explain post-bankruptcy improvements in environmental compliance. In many respects, management change may simply be a mechanism by which improvements in financing and moral hazard lead to better environmental performance post-bankruptcy. For instance, a firm with more free cash flow and a more stable capital structure on account of converting debt into equity in bankruptcy may be better able to recruit skilled managers. Furthermore, the shareholders of such a firm may have better incentives in selecting and supervising those managers. Nevertheless, in the empirical specifications below, I examine evidence for whether management change may be a significant mechanism through which improvements in finance frictions and moral hazard lead to improvements in environmental compliance.

3.5 Other Explanations for Changes in Compliance

There may be other reasons apart from changes in finance frictions and moral hazard that explain why firms' environmental compliance deteriorates prior to bankruptcy and improves after bankruptcy. One reason that firms near bankruptcy might exhibit increased environmental violations could be simply because firms that are poorly managed are both more likely to enter bankruptcy and more likely to fail to adequately comply with environmental regulations. Higher violations for pre-bankruptcy firms could also result if the regulatory violations (and subsequent penalties) themselves played a material role in forcing some firms into bankruptcy.

approved, administrative claims must be paid in full (11 U.S.C. §1129(a)(9)(A)). In theory, creditors could effect an asset sale and subsequent liquidation to avoid paying these claims, but doing so would be subject to the approval of the bankruptcy judge, who may not look favorably on such an effort to avoid responsibility for a firm's actions. In any event, while there is no guarantee that post-bankruptcy liabilities will be paid in full, they have a meaningfully higher expected payout than pre-bankruptcy unsecured claims.

[36] Many DIP loans for firms in my sample give lenders significant rights to supervise environmental compliance. For instance, Seventy Seven Energy Inc, Patriot Coal Corporation, Noranda Alumina LLC all have DIP loans that provide for inspections of their facilities by third-party auditors in order to ensure compliance with environmental regulations. For the importance of such inspections in lenders' efforts to monitor borrowers' environmental compliance, see Ohlrogge (2022). Even if a pre-bankruptcy creditor does not provide DIP finance, greater incentives to avoid post-bankruptcy environmental liabilities may influence creditor behavior. For instance, secured creditors could take less aggressive stances to collect post-petition rents and proceeds owed to them under §552(b) of the bankruptcy code, if more aggressive collection would deprive a debtor of funds needed to comply with environmental laws. Similarly, a creditor that believes a debtor's management is squandering firm value (and thus recovery to the creditor) through poor environmental compliance could petition the bankruptcy court to intervene to force the debtor to more fully comply or risk appointment of a receiver.

[37] For instance, among firms in my sample, 82% replace their CEOs around the time of their bankruptcy filings. See Section A.2.1 for details. See also Eckbo et al. (2016), conducting in-depth investigation into management change for public firms that enter bankruptcy.

Post-bankruptcy compliance might improve due to the fact that firms in bankruptcy are supervised by judges who could become displeased if firms are frequently violating the requirements of their environmental permits. Alternatively, if firms have high numbers of regulatory violations pre-bankruptcy, these may trigger increased regulatory scrutiny that simply happens to coincide in timing with bankruptcy filings. Or, bankruptcy filings themselves might prompt regulators to more closely examine a firm. In this case, it could be the increased regulatory scrutiny, rather than changes in firms' financial structure, that leads to improved compliance. Relatedly, regulators may become less concerned about firms' "ability to pay" after they file for bankruptcy, and thus may impose more stringent penalties. Post-bankruptcy firms might report fewer regulatory violations if they scale back their production. Finally, the bankruptcy process may shine a "spotlight" on a firms' operations, leading managers to notice and correct problems that previously went undetected.[38]

In the empirical sections below, I devise tests for these alternative mechanisms and find that it is unlikely they explain the patterns of pre- and post-bankruptcy environmental compliance changes that I observe. By contrast, I find specific empirical evidence that supports the moral hazard and finance friction explanations; in particular, I find that it is the firms with the lowest solvency and cash resources at the time of their bankruptcy filings that deteriorate the most in their pre-bankruptcy compliance. Thus, I conclude that the most likely explanation for deteriorating pre-bankruptcy compliance and improved post-bankruptcy compliance lies in the changes in firms' capital structures that occur in the leadup to and during bankruptcy proceedings, and the implications these capital structure changes have for moral hazard and financial constraints. Furthermore, at least many of the policy recommendations that I make, such as promoting tools to encourage firms to resolve financial distress sooner rather than later, will still be advisable under a range of causal interpretations of empirical results.

4 Data

[38] Presumably this would apply most relevantly in situations where the pre-bankruptcy CEO remains on the job, since a new CEO would not be in a position to "re-examine" operations.

4.1 CWA Compliance Data

The data at the core of this study comes from Discharge Monitoring Reports (DMRs) submitted by firms as part of their NPDES permit requirements.[39] NPDES permits for given industrial facilities will specify what a firm must monitor and report on, as well as specifying a required frequency for reporting. Reports include readings for the amounts of different pollutants within a single outflow pipe to a public waterway, or the amounts of a particular pollutant in multiple outflow pipes. Reports also can include information on factors such as the overall acidity, temperature, or similar characteristics of a facility's effluent discharges. Reports compare a facility's actual releases to the permitted limit, thus making it possible to determine whether a facility has violated its permit limits and if so, by how much.

The NPDES data has several advantages over other sources of environmental data, which makes it particularly suited to the present investigation. First, the data is very granular in its time frequency, with facilities generally reporting compliance on a quarterly or more frequent basis. This makes it possible to precisely identify the periods immediately before and after firms file for bankruptcy, and to compare compliance between these periods.[40]

Second, NPDES data depicts real-time compliance levels based on actions taken by regulated facilities. This contrasts with many other types of environmental enforcement data, such as the RCRA compliance database, which identify regulatory violations primarily based on inspections and other enforcement actions by regulators. As I show in Appendix A.3.3, regulatory inspections and enforcements can be a lagging indicator, only showing problems in a facility's compliance some time after the underlying performance has deteriorated. As such, a decrease in compliance pre-bankruptcy might, for instance, instead show up as an increase in regulatory penalties that do not occur until post-bankruptcy, thus confusing the relationship between proximity to bankruptcy and environmental compliance. Fi-

[39] As of the date of this writing, these are available for download on the EPA's website at the following address: https://echo.epa.gov/tools/data-downloads#downloads

[40] Other frequently used pollution databases, such as the Toxics Release Inventory (TRI), report only at an annual frequency. This can result in pre-bankruptcy observations coming at substantially different periods of time prior to a bankruptcy. For instance, consider two firms, one of which declares bankruptcy in January 2015 and the other in December, 2015. For each of these firms, the 2014 observation from the TRI data would be marked as occurring 1 year prior to bankruptcy. Yet, for one of the firms, the interval would cover between 13 and 1 months prior to bankruptcy, whereas for the other firm, the interval would cover between 23 and 12 months prior to bankruptcy. As I show in the analysis section, firms' compliance changes significantly on at least a quarter-by-quarter basis as they approach bankruptcy. Using observations on a yearly basis risks adding substantial noise to parameter estimates and potentially masking important details about time trends.

nally, the NPDES database has a very large number of facilities in it,[41] which helps to maximize the number that I can match to bankruptcy data.

Despite these advantages, NPDES data also come with challenges, particularly stemming from the fact that the data is self-reported. On the one hand, there are a number of important safeguards of NPDES data quality. Both companies and individual employees can be held criminally liable for falsifying records (see, e.g., McCall, 2017, p.333, citing examples of criminal prosecutions). The EPA and state environmental agencies conduct inspections of facilities,[42] with a primary goal of these inspections being to assess data accuracy.[43] Furthermore, as I discuss in Section 3.1, many companies conduct audits of their environmental control and reporting systems. Lenders also hire auditors to investigate the environmental controls of borrowers they lend to.[44]

Nevertheless, none of these can guarantee perfect data accuracy. In many respects, the most important guard against concerns over the self-reported nature of the data is that it is difficult to envision a scenario in which this could introduce bias that leads to an over-estimation of the key results in this study, which show an increase in regulatory violations pre-bankruptcy and then a decrease post-bankruptcy.

In particular, while firm owners and managers might at times have incentives to misreport data, even given the existing deterrents, it is hard to understand why owners or managers would become *less* willing to misreport data when their firms approach bankruptcy. If anything, one might anticipate firms near bankruptcy might become more willing to misreport data, particularly if owners or managers view themselves in a "last period" situation and worry that disclosures of pollution violations could endanger firm survival.[45] To the extent this is true, the results I report would underestimate the extent to which compliance deteriorates in the leadup to bankruptcy.

It is also hard to understand why the incentives to misreport data would increase after firms file

[41] There are roughly 700,000 facilities in the NPDES data, compared to, for instance, roughly 300,000 in the EPA's Clean Air Act database, and roughly 60,000 in the EPA's Toxics Release Inventory (TRI).

[42] Facilities in my sample are inspected on average once every 2.4 years, and have some form of contact with regulators (either inspections or enforcement actions) on average once every 1.3 years.

[43] NPDES Compliance Inspection Manual, Environmental Protection Agency, January 2017. Available https://www.epa.gov/compliance/compliance-inspection-manual-national-pollutant-discharge-elimination-system.

[44] On the role of auditors in lender monitoring of environmental compliance, see Ohlrogge (2022).

[45] Indeed, Arlen and Carney (1992) find that managers of firms become more likely to commit securities fraud, lying to make their companies look overly good, as their firms enter financial distress.

for bankruptcy, something which could overstate post-bankruptcy compliance improvements if it occurred. As mentioned previously, if anything, the incentives for misreporting would likely be highest pre-bankruptcy, thus implying they would drop post-bankruptcy. More generally, fraudulent misreporting is a risky strategy that trades short-term gains against the risk of a potentially low-probability, but high-cost consequence. Thus, such a strategy is likely to be more profitable for a thinly capitalized pre-bankruptcy firm than a more well-capitalized post-bankruptcy firm.[46] Thus, to the extent that firms become more willing to truthfully disclose violations post-bankruptcy, the effects I find might actually understate the extent to which environmental performance improves after firms file for bankruptcy.

A related challenge with the NPDES data comes from concerns about the quality of the EPA's Clean Water Act data in general. A recent GAO report was quite critical of the EPA, finding many faults with its CWA data (GAO, 2021). Nevertheless, the majority of the GAO's key concerns relate to aspects of the data that are not directly used in this study.[47] Furthermore, because the GAO's concerns were with how the EPA works with state environmental agencies to collect, summarize, and report data, it is hard to imagine how these problems would cause a spurious pattern of an increase in violations before individual firms declare bankruptcy and a decrease after those firms enter bankruptcy.

4.2 Bankruptcy Data and Matching

In order to identify facilities with NPDES permits that are owned by companies that declare bankruptcy, I cross reference the universe of NPDES permitted facilities[48] with a list of 500,000 corporate bankruptcies licensed from New Generation Research (NGR). NGR has developed software to mine the PACER

[46] Misreporting might also decrease after firms file for bankruptcy due to greater scrutiny from the bankruptcy judge. Where a firm acquires new management near the time of its bankruptcy filing, as often occurs, misreporting might also decrease if the new managers discover past fraud and refuse to enter into complicity with it. New creditors and investors who enter a firm may also be more likely to identify and rectify fraudulent misreporting.

[47] For instance, the GAO report notes that prior to 2015, the EPA required states only to report data on major facilities, that release at least 1 million gallons of water per day, whereas in 2015, the EPA began requiring state reporting on permit compliance by minor facilities. Nevertheless, prior to 2015, some states voluntarily reported data on minor facilities. The GAO, on page 22 of its report, is critical that in an online "dashboard" aimed at making regulatory data more accessible to members of the general public, state-level compliance statistics do not well account for the changing compositions of facilities reporting data, thus making it possible that some states could appear to have improving/deteriorating compliance, when in fact it is simply a product of the changing composition of facilities reporting. Yet, these issues are not a problem for this study. First I access the individual discharge monitoring reports directly, rather than using simplified online interfaces that produce only high-level summaries. Secondly, because I conduct my analyses a facility level, I will only include a given facility if there is a full history of compliance data for it in the time leading up to or following its bankruptcy filing. As such, at most, changes in which states report data on which types of facilities may lead my sample to have more facilities in some states rather than others, but it should not affect the validity of those analyses within the set of facilities I analyze.

[48] As of the date of this writing, this is available at the following link: https://echo.epa.gov/files/echodownloads/npdes_downloads.zip

database for a fairly comprehensive listing of all corporate bankruptcy filings over the past two decades. Appendix A.4.1 discusses in more detail the procedures by which I match companies between the NPDES and NGR databases. The matched set gives me information on 583 facilities owned by 351 companies that go bankrupt between 1992 and February 2020. I stop here because in March 2020, under direction from the administration of President Trump and in partial response to the Covid pandemic, the EPA announced that monitoring and compliance with NPDES permits would become optional for regulated facilities.[49] Due to the challenges of interpreting data reported after this change occurred, I chose to end my sample prior to the new policy's effective date.

Appendix A.4 gives additional information on the companies in my sample, including the distribution of company size, bankruptcy dates, industry and geography.

For most of my analyses, I use data from both firms that declare bankruptcy and from a matched sample from firms that do not. In particular, for each facility owned by a firm that declares bankruptcy, I find the set of facilities that have the same 2-digit SIC industry code and that submit DMR reports during the same time period I observe the facility owned by a firm that declares bankruptcy. Among this exactly matched set, I find the five facilities with the nearest number of of DMR reports submitted per calendar quarter.[50] This aims to match facilities that are similar in their size and complexity of operations, while avoiding problems of matching directly on outcomes of interest. Table A.16 in Appendix A.4 presents a series of analyses to validate that these matched control facilities are comparable to facilities owned by firms that will eventually declare bankruptcy.

In theory, one could supplement these analyses of firms that declare bankruptcy by performing similar investigations of firms that engage in private restructurings. Unfortunately, because there have historically been far fewer private restructurings than bankruptcies, there are not enough instances of such restructurings of firms regulated under the CWA. In particular, for instance, using a list of distressed exchanges generously supplied by Ed Altman, I am only able to identify one company regulated by

[49] See https://www.epa.gov/sites/default/files/2020-03/documents/oecamemooncovid19implications.pdf

[50] NPDES permits generally require facilities to monitor various pollutants in their effluent and report on the released amounts relative to their permitted maximums. Some NPDES permits also require facilities to monitor and report on other pollutants, but do not set maximums for releases. Thus, a facility need only submit the monitoring report to comply with these requirements. Because these "monitor only" reports by definition cannot give rise to permit violations for exceeding permitted limits, I do not directly analyze them in this investigation. Likewise, when matching facilities, I do not count "monitor only" reports when measuring the number of DMR reports facilities submit.

NPDES for which I can track both pre- and post-exchange compliance history.

4.3 Characteristics of Firms in Bankruptcy

I gather accounting data from firms' bankruptcy filings in order to measure the extent to which they are under-capitalized or liquidity constrained at the time of their bankruptcy filings. In particular, I examine Schedules A and B which provide information on firms' assets and liabilities. These statements are not presented in accordance with Generally Accepted Accounting Practices and they contain in many respects less detail than, for instance, accounting disclosures made by publicly traded firms. Furthermore, these schedules are not available in all bankruptcy filings.[51] Nevertheless, where available, these contain accounting estimates of asset value, measures of total liabilities, and cash on hand.[52]

Since the key driver of moral hazard concerns for equity holders is under-capitalization, I measure the difference between a firm's asset value and total liabilities, and then scale this by dividing by total liabilities. I choose total liabilities, rather than assets, as the scaling factor since asset value is only approximately known, whereas total liabilities can generally be determined with certainty. I label this the "solvency ratio." To measure the extent to which firms are constrained by finance frictions, I measure the total amount of cash and cash equivalents they have on hand,[53] and scale this by dividing by total liabilities. I label this the "cash ratio." For both this and my measure of solvency, I use the quantile of the ratio as my explanatory variable in analyses, thus enabling comparison of coefficient sizes in the regressions and accounting for the high degree of dispersion displayed by the "cash ratio." Figure A.6 in Appendix A.4 plots the distributions of these ratios among the firms I am able to compute them for.

[51] For instance, courts frequently grant debtors extensions of the time required to file these schedules, and if the case is resolved before the schedules are filed, then they may never become available. Another challenge with these schedules is they do not present information on a consolidated basis among entities within a corporate group. In some situations, this is advantageous. For instance, the capitalization of a specific subsidiary engaged in environmentally dangerous activities may matter for the moral hazard affecting it, given that regulators may have relatively few options for holding the parent corporation liable for its subsidiary's regulatory violations. In other situations, however, particularly in a complicated corporate family, it can be quite difficult to determine which assets and liabilities a given corporation controls.

[52] I supplement this data with information, if available, from firms' Chapter 11 plan disclosure statements, and from 10-Q filings if they were public corporations prior to their bankruptcy. Ultimately, I am able to obtain accounting data for most but not all of the corporations in my sample. Some corporations never file bankruptcy schedules. This can occur if the court approves a plan of reorganization or dismisses the case before the schedules are submitted. Other firms I exclude because their schedules list ownership of other corporations under their assets, but there is not enough information available to assess the value of those corporate holdings, thus making it impossible to compute the total value of a corporation's assets.

[53] I exclude cash or cash equivalents that are explicitly pledged as collateral on other obligations and are thus not available for a firm to use pre-bankruptcy.

5 Analysis

5.1 Baseline Analyses and Results

I begin my analyses with a simple descriptive plot, considering the average number of NPDES permit violations per calendar quarter among facilities owned by firms that declare bankruptcy. Figure 1 tracks facilities from four years (sixteen calendar quarters) pre-bankruptcy until three years (twelve calendar quarters) after filing for bankruptcy. In constructing this plot, I require that the same set of facilities be present in the data at the beginning of the pre-bankruptcy period as are present at the end of the post-bankruptcy period, in order to ensure that the changes in compliance behavior depicted are not simply due to changes in sample composition. Figure 1 shows that four years prior to bankruptcy, facilities violate NPDES permitted limits at a rate of roughly 0.5 to 0.6 times per quarter. Within one-to-two years prior to bankruptcy, violation rates rise to close to 0.8 times per quarter, and then immediately following bankruptcy, violation rates drop to roughly 0.5 times per quarter.[54]

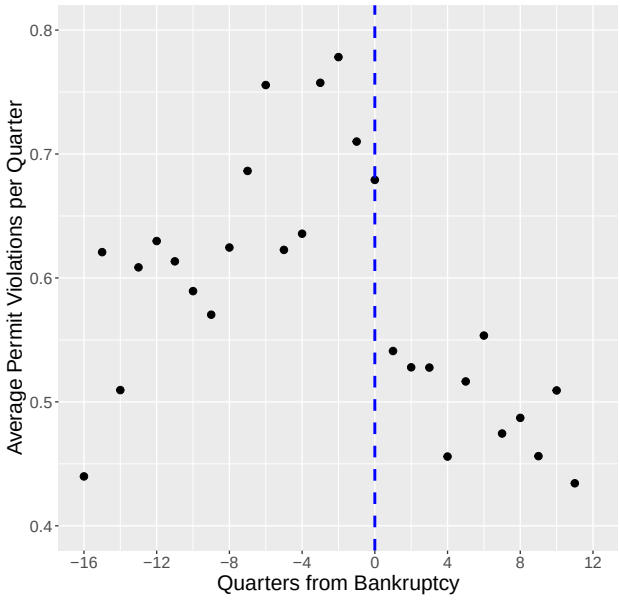


Figure 1. Average NPDES permit violations per facility and calendar quarter, raw data. All facilities represented in this plot are observed at least four years prior to their bankruptcy and at least three years following, thus ensuring that the observed patterns of violations are not driven by compositional changes in the sample.

[54]Figure A.7 in Appendix A.4 presents plots of the violation rates of a selection of individual facilities that typify the overall pattern from the average across facilities depicted in Figure 1.

I next formalize this analysis through a series of regression models that test two separate hypothesis. First, is there a statistically significant increase in violations prior to firms filing for bankruptcy? And second, is there a statistically significant decrease in violations after firms file? In fitting these models, I include data both from companies that declare bankruptcy as well as the matched data (discussed in Section 4.2) from companies that do not declare bankruptcy during my sample period.

The number of regulatory violations per facility in a given quarter is a discrete count variable with a significant portion of facilities (roughly 79%) showing zero violations in any given calendar quarter. As such, the data are a poor fit for the assumptions behind linear regressions. Instead, I use conditional negative binomial regressions, which enable fixed effects while avoiding the incidental parameter problem (Cameron and Trivedi, 2013) that would otherwise occur through their use in a nonlinear model (Neyman and Scott, 1948; Heckman, 1981).[55] Under the negative binomial formulation as applied to my data, the expectation for the number of violations in a given facility (i) in calendar quarter (t) is given by:

$$\mathbf{E}[\text{N Violations}_{it}] = \exp\left\{(\text{Years from BR})'_{it}\beta + (\text{Facility}_i)'\Gamma_1 + ((\text{Industry})_i \text{x } (\text{Calendar Quarter})_t)'\Gamma_2 + \varepsilon_{it}\right\} \tag{1}$$

This model features facility and industry-by-quarter fixed effects,[56] and I double cluster the standard errors by company and by calendar quarter. "Years from BR" is a factor variable. When testing for an increase in regulatory violations pre-bankruptcy, I set the base level for this factor to be the period more than four years prior to when a firm declares bankruptcy. Thus, each estimated level of this factor (for instance, the variable corresponding with two years prior to bankruptcy) will be an indicator that equals one for all firms that are two years from declaring bankruptcy, and zero for all firms that are not, either because they never declare bankruptcy or because their bankruptcy is other than two years away at a given point in time.

Given this definition of the "Years from BR" factor, plus the facility and calendar quarter fixed effects, this model is very similar to a difference in differences formulation. In a canonical DiD formulation, the

[55] Another option for data are conditional Poisson models. As my data exhibits some evidence of overdispersion, I favor the conditional negative binomial, but in general, results under the Poisson formulation are quite similar to those presented here.

[56] I measure industry on the basis of two-digit SIC code.

base level of the factor variable would be set to the time period immediately preceding the "treatment" event. For the analysis of pre-bankruptcy changes, however, there is no discrete time at which "treatment" occurs. In other words, there is no discernible point in time at which firms that will eventually go bankrupt receive some signal indicating that they will eventually and inevitably fail. Nevertheless, similar to a DiD model, the coefficient estimates represent how much the regulatory violation rate of the firms that eventually declare bankruptcy changes relative to the violation rate of similar firms that do not declare bankruptcy. Appendix A.3.4 discusses the "staggered" nature of this model and presents robustness results over stacked estimators as described in Cengiz et al. (2019); Baker et al. (2022).

5.2 Pre-Bankruptcy Results

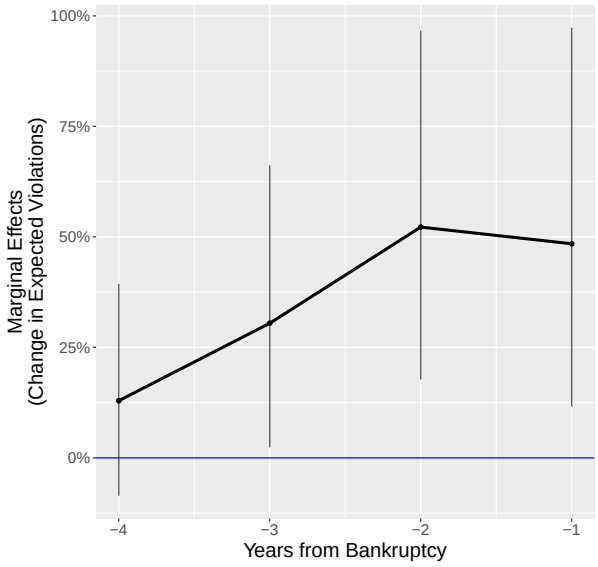
Figure 2 presents the results of the pre-bankruptcy analysis, using all observations for bankrupt firms up until the time they declare bankruptcy. Each dot represents a coefficient estimate for a separate value of the "Years from BR" factor, and the vertical lines show 95% confidence intervals. Given the form of Equation 1, I exponentiate each coefficient estimate[57] and each end of the confidence intervals in order to show their marginal effects on the expected number of quarterly violations.

Panel (a) of Figure 2 shows results for the 464 facilities (owned by 270 companies) for which I have data more than four years prior to bankruptcy and panel (b) shows results for the 347 facilities (owned by 218 companies) for which I have data that extends more than six years prior to bankruptcy. Both figures show a roughly 40-50% increase in the expected number of permit violations in the years preceding bankruptcy. In Appendix A.1.1, I show that "serious" violations, which I define as instances in which a facility exceeds its permitted release limits by more than 100%, increase even more in the leadup to bankruptcy, rising by 80% in the two years before firms file.

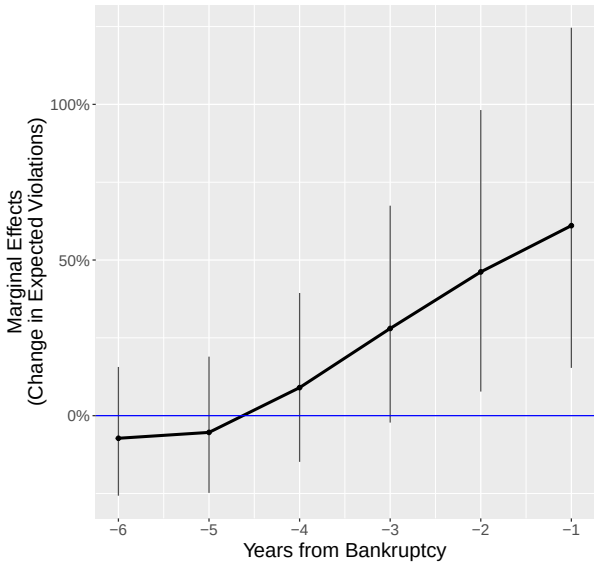
The plots in Figure 2, and in particular the longer pre-bankruptcy history in panel (b), show relatively flat patterns of coefficients before the estimates begin climbing in advance of the bankruptcy filings. These flat trajectories can be seen as somewhat akin to a parallel trends test in a DiD setting. Thus, they give some comfort that the groups of facilities owned by companies that go bankrupt and the groups

[57] Specifically, if β_j is the coefficient for the binary indicators I use in these analyses, I compute the marginal effect in percent change as $\exp(\beta_j) - 1$, following Winkelmann (2008); Cameron and Trivedi (2013).

owned by companies that do not go bankrupt are following similar trajectories when one measures their performance a sufficiently long time before bankruptcy.



(a) Four Years Prior to Bankruptcy. Data from 464 facilities owned by 270 separate companies that declare bankruptcy. All facilities in the "treatment" group that declare bankruptcy in this sample are observed at least four years prior to their bankruptcy and in the year prior to declaring bankruptcy.



(b) Six Years Prior to Bankruptcy. Data from 347 facilities owned by 218 separate companies that declare bankruptcy. All facilities in the "treatment" group that declare bankruptcy in this sample are observed at least six years prior to their bankruptcy and in the year prior to declaring bankruptcy.

Figure 2. Fitted annual coefficient estimates and confidence intervals from Equation 1. The base level for the "Years from Bankruptcy" factor variable is set to an indicator that covers time periods greater than four years prior to bankruptcy for panel (a), and periods greater than six years prior to bankruptcy for panel (b).

5.3 Pre-Bankruptcy Mechanisms

I next turn to investigations into what might explain the increase in violations as firms approach bankruptcy. For these investigations, I generate a table focusing just on an indicator for the two years prior to bankruptcy. The first column of Table 1 presents a baseline analysis, with a coefficient estimate for the two-years prior to bankruptcy is 0.5011 ($t = 3.219^{***}$), indicating a 50% average increase[58] in violations compared to a baseline level from more than four years prior to bankruptcy.

5.3.1 Actions by Regulators

If the reason that firms file for bankruptcy is because they receive harsh regulatory sanctions, then an association between proximity to bankruptcy and higher regulatory violations might not actually

[58] As with the results in figures in this paper, the tables in this paper include exponentiated versions of the coefficients in order to show marginal effects on the expected number of quarterly violations.

Table 1
Summary of pre-bankruptcy compliance changes. This table presents results from a simplified version of Equation 1, that replaces the "Years from Bankruptcy" factor variable with two indicators corresponding with the three and four years prior to bankruptcy and the one and two years prior to bankruptcy. Coefficient estimates for the one and two years pre-bankruptcy estimator are presented here. Column (1) presents a baseline analysis. Column (2) adds controls for regulator activity in the form of facility inspections, informal enforcement actions, and formal enforcement actions. Coefficient estimates for these controls are omitted for brevity, but can be found in Appendix A.3.2. Column (2) also omits firms that were subject to prosecution by the Department of Justice (DOJ) or the EPA, or that received regulatory penalties in excess of $10,000 within the two years prior to declaring bankruptcy. Column (3) presents results only for firms that file for Chapter 7 bankruptcy, and Column (4) only for Chapter 11. Columns (5) through (7) add tests using the "Solvency Ratio" and "Cash Ratio" whose construction is described in Section 4.3. Finally, column (8) presents results just for private corporations, and column (9) just for public corporations. All errors are double clustered at the company and calendar quarter level, and robust t-statistics are in parentheses.

	(1) Baseline	(2) Enforcement Controls	(3) Chapter 7	(4) Chapter 11	(5) Solvency Ratio	(6) Cash Ratio	(7) Solvency & Cash Ratios	(8) Private	(9) Public
Pre-BR (1-2 yrs)	0.5011 ***	0.5042 ***	1.1366 ***	0.4137 **	1.2663 ***	1.4505 ***	1.4925 **	0.6073 ***	0.3790
	(3.219)	(3.096)	(2.660)	(2.486)	(2.841)	(3.105)	(2.488)	(3.105)	(1.190)
Pre-BR (1-2 yrs) x (Solvency Ratio, Quantile)					-0.6687 **		-0.5509		
					(-2.265)		(-1.398)		
Pre-BR (1-2 yrs) x (Cash Ratio, Quantile)						-0.5954 **	-0.3160		
						(-2.044)	(-0.751)		
Observations	161,644	158,167	146,947	159,121	157,109	156,358	155,165	155,094	132,787
N Bankruptcies	308	299	68	240	213	226	196	240	46
N Facilities in Bankruptcy	530	400	75	455	406	350	315	350	144
Pseudo R^2	0.110	0.110	0.109	0.110	0.109	0.109	0.109	0.111	0.105
Facility FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
SIC2 x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Remove Firms with Large Pre-BR Penalties	no	yes	no	no	no	no	no	no	no
Enforcement Controls	no	yes	no	no	no	no	no	no	no

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

indicate that firms in financial distress are more likely to violate regulatory requirements. I account for this in column (2) of Table 1. There, I perform the same analyses as in column (1), but I exclude firms that were subject to prosecution by the Department of Justice (DOJ) or the EPA, or that received regulatory penalties in excess of $10,000 within the two years prior to declaring bankruptcy.

Column (2) also adds controls for the number of inspections, formal enforcement actions, and informal enforcement actions a facility has received in each of the past three years.[59] This helps to address the possibility that pre-bankruptcy deterioration in compliance is due to regulators granting greater leniency for firms in financial distress. Adding these controls and making these exclusions does essentially nothing to weaken the strength of the pre-bankruptcy effect. Appendix A.2.7 presents additional tests suggesting that regulatory activities are not likely a leading driver of the pre-bankruptcy environmental compliance deterioration that I observe.[60]

[59] For brevity, the coefficient estimates on these controls are omitted from Table 1 and are instead presented in Appendix A.3.2.

[60] In particular, I measure whether states with Republican versus Democratic governors have different patterns in how much compliance deteriorates pre-bankruptcy. If regulatory leniency for firms in financial distress is driving my results, then one might expect that firms in states with Republican governors would deteriorate more pre-bankruptcy, since in general the Republican party places less emphasis on environmental protection, and more emphasis on preserving jobs and economic development. The results in Appendix A.2.7, however, show no meaningful differences in pre-bankruptcy patterns based on the political affiliation of the states' governors. This further suggests that regulatory leniency for firms in financial distress is not the driver of pre-bankruptcy compliance deterioration.

5.3.2 Moral Hazard and Financial Frictions

If moral hazard or finance frictions are key drivers of firms' pre-bankruptcy compliance deterioration, then one may expect that firms that file for bankruptcy under Chapter 7 (liquidation) might deteriorate more than firms that file for bankruptcy under Chapter 11 (reorganization).[61] For instance, firms filing for Chapter 7 may have experienced particularly large declines in their asset values, creating severe under-capitalization or negative equity values of the type that can accentuate moral hazard concerns. Both employees and owners of such firms may more acutely believe they are in a "last period" situation in which they believe there is little left to lose if a firm is unable to avoid bankruptcy. This may then further heighten moral hazard concerns. Such firms may also face particularly acute finance frictions, as both creditors and equity investors may be reluctant to invest more money in a firm with little going concern value.

In columns (3) and (4) of Table 1, I consider how the pre-bankruptcy compliance changes vary among firms that file for Chapter 7 liquidations or Chapter 11 reorganizations. The coefficient estimates indicate that firms that file for Chapter 7 deteriorate more than twice as much as those that file for Chapter 11, increasing by 114% ($t = 2.660^{***}$) for Chapter 7 filers, compared to 41% ($t = 2.486^{**}$) for Chapter 11 filers.[62] Although other explanations for these results are possible, they line up closely with what one would expect if moral hazard and finance frictions are key drivers of firms' pre-bankruptcy deterioration in environmental compliance.[63]

[61] Whether a firm files under Chapter 7 or Chapter 11 is by no means a perfect indicator of whether it will be liquidated. First, firms can file under one chapter and then convert to the other during the bankruptcy proceedings. Second, a firm in a Chapter 7 proceeding can sell all or most of its assets to a single purchaser, which may be a corporation newly created for the express purpose of buying those assets. This in effect accomplishes the functional equivalent of a reorganization, despite the filing under Chapter 7. Conversely, a firm can sell most or all of its assets, potentially to many different buyers, in a Chapter 11 proceeding, thus in effect accomplishing a liquidation. Finally, even the concepts of "liquidation" versus "reorganization" are not precisely defined. E.g. if a firm sells 30% of its assets to one buyer and retains 70%, would that qualify as a liquidation or a reorganization? What if the firm sells 60% and retains 40%? Nevertheless, the chapter under which a company files for bankruptcy at least gives some indication of what the owners and creditors expect for it at the time of the filing, and it reflects only information available at the time of the filing. By contrast, efforts to classify liquidations versus reorganizations based on the ex-post outcome of the bankruptcy proceeding would draw heavily on information not knowable at the time of a firm's filing.

[62] In unreported tests, I further segment the group of facilities owned by firms that file for Chapter 7. In one group, I consider facilities that continue operation at least 3 years following firm's bankruptcies. In general, these will be ones that are sold to new owners. Facilities that ultimately go on to continue operating experience much less pre-bankruptcy deterioration in compliance than those that shut down. In particular, facilities that ultimately continue operating, despite a Chapter 7 filing, experience a 52% increase in violations in the leadup to bankruptcy, whereas facilities that cease operations within 3 years of the bankruptcy filing experience an astonishing 213% increase in violations prior to bankruptcy. Quite possibly then, the set of facilities that are both owned by firms that file for Chapter 7 and that cease operating post-bankruptcy experience even worse moral hazard and finance frictions than the set of facilities that continue operating after a Chapter 7 filing. Thus, these results within the set of Chapter 7 filers in many ways replicate the relationship I find when comparing Chapter 11 to Chapter 7 filers.

[63] In Appendix A.2.3 I present analyses of post-bankruptcy compliance improvements, broken out separately between facilities owned by firms that file for Chapter 7 and those that file for Chapter 11.

To further investigate moral hazard and finance frictions, I turn to the "solvency ratio" and "cash ratio" measures for firms, whose construction I describe in Section 4.3. As discussed in Section 3.3, firms that are closer to insolvent will tend to face worse moral hazard problems, and firms' cash positions at the time of their bankruptcies can help gauge their liquidity constraints. Because moral hazard and finance frictions are in many situations two sides of the same coin, the analyses using these variables are not suited to answering the question of whether moral hazard or finance frictions are "more" important. Nevertheless, they can at least provide some suggestive evidence of whether either or both appear to play a meaningful role in firms' pre-bankruptcy environmental compliance changes.

Columns (5) through (7) of Table 1 present the results of these analyses. In the column (5), I include an interaction of the pre-bankruptcy indicator with the "solvency ratio" measure.[64] The coefficient on the interaction is large, negative (−0.6687), and statistically significant ($t = -2.265^{**}$). It indicates that firms that were more solvent experienced substantially less deterioration in pre-bankruptcy compliance than other firms. In the column (6), I include an interaction of the pre-bankruptcy indicator with the "cash ratio" measure. The coefficient is also negative (−0.5942) and statistically significant ($t = -2.044^{**}$), indicating that firms with more cash deteriorated less in their compliance. Finally, in column (7), I include interactions for both the "solvency ratio" and the "cash ratio." The coefficient estimate for the solvency ratio is now somewhat larger in magnitude than that for the cash ratio (-0.5509 versus -0.3160) but neither is statistically significant in the combined formulation. Overall, these results suggest that both solvency and liquidity are important for predicting firms' pre-bankruptcy deterioration in environmental compliance.

5.3.3 Conflicts Between Equity and Management

Another possible explanation for pre-bankruptcy compliance deterioration could be conflicts between equity and management that can lead managers to violate laws even when it is not in the in-

[64] When fitting these models, I also include an indicator for the three and four years prior to bankruptcy. I also include the same interactions with that indicator as I do with the indicator for the two years prior to bankruptcy. For conciseness of presenting results, however, I omit those coefficients from Table 1. In general, the coefficients on the interactions with the indicator for three to four years prior to bankruptcy are of the same sign, but are of lower magnitude and statistical significance than the coefficients associated with interactions with the indicator for the two years immediately prior to bankruptcy. This is unsurprising, given that the accounting data is measured as of the time of firms' bankruptcy filings, and as such is less informative about the state of firms' finances the further back in time from the bankruptcy filing one considers.

terests of management (Arlen and Carney, 1992). In general, this misalignment of incentives between shareholders and managers will be strongest among public corporations, due to the weaker control shareholders of public corporations have over management. In columns (8) and (9) of Table 1, I fit models separately using only private and only public corporations. For private firms, the coefficient estimate indicates an average 61% increase in pre-bankruptcy violations ($t = 3.105^{***}$), whereas for public firms, the coefficient indicates a 38% increase in pre-bankruptcy violations ($t = 1.190$). Although the results for public firms are not statistically significant, the coefficient estimate still suggests a relatively large increase in violations, and the lack of significance may be influenced by the relatively small pool of public firms.[65] Thus, while it is possible that owner-manager conflicts are a contributing factor to deteriorating compliance among public companies, the fact that the deterioration among private companies is larger and robustly significant suggests that such owner-manager conflicts are likely not the primary explanation for the findings across the broader range of firms I consider.

5.3.4 Can Management or Employee Characteristics Explain Pre-Bankruptcy Deterioration?

Another possible explanation for elevated regulatory violations by firms near bankruptcy is that firms that are poorly managed are more likely both to fail to comply with environmental regulations and to go bankrupt. Alternatively, some managers may simply be more inclined towards taking risks, which could likewise create a correlation between bankruptcy and environmental violations. Since management is often replaced after firms file for bankruptcy, these dynamics could in theory explain both heightened violations pre-bankruptcy and reduced violations post-bankruptcy. If these effects were driving the results that I observe, then it could mean that there is not, in fact, anything special about financial distress that worsens compliance, leaving the effects that I observe largely a spurious correlation.

Nevertheless, there are several aspects of the empirical findings that would be hard to explain if this theory of manager characteristics were the primary effect driving the results I observe. The first difficulty for this theory is the steady increase in regulatory violations occurring over many years leading up to bankruptcy, as evidenced in Figures 1 and 2. It is hard to imagine why a particular manager would

[65] For post-bankruptcy analyses, both private and public firms show statistically significant improvements in compliance. See Appendix A.2.3.

become steadily less skilled as their firm approaches bankruptcy, nor why they would become steadily more risk-loving, unless it were due to issues such as moral hazard that are already at the center of the conceptual analysis of this investigation. A second challenge with this theory is that as the results in Table 2 indicate, even among firms that do not replace their CEOs around the time of their bankruptcy proceeds, environmental compliance improves substantially post-bankruptcy. If unskilled or risk-loving management were driving pre-bankruptcy deterioration, it would be hard to explain why compliance would improve even among firms that do not change management post-bankruptcy.[66]

While it may be implausible that an individual manager's skill would decrease as their firm approaches bankruptcy, it is more plausible that more skilled managers would become more likely to leave a firm as it approaches bankruptcy. Indeed, Sautner and Vladimirov (2018); Baghai et al. (2021) show that firms in financial distress have more difficulty retaining and attracting employees, something which could in theory help to explain deteriorating compliance. As I discuss in Section 3.3, this could represent an "employment friction" channel that is distinct from the moral hazard or financial friction channels. Unlike the spurious correlations discussed above, these employment frictions would suggest a true elevation of environmental risk for firms that is driven by financial distress, but the reasons would be different from the explanations based on financial frictions or moral hazard.

Nevertheless, there are challenges with the notion that employment frictions could be a significant explanatory factor. Employee flight appears to persist (Graham et al., 2022) or even accelerate (Ellias, 2022) when firms file for bankruptcy, yet this is precisely when firms begin improving their compliance. Relatedly, the results in Section 3.4 and Figure 1 suggest that after firms file for bankruptcy, they return to their base levels of compliance from well before they file for bankruptcy. If "employment frictions" were a significant contributor to pre-bankruptcy deterioration, then, since these frictions do not improve upon firms' filing for bankruptcy, one would anticipate that firms would remain at elevated violation levels post-bankruptcy, which does not match the observations in this analysis. Nevertheless, because of

[66] In theory, one could posit that unskilled management was primarily relevant only among the set of firms that did replace their managers around the time of their bankruptcies. In practice, however, almost all large firms replace their CEOs, and almost no small firms do. It would seem odd that unskilled managers would only be a problem for large firms. Furthermore, as indicated above, even if it were the case that unskilled managers were primarily a problem among firms that replaced their CEOs, it would be hard to explain why those CEOs would have become steadily less skilled the closer they got to bankruptcy. Accordingly, while it is always possible that in some particular instances a particular manager's lack of skill or risk proclivities influenced both a firm's regulatory failings and its financial failings, it is difficult to see how this can explain a large portion of the effects documented in this investigation.

the size of the confidence intervals on the point estimates for post-bankruptcy improvement, one cannot rule out the possibility that post-bankruptcy compliance only partially improved, even if the coefficient estimates suggest a largely complete resolution of compliance problems. Thus, a safe interpretation is simply to note that the available evidence provides little support for the "employment friction" channel being a primary driver of pre-bankruptcy compliance changes.

5.4 Extensions: Broader Links Between Financial Distress and Environmental Compliance

Appendix A.1 contains several extensions of the preceding analyses linking proximity to bankruptcy to increased environmental violations. In Appendix A.1.2 I show robustness of my analyses to two metrics of financial distress beyond just an individual firm's proximity to bankruptcy. First, I show that the average rate of NPDES permit violations at an industry level (measured by two-digit SIC code) is significantly tied to the total number of bankruptcy filings in that industry at a given time. This likely reflects increased violations from firms that ultimately go on to file for bankruptcy, as well as firms that are in significant distress but that manage to avoid bankruptcy. Next, I show that for firms in my sample with publicly rated bonds, those with credit ratings below the "investment grade" threshold violate NPDES permit requirements at significantly higher rates than those with better credit ratings.

In Appendix A.1.3 I seek to estimate the net impact of financial distress on the total number of NPDES permit violations that occur across all regulated facilities. This accounts for the fact that while my prior results show that firms that enter bankruptcy or other financial distress violate NPDES permit requirements at significantly higher rates, at any given time most firms will be financially healthy. To estimate the net impacts of bankruptcy and financial distress, I build on the analyses linking industry-wide bankruptcy rates with industry-wide permit violation rates. I use the coefficient estimates from those analyses to estimate a counterfactual violation rate that would occur if there were no bankruptcy filings or financial distress, and compare this counterfactual violation rate to the actual observed number of regulatory violations. Based on this, I estimate that bankruptcy and financial distress lead to a roughly 5.7% increase in total regulatory violations across all firms and time periods.

In Appendix A.1.4 I extend these estimates to produce a back of the envelope calculation for the total amount of additional pollutants released into public waterways on account of financial distress. I begin by observing that while permit violations are relatively infrequent, when they occur, they tend to be fairly severe, such that a disproportionately large amount of total pollutant releases occur in situations where a facility breaches its NPDES permitted effluent limits. Drawing on this insight, along with additional calculations, I estimate that annually, on average, there are roughly 3.6 billion extra pounds of pollutants released into public waterways on account of the heightened regulatory violations that accompany financial distress.

This amounts to roughly 1.3% of the total 250 billion pounds of pollutants annually released, as of 2019. Thus, while the amount is small in percentage terms, it is very large in absolute terms, due to the large total quantities of pollutants that get released.[67] The amounts of excess pollutants released on account of financial distress roughly equal the total pollutants released annually in the states of West Virginia or Utah. Within this total amount of extra annual pollutant releases I estimate, for instance, approximately 2 billion additional pounds of chloride, 500,000 additional pounds of magnesium, 64,000 additional pounds of chromium, 18,000 additional pounds of strontium, 7,400 additional pounds of cadmium and 4,150 additional pounds of arsenic.

5.5 Post-Bankruptcy Compliance Changes

I now turn to analyses of firms' compliance with NPDES permits after they file for bankruptcy. The pattern in Figure 1 suggests a marked improvement post-bankruptcy. To test whether this is statistically significant, I fit models following Equation 1. Now, however, I set the base level for the "Years from Bankruptcy" factor variable to be the period one-year prior to firms' bankruptcy filings and use observations for bankrupt firms that extend from one year prior to bankruptcy through six years following bankruptcy. Thus, I am testing whether post-bankruptcy performance is statistically distinguishable from performance in the year prior to bankruptcy. Figure 3 presents the individual annual coefficient

[67] On the one hand, the fact that financial distress accounts for only 1.3% of total water pollution shows that even if the policy reforms that I suggest in the introduction to this paper are implemented and the environmental hazards of financial distress are significantly reduced, it will not in and of itself revolutionize water pollution problems. At the same time, many major efforts for environmental reform depend not on a single silver bullet but upon compounding many incremental steps. The results here suggest that reforms based on an understanding of bankruptcy law can play a meaningful part of broader efforts to combat pollution.

estimates for this analysis, and Table 2 presents coefficient estimates for a single post-bankruptcy indicator, covering the six-years following a firm's bankruptcy filing. The estimates indicate that after firms file for bankruptcy, their rate of permit violations drops roughly 28% ($t = -3.5^{***}$) compared to their violation rates in the year prior to bankruptcy. If a facility were to begin at a given baseline violation rate, increase that rate by 50% (as indicated in the point estimate from the first column of Table 1) and then decrease by 28.1% following bankruptcy, the result would be a post-bankruptcy violation rate that is 8% above the initial baseline.[68] In other words, the two point estimates from Table 2 suggest that a large majority, but not all, of the pre-bankruptcy increases in violations are alleviated post-bankruptcy. There is, of course, a substantial margin of error around this estimate. Nevertheless, it is largely consistent with the results from Figure 1, which shows facilities returning to a post-bankruptcy compliance level that is very similar to their baselines from well before bankruptcy.[69]

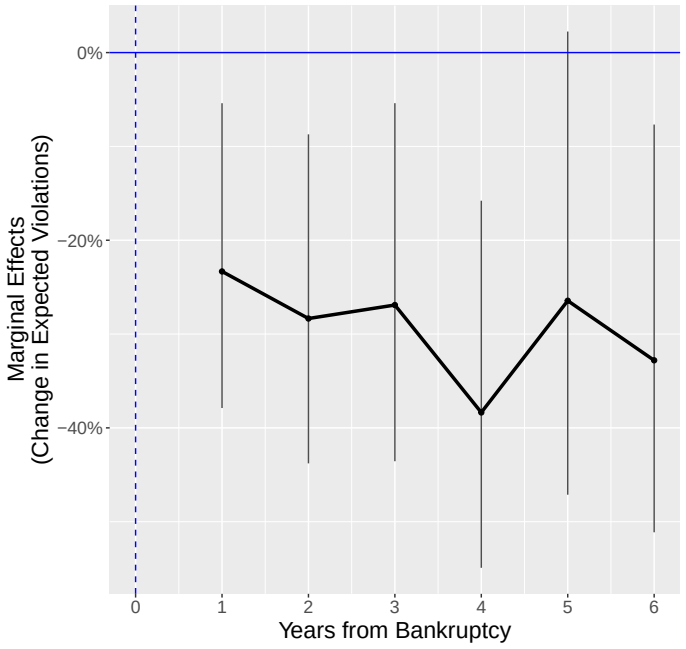


Figure 3. Fitted coefficient estimates and confidence intervals from Equation 1. The base level for the "Years from Bankruptcy" factor variable is set to be an indicator for the one year prior to firms' filing for bankruptcy. Thus, fitted coefficient estimates represent changes in expected number of NPDES permit violations that occur compared to this base level.

The "baseline" model in column (1) of Table 2 uses data from all facilities regardless of the length

[68] (1 + 0.5)(1 - 0.281) = 1.0785.

[69] An alternative perspective is to compare post-bankruptcy compliance to compliance during periods more than four years prior to bankruptcy - i.e. to use the same "base level" of compliance as I use in my pre-bankruptcy analyses. Doing this yields a coefficient on the post-bankruptcy variable of 0.03, $t = 0.15$, thus also indicating that post-bankruptcy, compliance returns to roughly the level it was at before the pre-bankruptcy deterioration began.

Table 2
Summary of post-bankruptcy compliance changes. This table presents results of an analysis of firms firms between the period of one-year prior to filing for bankruptcy and six years subsequent. The analysis is based on Equation 1, but instead of the "Years from Bankruptcy" factor, it uses a single indicator for the post-bankruptcy period. Column (1) presents a baseline analysis and column (2) presents results from a balanced panel that uses only facilities that are observed in the data over the whole period between one year prior to bankruptcy and six years following bankruptcy. Column (3) performs the same analysis as in column (1), but restricting to facilities that provide data on their average daily flow. Column (4) then adds controls to this group for average daily waterflow. Column (5) adds controls for regulatory enforcement variables and excludes firms subject to prosecution. Coefficient estimates for the enforcement variables are omitted for conciseness from this table, but are available in Appendix A.3.2. Column (6) restricts the sample to only firms where the CEO remains in place from one year prior to the bankruptcy through one year following the bankruptcy. Column (7) uses observations only from the one-year prior to bankruptcy and the period after a firm or facility has exited bankruptcy, either through confirming a plan of reorganization, conducting an asset sale, or seeing the case dismissed (which usually accompanies a transfer of assets to creditors). Columns (8) through (10) add tests using the "Solvency Ratio" and "Cash Ratio" whose construction is described in Section 4.3. All errors are double clustered at the company and calendar quarter level, and robust t-statistics are in parentheses.

	(1) Baseline	(2) Balanced	(3) Production Control	(4) Production Control	(5) Enforcement Controls	(6) CEO Stay	(7) Post-BR Exit	(8) Solvency Ratio	(9) Cash Ratio	(10) Solvency & Cash Ratios
Post-BR (6 yrs)	-0.2819 ***	-0.2703 ***	-0.2838 **	-0.2819 ***	-0.2717 ***	-0.3628 ***		-0.3921 **	-0.5416 ***	-0.5119 **
	(-3.463)	(-2.653)	(-2.590)	(-2.612)	(-3.250)	(-2.955)		(-2.199)	(-3.361)	(-2.490)
log(1 + Average Daily Flow)				0.2988 ***						
				(6.120)						
Post-Exit							-0.2471 **			
							(-2.515)			
Post-BR (6 yrs) x (Solvency Ratio, Quantile)								0.4606		0.2077
								(0.994)		(0.436)
Post-BR (6 yrs) x (Cash Ratio, Quantile)									1.0995 **	0.6642
									(2.069)	(1.392)
Observations	154,637	135,107	103,402	103,402	154,614	146,419	151,158	153,357	152,939	152,233
N Bankruptcies	344	181	271	271	342	59	248	232	242	210
N Facilities in Bankruptcy	564	244	473	473	562	100	458	431	371	334
Pseudo R^2	0.115	0.111	0.117	0.118	0.116	0.115	0.115	0.116	0.116	0.115
Facility FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
SIC2 x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Restrict to Firms with Flow Data	no	no	yes	yes	no	no	no	no	no	no
Enforcement Controls	no	no	no	no	yes	no	no	no	no	no
Exclude Firms Subject to Prosecution	no	no	no	no	yes	no	no	no	no	no

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

of time that I am able to track them post-bankruptcy. An alternative is to use a balanced panel, where I use data only from facilities that I observe for the entire post-bankruptcy pattern. Column (2) of Table 2 presents the results from such a balanced panel. Although the balanced panel reduces the number of facilities and companies by more than half, compared to the unbalanced panel,[70] the coefficient estimate is nearly identical. Furthermore, although some of the incidence of facilities dropping out of the data is likely attributable to the bankruptcy process, facilities regularly drop out for many other reasons too. For instance, across all of the NPDES data, the median amount of time that a permitted facility reports data for is 5 years.[71] Because the focus of my investigation is on how environmentally safe the operations are at facilities that continue to operate, and because the results are so similar between the balanced and unbalanced panels, I focus the remainder of my investigations on the unbalanced panel, as that affords a substantially larger sample size and thus a better ability to investigate heterogeneous impacts across different subgroups of the data.

In addition to facilities dropping completely out of the data (for instance, due to shutting down), facilities might remain in the data but scale back their production. If so, then it is possible that reductions in regulatory violations might simply be a product of reduced production, rather than safer production. To investigate this, I start by using a measure of the total amount of water that passes through a facility's machinery on an average day,[72] something that has been used in prior literature as a measure of total production (Earnhart and Segerson, 2012). Not all companies in the sample that I investigate are required to report this figure, so column (3) of Table 2 presents the same analyses as in column (1), but restricted to the set of 296 firms for which this information is available. Column (4) then adds the control for average daily flow. The results show that daily waterflow is a strongly statistically significant predictor of regulatory violations, thus supporting the notion that it is a useful

[70] In particular, the unbalanced panel has 564 facilities owned by 344 separate firms, whereas the balanced panel has 244 facilities owned by 181 different firms.

[71] The NPDES data contains information on the address and latitude and longitude of facilities. I use this to check whether facilities that stop reporting data have simply switched owners or obtained a different permit, and find that this is a very rare occurrence. Instead, when a new owner takes over a facility, they almost always maintain the same permit and permit number as the old owner. Thus, facilities that drop out of the data do so because either they shut down or because they cease releasing pollutants into waterways in such a manner as to fall within the NPDES program.

[72] Where possible, I obtain this data from the EPA's custom facility search, which generally provides the information on a quarterly or more frequent basis. That is available at https://echo.epa.gov/trends/loading-tool/get-data/custom-search. For facilities that do not have average daily flow information through that tool, I access it through the EPA's "Water Pollution Search" which provides the information on a broader range of facilities, but updated only on an annual basis. That is available at https://echo.epa.gov/trends/loading-tool/water-pollution-search.

proxy for total output. Nevertheless, adding this control has almost no impact on the size or statistical significance of the post-bankruptcy coefficient estimate. To investigate why this might be, I fit a separate linear model that examines average daily flow as a response variable and uses the same set of predictors as in the post-bankruptcy models here. In that analysis, I obtain a coefficient estimate that suggests that firms reduce water flow by only roughly 4% (significant only a the $p < 0.1$ level) post-bankruptcy. Thus, while daily waterflow is an important predictor of levels of regulatory violations, it does not change dramatically post-bankruptcy.[73] In additional tests in Appendix A.2.6, I present similar results when considering the subset of firms in my sample that are public corporations and when adding controls for total sales and total assets to my post-bankruptcy analyses.[74] Overall, these tests suggest that the reduction in violations post-bankruptcy is not simply a mechanical response to reduced production post-bankruptcy.

Columns (5) through (7) of Table 2 present the results of additional tests to address potential confounding factors that one might worry are driving the post-bankruptcy results. In column (5), I explore the possibility that regulators might become tougher on firms after they file for bankruptcy, either because regulators cease worrying that enforcements could tip a firm into bankruptcy or because regulators are responding, with a lag, to the increase in violations that occur pre-bankruptcy. Thus, the model in column (5) excludes firms that were subject to prosecution by the DOJ or EPA, and also adds numeric controls for the number of inspections, formal enforcement actions, and informal enforcement actions that each facility received in each of the three prior years.[75] Making these changes has little impact on the coefficient estimate or statistical significance of the post-bankruptcy indicator. In Appendix A.2.4 I provide additional analyses that suggest that changes in how regulators implement "ability to pay" policies are similarly unlikely to be able to explain the changes in post-bankruptcy compliance. In particular, I note that regulatory guidance on "ability to pay" suggests decreasing fines for both firms

[73] While some firms undoubtedly do reduce output post-bankruptcy, other firms use bankruptcy as an opportunity to restructure their financing so that they can increase output. For instance, in the disclosure statement accompany its proposed plan of reorganization, Full Circle Dairy, LLC, discusses using provisions of the bankruptcy code, such as the ability to sell assets free and clear of liens, in order to raise money to expand its operations. See In re Full Circle Dairy, LLC, Case No. 3:10-BK-6895-JAF, Disclosure Statement filed January 26, 2012.

[74] Because of the much smaller sample size, while the coefficient estimate for the post-bankruptcy indicator is very similar in magnitude to the coefficient estimate in Table 2, it is not statistically significant. Thus, I am merely able to observe that the magnitude of this coefficient changes little when additional controls for output are added.

[75] Due to space limitations, I omit presenting coefficient estimates for these enforcement controls in Table 2. Instead, I present them in full in Appendix A.3.2.

near bankruptcy and in bankruptcy, and I further find no evidence that the stringency of fines increases post-bankruptcy. Overall, these analyses suggest that firms' post-bankruptcy compliance improvements are not driven by increased regulatory stringency.

In column (6), I investigate the possibility that post-bankruptcy compliance improvements could be due to firms replacing top management, with new managers potentially better able to maintain compliance. To do this, I restrict my post-bankruptcy sample to the set of firms that do not change their CEO at any time during the period beginning one year prior to filing for bankruptcy and extending until one year after filing for bankruptcy.[76] This leaves only 18% of firms that keep their CEOs throughout the bankruptcy process (specifically, 59 firms owning 100 separate facilities). Nevertheless, as shown in column (6), these firms where the CEO stays show a large drop in regulatory violations (36.28%) and a highly statistically significant effect ($t = -2.955^{***}$). Appendix A.2.1 provides additional details on these analyses and the data construction that goes in to them. Overall, these results suggest that while a new CEO may help improve compliance in some individual instances, these results are difficult to square with the notion that new management is the primary driver of the widespread improvement in compliance I document throughout my sample.

In column (7), I investigate the possibility that some aspect of the bankruptcy process, such as supervision by the bankruptcy judge, might be driving improvements such that when firms exit bankruptcy, the compliance improvements dissipate. A firm or facility can exit bankruptcy when a firm confirms a plan of reorganization,[77] when a firm sees its bankruptcy case dismissed,[78] or when a facility owned by a firm is sold as part of the bankruptcy process, even if the facility's former owner remains in bankruptcy. Column (7) presents the results of an analysis that compares facilities' compliance from one-year prior to bankruptcy (as in the main analyses) to their performance after exiting bankruptcy. It shows a 25% reduction in violation rate ($t = -2.515^{**}$), which is very similar to the 28% reduction in the base-

[76] My presumption is that if a firm changes its CEO more than one year after its bankruptcy concludes, then that likely represents normal turnover that is relatively comparable between "treatment" and "control" firms that do not enter bankruptcy. As such, there is less concern that such CEO turnover is a unique consequence of the bankruptcy that might be driving compliance improvements in "treatment" firms (that undergo bankruptcy) compared to "control" firms that do not.

[77] A more technically precise measure would be the effective date for firms' plans of reorganization. As a practical matter, however, it is far more difficult to find information on this date from firms' bankruptcy filings. Because of this, and because there is usually only a relatively short interval between the confirmation of a reorganization plan and its effective date, I base these analyses on the confirmation date.

[78] This can occur, for instance, when the debtor and creditors reach an out of court settlement, often resulting in a transfer of assets to the creditors. A case can also be dismissed if a creditor has already foreclosed on essentially all of a debtor's assets, thereby leaving little left for the bankruptcy to adjudicate.

line specification in column (1). Appendix A.2.2 provides additional details into this post-exit analysis. Overall, these results suggest that compliance improvements thus persist even after firms and facilities exit the bankruptcy process.

Finally, columns (8) through (10) of Table 2 investigate potential evidence that post-bankruptcy compliance improvements could be attributable to the bankruptcy process relieving problems of moral hazard and finance frictions, I return to the analyses based on the "solvency ratio" and "cash ratio" that I analyze in Table 1. If firms that had the worst solvency problems, or the least cash availability pre-bankruptcy are the ones that most improve post-bankruptcy, then it would lend some support to the notion that post-bankruptcy improvements are driven by alleviation of these concerns.

Column (8) interacts the post-bankruptcy indicator with the "solvency ratio." It finds a large, positive (0.4606) but statistically insignificant ($t = 0.994$) coefficient. The sign of this coefficient is as one would expect - namely, firms that were least solvent pre-bankruptcy improve the most post-bankruptcy. In column (9), the interaction between the post-bankruptcy indicator and the "cash ratio" is larger, positive (1.0995) and more statistically significant ($t = 2.07^{**}$). The sign is again as predicted: firms that had less cash improve more post-bankruptcy. The final column of Table 1 includes interactions between the post-bankruptcy indicator and both the "solvency ratio" and the "cash ratio" variables. While neither coefficient is statistically significant, the magnitude of the coefficient on the "cash ratio" is larger (0.6642 versus 0.2077).

Together, these results may suggest that the bankruptcy process is more effective at resolving financial frictions, but somewhat less effective at resolving moral hazard problems. If so, this could potentially be because firms may still remain relatively thinly capitalized, even after going through the bankruptcy process.[79] At the same time, the imprecision of the measures of solvency and liquidity, and the fact that the problems of moral hazard and financial frictions are closely linked,[80] warrants significant caution before concluding that bankruptcy is more or less effective at resolving certain types of

[79] For theories related to this, see, for instance, LoPucki and Doherty (2002), arguing that even after emerging from bankruptcy, many large firms are in precarious positions that leave them prone to failing again soon afterwards.

[80] In particular, for instance, it could easily be the case that the reason that some firms have very little cash at the time they declare bankruptcy is because they have particularly acute solvency problems, and accounting measures of asset and liability value might well not fully capture the extent of firms' solvency deficiencies. Furthermore, while the solvency ratio has a notably smaller coefficient than the cash ratio in the combined post-bankruptcy test in column (10) of Table 2, the relationship of the sizes of the two coefficients is reversed in the combined pre-bankruptcy test in column (9) of Table 1.

financial distress.

6 Policy Implications

The empirical findings in this article have important implications for several areas of policy. In this section I briefly review these, although I emphasize that a complete cost-benefit analysis of any particular policy change lies beyond the scope of this current investigation.

First, the results of this investigation support a series of policies to encourage firms to resolve financial distress sooner rather than later. These include changes in tax law to encourage creditors to negotiate out-of-court restructurings (Campello et al., 2019; Donaldson et al., 2022).[81] Another way to encourage firms in financial distress to file for bankruptcy is to reduce the costs of the bankruptcy process. The recent Small Business Reorganization Act (SBRA) of 2019 sought to achieve this by substantially simplifying the bankruptcy process for small business filers (Lawless, 2020). Congress is still debating the size of firms that will be eligible for this new law[82] and the results from this investigation point to benefits from relatively wide applicability to small businesses. In some instances, simply increasing awareness among small businesses of the benefits of bankruptcy, and dispelling misconceptions about bankruptcy, may increase their likelihood of filing for bankruptcy (Bernstein et al., 2022). Conversely, the results of this investigation provide additional reasons for judges to be skeptical of controversial tools, such as those documented by Buccola (2022), that firms have begun to use to delay bankruptcy and the resolution of financial distress.

The results of this investigation also lend support to a series of measures designed to reduce the moral hazard faced by creditors and shareholders of firms near insolvency. Research has shown that policy changes such as mandatory insurance and bonding (Boomhower, 2019), and increasing priority of environmental claims in bankruptcy (Ohlrogge, 2022), can improve the environmental performance of firms by reducing moral hazard concerns. This current investigation shows more clearly than prior research how large the deterioration in environmental performance for firms near bankruptcy can be,

[81] See Donaldson et al. (2022) for additional policy recommendations designed to encourage firms to resolve financial distress sooner rather than later.

[82] https://www.jdsupra.com/legalnews/subchapter-v-eligibility-congress-fixes-6812569/

thus emphasizing the importance of reforms aimed at reducing moral hazard.

Finally, this investigation informs regulatory enforcement policy. The results here provide additional reasons to be skeptical of "ability to pay" policies that reduce fines for firms in financial distress. If a firm is so financially precarious that a fine could imperil its survival, then that firm may well be externalizing environmental and other harms at a significantly elevated level. Given this, it is less obvious that reducing fines through "ability to pay" policies will be optimal. The results here also suggest that it may be efficient for regulators to increase inspections of firms likely to be in financial distress.[83] Given that inspections are costly for regulators, the question is whether the marginal benefit of increasing inspections is higher for firms that are financially distressed or for firms that are financially healthy. As I show in Appendix A.3.1, in a large number of situations and under plausible assumptions, increasing inspections for firms in financial distress will represent an efficient allocation of limited enforcement resources.

7 Conclusion

In this article, I demonstrate that compliance with permit requirements under the Clean Water Act deteriorates substantially as firms approach bankruptcy, but that this compliance then substantially improves after firms file for bankruptcy. The improvements are driven both by improvements in the operations of firms that reorganize, as well as by asset sales that transfer facilities to new owners that operate them more safely. I conclude that firms' pre-bankruptcy deterioration most likely is attributable to the growth of financial frictions and moral hazard problems that affect thinly capitalized firms, and that post-bankruptcy improvements are most likely driven by mechanisms of the bankruptcy process that significantly resolve financial frictions and moral hazards.

These results have several implications. Perhaps most fundamentally, the results here suggest a new way to view the bankruptcy process, as an important tool to preserve public welfare in the face of

[83] It will not always be possible for regulators to identify firms in financial distress, but in many instances it will be possible. For instance, for firms that are public companies or that have publicly rated debt, it is relatively easy to observe financial condition. Furthermore, there are situations where industry groups experience waves of financial distress and bankruptcy, such as the wave of coal and oil bankruptcies from 2015 to 2017 discussed in Appendix A.1.2. Thus, identifying these instances, or potentially similar downturns in specific geographic areas, can give regulators insights into at least many instances of firms in financial distress.

substantial distortions that place firms in financial distress at significantly elevated risk of externalizing harms. Accordingly, the findings here add weight to calls for bankruptcy policies that encourage firms to resolve financial distress sooner (Donaldson et al., 2022), and add additional reason to be skeptical of policies that encourage firms to delay bankruptcy as long as possible (Buccola, 2022). Furthermore, by documenting more clearly than prior empirical literature the problems of externalities imposed by firms near insolvency, this work lends urgency to reforms to address moral hazard problems, including increasing the priority of bankruptcy claims for externalized harms, and increasing the use of bonding and insurance requirements for firms at risk of harming the public. Finally, the results here shed light on regulatory enforcement policy. In particular, the results add further reason for regulators to question "ability to pay" policies that give lighter penalties to financially precarious firms. The analyses in this paper further show that in many situations, regulators can improve regulatory effectiveness by more closely monitoring and inspecting firms in financial distress. Ultimately, the findings of this investigation emphasize that an analysis of bankruptcy and the impacts of financial distress is important for designing an effective set of public policies to constrain negative externalities imposed by corporations.

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A Appendix

A.1 Extensions

A.1.1 "Serious" Regulatory Violations

In the primary analyses throughout this paper, I follow the EPA's definition of a regulatory violation as occurring wherever a facility releases more of a pollutant than its permit allows. In this section of the appendix, I complement those analyses by considering "serious" violations, which I define as instances in which a facility releases more than twice as much as its permitted limit of a pollutant. Table A.1 presents the results of these analyses. It shows that in the leadup to bankruptcy, firms increase their rate of "serious" violations even more dramatically than they do when considering all violations. Similarly, after filing for bankruptcy, the rate of serious violations drops more than it does for regular violations.[84]

Table A.1
"Serious" Regulatory Violations. The models in this table use the same functional format and predictors as the main specifications in Table 1 and Table 2. The outcome variable, however, measures the number of times a "serious" permit limit violation occurs, rather than just any permit limit violation. I define a serious violation as one in which a facility's pollutant releases exceed its permitted maximum by 100% or more.

	Pre-Bankruptcy	Post-Bankruptcy
Pre-BR (1-2 yrs)	0.8078 ***	
	(3.311)	
Post-BR (6 yrs)		-0.3193 ***
		(-2.890)
Observations	161,644	140,600
N Bankruptcies	308	344
N Facilities in Bankruptcy	530	564
Pseudo R^2	0.086	0.086
Facility FE	yes	yes
SIC2 x Quarter FE	yes	yes

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

[84] For the post-bankruptcy analyses, serious violations only drop modestly more than regular violations, whereas for the pre-bankruptcy analyses, serious violations increase substantially more. It is possible that this indicates that the bankruptcy process is less effective at remedying the problems that lead to serious violations. At the same time, the discrepancy might simply be a product of the imprecision of estimators, and the fact that by definition, the set of serious violations encompasses less data than the set of all violations.

A.1.2 Other Metrics of Financial Distress

I now consider markers of financial distress apart from a given firm's proximity to bankruptcy, and examine whether these other markers are also predictive of deterioration in environmental compliance. For my first investigation, I consider financial distress on an industry-wide basis. To do this, I begin by computing, for the facilities in each industry (as measured by two-digit SIC code), the average number of NPDES permit violations in a given calendar quarter. For each of those industry-quarter observations, I then compute the total number of bankruptcies one year in the past, two years in the past, as well as one year in the future and two years in the future.[85] The goal here is to identify industries where either many bankruptcies have recently occurred, or industries in which many bankruptcies will soon occur, much as I identify individual firms that will soon experience bankruptcy in my main analyses.

If many firms in an industry are declaring bankruptcy, then it likely indicates that other firms in the industry are also in precarious financial positions. Thus, a measure of total industry bankruptcies will likely measure both the effects from the firms that themselves file for bankruptcy as well as the effects from firms in that industry that are financially distressed but that avoid bankruptcy.

Having computed the industry-wide rates of bankruptcies and pollution violations, I fit linear models of the following form:

$$\log(1+\text{Avg. Quarterly Number of Violations}_{it}) = \sum_{y\in\{-2,-1,1,2\}} \text{N Bankruptcies}_{ity}\beta_y + (\text{Industry}_i)\Gamma_1 + (\text{Calendar Quarter}_t)\Gamma_2 + \varepsilon_{it} \quad \text{(A.1)}$$

Here, i indexes industries, t indexes the calendar quarter of an observation, and y indexes years from a given quarterly observation. The term $\sum_{y\in\{-2,-1,1,2\}} \text{N Bankruptcies}_{ity}$ thus implements two yearly leads and two yearly lags in the number of industry-wide bankruptcies.

Table A.2 presents the results of these analyses, and Figure A.1 plots the coefficients from Table A.2 visually.[86] The pattern in Figure A.1 is notably similar to that in Figure 1, showing regulatory violations

[85] I begin these analyses in the year 2012 and end them in the year 2020, as with my primary analyses. The reason I begin in 2012 is that while New Generation Research's bankruptcy data extends prior to this, the data only begins tracking industry for the majority of filers in year 2012.

[86] In particular, I select the coefficients predicting serious violations in the model with the full set of year and industry fixed effects. The

spiking to their highest levels shortly before bankruptcy filings spike, with violations dampening down after waves of bankruptcies subside within a given industry.

As one would expect, the coefficient estimates in Table A.2 indicate that each individual bankruptcy has only a very minimal effect, adding just a few hundredths of a percent in expected increase in average number of regulatory violations. Nevertheless, where an industry experiences a large number of bankruptcies, the impact can add up. For instance, the oil and gas sector (SIC 13) experience a wave of 432 bankruptcies in 2016, which would be associated with a roughly 19% increase in industry-average NPDES violations as compared to a hypothetical scenario in which no bankruptcies occurred.[87]

To further the analysis of links between financial distress and environmental violations, I next consider the set of firms that have publicly rated bonds (regardless of whether they file for bankruptcy) and that own facilities subject to NPDES permits. Thus, this analysis includes some firms that are not in my main analyses, because they do not declare bankruptcy. In total, I identify 322 such firms, using matching techniques similar to those described in Appendix A.4.1.

I obtain credit ratings for these firms from the Mergent Fixed Income Securities Database (FISD), available through Wharton Research Data Services (WRDS). I use the same quarterly panel tracking NPDES permit violations, and the same negative binomial regression model that I use for my main analyses. In total, there are 18,049 firm-by-quarter observations in which I have data on both a firm's credit rating and on the NPDES compliance of facilities that it owns. If a firm has multiple rated credit instruments, I use the rating for the lowest rated instrument.

Among these observations, I examine whether firms with lower credit ratings violate their NPDES permit requirements more frequently. One challenge is that firms' credit ratings change only rarely, and often by small amounts. For instance, the median firm in my data changes its credit rating by only one degree (for instance, from BB to BB+) during the entire period I observe it. Thus, facility or company fixed-effects, as I use in my primary analyses, absorb almost all of the variation in credit ratings within my sample. In this analysis, therefore, I use quarterly fixed effects, but I do not employ

general pattern of coefficients is quite similar across the different models in Table A.2, although the statistical significance and precise size of the specific estimates varies to some degree.

[87] I compute this estimate as follows. I begin with the marginal effects estimate in the third column of Table A.2 for the year prior to bankruptcies. This estimate indicates a 0.04% increase in bankruptcy rates per bankruptcy. Since the marginal effects are obtained by exponentiating the initial coefficient estimates and subtracting one, I reverse the process by taking the log of one plus this estimate. I then multiply this by 432, and then return to the marginal effects representation by exponentiating the result and subtracting one.

Table A.2
Industry-wide Rates of Bankruptcy and Environmental Violations. This table presents results from Equation A.1.

	(1)	(2)	(3)
Panel 1: Effluent Violations			
N Industry Bankruptcies, 2 Years in Future	0.0004 *	0.0002	-0.0000
	(1.784)	(0.683)	(-0.035)
N Industry Bankruptcies, 1 Year in Future	0.0003	0.0005 **	0.0004 **
	(1.518)	(2.569)	(2.743)
N Industry Bankruptcies, 1 Year in Past	0.0003	0.0004	0.0001
	(1.517)	(1.476)	(1.597)
N Industry Bankruptcies, 2 Years in Past	-0.0000	0.0000	0.0003
	(-0.189)	(0.018)	(1.534)
Observations	2,714	2,714	2,714
Adjusted R^2	0.023	0.495	0.545
Panel 2: "Serious" Violations (>2x limit)			
N Industry Bankruptcies, 2 Years in Future	0.0001	-0.0001	-0.0000
	(0.380)	(-0.353)	(-0.163)
N Industry Bankruptcies, 1 Year in Future	0.0004 **	0.0005 ***	0.0003 ***
	(2.481)	(3.223)	(3.375)
N Industry Bankruptcies, 1 Year in Past	0.0003 ***	0.0004 **	0.0002 ***
	(2.842)	(2.282)	(3.006)
N Industry Bankruptcies, 2 Years in Past	0.0000	-0.0000	0.0001
	(0.000)	(-0.101)	(1.022)
Observations	2,714	2,714	2,714
Adjusted R^2	0.029	0.423	0.459
SIC2 FE	no	yes	yes
Quarter FE	no	no	yes

Cluster robust t-statistics in parentheses, clustering on industry and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

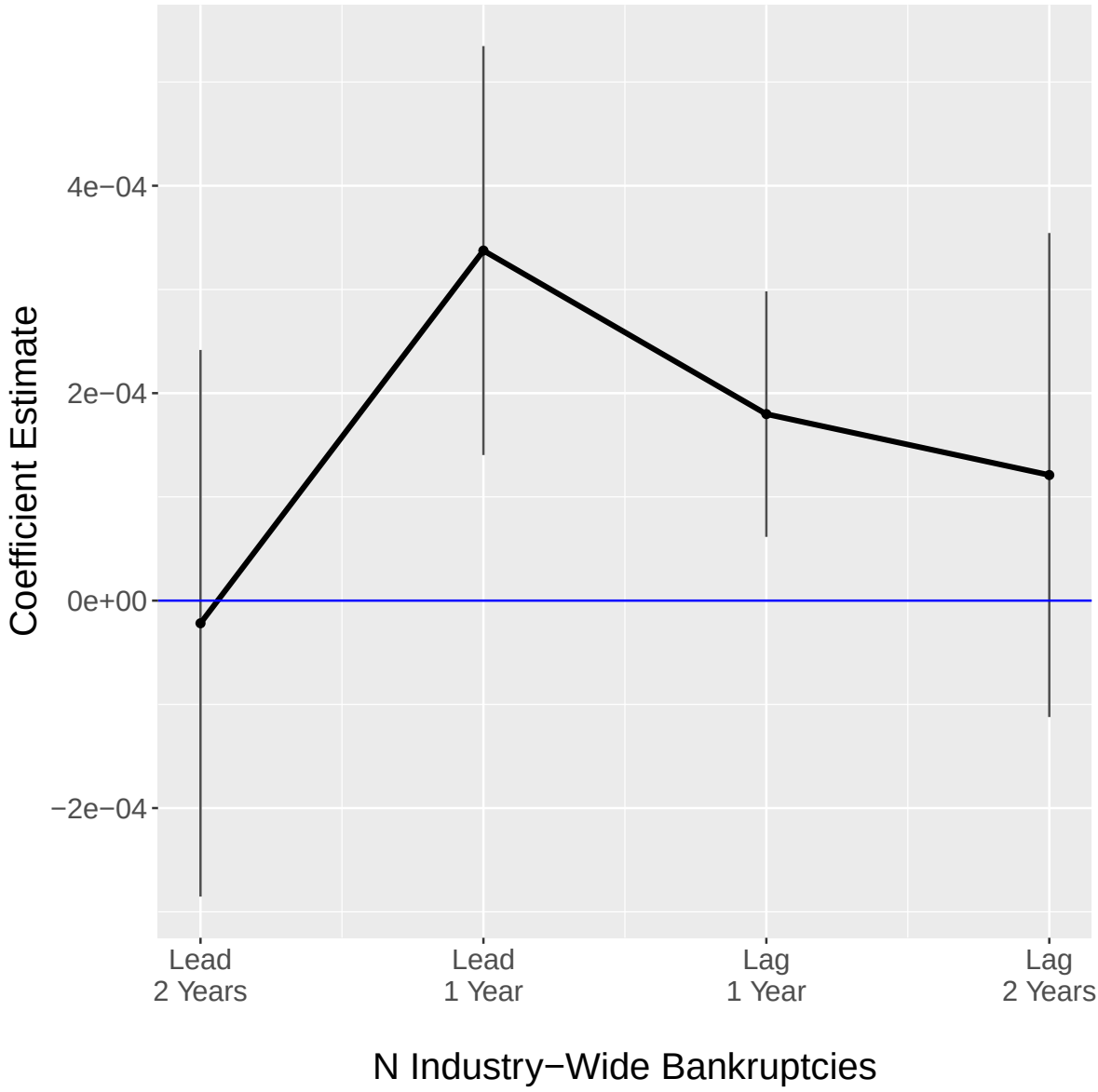


Figure A.1. This figure plots coefficient estimates from model (3) of the lower panel of Table A.2, estimating the relationship between industry-wide bankruptcies and average rates of NPDES permit violations in a given industry.

facility or company fixed effects. Furthermore, rather than a variable indicating time from bankruptcy, as in Equation 1, I use indicators for a firm's credit rating. In particular, I consider variations with an indicator for whether a firm has debt below "investment grade" ratings (below BBB-), and also for even lower-rated debt, with ratings of BB or below.

Table A.3 presents the results of these analyses. It shows, for instance, that firms with "junk" (i.e. non-investment grade) debt violate NPDES permits at a rate roughly 57% greater than do other firms. For firms with even lower debt, and for "serious" NPDES violations, the elevated violations rates are even higher. These analyses help to give additional robustness to the results in Table A.2 that show a link between broader measures of financial distress and failure by firms to comply with environmental permit requirements.

Taken together, these the analyses in Figure A.1 and Table A.3 help to validate the association this paper finds elsewhere between firm financial distress and elevated levels of environmental violations. Furthermore, while it will likely be quite difficult for regulators and other parties to know when in the future specific firms may declare bankruptcy, measuring credit ratings and industry-wide bankruptcy rates is much more feasible. Thus, to the extent that enforcement efforts take firms' financial conditions into account,[88] the results from this section point to practical ways to identify firms at greater risk of regulatory violations.

A.1.3 Total Effects of Financial Distress on Regulatory Violations

The results of my main analyses in Table 1 show that firms that declare bankruptcy experience a sharply elevated rate of environmental permit violations in the leadup to bankruptcies, and the results discussed above in the context of Table A.2 suggest that this extends to entire industries that experience significant financial distress. Nevertheless, at any given time period, the number of companies and industries experiencing significant financial distress will often be relatively low. Thus, the analyses so far do not reveal to what extent total rates of environmental permit violations may be impacted by the declines in compliance that occur for firms in financial distress.

[88] As I discuss in the introduction to this paper, enhanced regulatory scrutiny of firms in financial distress is likely to be useful in some but not all situations, in particular, in those situations where it is imperative to achieve zero or almost zero rates of violations.

Table A.3
Credit Ratings and Environmental Violation Rates. This table presents results of a negative binomial panel regression among the set of firms in my data that have debt rated by credit rating agencies. In total, I identify 322 firms with rated debt that also own facilities with NPDES permits. Model (1) predicts NPDES permit violations based on an indicator for whether a firm has a credit rating below investment grade (BBB- or lower). 43% of observations have this rating or lower. Model (2) predicts NPDES permit violations based on an indicator for whether a firm has a credit rating of BB or lower. 32% of observations have this rating or lower.

	(1)	(2)
Panel 1: Effluent Violations		
Junk Rating (Below BBB-)	0.5689 **	
	(2.413)	
Rating BB or Below		0.6187 ***
		(2.600)
Observations	18,049	18,049
Pseudo R^2	0.000	0.000
Panel 2: "Serious" Violations (>2x limit)		
Junk Rating (Below BBB-)	0.7491 **	
	(2.585)	
Rating BB or Below		1.1059 ***
		(3.347)
Observations	18,049	18,049
Pseudo R^2	-0.007	-0.005
Quarter FE	yes	yes

Cluster robust t-statistics in parentheses, clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

To gain insights into the total effects of financial distress on environmental violation rates, I extend the analyses of industry-wide bankruptcy rates as follows. For each industry-quarter observation used in the analyses presented in Table A.2, I estimate the percent by which the actual number of observed NPDES permit violations increased on account of the bankruptcies in the years surrounding that calendar quarter. To compute this percent, I use the following equation

$$\text{Net Percent Increase} = \sum_{y \in \{-2,-1,1,2\}} \text{N Bankruptcies}_y \hat{\beta}_y \tag{A.2}$$

Here N Bankruptcies_y is the number of bankruptcies that occurred in the given industry y years from a given observation. Thus, for instance, $y = -1$ corresponds with the number of bankruptcies one year prior to a given observation, or in other words, a one-year lagged count of bankruptcies. $\hat{\beta}_y$ is the coefficient estimate from Equation A.1 corresponding with the count of bankruptcies before or after a given observation.[89] After I compute the "Net Percent Increase" as in Equation A.2, I use it to estimate a counterfactual number of NPDES permit violations that would have occurred had there been no bankruptcies within two years of the given observation. Thus, for instance, if I observe an actual total of 110 permit violations in a given industry, and I compute a "Net Percent Increase" of 10%, then the counterfactual estimate of permit violations would be 100. I compute this counterfactual number of permit violations for all quarterly observations used in the analyses in Table A.2, and then sum those over the entire period.

Taken together, these analyses suggest that financial distress can explain roughly 51,392 NPDES permit violations out of a total of 944,791 violations during this period. In other words, total regulatory violations increased by roughly 5.7% on account of financial distress.

A.1.4 Total Effects of Financial Distress on Total Pollution

Building off the preceding results in Appendix A.1.3, I next perform a back of the envelope estimate to gauge the total amount of pollutant releases that can be attributed to the additional violations that occur on account of financial distress. NPDES effluent permit violations are relatively rare. As indicated

[89] By default, I use the coefficient estimates in the right-most column of the top panel of Table A.2, but because the coefficient estimates are relatively consistent across the models, the choice of these makes little difference to the conclusions.

in Section 5.1, permit violations occur only a few times per year for a typical facility. Yet, when violations do occur, they tend to be relatively severe. For instance, among the full set of NPDES data, when a violation has not occurred, the median releases are 11.6% of the permitted limit, whereas when a violation has occurred, the median releases are 152% of the permitted limits. The discrepancy in mean values is even more extreme. When a violation has not occurred, the mean releases are 20.3% of the permitted limit. When a violation has occurred, the mean releases are 4721% of the permitted limit. Even if I winsorize this at the 99th percentile, I still find that when a violation has occurred, mean releases are 405% of the permitted limit. The implications of this is that if one can reduce the incidence of NPDES permit violations, it can have an outsize impact on reducing total pollutants that enter public waterways.

In order to estimate the amount of total pollutants attributable to the 5.7% excess regulatory violations associated with financial distress, I begin with the set of all NPDES observations, not just those of firms that declare bankruptcy or the matched sample. Of the set of all instances where the releases are beyond the permitted limit, I create a counterfactual release amount as follows:

$$\text{Counterfactual Release} = (\text{Actual Release})(1-0.057) + (\text{Permit Limit})(0.057) \tag{A.3}$$

In other words, the counterfactual release represents the expected release amount if each release had a 5.7% chance of being replaced by the average pollutant releases that occur when no violation is present - namely, 20.3% of the permitted limit. I then compute how much each facility's releases of each pollutant would have decreased on account of a 5.7% decrease in violations, and compute the average reduction in total pollutants each facility.[90] Next, I access the EPA's accounting of total pollutants released for NPDES facilities[91] and reduce these pollutants by the average reduction I previously computed for each facility.[92] In the event a facility from the total pollution data set is not available in the NPDES violation

[90]The reason that I first compute a pollutant by facility average reduction, and then from that compute a facility-wide average reduction is that the units of different pollutants are often not comparable, making it difficult to directly compute a facility-wide average reduction.

[91]Available https://echo.epa.gov/trends/loading-tool/water-pollution-search.

[92]The EPA's data reports information on total amounts of each pollutant from each facility. In theory, then, I reduce each facility-by-pollutant pair by a facility-by-pollutant factor computed in the previous step. In practice, however, the ways that pollutants are measured in the two databases are not directly comparable. For instance, the EPA's accounting of total pollutants reports separately on strontium and strontium-90, a specific isotope of strontium. The NPDES permit compliance database, by contrast, has separate entries for "Strontium, total [as Sr]" and "Strontium, total recoverable," neither of which clearly map on to the classifications from the total pollutant database.

data set (which I use to compute the facility wide reduction percents), I impute to that facility the average decreases from facilities that do match between the two databases.[93]

Using these approximate calculations, I estimate that roughly 1.3% of total pollutant releases may be attributable to excess regulatory violations that occur due to financial distress.[94] Although this may seem to be a small percent, the total amount of pollutants released is huge, with over 250 billion pounds of pollutants released into public waterways in 2019 alone. Thus, a 1.3% reduction would correspond to roughly 3.6 billion pounds of pollutants. To put this in context, it would be comparable to completely eliminating all water pollution from the state of West Virginia.[95]

Lastly, in Table A.4 I consider a selection of the several hundred different pollutants tracked by the EPA. For each of the selected pollutants, I present the estimate, as derived above, of how many extra pounds of that pollutant per year are released on account of the excess regulatory violations attributable to financial distress.

A.1.5 Heterogeneous Effects by Firm Size

In this section, I consider heterogeneous effects based on firm size. In general, these results do not bear directly on any of the key mechanisms that I investigate, and so they are offered in general as additional descriptive results. The results in Table A.5 show that small firms exhibit the largest pre-bankruptcy deterioration in compliance and the greatest post-bankruptcy improvement in compliance. Nevertheless, even larger firms generally show significant pre-bankruptcy deterioration and post-bankruptcy improvements.

A.2 Mechanisms

[93] It is necessary to cross reference between these two databases because the Discharge Monitoring Report (DMR) database, the EPA's data that contains information on permit violations, does not directly contain information about the total amounts of pollutants released. Instead, the DMR database contains information about releases in the form of, for instance, mg per liter of water, but it is often not specified how much total water is flowing through a particular outlet where such a concentration measure is taken.

[94] The EPA also reports pollutants on the basis of "toxic weighted pound equivalents" (TWPEs). These aim to allow comparison of releases across different polutants by using different weightings based on a pollutant's toxicity. The calculations I employ here suggest that roughly 1% of total TWPEs may be attributable to excess regulatory violations occurring due to financial distress.

[95] This is based on a consideration of total pounds of pollutants. Water pollution from West Virginia has a higher average toxicity than that from other states. Thus, if considering the reduction in "toxic weighted pound equivalents" (TWPEs), eliminating excess pollution from financial distress would be comparable to completely eliminating all toxic water pollution from the state of Utah.

Pollutant Name	Excess Pounds per Year
Chloride	2,184,039,822
Solids, total suspended	515,296,832
Solids, total dissolved	476,307,520
Ammonia as N	119,134,184
Oil and grease	11,207,360
Nitrogen	7,113,280
Phosphorus	3,979,087
Aluminum	577,879
Magnesium	482,821
Chromium, Trivalent	51,800
Strontium	18,384
Barium	17,317
Lead	14,398
Chromium	12,533
Cyanide	8,698
Cadmium	7,444
Arsenic	4,152

Table A.4
Pollutants Attributable to Financial Distress. This table presents estimates for how many pounds of different pollutants, per year, may be attributable to excessive regulatory violations caused by financial distress. The results here are based on the estimation procedures described in Appendix A.1.3 and Appendix A.1.4. The pollutants included in this table are a sample of the several hundred different pollutants over which I perform these calculations.

A.2.1 Post-Bankruptcy Management Change: Additional Analyses

This portion of the appendix provides additional details of the analysis, presented in column (6) of Table 2, of firms that keep versus do not keep their CEOs throughout the bankruptcy process. To investigate this, I collect information on whether firms replace their CEOs during the period from one year before they file for bankruptcy up through one year after they exit bankruptcy. In some instances, this information is available in firms' reorganization plan disclosures filed with the bankruptcy court. I supplement that with information from press releases, other corporate websites (e.g. for CEOs' subsequent employers), and at times LinkedIn. I am able to identify whether management changed for all but 20 of the firms in my post-bankruptcy sample. Over all of my firms, the CEO remains through the bankruptcy process in 18% of the instances. Results are similar when considering firms by size group. For instance, among "small" firms with assets and liabilities under $100 million, 16% see the CEO stay following the bankruptcy process, and among "large" firms with assets or liabilities above $100 million, 20% see the CEO stay. In instances where the CEO does not stay, either a new CEO is appointed to run the reorganized firm or the firm's assets are sold to another company to operate under the direction of

Table A.5
Heterogeneous Effects by Firm Size, Pre and Post-Bankruptcy. This table presents results for different sized firms, measured based on the ranges of asset values firms declare upon their initial bankruptcy petitions.

	Pre-BR			Post-BR		
	≤ $10M	> $10M	≥ $1B	≤ $10M	> $10M	≥ $1B
Pre-BR (1-2 yrs)	1.1262 ***	0.3486 **	0.3566			
	(3.205)	(1.979)	(1.601)			
Post-BR (6 yrs)				-0.4092 ***	-0.2260 **	-0.3231 ***
				(-2.683)	(-2.266)	(-2.827)
Observations	148,344	157,724	153,431	147,081	151,257	148,951
N Bankruptcies	121	187	79	142	202	83
N Facilities in Bankruptcy	126	404	270	147	417	270
Pseudo R^2	0.109	0.110	0.110	0.115	0.115	0.115
Facility FE	yes	yes	yes	yes	yes	yes
Industry x Quarter FE	yes	yes	yes	yes	yes	yes

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

that firm's management.

Table A.6 presents the results of more detailed analyses into whether management changes are driving improvements in post-bankruptcy regulatory compliance. The first column presents results for the 59 firms and 100 facilities that retain their CEO throughout the bankruptcy process. The coefficient estimate indicates a large drop in regulatory violations (36.28%) and a highly statistically significant effect ($t = -2.955^{***}$). The magnitude of this is somewhat larger than the post-bankruptcy improvement for all firms measured in Table 2. Thus, the second column uses an interaction to test whether the difference is statistically significant, and finds that it is not. In the third column, I consider results just among the 265 firms and 443 facilities that do see top management change during the bankruptcy process. These experience a post-bankruptcy drop in regulatory violations of (25.54%, $t = -2.779^{***}$) that is quite similar to the overall post-bankruptcy result from Table 2. The fourth column considers a subset of facilities whose management changes on account of their being sold to existing operating companies (rather than simply reorganized) during the bankruptcy process. The coefficient estimate indicates a similar post-sale improvement for these facilities, but the effect is not statistically significant, likely due to the fact that there are only 28 facilities, owned by 25 different firms, for which I can conclusively identify such sales. [data collection is still ongoing to identify more such sales].

Table A.6
Management Change and Post-Bankruptcy Compliance Change. This examines heterogeneity in post-bankruptcy compliance changes based on whether firms replace their CEO (or equivalent title) within one year of entering and exiting bankruptcy. The first column presents results looking only at the 59 companies for which the CEO remains until at least a year following the bankruptcy. The second column uses an interaction variable to test whether the post-bankruptcy compliance change for these firms is statistically different from the change for firms where management is replaced. The third column looks just at the 265 firms for which top management changes during the bankruptcy process. The fourth column looks at the 28 facilities that are sold to new operating companies during the bankruptcy process. The remaining four columns consider additional heterogeneity by firm size. The fifth and sixth columns consider firms with assets and liabilities under $100 million, with the fifth column giving a 'baseline' estimate for all such firms, and the sixth column considering just those firms for which management remains. The seventh and eighth column consider firms with assets or liabilities that are at least $100 million. The seventh column presents a 'baseline' estimate for all such firms, and the eighth considers just those firms that did not change their top management as part of the bankruptcy process.

	All Size Firms				Firms < $100M		Firms ≥ $100M	
	(Only CEO-Stay)	(Interaction)	(CEO Change)	(Facility Sale)	(Baseline)	(CEO-Stay)	(Baseline)	(CEO-Stay)
Post-BR (6 yrs)	-0.3628 ***	-0.2661 ***	-0.2654 ***		-0.3178 **	-0.5280 **	-0.2588 **	-0.2643
	(-2.955)	(-2.784)	(-2.779)		(-2.531)	(-2.493)	(-2.472)	(-1.423)
Post-BR x (Management Stay)		-0.1352						
		(-0.762)						
Post-Asset-Sale (6 yrs)				-0.3358				
				(-0.861)				
Observations	146,419	153,463	151,571	145,191	148,375	145,110	150,808	145,855
N Bankruptcies	59	324	265	25	194	30	150	29
N Facilities in Bankruptcy	100	544	443	28	205	32	359	68
Pseudo R^2	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115
Facility FE	yes	yes	yes	yes	yes	yes	yes	yes
Industry x Quarter FE	yes	yes	yes	yes	yes	yes	yes	yes

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Finally, columns five through eight of Table A.6 examine whether there are significant differences among small versus large firms that retain their management post-bankruptcy. For small firms that keep their management (column 6), the post-bankruptcy compliance improvement is larger than the improvement for all small firms (column 5), and both effects are statistically significant. For large firms that keep their management (column 8), the post-bankruptcy compliance improvement is essentially identical to that of all large firms together, but the effect is statistically significant only when pooling large firms that do and do not change management.

Taken together, these results give little support to the notion that improvements in post-bankruptcy performance are driven primarily by changing management. Firms that do and do not change their management all appear to improve their post-bankruptcy compliance similarly to one another.

A.2.2 Post-Bankruptcy Exit: Additional Analyses

This portion of the appendix provides additional details of the analysis, presented in column (7) of Table 2, of firms' and facilities' compliance with environmental regulations after they exit the bankruptcy

process. Table A.7 presents more detailed post-bankruptcy analyses than those summarized in Table 2. The first column of Table 2 shows a baseline estimate for the total reduction in post-bankruptcy NPDES violations among the set of facilities I have confirmed bankruptcy exit dates for. [I am still working on finalizing identification of asset sales, so the final results of this table may shift slightly, but I do not anticipate large changes]. The coefficient in the first column indicates a roughly 26% reduction ($t = -2.9^{***}$) in effluent violations for these facilities following bankruptcy, a result very similar to the 28% reduction measured across all facilities in Table 2. The second column examines those same facilities, but only observing them after they have exited bankruptcy (thus replicating the result from column (7) of Table 2). It shows a 25% reduction in effluent violations ($t = -2.5^{**}$) after the facilities exit bankruptcy. The third column combines these two analyses by including indicators for both "post-bankruptcy" and "post-confirmation." It confirms that the difference between the "post-bankruptcy" and "post-exit" performance of firms is very small and not at all close to being statistically significant. Overall, these analyses, and in particular the results from the second column of Table A.7, suggest that improvements in compliance persist, even after firms and facilities are no longer participating in the bankruptcy process. It might still be the case that aspects of the bankruptcy process, such as supervision by a judge, lead firms to adopt new investments or policy changes that lead to persistent improvements in compliance. So, the findings here do not suggest that factors such judicial supervision are irrelevant. But, they show that post-bankruptcy environmental compliance improvements cannot be solely attributed to aspects of the bankruptcy process that terminate when firms and facilities exit bankruptcy.

A.2.3 Post-Bankruptcy Heterogeneity by Chapter 7 vs. 11 Filings and Private vs. Public Firms

Table 1 presents results for heterogeneous pre-bankruptcy compliance changes among firms that file Chapter 11 versus Chapter 7 bankruptcy petitions, and among private versus public firms. In this section of the appendix, I present comparable post-bankruptcy heterogeneity analyses.[96]

The first two columns of Table A.8 present post-bankruptcy analyses for firms that file for Chapter

[96]Table 2 in the body of the paper presents many other analyses of heterogeneity of post-bankruptcy compliance changes, but that table already contains ten other models. Furthermore, post-bankruptcy heterogeneity analyses along the the dimensions of Chapter 11 versus 7, and private versus public firms, are less directly informative on key mechanisms as their pre-bankruptcy counterparts. Accordingly, in the interests of focus and brevity of the body, I present these post-bankruptcy heterogeneity analyses in the appendix.

Table A.7
Environmental Performance, Post Bankruptcy Exit. This examines environmental performance for firms after they exit bankruptcy in order to test whether compliance may deteriorate after supervision by the bankruptcy judge ends. The panel considers all firms and facilities for which I can identify a bankruptcy exit date. These exit dates come from the dates reorganization plans are confirmed, the date facility sales are finalized, and the dates that bankruptcy cases are dismissed, generally due to debtors and creditors arranging an out-of-court settlement. The first column uses only an indicator for the post-bankruptcy period, evaluated over the subset of firms and facilities for which I can identify exit dates. The second column uses only observations from either prior to firms' bankruptcy filings or after they have exited the bankruptcy process. The third column uses all observations, and includes indicators for both post-bankruptcy and post-exit. The set of "control" firms that do not experience bankruptcy is the same across all columns.

	Effluent Violations		
	(1)	(2)	(3)
Post-BR (6 yrs)	-0.2581 ***		-0.2721 **
	(-2.917)		(-2.362)
Post-Exit		-0.2471 **	0.0261
		(-2.515)	(0.197)
Observations	152,930	151,158	152,930
N Bankruptcies	248	248	248
N Facilities in Bankruptcy	458	458	458
Pseudo R^2	0.115	0.115	0.115
Facility FE	yes	yes	yes
Industry x Quarter FE	yes	yes	yes

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

11 and Chapter 7, respectively. If a facility is owned by a firm that files for Chapter 7 and the facility continues to operate for a meaningful amount of time after the bankruptcy petition, this will generally be because the facility has been sold to new owners as part of the bankruptcy process. Column (1) shows an average decline in environmental violations of 27.6% ($t = -3.24^{***}$) for firms that file for Chapter 11 bankruptcy, which is very similar to the 28.1% decline found for all firms in column (1) of Table 2. For firms that file for Chapter 7, the second column of Table A.8 shows an average decline in violations of 32.6%, but it is not statistically significant, having $t = -1.316$. A key contributor to this lack of significance is likely the much smaller sample size: 83 facilities, owned by 76 firms (in the Chapter 7 sample), compared to 481 facilities, owned by 268 firms, in the Chapter 11 sample.

Another feature of these results is that although the improvements for firms that file for Chapter 7 are larger than those that file for Chapter 11, the difference is much less stark than for the pre-bankruptcy results. As presented in Table 1, firms that ultimately file for Chapter 7 deteriorate more than twice as much as those that ultimately file for Chapter 11. One potential explanation for this difference in pre vs. post-bankruptcy results is that firms and facilities that deteriorate the most in the leadup to a

Chapter 7 filing may be the most likely to simply cease operations, whereas those that deteriorate less may be more likely to be sold to a new buyer. The tests that I describe in footnote 62 confirm that this is indeed the case, and thus help to explain why the post-bankruptcy improvements for Chapter 7 filers are only a small amount larger than the post-bankruptcy improvements for Chapter 11 filers.

I now turn to comparison of post-bankruptcy improvements by private versus public corporations. For these analyses, I designate a firm as public or private based on its post-bankruptcy ownership. Columns (3) and (4) show similar results for each type of firm, with a post-bankruptcy decrease in environmental violations of 30% ($t = -2.816^{***}$) for the 255 private firms in the post-bankruptcy sample, and a post-bankruptcy decrease of 25% ($t = -2.068^{**}$) for the public firms. This is similar to the pre-bankruptcy results in Table 1, which show a greater pre-bankruptcy deterioration for private firms as compared to public firms.

Table A.8
Additional post-bankruptcy results. This table analyzes heterogeneity in post-bankruptcy compliance changes based on Chapter 11 versus Chapter 7 bankruptcy filings, and based on private versus public corporations. As such, it provides a complement to the pre-bankruptcy heterogeneity analyses along these dimensions presented in Table 1. All errors are double clustered at the company and calendar quarter level, and robust t-statistics are in parentheses.

	(1) Chapter 11	(2) Chapter 7	(3) Private	(4) Public
Post-BR (6 yrs)	-0.2758 ***	-0.3257	-0.2996 ***	-0.2530 **
	(-3.240)	(-1.316)	(-2.816)	(-2.068)
Observations	153,165	146,018	150,254	148,929
N Bankruptcies	268	76	255	89
N Facilities in Bankruptcy	481	83	357	207
Pseudo R^2	0.115	0.115	0.115	0.115
Facility FE	yes	yes	yes	yes
SIC2 x Quarter FE	yes	yes	yes	yes

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A.2.4 Post-Bankruptcy Changes in "Ability to Pay" Policies

One potential explanation for firms improvements in post-bankruptcy compliance is that regulators may increase the severity of enforcement actions after firms file for bankruptcy, perhaps due to decreased concern about firms' "ability to pay." Based on regulators' guidelines, it is not obvious that this would occur. The EPA's ability to pay guidelines, for instance, list being in "bankruptcy" as one of the

conditions that can trigger an "ability to pay" fee reduction.[97] If anything, it is at least possible that regulators might reduce penalties even more for firms in bankruptcy, since their financial distress may be more obvious and convincing.[98] Furthermore, if it were the case that regulators increase penalties after firms file for bankruptcy, on account of reduced concerns about "ability to pay," then this would largely represent another way that the process of filing for bankruptcy reduces moral hazard. Thus, this channel would represent a specific detail of how moral hazard for firms near bankruptcy operates, rather than an alternative to that channel.

To investigate the possibility that regulators increase the stringency of fines they impose after firms file for bankruptcy, I consider the set of all formal regulatory enforcements among firms in my sample. I examine the size of penalties imposed, conditional on an enforcement occurring, via the following linear model:

$$\log(1 + \text{Penalty Amount})_{it} = \text{BR Company}\beta_1 + \text{Post-BR}\beta_2 + \varepsilon_{it} \tag{A.4}$$

Roughly 90% of the facilities in my experience only at most one formal enforcement action during the periods I observe them. Because of this, using facility fixed effects, as I do in my primary specifications, washes out almost all variation in this regression. In place of these, therefore, I use a simple indicator ("BR Company") for whether a firm ever declares bankruptcy, or whether it is one of the "control" firms that never declares bankruptcy. The "Post-BR" variable is a simple indicator that equals one in the periods after these firms declare bankruptcy. In one variation on the model, I also add year fixed effects.

Table A.9 presents the results of this analysis. In both models, the "BR Company" variable is positive and statistically significant, indicating that firms receive higher penalties, compared to the control group that never goes bankrupt, prior to filing for bankruptcy. This is in line with my prior results on the frequency of effluent violations. Both models, however, show a large, though statistically insignificant, negative coefficient for the post-bankruptcy indicator. In other words, these analyses present no evi-

[97] See "Guidance on Evaluating a Violation's Ability to Pay a Civil Penalty in an Administrative Enforcement Action," Environmental Protection Agency, June 29, 2015, available https://www.epa.gov/sites/default/files/2015-06/documents/atp-penalty-evaluate-2015.pdf

[98] From a corporate finance perspective, once a firm has already declared bankruptcy, assessing an additional penalty should simply change how much value goes to different parties in the bankruptcy and should not impact whether the firm reorganizes. Thus, from some perspectives, it would not be rational for regulators to continue to reduce fines on account of firms being in bankruptcy. Yet, despite this, "bankruptcy" is one of the criteria for fine reductions in EPA guidelines. More generally, as documented by Atkinson (2022), much policy on ability to pay appears to be poorly informed from the perspective of corporate finance.

dence that regulators impose more stringent penalties after firms declare bankruptcy, and if anything, they may impose less stringent penalties, potentially on account of firms' financial distress being more salient after they file for bankruptcy.[99]

Ideally, these analyses would include a control for the underlying severity of the violations, measuring this in some way independent of the assessed fine amount. Thus, it is still conceivable that the same firm committing the same penalty would receive a more stringent fine post-bankruptcy than it would before, and that the reduction in observed fines is simply due to firms committing less egregious violations after they file for bankruptcy. At the very least, however, these tests reveal no evidence in support of the theory that regulators substantially increase the stringency of fines they impose after firms file for bankruptcy.

Table A.9
Penalty Conditional on Formal Enforcement Action. This table presents the results of a linear regression (Equation A.4) examining the penalty amounts assessed by regulators conditional on a formal enforcement action occurring. "BR Company" is an indicator for whether a firm ever experiences bankruptcy, and "Post-BR" is an indicator for whether a firm has already filed for bankruptcy.

	log(1 + Penalty)	
	(1)	(2)
BR Company	2.6052 **	1.7569 **
	(2.347)	(2.076)
Post-BR (6 yrs)	-1.8829	-1.7240
	(-1.446)	(-1.588)
Observations	1,174	1,174
Adjusted R^2	0.018	0.13
Year FE	no	yes

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

[99] One complication with this analysis is that it is possible that firms commit less serious violations after they file for bankruptcy, on account of an understanding that regulators will punish post-bankruptcy violations particularly harshly. In this case, the lower penalties observed post-bankruptcy would be indications of changed firm behavior in response to this added strictness. Yet, to make credible a threat of extra harsh penalties for firms that have already filed for bankruptcy, regulators would presumably need to at least some of the time impose particularly harsh penalties on post-bankruptcy firms, even if, on average, penalties are less severe, as indicated in Table A.9. To investigate this possibility, I fit quantile regressions matching the form of Equation A.4 and employing year fixed effects. I examine the 75th, 90th, and 95th quantiles. If regulators are imposing particularly harsh penalties on some post-bankruptcy firms as a way to induce the other firms to reduce serious compliance breaches, then one would anticipate positive coefficients on the "Post-BR," indicating that the higher end of the distribution of penalties has gotten more extreme. By contrast, in each of the 75th, 90th, and 95th percentiles, the coefficient on the "Post-BR" variable from Equation A.4 is negative, although in each case, the coefficient estimate is not statistically significant. Overall, therefore, these results at least present no evidence in support of the hypothesis of particularly harsh enforcement actions against firms after they declare bankruptcy.

A.2.5 Post-Bankruptcy Changes in NPDES Citizen Suit Intensity

As I discuss in Section 3.2.1, provisions that allow "citizen suits" to enforce NPDES permits are also a component of the formal enforcement framework affecting firms in my sample. An important motivation in bringing these suits is the ability of lawyers to win awards of attorneys fees. These awards, however, would become low priority claims against a firm that subsequently enters bankruptcy. Thus, there may be a reduced incentive to bring citizen suits for firms in financial distress, and a subsequent increase in incentive after firms file for bankruptcy. To the extent that this is present, it would illustrate the moral hazard problems stemming from the low bankruptcy priority given to such claims, rather than being an alternative mechanism as many of the other discussions in this appendix. Unfortunately, data limitations make it difficult to directly investigate this specific channel. In particular, through searches of the PACER database, I identify an average of only about 100 citizen suits per year throughout my sample period. Of these, only a very small handful target firms that are near bankruptcy, thus precluding meaningful statistical analyses.

A.2.6 Post-Bankruptcy Changes in Production Levels

In Section 5 and Table 2, I consider the possibility that drops in production post-bankruptcy could explain firms' post-bankruptcy compliance improvements. I present analyses that use average daily waterflow through a facility's machinery as a proxy for total production. I find that this average daily waterflow is highly predictive of violations (suggesting that it may well be a useful proxy for production), but that adding controls for it does little to impact the estimated change in post-bankruptcy compliance. In this section, I consider additional ways to control for changes in post-bankruptcy production.

In Table A.10, I supplement the analyses in Table 2 by examining the 39 firms in my sample that are public corporations before and after filing for bankruptcy. Greater amounts of information are available on the operation of these firms, including their total sales and total assets, which may enable for a more complete measure of changes in production. The first column of Table A.10 indicates a point estimate of a 24% decrease in NPDES permit violations after these firms file for bankruptcy, an estimate similar to that for the full sample of firms. In the second column, I add controls for the log of firms' total sales,

and log of firms' total assets. The post-bankruptcy point-estimate is now 26% under this specification, and the t-statistic is slightly higher as well. Likely because of the much smaller sample size, neither of these point estimates are statistically significant in and of themselves, yet the fact that adding controls for sales and assets produces no reduction in the size of the post-bankruptcy compliance improvement helps to give additional support to the notion that compliance improvements are simply driven by firms cutting back on production.

Table A.10
Post-Bankruptcy Compliance and Production Changes: Public Firms. This table is a complement to the models in Table 2 that control for average daily waterflow. As such, the results in this table also investigate whether post-bankruptcy environmental performance improvements can be attributed to changes in production levels. This table only considers the subset of firms that are public companies and thus report accounting data for the periods both prior and subsequent to their bankruptcy filings. The first column is a baseline, that does not use any controls for this accounting data, and the second column adds controls for total sales and total assets.

	(1)	(2)
Post-BR (6 yrs)	-0.2914	-0.2690
	(-1.155)	(-1.011)
log(1 + Total Sales)		0.3003
		(0.810)
log(1 + Total Assets)		-0.1622
		(-0.633)
Observations	7,762	7,762
N Bankruptcies	39	39
N Facilities in Bankruptcy		
Pseudo R^2	0.041	0.041
Facility FE	yes	yes
Quarter FE	yes	yes

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A.2.7 Pre-Bankruptcy Differences by Governorship Political Party

In Section 5.1, Table 1, and Appendix A.2.4 I present analyses to assess whether changes in regulatory enforcement might explain pre-bankruptcy deterioration in compliance or post-bankruptcy improvements in compliance, and in general find little evidence that this is a major contributing factor. Another way to examine the role that enforcement intensity might impact the results that I observe is to investigate how my results vary based on the political party that controls the state governorship during the time a firm is near bankruptcy. As the ability to pay guidelines indicate, when a firm enters financial

distress, there is potentially a tradeoff between ensuring it maintains good environmental compliance versus giving it a lighter regulatory burden in the hopes that it can avoid shutting down or scaling back its operations which could then have a negative impact on the local economy. The Democratic and Republican political parties tend to place different amounts of emphasis on preserving the environment versus preserving jobs. Since most of the NPDES enforcement is conducted by state environmental authorities who are answerable, in part, to state governors,[100] firms near bankruptcy might exhibit different levels of compliance deterioration based on current the party control of the governorship of their state. If this were the case, it could suggest that decreasing regulatory enforcement intensity for firms in financial distress might play a role in explaining firms' deteriorating compliance.

To investigate this, I access data on gubernatorial elections from the CQ Press Voting and Elections Collection, which gives comprehensive information on the party affiliation of winners of gubernatorial elections within the United States. I restrict my sample to firms within the 50 united states (thus excluding Puerto Rico and Washington DC) and to states that have either a Democratic or Republican governor. In model (1) of Table A.11 I conduct my baseline analyses with no additional controls on this restricted set of observations, replicating my main results from Table 1. In model (2), I add a binary indicator "GOP Gov" for whether a Republican controls the governorship of a state at the time of an observation. I use this indicator on its own as well as interacted with the indicators for firms 1-2 and 3-4 years prior to bankruptcy. The coefficient estimates on the "GOP Gov" indicator, as well as its interactions, are all small and statistically insignificant. One potential complicating factor is that states controlled by GOP governors may tend more heavily towards oil, gas, and mining industries, and firms in these industries themselves may exhibit greater deterioration of compliance as they approach bankruptcy. To investigate whether this could be confounding my analyses, in models (3) through (6) of Table A.11 I compute models separately depending on whether facilities are from the oil, gas, and mining industries (SIC 10-14). Models (3) and (5) do not contain the "GOP Gov" predictors. They show statistically significant pre-bankruptcy deterioration for firms both in and outside of the oil, gas, and mining industries, although the deterioration is substantially larger for the oil, gas, and mining

[100] Because of the role of the national EPA in supervising state enforcements, among other factors, state environmental authorities do not have complete discretion to set environmental policies within their states.

firms. In Models (4) and (6) I add the "GOP Gov" control as well as its interactions. The coefficients on this indicator and its reactions in general remain small and statistically insignificant.[101] Overall, these findings give further evidence that my primary results, showing deterioration in pre-bankruptcy compliance, cannot be explained by environmental enforcement growing more lax for firms in financial distress.

A.3 Supplemental Analyses

A.3.1 Evaluating the Marginal Impact of Increased Inspections

In Section 6 I consider whether an increase in regulatory scrutiny of firms in financial distress will be an efficient use of scarce regulatory resources. Here, I add some additional structure to the conceptual analyses of that section, and combine them with an analysis of empirical findings from the data I collect on firms near bankruptcy.

In determining the marginal impact of increased regulatory scrutiny, there are two potentially competing effects. First, firms near bankruptcy are likely less responsive to regulatory actions. Indeed, this has been the focus of extensive prior theoretical work and it is consistent with the primary empirical findings in this investigation. At the same time, if regulatory actions such as on-site inspections result in a proportional reduction in regulatory violations, then all else equal, inspections at sites that have elevated levels of violations should produce greater marginal reductions in violations. Given the elevated violation rates that I find for firms near bankruptcy, this second effect could potentially counterbalance or even outweigh the first effect.

An additional consideration in evaluating the marginal impact of enhanced scrutiny by regulators is that increased inspections may impact firms in two separate ways. First, the anticipation of increased scrutiny may induce firms to adopt safer environmental practices. Second, upon conducting an inspection and identifying deficient equipment or processes, regulators may directly require that facilities

[101] Out of the 18 total coefficient estimates associated with "GOP Gov" in Table A.11, one is statistically significant, but only at the $p < 0.1$ level. One coefficient out of 18 that is significant at $p < 0.1$ is in line with what would be expected to occur by chance even where there is no underlying relationship. There are also a few larger but not statistically significant coefficients, some positive and some negative, associated with model (6) which restricts data to the smaller set of oil, gas and mining firms. Again, this is along the lines of what one would anticipate given a noisy estimator (due to the smaller sample) and no underlying relationship between political party control and pre-bankruptcy compliance deterioration.

Table A.11
Pre-Bankruptcy Effects, Republican vs. Democratic Governors.

	All Firms		No Oil, Gas, Mining		Only Oil, Gas, Mining	
	(1)	(2)	(3)	(4)	(5)	(6)
Effluent Violations						
Pre-BR (3-4 yrs)	0.2018 *	0.2041	0.0637	0.1390	0.8971 **	0.4336
	(1.778)	(1.348)	(0.558)	(0.847)	(2.381)	(0.761)
Pre-BR (1-2 yrs)	0.4937 ***	0.5311 **	0.3532 **	0.1591	1.0249 *	1.5832
	(3.186)	(2.259)	(2.418)	(0.852)	(1.842)	(1.603)
GOP Gov		-0.0551		-0.0208		-0.2314 *
		(-1.349)		(-0.477)		(-1.679)
Pre-BR (3-4 yrs) x (GOP Gov)		-0.0076		-0.1163		0.5599
		(-0.047)		(-0.735)		(1.024)
Pre-BR (1-2 yrs) x (GOP Gov)		-0.0467		0.3143		-0.3518
		(-0.212)		(1.261)		(-0.755)
Observations	160,220	160,220	112,666	112,666	40,692	40,692
N Bankruptcies	337	337	258	258	65	65
Pseudo R^2	0.108	0.108	0.110	0.110	0.088	0.089
"Serious" Violations (>2x limit)						
Pre-BR (3-4 yrs)	0.3628 **	0.3901	0.1855	0.2351	1.4629 **	0.9188
	(2.150)	(1.576)	(1.078)	(0.931)	(2.302)	(0.970)
Pre-BR (1-2 yrs)	0.7565 ***	0.8111 **	0.4653 **	0.3054	2.3816 **	2.7009 *
	(3.142)	(2.488)	(2.181)	(1.152)	(2.072)	(1.730)
GOP Gov		-0.0470		-0.0203		-0.2524
		(-0.819)		(-0.340)		(-1.391)
Pre-BR (3-4 yrs) x (GOP Gov)		-0.0425		-0.0768		0.5417
		(-0.172)		(-0.312)		(0.631)
Pre-BR (1-2 yrs) x (GOP Gov)		-0.0646		0.2549		-0.1663
		(-0.214)		(0.734)		(-0.218)
Observations	160,220	160,220	112,666	112,666	40,692	40,692
N Bankruptcies	337	337	258	258	65	65
Pseudo R^2	0.080	0.080	0.078	0.078	0.078	0.078
Facility FE	yes	yes	yes	yes	yes	yes
Industry x Quarter FE	yes	yes	yes	yes	yes	yes

Cluster robust t-statistics in parentheses, clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

comply with instructions to improve their processes for handling pollutants. In some respects, these two separate mechanisms can be seen as similar to the deterrence versus incapacitation channels in criminal law, although environmental regulators' ability to enforce compliance is less absolute than in many criminal justice settings. Nevertheless, while firms near bankruptcy may be less responsive to the first of these mechanisms, they may remain at least relatively responsive to the second, particularly where managers face criminal penalties for directly disobeying regulatory orders.

To evaluate these dynamics more formally, let $\alpha < 0$ represent the elasticity of a facility's violation rate in response to an increase in on-site inspections. Let $\gamma < 0$ represent the extent to which the inspection elasticity is reduced for firms in financial distress. Let $b > 0$ represent a facility's baseline level of regulatory violations and let $e > 0$ represent the extent to which this baseline increases in the presence of financial distress. Thus, a firm not in financial distress will violate regulations at a rate of b, and violate at a rate of $b(1+\alpha)$, in response to an increase in inspections. A firm in financial distress will violate at a rate of $b(1+e)$ and in response to an increase in inspections will violate at a rate of $b(1+e)(1+\alpha(1+\gamma))$. Given these specifications, a marginal increase in inspections will have a greater marginal effect on firms near bankruptcy if the following condition is satisfied:

$$\gamma > \frac{1}{1+e} - 1 \tag{A.5}$$

In the results from this investigation, I find roughly a 50% increase in violations for firms near insolvency, thus yielding a value of $e = 0.5$. Given this, Equation A.5 indicates that in order for a marginal increase in inspections to have a greater marginal impact on firms near bankruptcy, it must be the case that $\gamma > -0.33$. In other words, as long as inspections lose less than 1/3 of their deterrent effectiveness for firms near bankruptcy, then an increase in inspections for firms near bankruptcy will be efficient.

Furthermore, there may be an even wider range of scenarios in which an increase in inspections for firms in financial distress would represent an efficient use of enforcement resources. The reason is that an increase in inspections may have two distinct impacts on firms' environmental compliance. First, firms' anticipation of inspections may induce them to proactively adopt safer environmental practices.

Second, when inspections actually occur, regulators may directly require firms to expend resources to improve their environmental performance. Firms near bankruptcy may be relatively insensitive to the first of these effects, but may still be relatively responsive to the second of these effects, at least to the extent that regulators can more directly enforce compliance with requirements they impose after an inspection. In other words, firms in financial distress may be more willing to gamble that they can reduce their compliance expenditures and not be caught, but conditional on receiving an inspection and being caught, they may respond relatively similarly to firms not in financial distress.

While it is difficult to directly measure firms' expectations of enforcement rates, the second of these two effects, firms' responsiveness to realized enforcement actions, can be relatively directly measured using available data. In particular, in Table A.12, I examine the extent to which facilities' violation rates change following regulatory inspections. The results in the first column show little change in the one year after an inspection, likely because facilities require time to implement the requirements imposed by inspectors. But, facilities show roughly 7.8% declines ($t = -2.871^{***}$) in violation rates in the second year following regulatory inspections.[102] In the second column of Table A.12, I examine whether firms in the two years prior to bankruptcy respond differently to inspections. All of the interaction terms have very low statistical significance ($|t| < 0.9$) and in general the magnitude of the terms is small.[103] Thus, there is little evidence of a disparate response by firms near bankruptcy.

Given these findings, the framework from above can be modified as follows. A firm not near bankruptcy can be expected to have a base rate of violations of b in the present period and an additional b violations in the following period, for a total number of $2b$ violations. Suppose now that this firm anticipates an increase in one inspection per period, and that it indeed does receive an additional inspection. The anticipated inspection will decrease its violation rate in this period to $b(1+\alpha)$. Furthermore, the realization of the inspection in the present period will decrease the the violation rate in the following period by some amount $\delta < 0$, giving it a violation rate in the following period of $b(1+\delta)$. Total violations for this financially healthy firm over the two periods, and given the addi-

[102] In the third year following regulatory inspections, facilities show roughly 5% declines, though the effect is on the border of statistical insignificance ($t = -1.75^{*}$).

[103] Furthermore, the signs of all of the interaction effects are negative. If anything, this would indicate that firms near bankruptcy are slightly more responsive to inspections than other firms, but since the magnitude and statistical significance of the coefficients is small I do not directly seek to interpret the coefficients.

Table A.12
Marginal Impact of Inspections. This table examines the extent to which permit violations decline in the years following facility inspections conducted by environmental regulators.

	(1)	(2)
Pre-BR (3-4 yrs)	0.2030 *	0.2047 *
	(1.815)	(1.829)
Pre-BR (1-2 yrs)	0.4738 ***	0.4919 ***
	(3.371)	(3.450)
N Inspections, Lag 1 Year	0.0130	0.0147
	(0.533)	(0.581)
N Inspections, Lag 2 Years	-0.0778 ***	-0.0760 ***
	(-2.871)	(-2.666)
N Inspections, Lag 3 Years	-0.0485 *	-0.0472 *
	(-1.745)	(-1.685)
Pre-BR (1-2 yrs) x (N Inspections, Lag 1 Year)		-0.0226
		(-0.253)
Pre-BR (1-2 yrs) x (N Inspections, Lag 2 Years)		-0.1323
		(-0.831)
Pre-BR (1-2 yrs) x (N Inspections, Lag 3 Years)		-0.0319
		(-0.263)
Observations	162,543	162,543
Pseudo R^2	0.111	0.111
Facility FE	yes	yes
Quarter FE	yes	yes

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

tional inspection are thus: $b(1+\alpha)+b(1+\delta)=b(2+\alpha+\delta)$. For a financially precarious firm, total violations among the two periods, in the absence of increased inspections would be $2b(1+e)$ and in the presence of increased inspections would be: $(1+\alpha(1+\gamma))(1+e)b+(1+\delta)(1+e)b$.[104] Putting these terms together yields the following condition for an increase in enforcements to have a greater marginal impact on firms in financial distress than upon other firms:

$$(1+e)(-\delta-\alpha(1+\gamma))>\alpha-\delta \tag{A.6}$$

Based on the results from Table A.12, one could adopt a conservative estimate of $\delta=-0.07$.[105] It is difficult to directly observe α in this framework, that is, the elasticity of firms' violations to their expectation of inspection frequency, given that it is difficult to directly observe firms' expectations.[106] Nevertheless, a plausible estimate of α is 0.07, the same elasticity as for the second period.[107] If we continue to assume that $e=0.5$, then Equation A.6 suggests that an increase in inspections for firms near insolvency will be efficient whenever $\gamma>-0.66$. In other words, as long as there is less than a 66% reduction in the extent to which financially distressed firms respond to changes in the expected rate of inspections, then it will still be efficient for regulators to increase inspections for firms in financial distress.

A.3.2 Coefficients for Enforcement Controls

Table A.13 presents the coefficient estimates for the enforcement control variables that were omitted from Table 1 and Table 2 for conciseness.

[104] In theory, one could allow for an additional term to be multiplied by δ in order to allow firms near bankruptcy to have a separate elasticity with respect to violation increases in period 2. Based on the results in Table A.12, that suggest that firms near bankruptcy respond similarly to other firms to the actual incidence of inspections, I omit that dimension to these computations.

[105] The results in Table A.12 reflect an analysis of three years following an enforcement action, not just a single period in this simplified analysis. Over the course of those three years, the average coefficient from the first column in Table A.12 −0.038. A 3.8% reduction in violations over each of three subsequent years would thus be roughly equivalent to an 11.1% reduction in a single year. Thus, adopting $\delta=-0.07$, rather than $\delta=0.111$ represents a conservative estimate, but one that is roughly in line with the most statistically significant single coefficient in Table A.12 −0.038.

[106] For efforts to accomplish such estimates through surveys, see Earnhart and Glicksman (2011), and for efforts to estimate this econometrically, see Earnhart and Segerson (2012).

[107] The smaller α is, the easier the condition in Equation A.6 is to satisfy. Furthermore, there is good reason to believe that $\alpha<\delta$, that is, that firms respond more strongly to actual inspections than to expected inspections. Thus, assuming $\alpha=\delta$ makes it more difficult to satisfy the condition in Equation A.6. Accordingly, this assumption is conservative when estimating the conditions necessary for a marginal increase in inspections to have a greater marginal impact on firms near bankruptcy.

Table A.13
Caption: Pre- and Post-Bankruptcy Compliance Changes with Enforcement Controls. This table presents analyses that match those in Table 1 and Table 2. The difference is that for the models that include controls for enforcements, Table 1 and Table 2 omits presenting the coefficient estimates on the enforcement controls, whereas this table presents them. As with Table 1 and Table 2, the results here also omit firms that were subject to major fines or prosecutions by the EPA or DOJ.

	Effluent Violations	
	Pre-Bankruptcy	Post-Bankruptcy
Pre-BR (2 yrs)		
Post-BR (6 yrs)		-0.2717 ***
		(-3.250)
N Inspections, Lag 1 Year	0.0085	-0.0157
	(0.294)	(-0.606)
N Inspections, Lag 2 Years	-0.0760 **	-0.0753 ***
	(-2.569)	(-2.807)
N Inspections, Lag 3 Years	-0.0438	-0.0387
	(-1.486)	(-1.248)
N Formal Enforcements, Lag 1 Year	0.0631	-0.0513
	(0.535)	(-1.546)
N Formal Enforcements, Lag 2 Years	0.0390	-0.1021 **
	(0.586)	(-2.511)
N Formal Enforcements, Lag 3 Years	0.0493	0.0450
	(0.793)	(0.744)
N Informal Enforcements, Lag 1 Year	0.0442 ***	0.0512 ***
	(3.105)	(3.035)
N Informal Enforcements, Lag 2 Years	0.0197 **	0.0189 **
	(2.124)	(2.129)
N Informal Enforcements, Lag 3 Years	0.0165 **	0.0069
	(2.057)	(0.872)
Observations	158,167	154,614
N Bankruptcies	299	342
N Facilities in Bankruptcy	400	562
Pseudo R^2	0.110	0.116
Facility FE	yes	yes
Industry x Quarter FE	yes	yes
Remove Firms with Large Penalties or EPA/DOJ Prosecutions	yes	yes

Cluster robust t-statistics in parentheses, clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A.3.3 Enforcements as Lagging Measure of Regulatory Violations

In this section, I investigate the temporal relationship between different metrics of regulatory compliance. In particular, I investigate whether the primary outcome I analyze in this study, violations of effluent limits set by NPDES permits, is a leading or lagging indicator of other regulatory outcomes, including inspections, formal enforcement actions, and informal enforcement actions. If effluent limit violations are leading indicators of other metrics of regulatory violations, then it may indicate that they are particularly well suited to identifying a precise relationship between proximity to bankruptcy and environmental compliance.

To investigate this, I use data from all facilities with NPDES permits, not just those owned by firms that declare bankruptcy or those in the matched control group discussed in Section 4.2. I fit negative binomial panel models with facility and calendar quarter fixed effects. For predictors in these models, I use the count of total effluent limit violations that occur in each of the three years prior and subsequent to a given quarterly observation. Table A.14 presents the results of these analyses. The first column, which considers inspections, shows that facilities with effluent limit violations tend to experience more inspections in the one and two-years following those violations, with both effects being statistically significant. The second column considers formal enforcement actions. It shows much larger effect sizes, both with high statistical significance, linking effluent violations to more formal enforcement actions in the following two years.[108] The third column considers informal enforcement actions. It shows that these also occur at a significantly elevated rate in the year after a facility violates its numeric effluent limits.[109] Overall, these results suggest that effluent violations are a leading indicator of other enforcement outcomes. As such, effluent violations are particularly well suited to identifying the precise moment when facilities' environmental compliance begins to deteriorate, and how the timing of that

[108] The second column also shows a statistically significant negative coefficient for the first leading measure of effluent limit violations. This indicates that facilities are less likely to violate effluent limits in the year after they are subject to formal enforcement actions, which is an intuitive result.

[109] The third model does show a statistically significant negative coefficient estimate suggesting that two-years after a facility violates effluent limits, it experiences fewer informal enforcement actions. The size and statistical significance of this estimate are dwarfed though by those of the large positive coefficient for one year following effluent violations. Most likely, this negative coefficient reflects the fact that after a facility receives an informal enforcement action, it is less likely in the next year to receive such an enforcement action. The third model also shows a statistically significant positive coefficient for the first leading indicator of effluent limit violations. This likely reflects that fact that a goal of informal enforcement actions is often to improve facilities' reporting and compliance procedures. Thus, facilities report more violations in the year following informal enforcements designed to improve their reporting systems.

moment compares to when firms file for bankruptcy.

Table A.14
Enforcements as a Lagging Measure of Regulatory Violations. This table uses data from all facilities with NPDES permits, rather than just those that are owned by firms that declare bankruptcy or those in the matched control group. The results reflect negative binomial panel models with facility and time fixed effects. The first column uses the number of inspections a facility receives in a quarter as its outcome variable. For the second column, the outcome is the number of formal enforcement actions a facility receives in a given calendar quarter, and for the third column, the outcome is the number of informal enforcement actions.

	Inspections	Formal Enforcements	Informal Enforcements
log(1 + N Violations, Lag 1 Year)	0.0367 ***	0.4325 ***	0.4347 ***
	(6.655)	(21.092)	(44.975)
log(1 + N Violations, Lag 2 Years)	0.0153 ***	0.1167 ***	-0.0344 ***
	(2.782)	(7.412)	(-4.237)
log(1 + N Violations, Lag 3 Years)	0.0028	-0.0069	-0.0004
	(0.484)	(-0.368)	(-0.054)
log(1 + N Violations, Lead 1 Year)	0.0048	-0.0484 ***	0.0411 ***
	(0.752)	(-2.716)	(5.646)
log(1 + N Violations, Lead 2 Years)	-0.0115 *	-0.0083	-0.0002
	(-1.899)	(-0.483)	(-0.032)
log(1 + N Violations, Lead 3 Years)	0.0023	-0.0079	-0.0066
	(0.395)	(-0.489)	(-0.840)
Observations	3,259,467	3,259,467	3,259,467
Pseudo R^2	0.142	-0.014	0.174
Facility FE	yes	yes	yes
Quarter FE	yes	yes	yes

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A.3.4 Stacked Estimators for Staggered Treatments

One aspect of the analyses in this paper is that the different firms in my sample file for bankruptcy at different points in time. Although the models that I use are not precisely the same as difference in difference specifications,[110] they share many features with difference in differences specifications. As such, the fact that bankruptcies occur at staggered times, rather than all at once, raise issues similar to those for staggered differences in differences, as discussed for instance by Baker et al. (2022); Sant'Anna and Zhao (2020); Cengiz et al. (2019). As a robustness to the potential concerns with staggered difference in differences, I employ stacked estimators of the type described in Cengiz et al. (2019); Baker et al. (2022). In particular, for each company that declares bankruptcy in my sample, I create a separate

[110] See Section 5.1 for a full discussion of the ways my models vary from traditional difference in differences designs.

data set that contains just facilities owned by that company as well as the control facilities owned by firms that do not declare bankruptcy. I then combine these separate datasets created for each combine into a single "stacked" dataset, and then add dataset-specific facility and time fixed effects. Finally, I fit models using this stacked dataset. One challenge of this approach is that it produces a very large final dataset (roughly 20 million observations) that makes fitting the negative binomial model computationally difficult. For tractability purposes, therefore, I fit a simple linear model instead, using as the response variable the number of NPDES permit violations that occur in a given quarter. The predictors are the same as those in Tables 1 and 2.

[Note: on the to-do list is to expand the robustness tests using these stacked estimators to cover more of the models in Tables 1 and 2 and various other supplemental analyses].

Table A.15 presents the results of these analyses. The results closely parallel those for my main specifications in Tables 1 and 2. In particular, it shows statistically significant increases in the rates of violations pre-bankruptcy and then statistically significant drops, of roughly equal magnitude, post-bankruptcy. The effect sizes are also comparable. For instance, Table 1 reports a 50% increase in the rate of violations during the two years immediately preceding bankruptcies. For this same period, the first column of the top panel of Table A.15 reports a coefficient estimate of 0.25, indicating an average increase of 0.25 violations per quarter. Given a baseline violation rate of 0.50 to 0.60 violations per quarter, as depicted in Figure 1, an increase of 0.25 violations per quarter comes quite close to matching the 50% increase documented in Table 1.

A.4 Data Descriptions

Table A.16 presents the results of a series of negative binomial regressions that I use to assess the comparability of facilities owned by firms that declare bankruptcy and the "control" facilities, described in Section 4.2, that are owned by companies that do not declare bankruptcy. Since the goal of the matching is to identify facilities that are comparable before they enter financial distress, I use only observations for the "bankruptcy" group that are at least four years prior to the firms declaring bankruptcy. The regressions in Table A.16 consider the rate of NPDES permit violations (the most important outcome

Table A.15
Stacked Estimators. This table presents results of stacked estimators for the pre- and post-bankruptcy periods to address complications associated with the staggered occurrence of bankruptcies among the companies in my sample. Predictors are defined in the same way as those in Tables 1 and 2.

	Pre-BR	Post-BR
Panel 1: Effluent Violations		
Pre-BR (2 yrs)	0.2545 **	
	(1.983)	
Post-BR (6 yrs)		-0.1732 **
		(-2.379)
Observations	19,862,914	21,007,649
N Bankruptcies	291	372
N Facilities in Bankruptcy		
Adjusted R^2	0.366	0.368
Panel 2: "Serious" Violations (>2x limit)		
Pre-BR (2 yrs)	0.2225 **	
	(2.539)	
Post-BR (6 yrs)		-0.1093 *
		(-1.903)
Observations	19,862,914	21,007,649
N Bankruptcies	291	372
N Facilities in Bankruptcy		
Adjusted R^2	0.285	0.298
Facility FE	yes	yes
Quarter FE	yes	yes

Cluster robust t-statistics in parentheses, double clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

variable I study), as well as three measures of regulatory enforcement activity: formal enforcement actions, informal enforcement actions, and inspections. As the results show, the differences between the treatment and control groups are small, not statistically significant, and of varying sign, all suggesting no pattern of systematic differences between the groups.

Table A.16
Comparison of Bankrupt Companies versus Control Group. This table presents a series of negative binomial regressions that compare outcomes for facilities owned by firms that declare bankruptcy, with outcomes for facilities owned by firms that never declare bankruptcy. Because the goal is to evaluate the comparability of the "treatment" and "control" groups before any firms enter financial distress, I use only observations that are four years or more prior to when firms declare bankruptcy.

	(Effluent Violations)	(Formal Enforcements)	(Informal Enforcements)	(Inspections)
BR Company	0.0213	-0.1164	0.0377	0.0813
	(0.127)	(-0.549)	(0.177)	(0.448)
Observations	154,863	154,863	154,863	154,863
Pseudo R^2	0.004	-0.002	0.000	0.065
Quarter FE	yes	yes	yes	yes

Cluster robust t-statistics in parentheses, clustering on company and calendar quarter.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure A.2 plots the distribution of sizes of companies in my sample that declare bankruptcy. My goal in measuring a firm's size is to get a rough gauge of the scope of its operations in the period before it began approaching bankruptcy. On account of this, I define firm size as the max of the value of assets or liabilities at the time a firm files for bankruptcy. Using asset value alone could give an inaccurate measure of a firm's size because some firms may see their asset value shrink dramatically in the leadup to bankruptcy. At the same time, using liabilities alone may give an inaccurate measure because some firms that declare bankruptcy have contractual, tort, or other liabilities whose precise value is not known at the time of a firm's bankruptcy, and thus which are not included in a firm's accounting of its total liabilities. Currently, this data is based on information contained in firms' initial bankruptcy petitions. In these, firms list assets and liabilities in terms of ranges of values they fit into. I am currently in the process of gathering information from firms' Statements of Financial Affairs, which are usually filed somewhat later in the bankruptcy process, and which have more precise accountings of asset and liability values.

Figure A.3 depicts the distribution of years that the firms in my sample file for bankruptcy. As the

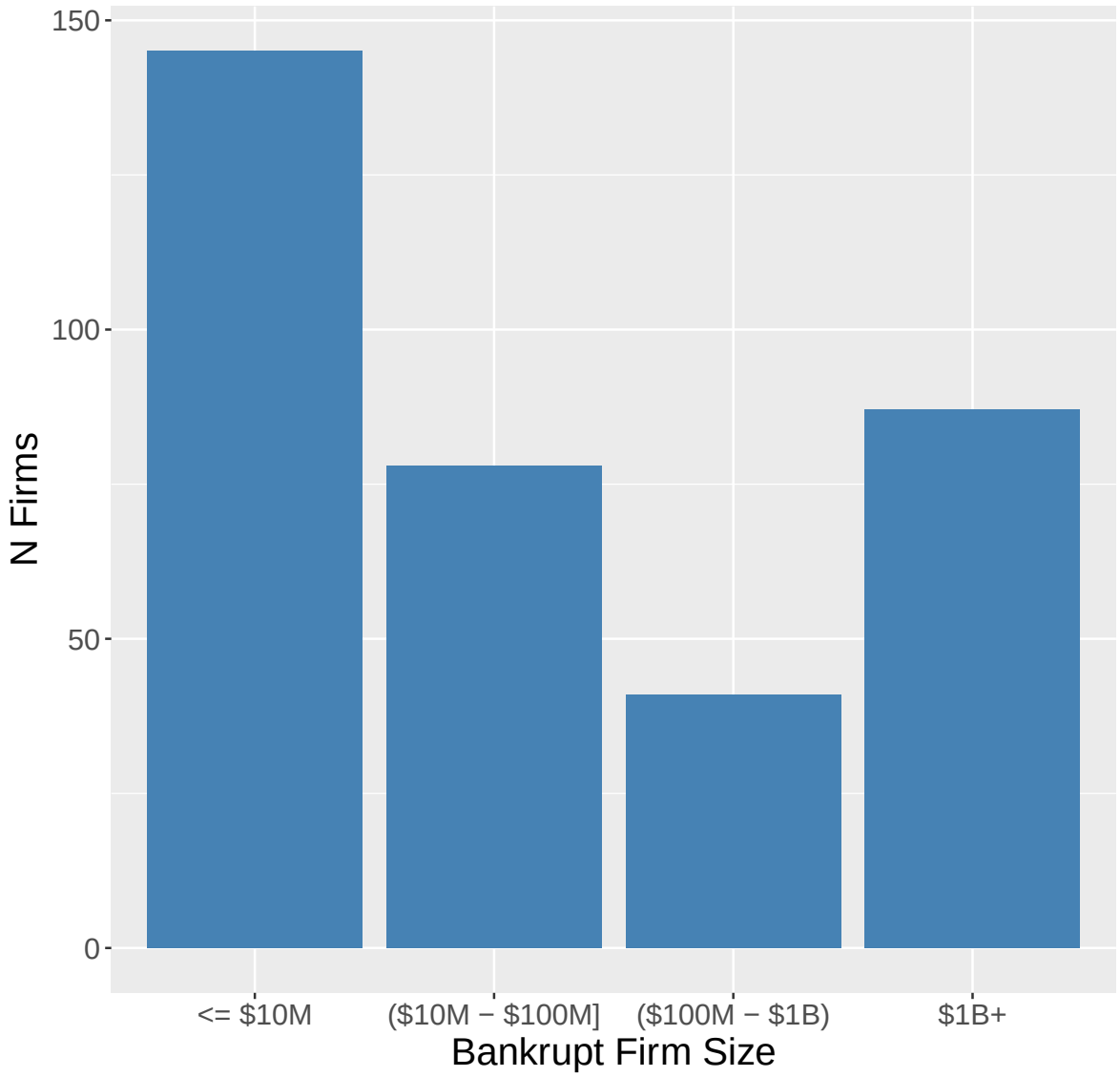


Figure A.2. Distribution of firms filing for bankruptcy by company size at time of filing.

plot shows, there are a very small number of filings in the 1990s, but the large majority of firms filed after 2000, with an even great concentration occurring post 2010. This is due to the scope of coverage of filings in the NGR bankruptcy database, which has more comprehensive coverage of bankruptcies from later periods of time.

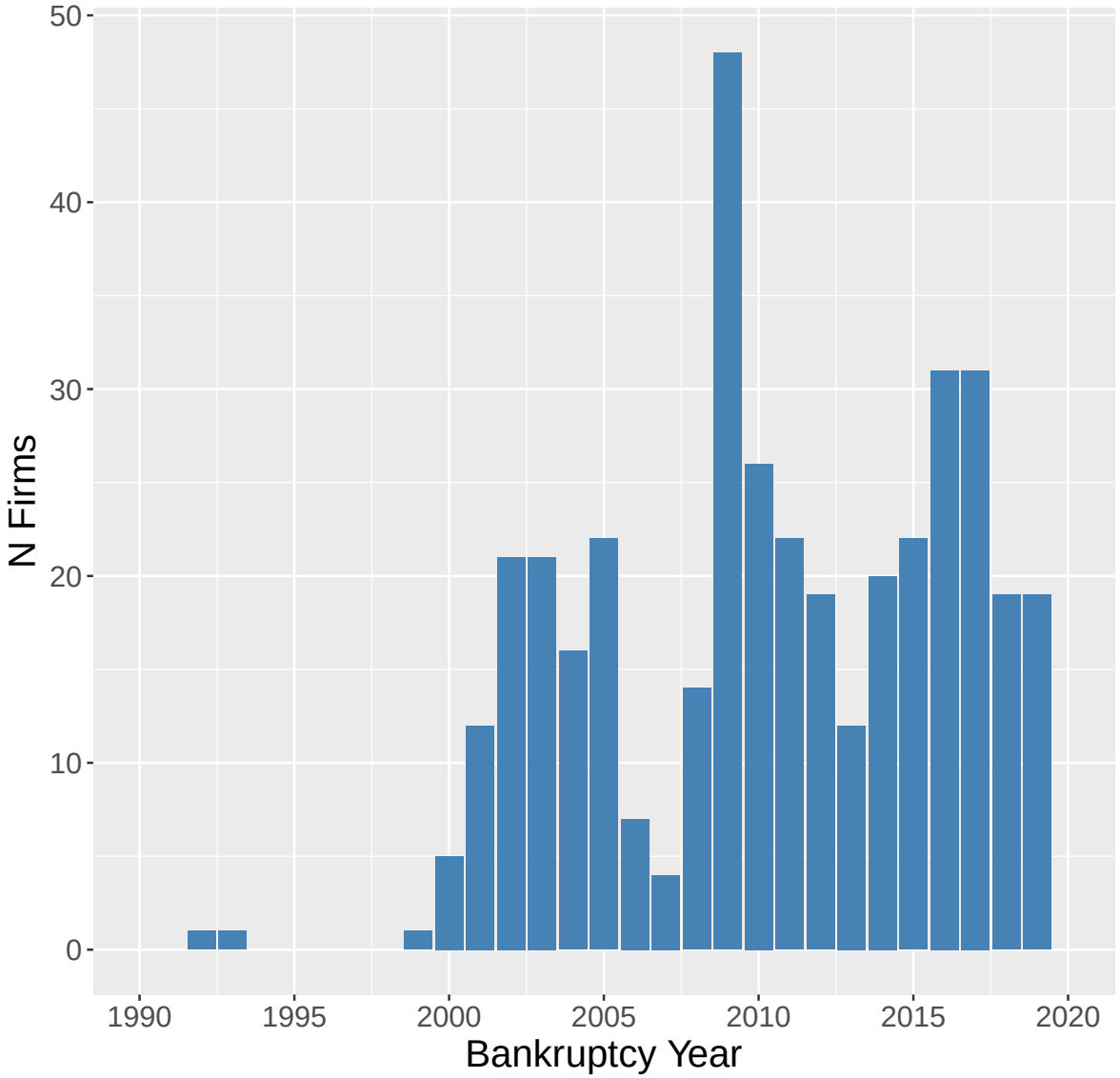


Figure A.3. Distribution of bankruptcy filings by year.

Figure A.4 depicts the distribution of facilities in my sample by industry and Figure A.5 plots the distribution of facilities by geography.

Figure A.6 plots the distributions of the "solvency ratio" and "cash ratio" whose construction I de-

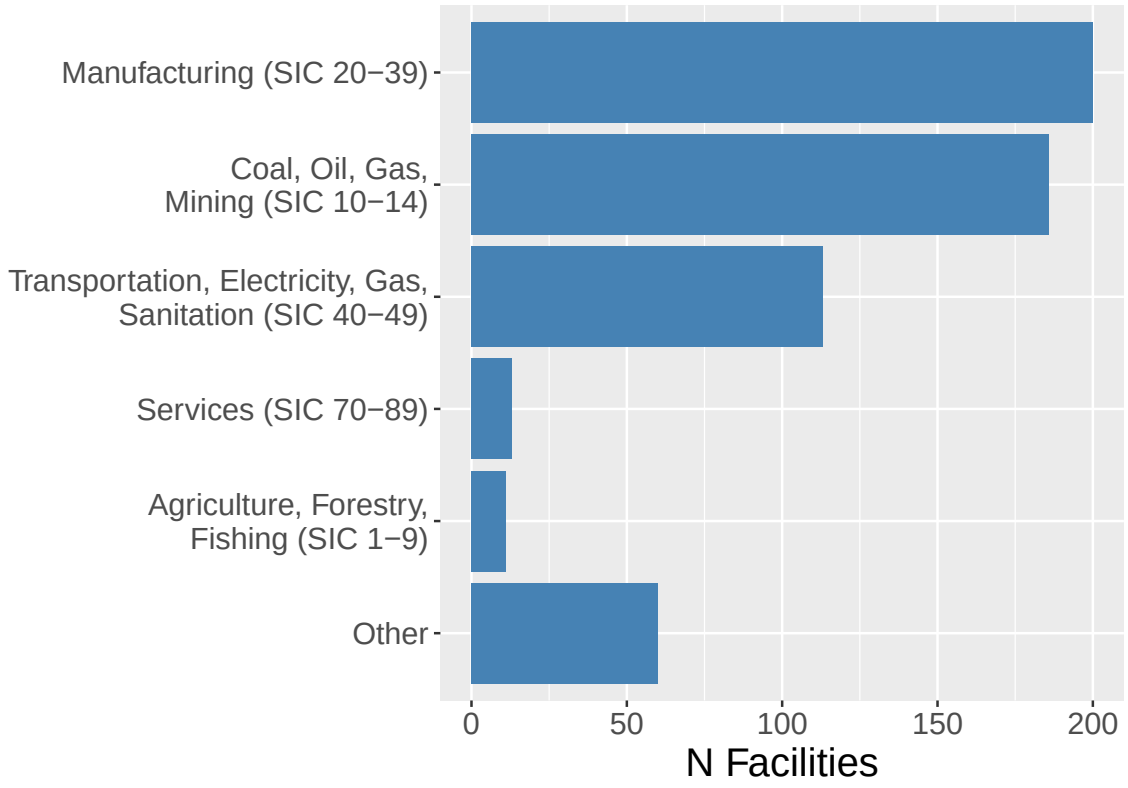


Figure A.4. Distribution of Facilities by Industry. This plot depicts the distribution of industries of facilities owned by firms in my sample that declare bankruptcy. Industry designations are based on SIC2 code, and the categories here are based on groupings of such codes. Some companies in my data own multiple facilities, so there are more facilities represented here than there are firms that declare bankruptcy in my data.

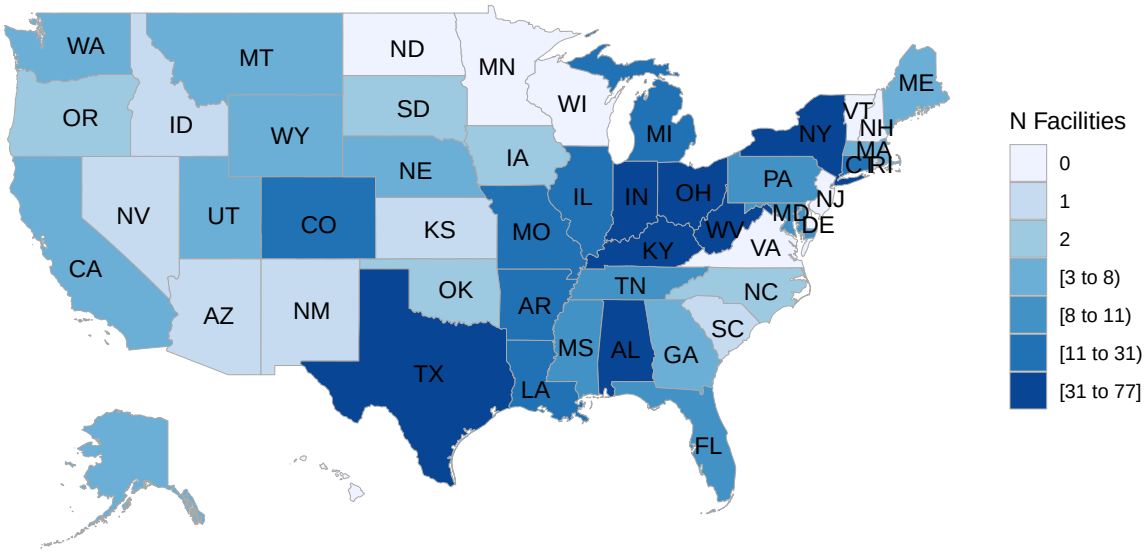
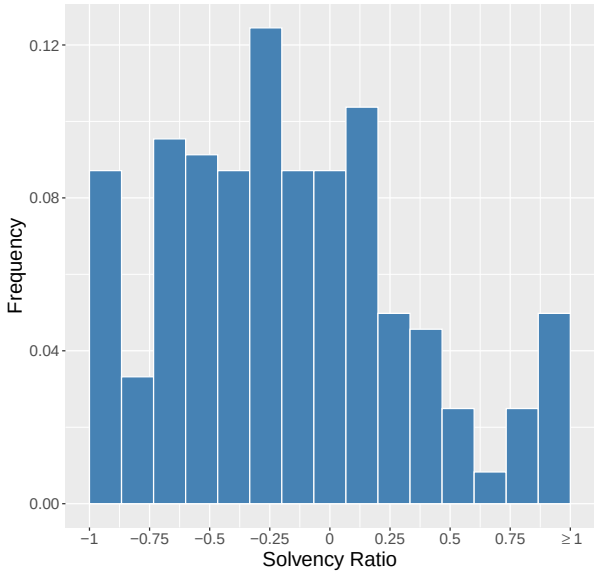
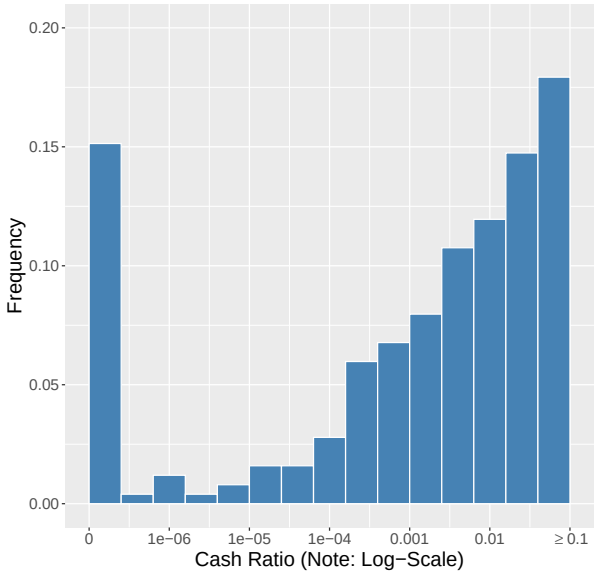


Figure A.5. Distribution of Facilities by Geography. This plot depicts the geographic distribution of facilities owned by firms in my data that declare bankruptcy.

scribe in Section 4.3.



(a) Solvency Ratio Distribution. This figure plots the distribution of the "solvency ratio" whose construction I describe in Section 4.3.



(b) Cash Ratio Distribution. This figure plots the distribution of the "cash ratio" whose construction I describe in Section 4.3.

Figure A.6. Solvency and Cash Ratio Distributions.

Finally, Figure A.7 presents some sample plots of violation patterns of individual facilities as the companies that own them approach and then enter bankruptcy proceedings. The purpose of the plot is to contextualize the results in Figure 1, which plots the average across all facilities in the data. Figure A.7 gives examples of specific facilities that typify the facility-wide average.[111] The plot labels each facility with the name of the company that owns it.

A.4.1 Matching Between NPDES and NGR Bankruptcy Data

I use a variety of techniques to identify matches between bankruptcy records in the New Generation Research (NGR) Bankruptcy Database and companies that are subject to NPDES permits. First, where possible, I match companies based on the Employer Identification Number (EIN), which is assigned to firms by the IRS primarily for tax purposes. The NGR data has relatively extensive coverage of the EIN field, covering roughly 240,000 bankruptcy filings, or just under half of the total database. For the facilities subject to NPDES permits, I obtain EIN numbers via the EPA's Facility Registry Service

[111] Needless to say, not every facility in my data follows such a pattern. Some facilities exhibit relatively little change in their violation rates during the period surrounding their bankruptcy filings, or other such patterns that are less congruent with the overall average results.

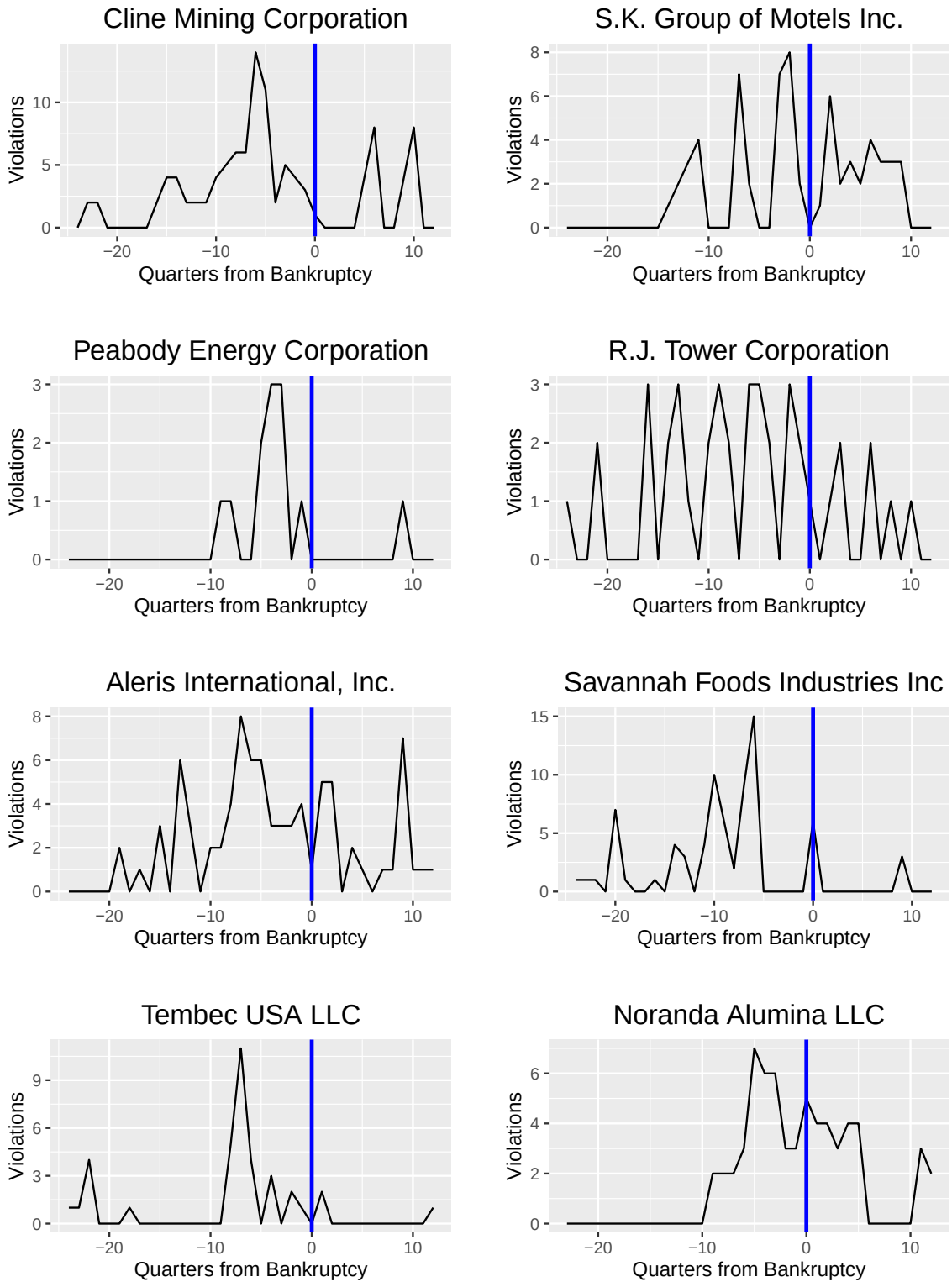


Figure A.7. Individual facility records of NPDES permit violations. This plot selects eight facilities that typify the pattern of violation rates shown in Figure 1, which depicts the average violation rates across all facilities as their parent corporations approach and then enter bankruptcy.

(FRS) database.[112] Unfortunately, FRS contains EIN numbers for only 1,980 facilities subject to NPDES permits, so the coverage of this field is somewhat limited.

Next, where possible, I look for exact matches between the bankruptcy data and the set of NPDES facilities based on address. The NPDES data generally lists the address of the regulated facility. For small and mid-sized firms, this is generally also the corporate headquarters (which is what will usually be listed on the bankruptcy petition). For larger firms, the corporate headquarters will often be separate from the regulated facilities, making this technique less useful. To account for differences in spelling and abbreviation of street names, towns, and so forth, I first geo-code addresses in the NPDES and NGR databases, using the service geocode.io. This delivers latitude-longitude coordinates for the addresses, and I look for exact matches based on these. After identifying an initial set of matches, I manually review each to ensure that the match is correct.[113]

To account for the fact that many firms will have corporate headquarters at separate addresses in locations other than where their NPDES regulated facilities are, I next use a combination of matching based on address and based on company name. For this, I take each firm in the bankruptcy database and identify the state in which its corporate headquarters resides. I then identify the set of NPDES regulated facilities in the same state. From among these, I use a fuzzy string matching algorithm to identify the closest name match among each dataset.[114] Finally, I manually review each identified match in order to check that it is accurate. An advantage of first matching firms based on state and then on name is that it can enable me to identify instances where the names of firms in the two databases are moderately different, but in which knowledge that there is a match between states, combined with manual review, enables me to confirm the match as correct. A disadvantage of this method is that it will not capture firms where the corporate headquarters is in a separate state from the regulated facilities. Thus, for a

[112] Available https://www.epa.gov/frs/epa-state-combined-csv-download-files

[113] In some instances, for example, this procedure can result in matching a bankruptcy filing to a company that owned a facility well in the past but then sold the facility to the firm that owned it at the time it filed for bankruptcy. In other instances, this procedure will result in an address-based match in which the name of the NPDES regulated company and the name of the bankrupt company are quite different. In these cases, I first consult the bankruptcy filings for the bankrupt company to obtain the list of firms within the bankrupt company's corporate family to identify if any of them match the name of the firm identified in the address match.

[114] For the algorithm, I begin by pre-processing the names, standardizing nomenclature such as switching "company" to "co", removing periods and extraneous spaces, and so forth. I then measure the Levenshtein distance between the names of firms in the bankruptcy database and those in the set of NPDES regulated firms. I express this distance as a faction of the string length of the processed name, with 0 indicating a perfect match. Because I manually review matches to check for accuracy, I do not use any set threshold of Levenshtein distance to define "acceptable" matches. Instead, I simply sort potential matches in ascending order of relative Levenshtein distance and stop reviewing after fifty or more instances of not identifying any matches that I deem accurate based on manual review.

final step in my matching, I identify the closest match between all names in the bankruptcy database and all names of NPDES regulated firms. I use the same algorithm described in footnote 114 and manually validate each match as described above. For all of my name matching efforts, I look for matches in the bankruptcy database using both the "Permit Name" field in the NPDES facility database, and the "Organization Name" field in the FRS database.