HEC MONTREAL

The Cost of Pollution: Investigating the Effect of Firms' Pollution on Financing Decisions

by

Ali Bolkhari Ghahi

Supervisor:

Dr. Jakub Hajda

Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Finance (M.Sc.)

November 2023

ABSTRACT

This thesis examines the impact of firm-level pollution on corporate financing decisions, focusing specifically on leverage and equity issuance. Regression analysis reveals a significant negative correlation between pollution and leverage, indicating that environmental concerns may constrain debt financing. Conversely, a similar analysis for equity issuance does not yield statistically significant results, suggesting a less pronounced association between pollution and this form of financing. The use of a natural experiment through the Difference in Difference method provides causal evidence of the impact on leverage due to firm-level pollution. My results indicate that an increase in total firm pollution by one standard deviation leads to a decrease in leverage by 0.02174, which equates to 7.5% of the average ratio in my sample. This effect is more pronounced when firms have higher operational costs or where there is increased community concern for environmental issues.

Keywords: Corporate Finance, Environmental Impact, Leverage, Equity Issuance, Financing Decisions.

RÉSUMÉ

Cette thèse examine l'impact de la pollution au niveau des entreprises sur les décisions de financement, en se concentrant spécifiquement sur l'effet de levier et l'émission d'actions. L'analyse de régression révèle une corrélation négative significative entre la pollution et l'effet de levier, indiquant que les préoccupations environnementales peuvent limiter le financement par la dette. Inversement, une analyse similaire pour l'émission d'actions ne donne pas de résultats statistiquement significatifs, suggérant une association moins prononcée entre la pollution et cette forme de financement. L'utilisation d'une expérience naturelle par la méthode de Différence des Différences fournit des preuves causales de l'impact sur l'effet de levier dû à la pollution au niveau de l'entreprise. Mes résultats indiquent qu'une augmentation de la pollution totale de l'entreprise d'un écart-type entraîne une diminution de l'effet de levier de 0,02174, ce qui équivaut à 7,5 % du ratio moyen dans mon échantillon. Cet effet est plus prononcé lorsque les entreprises ont des coûts opérationnels plus élevés ou lorsque la communauté est plus préoccupée par les questions environnementales.

Mots-clés : Finance d'entreprise, Impact environnemental, Endettement, Émission d'actions, Décisions de financement.

ACKNOWLEDGMENT

I would like to express my deepest gratitude to Dr. Jakub Hajda, my supervisor, for his invaluable guidance, patience, and expert advice throughout my research. His mentorship was pivotal in the completion of this thesis.

My heartfelt thanks go to my family—my parents and my sister—for their unwavering support and encouragement. Their love and sacrifices have been the cornerstone of my achievements.

I am grateful to HEC Montreal for providing me with an enriching educational environment and to the Ministry of Education and Higher Education for awarding me the Tuition Fee Exemptions Scholarship, which greatly assisted me in my studies.

Special appreciation is extended to Mr. Dalphond and Mr. Le Blanc for their generosity in awarding me the Le Blanc-Dalphond Scholarship. Their support has been instrumental in my academic journey.

I am indebted to my professors at HEC Montreal—Dr. Jakub Hajda, Amir Barnea, Vincent Gregoire—and all the faculty and staff members for their dedication and willingness to share their wisdom.

A sincere thank you to Mohamed Jabir at LACED for his assistance with the TRI Data, which was crucial for my research.

Finally, I am thankful to my friends—Ali, Amir, Hadiseh, Mahsa, Amin, Mohammad—and everyone who has lent their help along the way. Their camaraderie and support have been a source of strength and motivation.

Table of Contents

List of Tables

1- Introduction

This thesis investigates the influence of firm-level pollution on corporate financing decisions, with a particular focus on leverage and equity issuance. The central finding reveals a significant negative correlation between pollution levels and leverage, indicating a restraint on debt financing due to environmental concerns. Conversely, for equity issuance, the relationship is negative but not statistically significant, suggesting a milder effect of pollution. This study stands out by providing causal evidence through the application of a natural experiment framework, employing the Difference in Differences (DiD) method to elucidate the impact of pollution on leverage. However, it does not demonstrate a significant causal effect on equity issuance, highlighting the diverse ways environmental factors can shape different financing avenues.

The increasing impact of firm pollution is a critical concern, extending beyond environmental damage. It has profound implications for public health, regulatory frameworks, and corporate reputations worldwide. As awareness of corporate environmental responsibilities grows, businesses are compelled to manage their ecological footprint. This societal shift necessitates firms to balance economic growth with environmental stewardship.

The primary research question explores how firm pollution influences a company's propensity for leverage or equity issuance. A comprehensive literature review in Chapter 2 lays the foundation, examining existing theories and studies within corporate finance. This review informs two central hypotheses. The first hypothesis posits a negative relationship between pollution and leverage, suggesting that higher pollution levels may reduce borrowing capacity. The second hypothesis proposes a similar negative relationship with equity issuance, indicating that firm with higher pollution, issue less equity.

This study employs a robust dataset combining environmental and financial data. Pollution data is sourced from the Toxics Release Inventory (TRI) by the EPA, offering detailed insights into companies' environmental discharges. Financial variables, including leverage and equity issuance measures, are derived from Compustat. An algorithmic text-matching technique meticulously merges these datasets, accurately pairing environmental data with corresponding financial records.

The methodological approach of this study is rooted in panel data regression with fixed effects. This technique is critical for controlling unobserved heterogeneity, allowing for a clear isolation of the specific impact of firm-level pollution on financing decisions. To address potential endogeneity issues, such as reverse causality and omitted variable bias, the study employs a Difference in Differences (DiD) methodology. This advanced approach is instrumental in comparing the financing behaviors of firms before and after significant pollution events. Such a comparative analysis not only enhances the robustness of the findings but also crucially establishes causality. This analysis establishes a clear causal link, showing that higher levels of firm-level pollution are associated with a decreased propensity for debt financing, as reflected in lower leverage. Conversely, the connection between pollution and equity issuance is less definitive, with the findings indicating a minimal or non-determinant causal relationship in this aspect of corporate financing.

The findings have implications for policymakers, investors, and firms. By highlighting the financial cost of pollution, this research can inform policy decisions and investment strategies that take into account environmental performance. Additionally, it assists firms in improving their environmental and financial strategies, potentially benefiting their reputation and financial health in the long term.

The thesis is structured as follows: Chapter 2 presents a detailed literature review, discussing prior studies on firm pollution and its financial impacts, and introducing the main hypotheses Chapter 3 outlines the data sample used in this research, detailing the sources and methodology of data collection., Chapter 4 explains the analytical methods applied to the data, setting the stage for Chapter 5, where the results are presented and discussed. Finally, Chapter 6 concludes and summarizes the findings.

2- Literature Review and Theoretical Background

2-1 Financial dimensions of corporate pollution

In Chapter 2, I examine various research studies that explore the relationship between a company's pollution levels and its financial decisions, focusing mainly on leverage and equity issuance. From the literature, it is evident that pollution activities can significantly influence these financial choices. Based on my review, I draw two main hypotheses for my study. Firstly, I hypothesize that companies with more pollution tend to use less debt in their capital structure. Secondly, I anticipate that such companies might be less inclined to issue new shares. These hypotheses, developed from the literature, set the direction for my upcoming chapters.

In recent years, the issue of corporate pollution has gained attention, especially in light of growing concerns over climate change. The primary objective of this section of the thesis is to conduct a comprehensive literature review that covers research concerning corporate pollution and its financial implications. The first part of this section offers an overview of the historical context surrounding corporate pollution in finance. It aims to identify both general topics of interest as well as specific gaps in existing research. The subsequent parts focus more narrowly on the relationship between corporate pollution and two key financial variables: leverage and equity issuance. These parts are designed to build upon foundational financial theories and draw from prior studies to formulate hypotheses for further exploration.

The financial effects of corporate pollution have been a subject of academic study for several decades. It encompassing a broad array of topics including government regulatory impact, social responsibility and ESG investing, firm value and pollution, cost of capital, innovation and technology. Government regulations have a significant role in how companies approach pollution. Various laws and guidelines such as carbon taxes, have been implemented by government to limit the environmental impact of corporate activities. Xu et al. (2022) examine the impact of corporate-level environmental regulations on green finance in Chinese A-share polluting companies. They report a positive correlation primarily in eastern China, manufacturing, and non-state-owned enterprises. They also note the limitations of such regulations, including inefficacy in central and western China. Liu et al. (2018) investigate the impact of China's new Environmental Protection Law on the financing capacity of heavily polluting enterprises, finding a significant decrease. Some researchers focus on the cost of these regulations. Rayan (2012) demonstrated that the 1990 changes to the Clean Air Act increased the cost for new companies to enter the U.S. cement industry. However, subsequent research has shown that the regulatory environment doesn't just impose costs; it can also create opportunities. Some papers posit that certain flexible regulations can foster green innovation (Zhang et al., 2020).

In recent years, there has been a surge in what's known as ESG (Environmental, Social, and Governance) investing. This approach considers a company's environmental responsibility as a key criterion for investment decisions. Research suggests that companies with high pollution levels often find it challenging to attract investment from ESG-focused funds (Lie et al. 2021).

Some papers focus on the role of institutional investors in ESG investing. Raghunandan and Rajgopal (2022) examine U.S. ESG mutual funds and finds that they often invest in companies with poor records on labor and environmental compliance, despite higher average ESG scores. They also show that these ESG funds generally underperform financially and charge higher fees compared to other funds managed by the same institutions. Kim et al. (2019) investigate how local institutional investors influence companies to reduce toxic waste. The rise of socially responsible investing has added another layer to the financial implications of corporate pollution, as companies now have to consider potential limitations on their access to capital.

The relationship between a company's environmental practices and its market value has been an area of keen interest. Earlier research suggested that companies with better environmental records tend to have higher stock market values, suggesting that investors care about green practices (Cormier et al. 1993). Moreover, researchers find that companies see a drop in stock value right after pollution events (Wang et al., 2019). However, Di Giuli (2013) argues that this effect does not last in the long run. He finds that heavy pollution firms are not penalized by the market in long run. Xie et al. (2022) study how green innovation affects the value of companies that pollute heavily in China, finding that while it initially lowers a company's value, this effect is short-term. By adopting sustainable practices, companies not only improve their public image but can also attract investment from environmentally-conscious investors, thereby possibly increasing their market value. Jacobs et al. (2010) find that the market responds positively to environmental awards.

In recent years, shareholders have become increasingly vocal about corporate environmental practices, including pollution. Shareholder activism, where investors use their equity stake to influence company policy, has been shown to affect a company's environmental behavior positively. Studies indicate that activist campaigns often lead to significant changes, such as reductions in emission levels and improvements in sustainability reporting (Reid and Toffel, 2009). These actions not only contribute to environmental preservation but also may enhance the company's long-term financial performance and investor attractiveness.

Technological advancements have offered companies new avenues to mitigate their environmental impact. Investments in clean technology can lead to both environmental benefits and potential cost savings in the long run. Chen et al. (2022) indicate that innovative companies tend to pollute less. The effect varies by industry, location, and ownership, and is partly due to reduced energy consumption. Some studies show that firm pollution negatively affects corporate innovation by causing financial constraints (Tan and Yan, 2021). Firm pollution can cause government regulations and some of these regulations impact firms' innovation. Ling et al. (2020) examine China's Green Credit Guidance policy and find that it actually reduces technological innovation in pollution-intensive industries by limiting their long-term debt.

The discussion around corporate pollution takes on a unique perspective when focusing on emerging markets. Regulatory frameworks in these markets often lack the rigor found in developed economies, leading to different corporate behaviors concerning pollution. Firms operating in emerging markets are more likely to engage in environmentally harmful practices due to weaker regulation and oversight. However, studies indicates that capital markets in developing countries provide financial incentives for firms to control pollution (Dasgupta et al., 2001). The study suggests that weak regulatory enforcement could be supplemented by public disclosure mechanisms to inform capital markets. Earnhart et al. (2014) explore the varying drivers behind corporate environmental strategies in emerging economies, finding that foreign ownership and customer pressure are effective in improving practices, while government and civil society offer weaker incentives.

Various aspects of corporate pollution and its financial repercussions have been reviewed in this section. In the following sections, I will focus narrowly on the effect of firm pollution on firms' leverage and equity issuance. First, I will review the relevant research, and then, based on financial theories, I will develop the hypotheses and research questions.

2-2 Firm pollution and Capital Structure

Firms' leverage decisions has been the subject of extensive research and debate among experts. The study by Frank and Goyal (2009) has been pivotal in this effort as it was one of the first ones to analyze the determinants of capital structure in U.S. firms from 1950 to 2003 and highlighted important factors including industry median leverage, the market-to-book assets ratio, and profitability. Similarly, Rauh and Sufi's (2011) work emphasizes the importance of output measurement and the use of leased capital in explaining capital structure variation, underscoring the significance of a firm's production output and assets in determining its capital structure. Korteweg (2010) further contributes to this discourse by estimating the market's valuation of the net benefits to leverage, revealing that small and profitable firms often have high optimal leverage ratios, a finding that contrasts with some previous empirical evidence. These studies collectively enrich our understanding of leverage, offering nuanced perspectives that align with various theories, including the trade-off theory of capital structure. Recently, many researchers have focused on the relationship between environmental responsibility and capital structure. The primary objective of this section is to delve into existing research on leverage and environmental factors, particularly pollution, to establish a foundation for developing a hypothesis about the interplay between firm-level pollution and leverage decisions in corporate finance

One important aspect of research in this field examines the impact of pollution on a company's cost of capital. Higher pollution levels can lead to increased risk, which in turn can result in higher costs of debt. Chava (2014) found that companies with weak environmental records face higher costs for both equity and debt capital. Jung et al. (2018) suggest that lenders consider both historical carbon emissions and future carbon performance indicators when determining debt costs. Additionally, Fonseka et al. (2019) report that environmental information disclosure (EID) tends to lower the cost of debt for Chinese energy firms

Pollution levels of firms can significantly influence their access to capital and shape their financing decisions, especially as environmental considerations become central to lending criteria and investor preferences. Cheng et al. (2014) demonstrate that firms with higher corporate social responsibility (CSR) ratings experience fewer capital constraints, a benefit attributed to enhanced stakeholder engagement and increased transparency. Newton et al. (2022) report that firms facing higher ESG reputation risks tend to borrow more from markets than from banks, especially after experiencing negative ESG reputation shocks. Chang et al. (2021) show that firms with greater environmental liabilities typically have a lower debt-to-asset ratio. These firms also face reduced access to bank credit, suggesting that banks weigh environmental considerations more heavily than other lenders do. Ginglinger and Moreau (2023) state that firms with heightened forward-looking physical climate risks have reduced their leverage since 2015, following the Paris Agreement and the standardization of climate risk disclosure. Lastly, Lyu et al. (2022) find that firms tend to increase pollution emissions after issuing debt.

Theoretical Background:

Hypothesis 1: *Firms with higher levels of pollution will exhibit lower levels of leverage.*

The optimal capital structure of a firm has been a topic of significant debate, with Modigliani and Miller (1958) positing that, under ideal conditions, a firm's value is independent of its capital structure. While this theorem implies that the choice between debt and equity financing is irrelevant in a perfect market, real-world considerations like taxes and bankruptcy risks necessitate a deviation from this idealized perspective. The trade-off theory suggests a balance between the tax advantages of debt—such as the tax shield—and the rising costs associated with financial distress, proposing an optimal debt-to-equity ratio. Myers and Majluf's pecking order theory (1984) complements this by outlining a financing hierarchy where firms prefer internal financing and view equity issuance as a last resort due to the asymmetry of information. Additionally, Baker and Wurgler (2002) introduce the concept of market timing, arguing that firms capitalize on market conditions to optimize the cost of capital, issuing equity when its cost is low and repurchasing when it's high. These theories collectively inform the understanding of a firm's financing behavior in response to internal and external pressures. In the context of pollution, such pressures could manifest as increased financial distress costs due to potential legal liabilities, regulatory penalties, and reputational harm. Consequently, firms with higher pollution levels may find their optimal debt level reduced, opting for lower leverage to mitigate the risk of financial distress

Pollution can increase a firm’s financial distress costs in several ways:

1- **Legal liabilities**: A firm that pollutes heavily may face legal liabilities in the form of fines, penalties, and lawsuits. These legal costs can be substantial and can erode a firm’s profitability and cash flows, making it more difficult for the firm to service its debt obligation. As Chang et al. (2018) suggesting that environmental liabilities act as an alternative to financial liabilities.

2- **Regulatory Penalties:** In addition to legal liabilities, a firm that pollutes heavily may face regulatory penalties in the form of fines or orders to reduce emissions or clean up contaminated sites. These regulatory penalties can increase a firm’s operating costs, reduce its revenues, and damage its reputation, all of which can contribute to financial distress. Fullenbaum and Richards (2020) finds that recent and past regulations substantially elevate operating costs in US industries, with a 3.55% annual regulatory growth causing a 3.3% yearly increase in these costs.

3- **Reputational Damage:** Pollution can also damage a firm's reputation among customers, suppliers, employees, and investors. This reputational damage can reduce a firm's future cash flows by reducing demand for its products or services, increasing the cost of capital, and reducing access to financing. This argument is consistent with the Chang et al. (2021). They conclude that less environmentally responsible firms have a lower fraction of bank debt in total debt.

4- **Increased Operating Costs:** Pollution control measures can also increase a firm's operating costs, which can reduce profitability and cash flows, making it more difficult to service its debt obligations. Maloney and Yandle (1984) show that different methods of hydrocarbon pollution control lead to higher operational costs, but allowing firms more flexibility can reduce these costs.

These factors can increase a firm's financial distress costs, making it more difficult for the firm to meet its debt obligations and potentially leading to bankruptcy or other forms of financial distress. As a result, firms that pollute heavily may have a lower optimal debt level and a lower overall leverage ratio.

The pecking order theory, on the other hand, suggests that firms prefer to finance themselves with internal funds (such as retained earnings) and then with debt before resorting to equity. In this framework, the order in which firms issue securities is determined by their informational asymmetries and the associated costs of adverse selection. Pollution can increase the informational asymmetries faced by a firm by signaling lower quality or greater risk to investors, making it more difficult and expensive for the firm to raise debt or equity capital. As a result, firms that pollute heavily may have a higher preference for internal funds and lower levels of debt and equity financing, leading to a lower overall leverage ratio.

Market timing theory suggests that firms time their financing decisions based on market conditions. As mentioned in review section, many researchers report firm pollution can increase cost of debt (Chava, 2014 and Zerbib, 2019). Consequently, firm might reduce their debt issuance, especially during times when market is particularly sensitive to environmental issues.

Overall, the trade-off theory, the pecking order theory, and market timing theory suggest that pollution can have an impact on a firm's optimal capital structure by affecting the costs of financial distress, the informational asymmetries faced by the firm, and the preferences of investors and creditors for different types of financing.

2-3 Firm Pollution and Equity Issuance

As we explore the financial aspects shaped by environmental factors, equity issuance emerges as another significant area of interest. The literature on this topic offers insights into how firms' pollution profiles can impact their decisions and ability to issue equity. To fully understand this relationship, it's essential to review key studies and findings that illuminate the intersection between equity issuance strategies and environmental practices.

Firm pollution can elevate the cost of equity. Numerous studies suggest that firms with better CSR ratings often enjoy a lower equity capital cost (El Ghoul et al., 2011; Hong and Kacperczyk, 2009). Several studies highlight the correlation between CSR and return on equity. Cornett et al. (2016) find a positive link between CSR ratings and banks' return on equity. Dutordoir et al. (2018) observed a rise in stock prices for companies showcasing robust CSR initiatives during seasoned equity offerings from 2004 to 2014. Han et al. (2022) note that heightened air pollution is associated with diminished investor bid prices and larger SEO discounts for Chinese firms. Concerning equity issuance, Pijourlet (2013) states that high-CSR firms issue equity more frequently.

Hypothesis 2: *Firms with higher levels of pollution tend to issue less equity.*

Examining the relationship between a firm's environmental impact and its financial choices reveals some noteworthy correlations. One prominent observation is the linkage between a firm's pollution activities and its decisions related to equity issuance. The reasons for this negative correlation can be based on well-established financial theories:

1- **Cost of Capital**: Firms with higher pollution levels are seen as riskier due to potential environmental liabilities. Investors, recognizing these risks, expect a higher return for their capital. As a result, the cost of equity rises for these firms, making issuing new equity less appealing (El Ghoul et al., 2011; Hong and Kacperczyk, 2009).

2- **Information Asymmetry**: A firm's pollution levels might be interpreted as a reflection of its management's decision-making quality. If a company pollutes more, it might signal to investors that it isn't effectively managing or anticipating environmental risks. This perception gap can deter potential investors, leading to a drop in equity issuance. Jebjerg and Lando (1997) highlight how a firm's approach to pollution control, influenced by information asymmetry, can impact regulatory and investor responses.

3- **Market Sentiment & ESG Considerations**: Investors today are increasingly focusing on ESG (Environmental, Social, Governance) aspects when making decisions. Firms with high pollution levels might not align with this investment approach, leading to reduced demand for their equity. Park and Jang (2021) show that institutional investors prioritize environmental and governance aspects of ESG, significantly impacting their investment decisions.

4- **Regulatory and Legal Concerns:** Firms that pollute more are often more exposed to regulations and legal actions. The financial challenges posed by these potential issues can further discourage firms from issuing new equity.

Given these points, it is clear that a firm's pollution levels can influence its equity-related decisions, highlighting the observed negative correlation.

3- Data

The goal of this chapter is to provide a comprehensive overview of the datasets and summary statistics for the main variables. Understanding the data is crucial for interpreting subsequent findings and establishing the validity of the research. The chapter is divided into several sections. It starts with an examination of pollution data, followed by a review of financial data and firm characteristics. Subsequently, the data collection process is detailed, including how the two datasets were merged and prepared for analysis. Finally, descriptive statistics are presented to offer preliminary insights into the features of the dataset.

3-1 Firm Pollution Data

The Toxics Release Inventory (TRI) was established in 1986 as a part of the Emergency Planning and Community Right-to-Know Act (EPCRA) and administered by the US Environmental Protection Agency (EPA). The primary reason for creating this inventory was the chemical disaster in Bhopal, India, in 1984, where a Union Carbide plant released toxic gas, leading to thousands of deaths and even more injuries. This catastrophe ignited a renewed push for transparency in the reporting of toxic chemicals released into the environment.

The U.S. Congress passed the EPCRA, which, among other provisions, mandated the Environmental Protection Agency (EPA) to collect information on the release and transfer of particular toxic chemicals. The TRI program was developed to facilitate this requirement, focusing on providing public access to information regarding the amounts and types of toxic chemicals that facilities release annually into the air, water, and land.

Initially, the TRI covered around 300 chemicals and chemical categories and approximately 20,000 facilities in specific industries. Over the years, the scope expanded to include additional chemicals, sectors, and smaller facilities. Now it covers over 750 individually listed chemicals and chemical categories from various industries such as manufacturing, mining, electric power generation, and more.

Each year, facilities that meet TRI's reporting requirements must submit forms that detail the amounts of each TRI-listed chemical released, treated, or managed. These forms go through a stringent verification process, including cross-referencing with other environmental databases and on-site audits, to ensure data integrity.

The TRI data is publicly accessible and can be accessed through EPA’s website. The EPA employs quality checks to ensure that the data collection process is accurate and reliable. This includes checks for outliers, inconsistencies and other anomalies that might indicate reporting errors. Facilities that fail to report correctly or on time are subject to penalties, further ensuring the data’s quality.

TRI data has become an invaluable resource for a wide array of stockholders, Environmentalists, researchers and policymakers frequently use the data to identify pollution hotspots, assess the effectiveness of regulations, and inform community planning. Data from TRI have been extensively utilized in academic research, Li et al. (2022), Lyu et al. (2022), and Chang et al. (2021).

The TRI provides distinct data on two fronts: the volume of chemicals dispersed within a specific location (on-site) and the amount sent to other places for either further dispersal or waste management (off-site). Additionally, the TRI compiles an annual sum of toxic substances emitted by companies. In this context, "on-site release" refers to the discharge of chemicals within the premises of the reporting firm, often into the air, water, or land. "Off-site release," on the other hand, pertains to the transfer of these chemicals to external locations where they may be released, disposed of, or subjected to further waste management procedures.

The volume of on-site toxic releases serves as a reasonable indicator of a firm's pollution levels. However, it's important to note that chemicals transferred off-site can also negatively impact the environment. As an additional metric for gauging pollution, I consider the total firm releases, which combines both on-site and off-site emissions. In the subsequent chapter, I elaborate on how I define the firm's pollution proxy using TRI data.

3-2 Financial Data and Firm Characteristics

To study the impact of firm pollution on capital structure and equity issuance, I collect financial data and firm characteristics from Compustat. Established in 1962, Compustat is a database that provides the most comprehensive collection of financial and statistical data for publicly traded companies in the United States. The database offers a wide range of financial metrics, including income statements, balance sheets, statement of cash flows, and supplemental data items.

Compustat is currently owned by S&P Global, which assures data reliability and quality. The data undergoes rigorous verification processes, including cross-referencing with SEC filings such as 10-K and 10-Q reports. This ensures the accuracy and credibility of the information provided. Compustat is a subscription-based service and is commonly accessed via platforms like WRDS (Wharton Research Data Services) for academic research.

Compustat data is extensively used in financial modeling, investment decision-making, academic research, and market analysis. It is often used with other databases like CRSP for stock performance analysis, and it is a cornerstone for empirical research in finance.

I gathered data from companies that appear in both the Compustat records and have at least one location contributing toxic waste information to the TRI system over the span of 1988 to 2020. The financial metrics are derived from Compustat's annual industrial datasets.

Data from the TRI has been available since 1987. I start my dataset in 1988 to apply a one-year lag to the firm's pollution variables, as well as other control variables, in my regression analysis. This ensures that the data is available for the financial decision-making process within firms. In line with existing research, I exclude companies in the financial sector (SIC codes 6000–6900) due to the distinctive characteristics of their capital structures.

There is no shared identifier for companies between the TRI and Compustat datasets. To bridge this gap, I employ text-matching algorithms, specifically FuzzyWuzzy and RapidFuzz, to associate the parent company names listed in TRI with those in Compustat, thereby obtaining GVKEYs for the parent organizations of facilities that release toxins. This approach was similarly employed by Lyu et al. (2022). After executing the text-matching algorithms, I manually review each set of matched companies to validate the accuracy of the linkage. I identified 1,274 unique firms and 18,497 firm-year observations spanning from 1988 to 2020.

3-3 Summary Statistics of Sample

Table 1 presents the summary statistics for all variables concerning the firms in my dataset. To mitigate the effects of outliers, I winsorize variables at the 1% and 99% levels. Definitions for all variables will be provided in the subsequent chapter

On average, each company in the study releases 1.785 million pounds of toxic substances annually, with 1.51 million pounds of that being released on-site. Compared to Lyu et al. (2022)'s paper, where an average firm releases 1.211 million pounds of toxic substances annually with 0.976 million pounds on-site, my analysis reveals a higher on-site release. Additionally, the distribution of toxic substance releases in my study is highly skewed, suggesting that a small number of firms may contribute disproportionately to the total emissions When adjusted for sales and subjected to logarithmic transformations, my primary pollution variables for companies (labeled as Total Firm Pollution) exhibits an average value of 0.07 and a standard deviation of 1.51. For pollution specifically occurring on-site, the average remains the same, but the standard deviation is slightly lower at 1.49. In terms of financial metrics, the sample shows an average leverage ratio of 0.29 with a standard deviation of 0.23. The mean net equity issuance for the companies in the sample stands at 78.86. The merged sample shows a modest deviation from the full Compustat universe, with firms generally being larger and slightly more leveraged, and possessing a marginally higher tangibility ratio. This suggests a subtle but noticeable skew in the sample towards firms with more physical assets and slightly more debt relative to their equity. These differences, while notable, do not necessarily indicate a significant bias in the sample

Table 1. Summary Statistics

This table offers a summary of important variables employed in the regression analyses, covering the years 1988 to 2020. Companies in the financial sector, identified by SIC codes ranging from 6000 to 6999, are not included in the analysis. Data from the EPA's Toxic Release Inventory (TRI) is combined with Compustat's annual financial data for firms through a text-based matching of facility and company names. The variables have been winsorized at the 1% and 99% levels. For a comprehensive explanation of each variable, please refer to Chapter 4.

Variable	Mean	Median	Std.	Min	Max
Total Firm Pollution	0.07	0.01	1.51	0.00	96.95
On-Site Firm Pollution	0.07	0.01	1.49	0.00	96.93
Leverage	0.29	0.24	0.23	0.00	3.06
Book Leverage	0.29	0.27	0.20	0.00	2.82
Profitability	0.14	0.13	0.08	-0.08	0.95
Firm Size	7.2	7.17	1.95	2.53	13.68
M/B Ratio	1.3	1.04	0.90	0.35	19.39
Tangibility	0.33	0.30	0.19	0.05	0.98
R&D Expenses	0.03	0.02	0.04	0.00	1.04
Z-score	0.03	0.02	0.04	-0.06	1.90
Equity Issues (Net)	78.86	1.49	1459.57	-2042.00	74620.00
Dividend	171.66	7.28	692.66	0.00	14652.00
Income Available to Common and Preferred	386.49	33.58	2262.43	-1739.32	102580.00
Investment in Net Working Assets	22.62	3.84	382.20	-1105.00	15131.00
Investment in Net Fixed Assets	183.14	6.90	1298.49	-1113.74	60432.00

4- Methodology

4-1 Panel Data Regression with Fixed Effects

Panel data allows for the analysis of multiple firms over multiple time periods, offering both cross-sectional and time-series dimensions. This data structure is ideal for capturing the inherent complexities in examining the relationship between firm pollution and financing decisions, as it allows for the control of unobserved heterogeneity.

The use of an Ordinary Least Squares (OLS) regression model with fixed effects is tailored to exploit the panel nature of the data. Fixed effects models control for the time-invariant unobserved characteristics that are unique to each firm but constant over time. This technique reduces the risk of omitted variable bias and enhances the credibility of our estimated coefficients.

Year fixed effects are included in the model to account for time-specific shocks or characteristics affecting all firms uniformly in a given year, such as macroeconomic conditions or regulatory changes. By controlling for these, I isolate the impact of firm pollution on financing decisions from year-specific noise. Firm fixed effects account for unobservable, time-invariant characteristics unique to each firm, such as corporate culture or long-term strategic goals. By including firm fixed effects, I control for these latent variables, ensuring a more accurate estimate of the relationship between firm pollution and financing decisions.

The final regression model for leverage and equity issuance equations are as follows:

For leverage:

$$leverage_{i,t} = \alpha + \beta \ firm\,pollution_{i,t-1} + \gamma \ X_{i,t-1} + \delta \ firm_{i,t} + \theta \ year_i + \varepsilon_{i.t} \quad (eq. 1)$$

For equity issuance:

$$Equity\ issuance_{i,t} = \alpha + \beta \ firm\,pollution_{i,t-1} + \gamma \ X_{i,t-1} + \delta \ firm_{i,t} + \theta \ year_i + \varepsilon_{i.t} \quad (eq. 2)$$

Where:

α is the intercept.

β is the coefficient for the lagged firm pollution

γ is the coefficient vector for the lagged control variables (X) for each equation.

δ captures the firm-specific fixed effect

θ captures the year-specific fixed effect.

ε is the error term

In this study, the key explanatory variable is 'Firm Pollution,' and it, along with other control variables denoted by X, is lagged by one period in the equations. Specifically, these variables are lagged to better capture their effect on the financing decisions of the firm, as reflected through the dependent variables 'Leverage' in Equation 1 and 'Equity Issuance' in Equation 2. This lagged approach acknowledges the temporal dynamics in the decision-making process, allowing for the possibility that changes in pollution levels or other control factors may take time to influence financing outcomes.

The fixed effects for the firm and the year are captured by δ and θ, respectively. This inclusion allows the model to account for both time-invariant firm-specific factors and year-specific macroeconomic conditions or regulations that might otherwise confound the relationships being studied.

By constructing the equations this way, we can better understand the nuanced relationships between firm pollution and financing decisions, while controlling for firm and year-specific influences and other factors.

In the following sections, I will define the 'Firm Pollution' variable, followed by a detailed description of each control variable used in the two equations

4-2 Defining Firm Pollution

I follow Lyu et al. (2022) to construct firm pollution variable based on TRI dataset. The TRI gives us two sets of numbers every year: one for toxic chemicals released right at the company's own facility (on-site) and another for chemicals sent somewhere else to be managed or disposed of (off-site). It also adds up these figures to give us a total release number for each company for the year.

"On-site" toxic releases refer to the disposal or other releases of toxic chemicals at the same facility where they were generated. These releases can take various forms, such as emissions to the air, discharges to water bodies, or placement in some type of land disposal on the property of the facility itself.

"Total" toxic releases include not only the on-site releases but also off-site releases, which consist of transferring the waste to a different location for treatment, energy recovery, or disposal. This could be another facility entirely where the waste might be treated or stored.

By considering both "on-site" and "total" toxic releases, we can get a more nuanced picture of a firm's environmental impact. "On-site" releases give us an idea of the immediate environmental effect a facility has on its local surroundings. "Total" releases, on the other hand, provide a broader perspective, capturing the full extent of a facility's impact, including any transferred or off-site managed waste.

Including both types of measures in the study can therefore provide a more comprehensive understanding of a firm's pollution practices and their potential financial implications.

Total Firm Pollution is calculated as the natural logarithm of one plus the total toxic releases, all divided by the firm's sales (equation 3).

$$Total\ firm\ pollution = \frac{log(\ 1 + Total\ toxic\ release)}{Sales} \quad (eq. 3)$$

$$On - site\ firm\ pollution = \frac{log(\ 1 + On - site\ toxic\ release)}{Sales} \quad (eq. 4)$$

I divided the terms in both equations by sales to control for production levels. This approach allows for a fair comparison of pollution levels across firms of different sizes and industries, as recommended by Chang et al. (2021).

4-3 Leverage Equation

In this section, I will provide definitions for both the dependent and independent variables used in the leverage equation, which is Equation 3. I will also list and define the control variables specific to this equation.

The dependent variable in this equation is either Leverage or Book Leverage, both of which are defined according to the framework established by Frank and Goyal (2009). All the definition can be found in Appendix A.

The independent variable is either Total Firm Pollution or On-site Firm Pollution, both of which have been defined earlier in this chapter.

My control variables are constructed based on previous studies, specifically those by Frank and Goyal (2009) and Chang et al. (2021).

The control variables included in the regression are as follows:

- Profitability: to capture profitability
- Size: To control for firm size
- M/B Ratio: To control for growth opportunities, I use Market-to-Book Ratio.
- Tangibility: To control for assets tangibility
- R&D expense: To control for information asymmetry
- Dividend Indicator: To account for the financial limitations and risks encountered by firms Chang et al. (2021). The Dividend Indicator is set to 1 if the firm has paid dividends, and 0 otherwise. I use DVPSP (Compustat Item 201) to define Dividend Indicator.
- Z Score: To control for risk, I include Altman's (1968) unleveraged Z-score according to Chang et al. (2021)

All the definitions can be found in Appendix A.

4-4 Equity Issuance Equation

In this section, I will explain the dependent and independent variables in the equity issuance equation, which is Equation 4. I will also list and explain the control variables that apply to this equation.

For defining equity issuance, I use the method that has been employed by Gatchev et al. (2009). According to them, equity issuance is defined as follows, with numbers in parentheses corresponding to their respective Compustat item numbers.

$$Share\ Repurchases = \ Purchase\ of\ Common\ and\ Preferred\ Stock\ (115)$$

$$Equity\ Issues\ (Net) \\ = the\ change\ from\ year\ t-1\ to\ t\ of\ Stockholder's\ equity\ (216\ ) \\ - Retained\ earnings\ (36)$$

$$Equity\ Issues = Equity\ Issues\ (Net) + \ Share\ Repurchases$$

The independent variable is either Total Firm Pollution or On-site Firm Pollution, both of which have been defined earlier in this chapter.

I follow the approach of Gatchev et al. (2009) to construct my control variables. Some of these control variables, such as profitability, firm size, M/B ratio, and tangibility, have already been defined in the leverage equation. Leverage is also another control variable for this equation. Dividend, Income available to common and preferred, Investment in net working assets, and Investment in net fix assets are other crucial factors which should be considered. (Gatchev et al., 2009). All the definition can be found in the Appendix A.

5- Results

5-1 Baseline Regression Results for Leverage

Table 2 displays the initial results from the application of equation (1). In Table 2, the first column examines leverage as the outcome of interest, while the second column looks at book leverage. The data shows a negative and highly statistically significant link between a company's pollution and its leverage, evidenced by a 1% significance level and a t-statistic of -2.855. This suggests that increased pollution by a company correlates with a lower leverage ratio. The impact is not just statistically significant but also of notable magnitude. An increase in Total Firm Pollution by one standard deviation (1.51) is associated with a decrease in leverage by 0.02174 (calculated as -0.0144×1.51), which represents 7.5% of the average leverage ratio, standing at 0.29. The additional variables considered in Table 2 align with the findings of previous research (Frank and Goyal, 2009; Chang et al., 2021), such as Profitability, Firm Size, Market-to-book ratio, Asset Tangibility, Research & Development spending, Dividend Payout Indicator, and the Z-Score, all maintaining the expected signs. For instance, with Firm Size, a one standard deviation rise (1.95) corresponds to an increase in leverage by 0.0267 (calculated as 0.0137×1.95). Firm Size, frequently emphasized as a key factor on leverage in many studies (e.g., Frank and Goyal, 2009), exhibits an effect on leverage comparable in magnitude to that of Firm Pollution.

In the second column of Table 2, the analysis uses book leverage as the dependent variable. Here, while the total firm pollution does not show statistical significance, it still exhibits a negative correlation with book leverage. This indicates that even though firm pollution levels do not significantly impact the book leverage in a statistical sense, there is an association where higher pollution is associated with lower book leverage values.

The robustness checks confirm the persistence of the findings when modifying the pollution variable. Specifically, when substituting Total Firm Pollution with the logarithmic transformation of On-Site Firm Pollution, the outcomes remain largely unchanged. Table 3 provides the results of this adjusted model. The coefficient of On-Site Firm Pollution retains its negative sign and remains significant at the 1% level when assessing its effect on leverage. This indicates that an increase by one standard deviation in On-Site Firm Pollution in associated with a reduction in leverage of 0.02056.

The findings in Tables 2 and 3 support the initial hypothesis that there is a negative effect of firm pollution on leverage. The main findings may be affected by omitted variable bias and reverse causality, where unaccounted factors might influence the observed relationships, and financing decisions could be impacting firm pollution levels. The issue of endogeneity will be discussed in a later section of this chapter.

Table 2. Total Firm Pollution and Leverage

The table displays the findings of an OLS regression analysis, evaluating how a company's pollution levels impact its leverage and book leverage. The analysis primarily focuses on leverage, using book leverage as an alternate measure. The key independent variable is total firm pollution, represented as the log of one plus the total toxic releases from the preceding year. The analysis considers several controls at the firm level, including profitability, firm size, M/B ratio, tangibility, R&D expenses, dividend indicator, and the unleveraged z-score. Additionally, fixed effects for both the firm and year are factored in. Parenthesized figures indicate t-statistics derived from standard errors adjusted for heteroskedasticity. ∗∗∗, ∗∗, and ∗ represent statistical significance at 1%, 5%, and 10% respectively, based on a two-tailed test. For a comprehensive explanation of each variable, please refer to Appendix A.

Variables	(1) Leverage		(2) Book Leverage
Intercept	0.3423***	0.0884***	0.1382***
	(33.674)	(3.404)	(6.166)
Total Firm Pollution	-0.0144***	-0.0147***	-0.0032
	(-2.855)	(-3.439)	(-0.87)
Profitability	-0.3714***	-0.3805***	-0.1536***
	(-10.071)	(-11.441)	(-5.348)
Firm Size	0.0137***	0.0335***	0.0183***
	(11.887)	(10.477)	(6.61)
M/B Ratio	-0.0574***	-0.0288***	-0.0053***
	(-21.948)	(-12.027)	(-2.583)
Tangibility	0.1302***	0.1226***	0.0978***
	(9.814)	(5.275)	(4.874)
R&D Expenses	-0.8691***	-0.1631*	-0.1363
	(-14.148)	(-1.687)	(-1.634)
Dividend Indicator	-0.0744***	-01631**	-0.0056
	(-15.576)	(-2.425)	(-1.133)
Z-Score	-0.6506***	-0.2832***	-0.2163***
	(-9.146)	(-5.12)	(-4.528)
Firm FE	Yes	No	Yes
Year FE	Yes	No	Yes
Observations	7880	7880	7880
R- Squared	0.26	0.11	0.12

∗ 10% significance, ∗∗ 5% significance, ∗∗∗ 1% significance

Table 3. On-Site Firm Pollution and Leverage

The table displays the findings of an OLS regression analysis, evaluating how a company's pollution levels impact its leverage and book leverage. The analysis primarily focuses on leverage, using book leverage as an alternate measure. The key independent variable is on-site firm pollution, represented as the log of one plus the on-site toxic releases from the preceding year. The analysis considers several controls at the firm level, including profitability, firm size, M/B ratio, tangibility, R&D expenses, dividend indicator, and the unleveraged z-score. Additionally, fixed effects for both the firm and year are factored in. Parenthesized figures indicate t-statistics derived from standard errors adjusted for heteroskedasticity. ∗∗∗, ∗∗, and ∗ represent statistical significance at 1%, 5%, and 10% respectively, based on a two-tailed test. For a comprehensive explanation of each variable, please refer to Appendix A.

Variables	(1) Leverage	(2) Book Leverage
Intercept	0.3418***	0.1377***
	(33.669)	(6.1452)
On-Site Firm Pollution	-0.0138***	-0.0028
	(-2.705)	(-0.7441)
Profitability	-0.3695***	-0.1532***
	(-10.034)	(-5.334)
Firm Size	0.0138***	0.0183***
	(11.945)	(6.629)
M/B Ratio	-0.0575***	-0.0054***
	(-22.014)	(-2.594)
Tangibility	0.1300***	0.0979***
	(9.793)	(4.874)
R&D Expenses	-0.8688***	-0.1351
	(-14.140)	(-1.619)
Dividend Indicator	-0.0744***	-0.0056
	(-15.577)	(-1.139)
Z-Score	-0.6511***	-0.2163***
	(-9.152)	(-4.528)
Firm FE	Yes	Yes
Year FE	Yes	Yes
Observations	7880	7880
R- Squared	0.26	0.10

∗ 10% significance, ∗∗ 5% significance, ∗∗∗ 1% significance

5-2 Baseline Regression Results for Equity Issuance

Table 4 presents the results for Equation (2), where equity issues are defined based on Equation (16). The results indicate a negative relationship between Total Firm Pollution and Equity Issuance, which, however, is not statistically significant (t-statistic of -0.405). This finding aligns with the work of Lyu et al. (2022), who also reported a lack of statistical significance concerning equity issuance. The coefficient is not economically significant either; an increase of one standard deviation in total firm pollution leads to a decrease in equity issuance by 0.00529. In conclusion, there is insufficient evidence to support the second hypothesis, which posits a relationship between equity issuance and firm pollution.

The additional control variables presented in Table 4 correspond with the outcomes found in previous studies, such as those by Gatchev and colleagues in 2008. Investments in net working assets and net fixed assets, along with income available to both common and preferred stakeholders, are statistically significant, and their respective signs are consistent with the results reported by Gatchev et al. They also found that companies typically finance dividends mainly through equity issuance. As such, dividends are considered a key factor influencing equity issues. This is mirrored in my regression analysis, where dividends display comparable economic and statistical significance.

Table 5 displays the results using on-site firm pollution as the key independent variable. These results also indicate a lack of statistical significance in the relationship between firm pollution and equity issuance, though the direction of the relationship remains negative. The other variables demonstrate results consistent with those in Table 4.

Overall, while the results in Tables 4 and 5 suggest a negative relationship between firm pollution and equity issuance, in line with my second hypothesis, they do not provide sufficient evidence to confirm it.

Table 4. Total Firm Pollution and Equity Issuance

The table displays the findings of an OLS regression analysis, evaluating how a company's pollution levels impact its equity issuance. The key independent variable is total firm pollution, represented as the log of one plus the total toxic releases from the preceding year. The analysis considers several controls at the firm level, including profitability, firm size, M/B ratio, tangibility, leverage, dividend, income available to common and preferred, investment in net working assets and investment in net fixed assets. Additionally, fixed effects for both the firm and year are factored in. Parenthesized figures indicate t-statistics derived from standard errors adjusted for heteroskedasticity. ∗∗∗, ∗∗, and ∗ represent statistical significance at 1%, 5%, and 10% respectively, based on a two-tailed test. For a comprehensive explanation of each variable, please refer to Appendix A.

Variables	Equity Issues (Net)	
Total Firm Pollution	-0.0035	-0.0004
	(-0.405)	(-0.033)
Profitability	-0.0234**	-0.0125
	(-2.478)	(-0.956)
Firm Size	-0.0031	-0.0364
	(-0.353)	(-1.066)
M/B Ratio	0.0484***	0.0238*
	(4.909)	(1.743)
Dividend	0.1439***	0.1025***
	(11.811)	(6.175)
Leverage	0.0352***	0.0655***
	(3.692)	(4.356)
Tangibility	-0.0318***	0.0056
	(-3.812)	(0.266)
Income Available to Common	-0.3444***	0.3172***
and Preferred	(-27.821)	(-23.1)
Investment in Net Working	0.163***	0.1672***
Assets	(20.542)	(19.759)
Investment in Net Fixed	0.4181***	0.4427***
Assets	(46.862)	(45.439)
Firm FE	Yes	No
Year FE	Yes	No
Observations	13202	13202
R- Squared	0.23	0.18

∗ 10% significance, ∗∗ 5% significance, ∗∗∗ 1% significance

Table 5. On-Site Firm Pollution and Equity Issuance

The table displays the findings of an OLS regression analysis, evaluating how a company's pollution levels impact its equity issuance. The key independent variable is on-site firm pollution, represented as the log of one plus the on-site toxic releases from the preceding year. The analysis considers several controls at the firm level, including profitability, firm size, M/B ratio, tangibility, leverage, dividend, income available to common and preferred, investment in net working assets and investment in net fixed assets. Additionally, fixed effects for both the firm and year are factored in. Parenthesized figures indicate t-statistics derived from standard errors adjusted for heteroskedasticity. ∗∗∗, ∗∗, and ∗ represent statistical significance at 1%, 5%, and 10% respectively, based on a two-tailed test. For a comprehensive explanation of each variable, please refer to Appendix A.

Variables	Equity Issues (Net)	
On-Site Firm Pollution	-0.0034	-0.0003
	(-0.390)	(-0.0325)
Profitability	-0.0234**	-0.0125
	(-2.476)	(-0.955)
Firm Size	-0.0031	-0.0364
	(-0.350)	(-1.066)
M/B Ratio	0.0484***	0.0238*
	(4.907)	(1.743)
Dividend	0.1439***	0.1025***
	(11.810)	(6.175)
Leverage	0.0352***	0.0655***
	(3.693)	(4.357)
Tangibility	-0.0318***	0.0056
	(-3.812)	(0.266)
Income Available to Common	-0.3444***	0.3172***
and Preferred	(-27.821)	(-23.11)
Investment in Net Working	0.163***	0.1672***
Assets	(20.542)	(19.759)
Investment in Net Fixed	0.4181***	0.4427***
Assets	(46.862)	(45.439)
Firm FE	Yes	No
Year FE	Yes	No
Observations	13202	13202
R- Squared	0.24	0.16

∗ 10% significance, ∗∗ 5% significance, ∗∗∗ 1% significance

5-3 Robustness: Alternative Measure of Equity Issuance

To proceed with further analysis and robustness checks, I employ an alternative definition of equity issuance as suggested by Hovakimian et al. (2001). The new definition for equity issuance is as follows:

"A firm is defined as issuing (repurchasing) equity when net equity issued (repurchased) for cash divided by the book value of assets exceeded 5% (i.e., equity is issued when (Compustat Annual Item 108 – Compustat Item 115) / Compustat Item 6 > 5%) " [1]

Upon revisiting my analysis using an alternative definition of equity issuance (Table 6), the results have notably shifted. The relationship between equity issuance and firm pollution, which was previously negative and not statistically significant, has now achieved significance at the 10% level. This change suggests that my initial results were not random occurrences but may indicate a real inverse relationship between a firm's equity issuance and its environmental impact.

The revised definition of equity issuance might provide a more precise reflection of equity issuance activities. This improved measure could have minimized the noise in the data, thereby revealing a more distinct indication of the relationship. The negative coefficient indicates a trend: firms that pollute more tend to exhibit a reduction in equity issuance. However, the 10% significance level suggests there's a 10% probability that the observed effect might have arisen randomly.

The observation of a negative relationship between equity issuance and firm pollution, now statistically significant at the 10% level, should be interpreted with caution. This level of significance indicates a tentative link—it is noteworthy but not yet fully established.

Regarding the broader meaning, this result could imply that firms issuing equity might also be those investing in greener practices, or they are being closely watched by environmentally conscious investors. This adds a new layer to understanding how a firm's financial decisions are connected to its environmental footprint and suggests a need for further investigation into the strategic motivations behind equity issuance among polluting firms.

Overall, despite the negative relationship suggested by the revised definition, there still remains insufficient evidence to fully substantiate my second hypothesis.

[1] Hovakimian, A., Opler, T., & Titman, S. (2001). The debt-equity choice. *Journal of Financial and Quantitative analysis*, *36*(1), 1-24.

Table 6. Total Firm Pollution and Equity Issuance (New Definition)

The table displays the findings of an OLS regression analysis, evaluating how a company's pollution levels impact its equity issuance with new definition for equity issuance. The key independent variable is total firm pollution, represented as the log of one plus the total toxic releases from the preceding year. The analysis considers several controls at the firm level, including profitability, firm size, M/B ratio, tangibility, leverage, dividend, income available to common and preferred, investment in net working assets and investment in net fixed assets. Parenthesized figures indicate t-statistics derived from standard errors adjusted for heteroskedasticity. ∗∗∗, ∗∗, and ∗ represent statistical significance at 1%, 5%, and 10% respectively, based on a two-tailed test. For a comprehensive explanation of each variable, please refer to Appendix A.

Variables	Equity Issues (Net)	
Total Firm Pollution	-0.0068*	-0.004
	(-1.762)	(-0.673)
Profitability	-0.0656***	-0.045***
	(-20.422)	(-15.341)
Firm Size	-0.1162***	-0.091***
	(-33.732)	(-23.651)
M/B Ratio	0.0871***	0.041***
	(25.691)	(11.234)
Dividend	0.0035	0.003
	(0.801)	(0.75)
Leverage	0.0813***	0.065***
	(23.27)	(12.513)
Tangibility	0.0283***	0.012***
	(9.08)	(4.166)
Income Available to Common and Preferred	-0.0227***	-0.02***
	(-5.433)	(-5.47)
Investment in Net Working Assets	0.0078***	0.0071***
	(2.59)	(2.51)
Investment in Net Fixed Assets	0.0366***	0.0248***
	(11.615)	(8.19)
Firm FE	Yes	No
Year FE	Yes	No
Observations	25190	25190
R- Squared	0.11	0.06

∗ 10% significance, ∗∗ 5% significance, ∗∗∗ 1% significance

5-4 Firm-Initiated Equity Issuance and Firm Pollution

McKeon (2015) highlighted that the data on equity issuance frequently used in financial research includes a mix of both employee-initiated and firm-initiated issues. Employee-initiated issuance refers to shares issued predominantly when employees choose to exercise their options, a process not involving a strategic decision by management to release stock. In contrast, firm-initiated issuance involves raising capital through various channels such as Initial Public Offerings (IPOs), Secondary Equity Offerings (SEOs), and private placements. McKeon proposed a technique to distinguish firm-initiated equity issuance proceeds by examining the relative size of the issuance. This distinction is crucial to my thesis, which focuses on evaluating the impact of firm pollution on managerial financing decisions. Therefore, for a more detailed analysis, I adopt McKeon's definition of firm-initiated equity issuance.

McKeon characterizes the variable "ISSUE%" as the proportion of common stock sales to the market value of equity. A lower ISSUE% typically indicates that the proceeds are mainly derived from the exercise of options by employees, categorizing it as employee-initiated. Conversely, a higher ISSUE% often suggests the presence of a firm-initiated action. McKeon's research identifies a 3% threshold for ISSUE% as being effective for both quarterly and annual datasets. The results of a regression analysis, focusing on the relationship between Total Firm Pollution and firm-initiated issuance, are detailed in Table 8.

In Table 7, the regression results for firm-initiated equity issues are presented. Notably, Total Firm Pollution shows a coefficient of 0.0026 with a t-statistic of 0.883, indicating a lack of statistical significance at conventional levels. This suggests that the relationship between firm pollution and firm-initiated equity issuance is not as pronounced or clear-cut as hypothesized.

Other variables in the model, such as Profitability, M/B Ratio, Leverage, Tangibility, and Income Available to Common and Preferred Shareholders, demonstrate significant relationships with firm-initiated equity issuance, as evidenced by their respective coefficients and t-statistics

In summary, the lack of a statistically significant relationship between Total Firm Pollution and firm-initiated equity issuance in Table 7 corroborates the results from the earlier analyses. This reinforces the robustness of the findings, suggesting that firm pollution does not significantly influence firm-initiated equity issuance decisions, as indicated by the various definitions and methods employed in the study.

Table 7. Total Firm Pollution and Firm-Initiated Equity Issuance

The table displays the findings of an OLS regression analysis, evaluating how a company's pollution levels impact its firm-initiated equity issuance based on McKeon (2015)' definition. The key independent variable is total firm pollution, represented as the log of one plus the total toxic releases from the preceding year. The analysis considers several controls at the firm level, including profitability, firm size, M/B ratio, tangibility, leverage, dividend, income available to common and preferred, investment in net working assets and investment in net fixed assets. Parenthesized figures indicate t-statistics derived from standard errors adjusted for heteroskedasticity. ∗∗∗, ∗∗, and ∗ represent statistical significance at 1%, 5%, and 10% respectively, based on a two-tailed test. For a comprehensive explanation of each variable, please refer to Appendix A.

Variables	Firm- Initiated Equity Issues	
Total Firm Pollution	0.0026*	-0.0061*
	(0.883)	(-1.895)
Profitability	-0.0376***	-0.0238***
	(-12.086)	(-6.2062)
Firm Size	-0.0044	-0.0353***
	(-1.505)	(-3.5491)
M/B Ratio	0.0223***	0.0210***
	(6.827)	(5.2548)
Dividend	-0.0003	0.011**
	(-0.086)	(2.2630)
Leverage	0.0457***	0.0339***
	(14.449)	(7.7050)
Tangibility	0.0332***	0.0055
	(11.981)	(0.9003)
Income Available to Common	-0.0121***	-0.0051
and Preferred	(-5.433)	(-1.2801)
Investment in Net Working	-0.002	-0.0032
Assets	(-0.774)	(-1.2828)
Investment in Net Fixed	0.0109***	0.0054 *
Assets	(3.692)	(1.8944)
Firm FE	Yes	No
Year FE	Yes	No
Observations	13805	13805
R- Squared	0.06	0.02

∗ 10% significance, ∗∗ 5% significance, ∗∗∗ 1% significance

5-5 Solving Endogeneity of Firm Pollution

The primary findings could be influenced by two forms of endogeneity. The first is the risk of omitted variable bias; despite incorporating a standard set of variables identified by prior research as influential on leverage and equity issuance, there's a possibility that the observed relationship could be incidental if there are any overlooked variables that simultaneously impact firm pollution and leverage (or equity issuance). The second concern is the potential for reverse causality, where financing decisions could be influencing firm pollution levels. For instance, firms might raise debt or equity to invest in pollution control measures, acquire new technology to decrease pollution, or cover fines related to their pollution activities.

To address potential endogeneity concerns, I employ the difference-in-difference method alongside natural experiments. The difference-in-difference method is a statistical approach used to infer causal relationships by comparing the evolution of outcomes over time between a group affected by a policy or event (the treatment group) and a group that is not (the control group). The fundamental assumption here is that, had the treatment not been applied, the average outcome change in the treatment group would have mirrored that of the control group. For a natural experiment to be considered valid, it must meet three criteria: the change it introduces should be unexpected, it should only affect a subset of the population (the treatment group), and firms must not have the option to choose whether to be part of the experiment.

I use three different environmental regulation which meet these conditions.

1- California Global Warming Solution Act of 2006
2- Washington State's Clean Air Rule, 2016
3- Massachusetts Toxics Use Reduction Act (TURA), 1990

Each of these regulations inherently satisfies the three essential criteria for a valid natural experiment.

Unexpected Change: All three regulations – California's Global Warming Solutions Act, Washington's Clean Air Rule, and Massachusetts' TURA – were significant, unexpected legislative actions. None of these regulations were anticipated by the businesses they affected, ensuring that any strategic adjustments by firms in response to these regulations were not preemptive but reactive. This element of surprise is crucial for a natural experiment as it implies that the observed changes in financial behaviors post-implementation are likely due to the regulation itself.

Subset of the Population Affected: These regulations were geographically specific, each affecting a distinct subset of firms within their respective states. This geographical specificity creates a natural division between the treatment group (firms in the regulated states) and the control group (firms in states without similar regulations). Such a clear delineation is vital for drawing comparative insights about the effects of the regulation on financial decisions like leverage and equity issuance.

Lack of Choice in Participation: In each case, firms did not have the option to opt-out of compliance. The mandatory nature of these regulations ensures that the effects observed are not due to self-selection biases. Firms under these regulations had to adhere to the new rules, allowing us to attribute any observed changes in financial behavior directly to the impact of the regulations.

Collectively, these three regulations provide robust, varied contexts to study the impact of firm pollution on corporate financial decisions. Their compliance with the criteria for natural experiments strengthens the validity of the study, ensuring that the observed effects can be attributed more confidently to the regulations themselves rather than other extraneous factors.

California Global Warming Solution Act of 2006:

The California Global Warming Solutions Act of 2006, also known as Assembly Bill (AB) 32, represents a landmark legislation that set the precedent for comprehensive climate change policies in the United States. It was enacted with the primary goal of reducing California's greenhouse gas (GHG) emissions to 1990 levels by 2020, a target it ambitiously achieved ahead of schedule.[2]

In this natural experiment, the treatment group consists of public firms incorporated in California, and the control group comprises other firms across the USA, with the comparison made before and after the year 2006.

Washington State's Clean Air Rule, 2016:

The Washington State's Clean Air Rule, adopted in 2016, aims to regulate carbon emissions from significant stationary sources like power plants and industrial facilities. This rule establishes an emissions cap and mandates that covered entities must reduce their emissions or buy allowances from the state's emission market to comply with the set limits.[3]

In this natural experiment, the treatment group is made up of public firms incorporated in Washington state, while the control group includes firms from other parts of the USA. The impact of the Clean Air Rule is assessed by comparing data from these groups both before and after the year 2016.

Massachusetts Toxics Use Reduction Act (TURA), 1990:

The Toxics Use Reduction Act (TURA) underwent amendments in 1998. It mandates that facilities using specific chemicals above designated thresholds must report their usage and devise plans to minimize their use and waste production. TURA is applicable to a diverse array of industries such as manufacturing, healthcare, and higher education. Additionally, it obligates facilities to report their toxic chemical emissions to the Toxic Release Inventory (TRI)[4]

[2] For more details, please refer to https://ww2.arb.ca.gov/resources/fact-sheets/ab-32-global-warming-solutions-act-2006
[3] For more details, please refer to https://bit.ly/460PMVe
[4] For more details, please refer to https://www.mass.gov/toxics-use-reduction-act-tura-program

In this natural experiment, the treatment group includes public firms incorporated in Massachusetts, while the control group consists of firms located throughout the rest of the USA. The comparison of the two groups is conducted on data from before and after the year 1990.

The double difference estimator can be calculated for leverage equation as follow.

$$\beta_{DD} = \left(\overline{leverage}_{after}^{treated} - \overline{leverage}_{before}^{treated}\right) - \left(\overline{leverage}_{after}^{control} - \overline{leverage}_{before}^{control}\right)$$

Where $\overline{leverage}$ is the average of leverage, and treated and control refer to the treatment group and control group, respectively, in each experiment. A similar equation can be defined for equity issuance as well.

The estimation outcomes from the three natural experiments are detailed in Table 8. Panel A relates to the California Global Warming Solutions Act of 2006, Panel B to the Washington State's Clean Air Rule of 2016, and Panel C to the Massachusetts Toxics Use Reduction Act (TURA) of 1990.

Panel A: The implementation of the California Global Warming Solutions Act of 2006 appears to have a statistically significant negative impact on firms' leverage, indicating that firms' leverage decreased after the act was passed. The coefficient for "California × Post 2006" is negative and significant at the 10% level. The negative coefficient for "California" suggests that, regardless of the Act, being in California is associated with lower leverage compared to the baseline, and this is significant at the 1% level. The "Post 2006" variable also shows a significant negative relationship with leverage, suggesting that there was an overall trend of decreasing leverage after 2006.

Panel B: The Washington State's Clean Air Rule, 2016 does not show a statistically significant effect on leverage at conventional levels; the interaction term "Washington × Post 2016" is not significant. However, the "Post 2016" variable is significant and negative, indicating a general decrease in leverage after 2016.

Panel C: The Massachusetts Toxics Use Reduction Act (TURA) of 1990 does not have a statistically significant effect on leverage when considering the interaction term "Massachusetts × Post 1990". However, similar to the other panels, the "Post 1990" variable is significant and negatively associated with leverage.

Overall, environmental regulatory acts appear to correlate with a decrease in firms' leverage, although the strength and significance of this relationship vary by state and regulation.

Table 8.Addressing Endogeneity in Firm Pollution for Leverage Equation

This table presents the outcomes of addressing the endogeneity issue using three natural experiments. Panel A concerns the California Global Warming Solution Act. Panel B relates to Washington State's Clean Air Rule. Panel C involves the Massachusetts Toxics Use Reduction Act. For all regressions, the dependent variable is leverage. All models account for control variables, as well as firm and year fixed effects. Parenthesized figures indicate t-statistics derived from standard errors adjusted for heteroskedasticity. ∗∗∗, ∗∗, and ∗ represent statistical significance at 1%, 5%, and 10% respectively, based on a two-tailed test.

Panel A. California Global Warming Solution Act of 2006		
Variables	Dep. Variable = Leverage	
California × Post 2006	-0.025*	-0.076***
	(-1.656)	(-6.041)
California	-0.0276***	-0.083***
	(-2.85)	(-5.364)
Post 2006	-0.0499***	-0.124***
	(-10.509)	(-11.685)
Firm FE	Yes	No
Year FE	Yes	No
Adj. R-squared	0.28	0.12
Panel B. Washington State's Clean Air Rule, 2016		
Variables	Dep. Variable = Leverage	
Washington × Post 2016	-0.0705	-0.0684*
	(-1.34)	(-1.836)
Washington	0.0331	0.0301*
	(1.396)	(2.012)
Post 2016	-0.0273***	-0.0458***
	(-4.277)	(-5.605)
Firm FE	Yes	No
Year FE	Yes	No
Adj. R-squared	0.27	0.11
Panel C. Massachusetts Toxics Use Reduction Act (TURA), 1990		
Variables	Dep. Variable = Leverage	
Massachusetts × Post 1990	0.0163	-0.0223
	(0.492)	(-0.853)
Massachusetts	-0.051	-0.021*
	(-1.613)	(-1.921)
Post 1990	-0.0402***	-0.0467***
	(-4.636)	(-5.083)
Firm FE	Yes	No
Year FE	Yes	No
Adj. R-squared	0.27	0.09

∗ 10% significance, ∗∗ 5% significance, ∗∗∗ 1% significance

Similarly, the estimation method applied to leverage was used to assess equity issuance, with the results detailed in Table 9.

Panel A (California Global Warming Solution Act of 2006): The interaction term "California × Post 2006" is not statistically significant, indicating that there isn't a discernible impact of the act on equity issuance for firms in California in the period after the act was implemented. The coefficients for "California" and "Post 2006" are also not statistically significant, suggesting that neither being located in California nor the time period after the act has a significant effect on equity issuance.

Panel B (Washington State's Clean Air Rule, 2016): Similar to Panel A, the interaction term "Washington × Post 2016" does not show a significant effect on equity issuance. The coefficients for "Washington" and "Post 2016" are also not significant, indicating no noticeable impact of the rule on equity issuance for firms in Washington after 2016.

Panel C (Massachusetts Toxics Use Reduction Act, 1990): Again, the interaction term "Massachusetts × Post 1990" does not show a significant effect on equity issuance. The "Massachusetts" and "Post 1990" coefficients are not significant as well, which suggests that the TURA did not have a significant impact on equity issuance in the period after its implementation.

Overall, the lack of significant findings suggests that the environmental regulations examined did not have a statistically significant impact on equity issuance in the sample of firms studied. This could imply that while leverage might be sensitive to such regulatory changes, equity issuance is less so, or that the effects might take longer to manifest in equity issuance behavior than they do in leverage.

Table 9. Addressing Endogeneity in Firm Pollution for Equity Issuance equation

This table presents the outcomes of addressing the endogeneity issue using three natural experiments. Panel A concerns the California Global Warming Solution Act. Panel B relates to Washington State's Clean Air Rule. Panel C involves the Massachusetts Toxics Use Reduction Act. For all regressions, the dependent variable is equity issues. All models account for control variables, as well as firm and year fixed effects. Parenthesized figures indicate t-statistics derived from standard errors adjusted for heteroskedasticity. ∗∗∗, ∗∗, and ∗ represent statistical significance at 1%, 5%, and 10% respectively, based on a two-tailed test.

Panel A. California Global Warming Solution Act of 2006		
Variables	Dep. Variable = equity issues	
California × Post 2006	-0.0543	-0.1404
	(-0.801)	(-1.621)
California	0.0303	-0.08
	(0.701)	(0.91)
Post 2006	-0.0209	-0.042
	(-1.158)	(-1.309)
Firm FE	Yes	No
Year FE	Yes	No
Adj. R-squared	0.19	0.17
Panel B. Washington State's Clean Air Rule, 2016		
Variables	Dep. Variable = equity issues	
Washington × Post 2016	0.0993	0.0959
	(0.473)	(0.407)
Washington	0.0007	0.002
	(0.007)	(0.026)
Post 2016	0.0331	0.044
	(1.342)	(0.764)
Firm FE	Yes	No
Year FE	Yes	No
Adj. R-squared	0.19	0.13
Panel C. Massachusetts Toxics Use Reduction Act (TURA), 1990		
Variables	Dep. Variable = equity issues	
Massachusetts × Post 1990	0.0191	0.0032
	(0.129)	(0.0189)
Massachusetts	0.0206	0.147
	(0.141)	(0.652)
Post 1990	0.0189	0.0348
	(0.572)	(0.804)
Firm FE	Yes	No
Year FE	Yes	No
Adj. R-squared	0.19	0.16

∗ 10% significance, ∗∗ 5% significance, ∗∗∗ 1% significance

5-6 Debt Issuance and Firm Pollution

Table 10 presents the results for the relationship between Net Debt Issuance and Total Firm Pollution. The regression analysis reveals a significant negative relationship between Total Firm Pollution and Net Debt Issuance. Specifically, the coefficient for Total Firm Pollution is -0.0032, and it is statistically significant at the 1% level, as indicated by the t-statistic of -2.91. This suggests that as a firm's pollution increases, its net debt issuance decreases. The negative coefficient implies that firms with higher pollution levels tend to retire more debt than they issue, indicating a reduction in their overall debt levels. This aligns with Zerbib (2019), who found a positive association between the cost of debt and firm pollution, suggesting that higher pollution levels may increase financial costs and influence debt management strategies

The strong negative relationship between Leverage and Net Debt Issuance, with a coefficient of -0.1711 significant at the 1% level, is particularly noteworthy. This indicates that firms with higher leverage are significantly reducing their debt levels, possibly as a strategy to manage their financial risk. This observation aligns with the results presented by Chang et al. (2021).

Overall, the findings from regression table suggest that increased pollution levels in a firm are associated with a reduction in net debt issuance, indicating a tendency towards debt retirement. This could be a strategic move by firms to manage financial risks associated with environmental impacts or could reflect external pressures such as regulatory requirements or investor preferences for environmentally responsible firms.

Table 10. Total Firm Pollution and Net Debt Issuance

The table displays the findings of an OLS regression analysis, evaluating how a company's pollution levels impact its net debt issuance. The key independent variable is total firm pollution, represented as the log of one plus the total toxic releases from the preceding year. The analysis considers several controls at the firm level, including profitability, firm size, M/B ratio, tangibility, R&D expenses, dividend indicator, leverage, and the unleveraged z-score. Additionally, fixed effects for both the firm and year are factored in. Parenthesized figures indicate t-statistics derived from standard errors adjusted for heteroskedasticity. ∗∗∗, ∗∗, and ∗ represent statistical significance at 1%, 5%, and 10% respectively, based on a two-tailed test. For a comprehensive explanation of each variable, please refer to Appendix A.

Variables	Dep Variable: Net Debt Issuance	
Total Firm Pollution	-0.0032***	0.0076*
	(-2.91)	(1.791)
Profitability	0.0272	-0.0016
	(0.707)	(-0.053)
Firm Size	-0.0124***	-0.0012
	(-3.385)	(-1.312)
M/B Ratio	0.0096***	0.0107***
	(3.474)	(4.958)
Tangibility	-0.0098	-0.0058
	(-0.377)	(-0.556)
R&D Expenses	-0.3674***	-0.0679
	(-3.386)	(-1.384)
Dividend Indicator	0.0169***	-0.007*
	(2.664)	(-1.834)
Z-Score	0.0775	0.08
	(1.258)	(0.857)
Leverage	-0.1711***	-0.0593***
	(-12.298)	(-6.344)
Firm FE	Yes	No
Year FE	Yes	No
Observations	7082	7082
R- Squared	0.05	0.02

∗ 10% significance, ∗∗ 5% significance, ∗∗∗ 1% significance

5-7 The Impact of Operational Costs on the Leverage-Pollution Relationship in Firms

In Chapter 2, I discussed how pollution can escalate a firm's financial distress costs in various ways. In this section, and the subsequent one, I examine two of these aspects. One key aspect is the operating costs. Pollution can adversely impact leverage through increased operational costs. As companies implement measures to control pollution, their operational expenses may rise. This increase in costs can strain the firm's financial resources, reducing profitability and cash flows, which are essential for servicing debt. Consequently, firms might choose to lower their leverage to maintain financial stability in the face of heightened operational costs associated with pollution control.

Table 11focuses on the influence of operational costs on the relationship between Total Firm Pollution and Leverage. The dataset is divided into two groups based on the operational cost's median: Higher Operational Costs and Lower Operational Costs.

In the group with Higher Operational Costs, the coefficient for Total Firm Pollution is -2.591, significant at the 5% level (t-statistic of -2.06). This indicates a strong negative relationship between pollution and leverage in firms with higher operational costs. This is in line with the hypothesis that firms with higher operational costs and higher pollution levels are more inclined to reduce their leverage. The magnitude of the coefficient in this group is notably larger compared to the group with Lower Operational Costs, where the coefficient is -0.0183, significant at the 1% level (t-statistic of -2.897). The significant negative relationship in both groups suggests that increased pollution consistently correlates with reduced leverage, but this effect is more pronounced in firms with higher operational costs.

The more pronounced negative effect in the group with higher operational costs suggests that these firms may be more sensitive to the financial implications of pollution, potentially due to the additional burden of higher operational expenses. This could reflect a strategic approach by these firms to manage financial risks associated with environmental factors in the context of their operational cost structure.

Table 11. The Impact of Operational Costs on the Leverage-Pollution Relationship

The table displays the findings of an OLS regression analysis, evaluating how a company's pollution levels impact its leverage, and further explores the influence of operational costs by dividing the data into groups based on their median operational costs. The key independent variable is total firm pollution, represented as the log of one plus the total toxic releases from the preceding year. The analysis considers several controls at the firm level, including profitability, firm size, M/B ratio, tangibility, R&D expenses, dividend indicator, and the unleveraged z-score. Additionally, fixed effects for both the firm and year are factored in. Parenthesized figures indicate t-statistics derived from standard errors adjusted for heteroskedasticity. ***, **, and * represent statistical significance at 1%, 5%, and 10% respectively, based on a two-tailed test. For a comprehensive explanation of each variable, including operational costs, please refer to Appendix A.

Variables	Dep. Variable: Leverage	
	Higher Operational Costs	Lower Operational Costs
Total Firm Pollution	-2.591**	-0.0183***
	(-2.06)	(-2.897)
Profitability	-0.594***	-0.1799***
	(-9.804)	(-3.496)
Firm Size	0.0061**	0.0087***
	(2.066)	(2.958)
M/B Ratio	-0.056***	-0.0646***
	(-14.434)	(-16.383)
Tangibility	0.1169***	0.1812***
	(7.167)	(8.242)
R&D Expenses	-0.704***	-1.1395***
	(-7.875)	(-12.299)
Dividend Indicator	-0.0727***	-0.0748***
	(-10.871)	(-11.06)
Z-Score	-0.3433***	-0.933***
	(-3.933)	(-8.113)
Firm FE	Yes	Yes
Year FE	Yes	Yes
Observations	3874	3873
R- Squared	0.31	0.25

∗ 10% significance, ∗∗ 5% significance, ∗∗∗ 1% significance

5-8 The Effect of Environmental Attitudes on the Leverage-Pollution Relationship

Recent research, including a study by Lyu et al. (2022), indicates that individuals who support the Republican party tend to be more skeptical about environmental issues compared to those who identify as Democrats. I have adopted the methodology developed by them to use state political orientation as a proxy for support for stricter environmental regulations. The dataset is segmented into three subgroups: Blue states, Red states, and Swing states. A state is classified as a Blue state if the Democratic party secured more electoral votes than the Republican party in at least four of the last five presidential elections (2004-2020). Conversely, a state is defined as a Red state if the Republican party won more electoral votes during the same period. States that do not meet either criterion are categorized as Swing states.

Table 12 presents the regression analysis of leverage as influenced by total firm pollution, categorized by state political orientation: Blue States, Swing States, and Red States. The analysis yields distinct results across these categories, reflecting the varying impact of pollution on leverage in different political environments.

In Blue States, there is a significant negative relationship between Total Firm Pollution and Leverage, with a coefficient of -0.0217, significant at the 1% level (t-statistic of -3.403). This suggests that in states that predominantly vote Democratic, higher levels of firm pollution are associated with lower levels of leverage. The negative coefficient may reflect a stronger regulatory environment or greater public scrutiny over environmental practices in these states.

Conversely, in Swing States, the relationship between Total Firm Pollution and Leverage is not statistically significant, indicated by the coefficient of -0.0257 and a t-statistic of -0.344. This lack of significance could imply that in politically mixed states, the impact of pollution on corporate financial structure is less clear or influenced by other factors not captured in this model.

Interestingly, in Red States, which typically lean Republican, the coefficient for Total Firm Pollution is 0.001 with a t-statistic of 0.106, indicating no significant impact on leverage. This could suggest that in these states, concerns about pollution may not significantly influence corporate leverage decisions, possibly due to differing regulatory priorities or public perceptions about environmental issues.

Table 12. The Effect of Environmental Attitudes on the Leverage-Pollution Relationship

The table displays the findings of an OLS regression analysis, evaluating how a company's pollution levels impact its leverage across different state political orientations, categorized into Blue States, Swing States, and Red States. The key independent variable is total firm pollution, represented as the log of one plus the total toxic releases from the preceding year. The analysis considers several controls at the firm level, including profitability, firm size, M/B ratio, tangibility, R&D expenses, dividend indicator, leverage, and the unleveraged z-score, across these state categories. Additionally, fixed effects for both the firm and year are factored in. Parenthesized figures indicate t-statistics derived from standard errors adjusted for heteroskedasticity. ***, **, and * represent statistical significance at 1%, 5%, and 10% respectively, based on a two-tailed test. For a comprehensive explanation of each variable, including the categorization of states, please refer to Appendix A

Variables	Dep. Variable: Leverage		
	Blue State	Swing State	Red State
Total Firm	-0.0217***	-0.0257	0.001
Pollution	(-3.403)	(-0.344)	(0.106)
Profitability	-0.4395***	0.1375	-0.2933***
	(-9.897)	(1.048)	(-3.827)
Firm Size	0.0172***	0.0216***	0.0025
	(12.874)	(4.551)	(0.948)
M/B Ratio	-0.0479***	-0.1058***	-0.077***
	(-16.225)	(-8.918)	(-12.269)
Tangibility	0.1318***	0.0474	0.1548***
	(8.126)	(0.928)	(5.934)
R&D Expenses	-0.8495***	-0.104	-0.9467***
	(-12.647)	(-0.307)	(-5.809)
Dividend Indicator	-0.0661***	-0.1738***	-0.0564***
	(-11.617)	(-10.618)	(-5.539)
Z-Score	-0.696***	-0.684***	-0.4776***
	(-7.961)	(-2.751)	(-3.491)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	5244	786	1821
R- Squared	0.28	0.32	0.24

∗ 10% significance, ∗∗ 5% significance, ∗∗∗ 1% significance

6-Conclusion

In conclusion, this thesis has investigated the relationship between firm pollution levels and financing decisions, focusing on the aspects of leverage and equity issuance. I set out to examine two hypotheses: the first predicted a negative correlation between pollution and leverage, while the second anticipated a similar trend concerning pollution and equity issuance.

My findings on the first hypothesis were clear-cut. Through rigorous regression analysis, I discovered a significant negative correlation between firm pollution levels and leverage, substantiated at a 1% significance level. This confirmed my initial postulation that firms with higher pollution output might be disinclined or constrained in their leverage options.

The journey to substantiate the second hypothesis, however, encountered more ambiguity. The regression results indicated a negative relationship between pollution and equity issuance, but this correlation did not achieve statistical significance. Even after redefining equity issuance in line with Hovakimian et al. (2001), the results only reached significance at the 10% level, which does not provide a strong enough foundation to fully endorse the hypothesis. Applying McKeon's (2015) method to define firm-initiated equity issuance led to similar results, revealing no statistical significance between firm pollution and firm-initiated equity issuance.

In an effort to refine my analysis and address potential endogeneity, I utilized a natural experiment approach, applying the Difference in Differences method to my regression models for both leverage and equity issuance. The results for leverage remained negative and significant, suggesting a causal relationship between environmental regulations and firms' leverage decisions. This indicates that environmental regulations have a discernible, albeit varied, impact on how firms manage their leverage. However, the equity issuance results did not exhibit the same level of significance. This outcome implies either a lesser impact of environmental regulations on equity strategies or that the effects on equity issuance may manifest more slowly.

In addition to the initial findings, this thesis further explores the intricate relationship between firm pollution levels and financial decisions through three additional aspects. Firstly, a significant negative relationship between Total Firm Pollution and Net Debt Issuance was observed, suggesting firms with higher pollution levels tend to reduce their net debt issuance, possibly due to increased financial costs or as a strategic risk management response. This is aligned with the notion that environmental impacts influence debt management strategies. Secondly, the investigation into the role of operational costs revealed that increased pollution consistently correlates with reduced leverage, particularly pronounced in firms with higher operational costs. This underscores the financial strain pollution-related operational expenses place on firms, compelling them to adjust their leverage. Lastly, an analysis of the leverage-pollution relationship in the context of state political orientation uncovered that in Democratic-leaning (Blue) states, higher pollution correlates with lower leverage, likely reflecting stronger environmental regulations or public scrutiny. Conversely, in Republican-leaning (Red) states and politically mixed (Swing) states, this relationship was less pronounced or insignificant, indicating varying influences of political climate on corporate financial structures.

Through this thesis, I have contributed to the dialogue on how environmental issues interact with financial decision-making within firms. The significant findings related to leverage provide clear evidence of the financial repercussions of pollution, whereas the inconclusive results on equity issuance invite further research. These findings provide valuable insights for policymakers, investors, and corporate managers who must balance environmental accountability with financial considerations.

7- References

Altman, E. I. (1968). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The journal of finance*, *23*(4), 589-609.

Baker, M., & Wurgler, J. (2002). Market timing and capital structure. *The journal of finance*, *57*(1), 1-32.

Chang, X., Fu, K., Li, T., Tam, L., & Wong, G. (2021). Corporate environmental liabilities and capital structure. *Available at SSRN 3200991*.

Chava, S. (2014). Environmental externalities and cost of capital. *Management science*, *60*(9), 2223-2247.

Chen, F., Wang, M., & Pu, Z. (2022). The impact of technological innovation on air pollution: firm-level evidence from China. *Technological Forecasting and Social Change*, *177*, 121521.

Cheng, B., Ioannou, I., & Serafeim, G. (2014). Corporate social responsibility and access to finance. *Strategic management journal*, *35*(1), 1-23.

Cormier, D., Magnan, M., & Morard, B. (1993). The impact of corporate pollution on market valuation: some empirical evidence. *Ecological economics*, *8*(2), 135-155.

Cornett, M. M., Erhemjamts, O., & Tehranian, H. (2016). Greed or good deeds: An examination of the relation between corporate social responsibility and the financial performance of US commercial banks around the financial crisis. *Journal of Banking & Finance*, *70*, 137-159.

Dasgupta, S., Laplante, B., & Mamingi, N. (2001). Pollution and capital markets in developing countries. *Journal of Environmental Economics and management*, *42*(3), 310-335.

Di Giuli, A. (2013). Pollution and firm value. *Available at SSRN 2227034*.

Dutordoir, M., Strong, N. C., & Sun, P. (2018). Corporate social responsibility and seasoned equity offerings. *Journal of Corporate Finance*, *50*, 158-179.

Earnhart, D. H., Khanna, M., & Lyon, T. P. (2014). Corporate environmental strategies in emerging economies. *Review of Environmental Economics and Policy*.

El Ghoul, S., Guedhami, O., Kwok, C. C., & Mishra, D. R. (2011). Does corporate social responsibility affect the cost of capital?. *Journal of banking & finance*, *35*(9), 2388-2406.

Frank, M. Z., & Goyal, V. K. (2009). Capital structure decisions: which factors are reliably important?. *Financial management*, *38*(1), 1-37.

Fullenbaum, R., & Richards, T. (2020). The Impact of Regulatory Growth on Operating Costs.

Ginglinger, E., & Moreau, Q. (2023). Climate risk and capital structure. *Management Science*.

Han, L., Cheng, X., Chan, K. C., & Gao, S. (2022). Does air pollution affect seasoned equity offering pricing? Evidence from investor bids. *Journal of Financial Markets*, *59*, 100657.

Hong, H., & Kacperczyk, M. (2009). The price of sin: The effects of social norms on markets. *Journal of financial economics*, *93*(1), 15-36.

Hovakimian, A., Opler, T., & Titman, S. (2001). The debt-equity choice. *Journal of Financial and Quantitative analysis*, *36*(1), 1-24.

Jacobs, B. W., Singhal, V. R., & Subramanian, R. (2010). An empirical investigation of environmental performance and the market value of the firm. *Journal of Operations Management*, *28*(5), 430-441.

Jebjerg, L., & Lando, H. (1997). Regulating a polluting firm under asymmetric information. Environmental and Resource Economics, 10, 267-284.

Jung, J., Herbohn, K., & Clarkson, P. (2018). Carbon risk, carbon risk awareness and the cost of debt financing. *Journal of Business Ethics*, *150*, 1151-1171.

Kim, I., Wan, H., Wang, B., & Yang, T. (2019). Institutional investors and corporate environmental, social, and governance policies: Evidence from toxics release data. *Management Science*, *65*(10), 4901-4926.

Korteweg, A. (2010). The net benefits to leverage. The journal of finance, 65(6), 2137-2170.

Li, W., Neupane-Joshi, S., & Tan, K. J. K. (2022). Toxic emissions and corporate green innovation. *Available at SSRN*.

Ling, S., Han, G., An, D., Hunter, W. C., & Li, H. (2020). The impact of green credit policy on technological innovation of firms in pollution-intensive industries: evidence from China. *Sustainability*, *12*(11), 4493.

Liu, F., Kang, Y., Guo, K., & Sun, X. (2021). The relationship between air pollution, investor attention and stock prices: Evidence from new energy and polluting sectors. *Energy Policy*, *156*, 112430.

Liu, X., Wang, E., & Cai, D. (2018). Environmental regulation and corporate financing—quasi-natural experiment evidence from China. *Sustainability*, *10*(11), 4028.

Maloney, M. T., & Yandle, B. (1984). Estimation of the cost of air pollution control regulation. Journal of environmental economics and management, 11(3), 244-263.

Modigliani, F., & Miller, M. H. (1958). The cost of capital, corporation finance and the theory of investment. *The American economic review*, *48*(3), 261-297.

Myers, S. C., & Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of financial economics*, *13*(2), 187-221.

Newton, D., Ongena, S., Xie, R., & Zhao, B. (2022). Firm ESG Reputation Risk and Debt Choice. *Swiss Finance Institute Research Paper*, (22-22).

Park, S. R., & Jang, J. Y. (2021). The impact of ESG management on investment decision: Institutional investors' perceptions of country-specific ESG criteria. International Journal of Financial Studies, 9(3), 48.

Pijourlet, G. (2013). Corporate social responsibility and financing decisions. *JEL Classification G*, *32*, M14.

Raghunandan, A., & Rajgopal, S. (2022). Do ESG funds make stakeholder-friendly investments?. *Review of Accounting Studies*, *27*(3), 822-863.

Rauh, J. D., & Sufi, A. (2012). Explaining corporate capital structure: Product markets, leases, and asset similarity. Review of Finance, 16(1), 115-155.

Reid, E. M., & Toffel, M. W. (2009). Responding to public and private politics: Corporate disclosure of climate change strategies. *Strategic management journal*, *30*(11), 1157-1178.

Ryan, S. P. (2012). The costs of environmental regulation in a concentrated industry. *Econometrica*, *80*(3), 1019-1061.

Tan, Z., & Yan, L. (2021). Does air pollution impede corporate innovation?. *International Review of Economics & Finance*, *76*, 937-951.

Wang, C., Zhang, H., Lu, L., Wang, X., & Song, Z. (2019). Pollution and corporate valuation: evidence from China. *Applied Economics*, *51*(32), 3516-3530.

Xie, Z., Wang, J., & Zhao, G. (2022). Impact of green innovation on firm value: evidence from listed companies in China's heavy pollution industries. *Frontiers in Energy Research*, *9*, 806926.

Xu, Y., Li, S., Zhou, X., Shahzad, U., & Zhao, X. (2022). How environmental regulations affect the development of green finance: Recent evidence from polluting firms in China. *Renewable Energy*, *189*, 917-926.

Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of banking & finance*, *98*, 39-60.

Zhang, J., Kang, L., Li, H., Ballesteros-Pérez, P., Skitmore, M., & Zuo, J. (2020). The impact of environmental regulations on urban Green innovation efficiency: The case of Xi'an. *Sustainable Cities and Society*, *57*, 102123.

Appendix A: Defining Variables

Main Independent Variables:

$$Total\ Firm\ pollution = \frac{Log(\ 1 + total\ toxic\ release)}{sales}$$

$$on - site\ Firm\ pollution = \frac{Log(\ 1 + on\ site\ toxic\ release)}{sales}$$

Dependent Variable for Leverage Equation:

The dependent variable in this equation is either Leverage or Book Leverage, both of which are defined according to the framework established by Frank and Goyal (2009).

$$Leverage = \frac{Total\ Debt}{Market\ Value\ of\ Assets}$$

$$Book\ Leverage = \frac{Total\ Debt}{Total\ Assets}$$

Where Total Debt, Market Value of Assets, and Total Assets are defined as follows, with numbers in parentheses corresponding to their respective Compustat item numbers.

$$Total\ Debt = Debt\ in\ current\ liabilities\ (34) + long\ term\ debt\ (9)$$

$$\begin{aligned} &Market\ Value\ of\ Assets \\ &\quad = \big(\ price\ close\ (199)\ \times share\ outstanding\ (54)\big) + Total\ Debt \\ &\quad + preferred\ liquidation\ value\ (10) \\ &\quad - deferred\ taxxes\ and\ investment\ tax\ credit\ (35) \end{aligned}$$

Total assets is Compustat item 6.

Control Variables in Leverage Equation:

My control variables are constructed based on previous studies, specifically those by Frank and Goyal (2009) and Chang et al. (2021).

The control variables are as follows:

- Profitability: to capture profitability, I define profitability as follow:

$$Profitability = \frac{EBITDA}{Total\ Assets}$$

- Size: To control for firm size

$$Size = Log(Total\ Assets)$$

- M/B Ratio: To control for growth opportunities, I use Market-to-Book Ratio.

$$MB\ ratio = \frac{Market\ Value\ of\ Assets}{Total\ Assets}$$

- Tangibility: To control for assets tangibility

$$Tangibility = \frac{Net\ property, plant, and\ equipment\ (8)}{Total\ Assets}$$

- R&D expense: To control for information asymmetry

$$R\&D\ expense = \frac{R\&D\ expense\ (46)}{Total\ Assets}$$

- Dividend Indicator: To account for the financial limitations and risks encountered by firms Chang et al. (2021). The Dividend Indicator is set to 1 if the firm has paid dividends, and 0 otherwise. I use DVPSP (Compustat Item 201) to define Dividend Indicator.

- Z Score: To control for risk, I include Altman's (1968) unleveraged Z-score according to Chang et al. (2021), which is defined as follows

$$Unleveraged\ Z\ score = \frac{(1.2\ \times A + 1.4\ \times B + 3.3\ \times C + 0.999\ \times D)}{Total\ Assets}$$

Where:

A is Working Capital

B is Retained earnings

C is EBIT

D is Sales

Dependent Variable for Equity Issuance Equation:

For defining equity issuance, I use the method that has been employed by Gatchev et al. (2009). According to them, equity issuance is defined as follows, with numbers in parentheses corresponding to their respective Compustat item numbers.

$$Share\ Repurchases = \ Purchase\ of\ Common\ and\ Preferred\ Stock\ (115) \quad (eq.15)$$

$$\begin{aligned} &Equity\ Issues\ (Net) \\ &\quad = the\ change\ from\ year\ t-1\ to\ t\ of\ Stockholder's\ equity\ (216\ ) \\ &\quad - Retained\ earnings\ (36) \qquad\qquad (eq.16) \end{aligned}$$

$$Equity\ Issues = Equity\ Issues\ (Net) + \ Share\ Repurchases \quad (eq.17)$$

Control Variables in Equity Issuance Equation:

I follow the approach of Gatchev et al. (2009) to construct my control variables. Some of these control variables, such as profitability, firm size, M/B ratio, and tangibility, have already been defined in the leverage equation. Leverage is also another control variable for this equation. Next, I will define the remaining control variables:

- Dividend:

$$Dividend = preferred\ Dividends\ (19) + \ Common\ Dividends\ (21) \quad (eq. 18)$$

- Income Available to Common and Preferred:

$$Income\ available\ to\ common\ and\ preferred = Retained\ Earnings\ (36) in\ year\ t\ - Retained\ Earnings\ in\ year\ t - 1 + Dividends$$

- Investment in Net Working Assets:

$$Investment\ in\ Net\ Working\ Assets = the\ change\ from\ last\ year\ to\ this\ year\ of\ [current\ assets\ (4) - cash\ and\ short\ term\ investment\ (1)] - [current\ liabilities\ (5) - Debt\ in\ Current\ liabilities\ (34)]$$

- Investment in Net Fixed Assets:

$$Investment\ in\ Net\ Fixed\ Assets = the\ change\ from\ last\ year\ to\ this\ year\ of\ Net\ property, Plant\ and\ Equipment\ (8)$$

Net Debt Issuance:

$$Net\ Debt\ Issuance = Debt\ in\ Long\ Term\ Issued\ - \ Debt\ in\ Long\ Term\ Retired$$

Other Variables:

Blue State: A state is classified as a Blue state if the Democratic party secured more electoral votes than the Republican party in at least four of the last five presidential elections (2004-2020).

Red State: A state is classified as a Red state if the Republican party secured more electoral votes than the Democratic party in at least four of the last five presidential elections (2004-2020).

Swing State: States that do not meet either criterion are categorized as Swing states.