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Essays on environmental regulations and performance of firms

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ESSAYS ON ENVIRONMENTAL REGULATIONS AND PERFORMANCE OF FIRMS

BY

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PREFACE

This dissertation consists of three essays that study the effect of external pressure and internal awareness on a firm's environmental performance, under information-based environmental regulations.

The first essay, "Neighborhood Characteristics, Media Attention and the US-Environmental Protection Agency's Toxic Release Inventory Program", explores the response of the national print media to the first wave of the Toxic Release Inventory (TRI) filings. It studies the degree to which neighborhood characteristics like racial composition and income status associate with the number of newspaper articles written about a polluting establishment, controlling for the volume of pollution, industry and observable establishment-level characteristics. The measure of media reports, gathered from the LEXIS-NEXIS database, identifies newspaper articles that mention specific polluting facilities in reference to the TRI program. Regression results, based on 1989 media reports that corresponded to the first release of TRI data, suggest that neighborhoods with a higher percentage of non-white population are more likely to be included in media reports, but the results are not consistently statistically significant across four different measures of media attention. Richer neighborhoods are positively and significantly associated with media attention.

The second essay, "Firm's Response to Media Attention under US-Environmental Protection Agency's Toxic Release Inventory Program", builds on the first one and asks whether initial media attention affects subsequent pollution behaviors. This essay examines the relationship between media attention and pollution behavior of TRI firms. Using a difference-in-differences approach, I find that firms with media attention are more likely to reduce emissions compared to those without media attention and the results are statistically significant. However, a two-stage estimation technique does not reveal any statistically significant causal effect of media attention, and the signs of the treatment effect are mixed. A matching technique produces a similarly insignificant treatment effect of media attention. Hence, while firms with media attention might behave differently in reducing future toxic releases, this study does not find evidence that such attention may cause reductions in toxic releases.

The last essay (co-authored with Robert D. Mohr) is centered on a controversial issue in environmental economics, the "Porter Hypothesis". The Porter Hypothesis argues that environmental regulations benefit firms by fostering innovation. This paper derives four examples consistent with this idea. Each example highlights either the distribution of benefits or costs, or the presence of some additional distortion, other than pollution. To emphasize that numerous such scenarios exist, examples are organized according to the list of market failures. Adding any one market failure creates the possibility that firms benefit from regulations. While each example can be fully consistent with the Porter Hypothesis, it is also possible that regulations benefit firms even without fostering innovation, a result that would be empirically difficult to distinguish from the Porter Hypothesis.

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ABSTRACT

ESSAYS ON ENVIRONMENTAL REGULATIONS AND PERFORMANCE OF FIRMS

by

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There has been a surge in the development of new, non-traditional and innovative approaches to address environmental problems in the last three decades of U.S environmental policies. These new approaches affect polluting behavior via instruments other than taxes, permits or direct imperatives. They rely heavily on active engagement, collaboration and information sharing among firms and industry peers. This dissertation adds to our current understanding of these newer approaches by studying how external pressures and internal awareness affect a firm's polluting behavior. Two essays focus solely on the role of the print media, an external pressure to firms, under the U.S Toxic Release Inventory program. It first studies the association of media attention with socio-economic characteristics to help explain some findings associated with "environmental justice". It then studies whether such external pressure imposes reputation costs on a firm so that it may change subsequent toxic releases. The last essay focuses on internal awareness and considers a hypothesis whereby certain flexible forms of environmental regulations can benefit regulated firms by fostering innovation. It is known as the Porter hypothesis. Regulations typically impose costs thereby decreasing a firm's profit

increasing opportunities. But this essay derives four examples consistent with the Porter hypothesis, within the standard assumptions of economic theory.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The last two decades have seen some notable trends in the development of environmental policy in the United States and across the globe. These include a greater emphasis on market-based instruments to control pollution, the emergence of policies to address global climate change, and a greater emphasis on recycling and waste management. Associated with these trends, there has also been a surge in the development of new and innovative approaches to address environmental problems. These new approaches complement existing policies by affecting the polluting behavior of firms via instruments other than taxes, permits or direct imperatives. Instead, these new policies attempt to improve environmental outcomes by actively engaging firms to reduce pollution, to collaborate with industry peers or to provide information about their polluting activities.

The economics literature has only gradually recognized this shift. The vast majority of theoretical and empirical work focuses on the more traditional, and better understood, environmental policies. While voluntary, collaborative and information-based policy tools have increasingly been used to address environmental issues, the effectiveness of such programs is often questioned and the impact of such programs is not well understood (Tietenberg 1998, Arimura et al. 2008, Brouhle et al. 2009). Only in the last decade has the literature on such voluntary, collaborative and information-based environmental policies gained significant momentum. The topics still lack in an accepted set of theoretical and empirical conclusions. This dissertation adds to that current understanding by providing three new research essays on information-based environmental regulations.

This dissertation contributes to the literature on information-based policies by arguing that information provision policies can affect the behavior and environmental performance of a firm by creating external pressures and raising internal awareness. External pressure comes in the form of community activists, shareholders, press, regulators, members of the supply chain, or even ordinary citizens demanding changes in the environmental performance of a firm (Tietenberg 1998, Sunstein 1999, Reinhardt 2000, Fung and O'Rourke 2000, Bennear and Olmstead 2008). Internal awareness can arise because an information provision policy forces facility managers to track and account for pollutants (Porter and van der Linde 1995, Hart 1997, Karkkainen 2001). Since pollutants can represent potentially-valuable production inputs that might be conserved, used more efficiently, or recycled, facility managers may discover opportunities to reduce releases of toxic pollutants in a way that imposes little or no cost. In fact, a number of case studies highlight scenarios where increased internal awareness simultaneously led to improved environmental performance and improved productivity for the facility. (Porter 1991, Porter and van der Linde 1995).

The new research in this dissertation consists of three separate studies, which are presented in chapters 2 through 4. The first two studies are empirical and focus on the external pressure associated with one of the most prominent information provision policies in the U.S, the Toxic Release Inventory (TRI). Chapter 2 studies a key source of external pressure: the role of the print media. It studies the degree to which neighborhood characteristics like racial composition and income status associate with print media attention. The goal is to study how the media responded to pollution news that may help explain some findings associated with "environmental justice", the concept that firms pollute more in poor and minority neighborhoods. If the media are less likely to report about toxic releases in such neighborhoods, and firms perceive negative publicity as a cost, then firms in poor or minority neighborhoods have an incentive to pollute more. This understanding of the behavior of the media not only sheds light on issues related to environmental justice, but also sets the stage to explore firm responses to media attention in Chapter 3. Chapter 3 studies how polluting facilities react after their TRI emissions are discussed in the print media. If media attention imposes costs on the firm, the firm may have an incentive to change its subsequent behaviors. This chapter studies how TRI-related media attention is associated with a firm's subsequent toxic releases.

Chapter 4 is a theoretical work that focuses on internal awareness. It considers a hypothesis put forward by Michael Porter, who argues that information provision policies as well as other flexible forms of environmental regulation can lead to new innovations and even benefit regulated firms. The idea is that when faced with regulations, sufficiently flexible firms can mitigate or even fully offset the regulatory costs by finding creative ways to solve their environmental problems. A good candidate for such "properly designed" environmental regulation is an information provision policy like the U.S Toxic Release Inventory (TRI). Porter emphasizes that "regulation focused on information gathering can achieve major benefits by raising corporate awareness" (Porter and van der Linde 1995). Referring specifically to the TRI, he argues that "information gathering often leads to environmental improvements without mandating pollution reductions, sometimes even at lower costs." (p. 100, Porter and van der Linde 1995).

Economists, like Palmer, Oates and Portney (1995), argue that environmental regulations, which are traditionally evaluated by comparing social costs and benefits, typically cannot generate such private benefits to firms. Regulations impose costs, and stricter regulations will only add greater constraints to the firm's profit increasing opportunities. But economic theory allows for a variety of ways where firms *can* benefit from stricter regulations. Critics have categorically overlooked such instances. Chapter 4 derives four examples consistent with the Porter hypothesis and explains these examples within the same framework that critics use to refute the Porter hypothesis. The results of the four examples are applicable not only to information-based policies like the Toxic Release Inventory but also to a broader set of environmental policies like market-based instruments (emission fees, auctioned or non-auctioned permits).

The rest of this chapter is devoted to a review of the literature on the main topics that are presented in the three essays of the dissertation, and explains how the research presented here builds upon and extends that prior literature. Specifically, the dissertation brings together and contributes to two key strands of the prior literature. The first one is the literature on the voluntary, collaborative and information-based environmental policies. This literature provides the context for Chapters 2 and 3 of the dissertation. These chapters extend our understanding of how firms respond to these new approaches of environmental regulation. These chapters specifically study the role of the print media in influencing firm behaviors under information provision policies. By studying the role of the print media and its association with socio-economic characteristics, Chapter 2 sheds light on "environmental justice" related issues, which was never studied from the standpoint of media activities. Chapter 3 studies the role of the print media in influencing subsequent pollution behavior. To my knowledge, only one other study analyses the effect of media attention on polluting behavior of firms. Since chapters 2 and 3 focus solely on information-based policies, the literature review will focus on results that allow us to understand firm responses under this policy. The literature review, however, will first present a broad overview of the voluntary, collaborative and information-based policies. This will help to understand how these policies work and how these types of polices may affect firm behavior.

The second literature that this dissertation contributes to is the literature on environmental competitiveness. The focus here is on the Porter hypothesis. The different examples presented in chapter 4 helps organize much of the existing literature on the Porter hypothesis and draws the examples from previously published research. The review presented surveys the literature related to the Porter hypothesis with a focus on the theoretical contributions.

The rest of this chapter is divided into five sections. The first section is devoted to an overview of the voluntary, collaborative and information-based environmental policies. The second section presents the US. Toxic Release Inventory program: its historical background, and some of the strengths and limitations of this program. The third section discusses the TRI program and its association with media attention and environmental justice related issues. This section also provides a brief preview of Chapter 2. The fourth section discusses the TRI and firm responses literature and highlights the question addressed in Chapter 3. The last section extensively surveys the theoretical literature on the Porter hypothesis and also touches upon the empirical literature on the hypothesis.

1.2 Voluntary, Collaborative and Information-based Environmental Policies

The innovative methods of environmental protection developed in the last two decades can be broadly categorized into voluntary, collaborative and information-based policies. Voluntary approaches, like U.S. Energy Star program, are programs that ask firms to voluntarily improve their environmental performance in exchange of benefits like recognitions, cost savings and regulatory relief (Bruijn and Norberg-Bohm 2005). Collaborative approaches, like the power sector's collaboration with U.S. Department of Energy, require explicit interaction between the private sector, the government, members in the supply chain (both with upstream suppliers and downstream customers) in the decision making process to meet environmental targets (Vachon and Klassen 2008). Mandatory information disclosure policies, like uniform eco-labeling of household appliances, rely on information affecting a host of intermediate actors like the press, local communities, consumers, peer firms, investors and the polluting firms themselves (Beierle 2003). Even though the voluntary and collaborative approaches do not mandate information dissemination, information sharing becomes an integral part of these policies in order to promote transparency in negotiations and monitoring of firm activities. In fact, voluntary and collaborative approaches are often considered complementary to information-based regulations.

Although these three approaches affect firm's polluting behaviors in different and unconventional ways, the main goal is to stimulate superior environmental performances via active involvement of the regulators, firms, and consumers. Such initiatives may lead to better solutions for the environment by building new relationships among the stakeholders, actively engaging the industry in the learning process, creating capabilities within firms, and creating first movers who would invest in business strategies to improve environmental performance (Bruijn and Norberg-Bohm 2005).

In voluntary approaches or agreements, a firm or group of firms voluntarily commit to make efforts towards meeting environmental targets, which are mostly set beyond regulatory compliance. Even though they are voluntary commitments, some commitments may be binding as they come under the threat of alternative legislative intervention. Depending on the degree of regulatory intervention, three types of voluntary agreements are identified (Glachant 2007). If firms agree to make abatement efforts to meet goals set by the regulator, they are known as *public voluntary agreements.* A classic example in this context is the EPA's first voluntary program, the 33-50 that was introduced in 1991. Under this program, EPA asked manufacturing establishments that were reporting to the TRI to take additional steps to reduce the aggregate emissions of 17 target chemicals by 33% in 1992 and 50% by 1995 (Gamper-Rabindran 2006).

A *negotiated agreement* is a type of voluntary agreement where firms and regulators jointly devise the commitments through bargaining. For example, in the 1990s the European Commission negotiated agreements with European, Japanese and Korean car manufactures to reduce new car CO_2 emissions (Glachant 2007). The third type of voluntary agreement is *self-regulation or unilateral commitments.* Here the polluter takes the initiative to control his environmental actions without any regulatory influence. It is a voluntary initiative, rather than an agreement. Chemical industries in 52 countries under the Responsible Care program have voluntarily taken the initiative to work through their national associations and companies to continuously improve their health, safety and environmental performance, and to communicate with stakeholders about their products and processes (Responsible Care 2010)[1].

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[1] A detailed survey of case studies on voluntary agreements is presented in Morgenstern and Pizer (2007) which specifically reports on voluntary agreements related to climate change. The OECD report (2003) and Bruijn and Norberg-Bohm (2005) cover a host of other voluntary agreements in the U.S and Europe. A survey of voluntary and information disclosure programs in developing countries is presented in Blackman (2009).

Collaborative approaches to environmental protection are defined as "direct involvement of an organization with its suppliers and customers in planning jointly for environmental management and environmental solutions" (Vachon and Klassen 2008). For example, Vachon and Klassen (2008) cite the case of Custom Print, a commercial printer located in Virginia, which reduced its wasted chemicals by working closely with its chemical suppliers (upstream in the supply chain). A thorough audit of its inputs inventory identified huge chemical stocks that were underutilized before expiration date and hence wasted. Collaboration with suppliers from the chemical industry improved utilization and lessened such wastes (EPA 1996). Collaboration between stakeholders can improve organizational capabilities and may translate into better environmental performance due to lower costs or improved resource productivity as suggested by Michael Porter.

Information provision or disclosure programs use environmental information as a strategy for improving environmental performance. The strategy is that disclosure of environmental information will trigger a complex web of communication and action among environmental groups, press, local communities, consumers, investors that may pressurize polluting firms to improve environmental performance. Negative recognition, an external pressure produced under such programs, can affect public awareness of a firm's actions which, in turn, can motivate the firm to change its environmental behaviors. Hamilton (1995a), Hamilton and Viscusi (1999) and Konar and Cohen (1997) all show that external non-regulatory pressure can affect firms financially: firms on the TRI list suffer significant losses in the stock market. Apart from external pressures, information-based policies also generate internal awareness about the way firms work. Information gathering may make them aware of some unutilized resources which can otherwise be allocated more efficiently.

The EPA's TRI is the most prominent and most studied information disclosure program. However, results from research about the TRI may have broader applicability. The success of the TRI led to the introduction of several other information disclosure programs in the United States. The Energy Policy Act of 1992 and 1996 required that household appliances like fluorescent and incandescent lamps, certain types of rechargeable batteries, showerheads, faucets and toilets must carry labels with information on energy efficiency, estimated annual energy costs, and water flow information. Safe Drinking Water Amendments in 1996 require that all community drinking water systems to mail their customers an annual report on the quality of water and level of contaminants (Portney and Stavins 2000).

Information disclosure programs have also been introduced in developing countries and for specific industries. Some of the prominent information-based programs in the developing countries are Program for Pollution Control Evaluation and Rating (PROPER) in Indonesia, and India's Green Rating Project. Lesser known but other prominent initiatives in the U.S. chemical industry are the Chemical Risk Management Plans, Materials Accounting and the Sector Facility Indexing Project[2]. Chemical risk management plans provides detailed information on chemical

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[2] A detailed survey of these programs is presented in Beierle (2003).

accident risks and prevention. The Materials Accounting program provides information on how chemicals traveled through process at industrial facilities. The Sector Facility Indexing Project consolidates enforcement, compliance and other data into a package of environmental performance indicators.

1.3 Toxic Release Inventory

1.3.1 Background

The most prominent and structured information disclosure program in the United States is the Toxic Release Inventory (TRI). A variety of federal and state laws since the 1960s attempted to collect information about toxic chemicals from corporations, government and other organizations. These laws were part of a broader effort to assess the risks associated with such toxics, and impose bans and limits on their use. But there were concerns that such information would reveal business trade secrets and may not create the right incentives for businesses to reduce pollution. By the early 1980s, the idea that a community has the right to know about toxic pollution in their neighborhood started gaining national awareness. Such attention was further intensified by major chemical accidents in the early 1980s. The Bhopal gas tragedy in 1984 in one of Union Carbide's chemical plants in Bhopal, India, and other less serious chemical leaks at Union Carbide's plant in Union, West Virginia in the next two years raised public concern about potential dangers of accidental pollution. In response to these concerns, Congress passed the Emergency Planning and Community Right-to-Know Act in 1986 which aimed at protecting public against chemical accidents[3].

The Toxic Release Inventory (TRI) is a provision under this Act. Under this provision, detailed information about the toxic releases and transfers of manufacturing facilities (under certain Standard Industrial Classification (SIC) codes) are routinely made publicly available via a database maintained by the Environmental Protection Agency (EPA)[4]. This database is known as the Toxic Release Inventory database. This database contains information about release of toxic chemicals for each calendar year, by facility and by chemical. At the time of inception, manufacturing facilities that employed more than 10 full-time employees and manufactured or processed more than 25,000 pounds, or used more than 10,000 pounds of the 320 listed chemicals had to report to the EPA annually via a standardized form known as Form-R. Once establishments collect this information, it is sent to the EPA, where it takes about two years to clean the data and put them into publicly accessible databases.

The TRI, since its inception in 1988, has gone through some major changes. One important change is in the list of chemicals, which has expanded over time to include some carcinogenic and persistent bioaccumulative chemicals (PBT). Currently the list contains 600 listed chemicals. Seven new industry sectors have been added in 1998, thereby expanding the scope of the program to other polluting industries. While there has been no change in the frequency of reporting, in 2006

[3] For a detailed survey on the background of the TRI refer to Greenwood and Sachdev (1999).
[4] Federal facilities are not required to report to the TRI.

the Bush administration proposed changing the reporting requirement from annual to biennial, in order to save administrative costs. There were also talks about raising the threshold of the toxic chemicals. The goals for these changes were to save millions of dollars in administrative costs by the EPA and information gathering costs on the part of the companies. Even though the proposal was rescinded in 2009, it did underscore the large gaps in understanding the effects of this program.

1.3.2 Strengths and Drawbacks of the TRI

The TRI's claim to success is that the program led to significant drop in the release of toxic chemicals, nearly half in ten years compared to 1988, the baseline year (EPA 2000, Marchi and Hamilton 2006). Most of these cuts were observed in the first three years of its inception. However, the success story is rather complex and highlights the strengths and limitations of the program. While the toxic releases have decreased, toxic waste generation has increased (Poje and Horowitz 1990, Daniels and Friedman 1999)[5]. While there were decreases in carcinogens, there were changes in geographical areas where these toxic releases were concentrated (Hamilton 1999, Hamilton and Viscusi 1999). As Chapter 3 will highlight, it is very difficult to know if this decline is causally linked to the implementation of the program.

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[5] The relationship between toxic wastes and TRI releases is that 10 percent of toxic wastes are released while the rest is either recycled (45%) or treated (25%) or burned for energy recovery (16%) (Graham and Miller 2001).

The program's strength lies in the rather unconventional ways in which it provides incentives to businesses to change their polluting behavior. Since businesses are required to gather information about their toxic releases from all establishments and from all mediums into which toxics were released, it gives company executives the chance to get a complete picture of the toxic pollution created by their company and their internal waste management practices. Under normal circumstances, information about waste disposal and costs associated with it might be entered as overhead costs, filed away and never evaluated.

Since the summary of toxic releases had to be sent to the EPA for public dissemination, it inevitably produced national and local level awareness about top polluters. Lists of top polluters were generated, local and national newspapers covered news on the TRI polluters or defaulters who failed to report to the TRI, and it created incentives for citizen action at several levels. In general, it created public pressure that was external to the firm. Companies now had a chance to evaluate their relationship with peer firms, surrounding communities, local pressure groups and the press to minimize this public reaction (Graham and Miller 2001). Stakeholder and investor reactions also warranted them of their public image as potential polluters and the associated negative recognition costs.

The program also has some limitations. Under the provisions made by the program, only big manufacturing establishments report to the TRI. Even though seven industry sectors were added in 1995, they belonged to the manufacturing sectors. Mobile sources of toxic pollution like cars and trucks or small businesses may also be highly polluting but they are not required by the program to report to the TRI (Graham and Miller 2001, Daniels and Friedman 1999). The list of toxic chemicals is rather small. There are more than 300 harmful substances that are generated by industrial activities in the United States. But only a small fraction of these chemicals are subject to reporting (Daniels and Friedman 1999).

Perhaps the biggest limitation about the TRI database is that the toxic releases are self-reported. It raises questions about non-compliance and accuracy of the data. Nearly one-third of establishments that were required to report under the TRI program did not file reports in the first wave of TRI reports. Several outreach efforts by Minnesota environmental regulators in 1990 forced one-fourth of non-complying Minnesota facilities to report to the TRI, but these facilities accounted for a small percentage of the total toxic releases in Minnesota (Brehm and Hamilton 1996). This study concluded that this type of non-compliance was prevalent in the early years of the TRI program and that such non-compliance can be attributed to ignorance of reporting requirement rather than "strategic evasion" (Brehm and Hamilton 1996). Under the TRI program, there are provisions for environmental compliance inspections and civil penalty from violation of the reporting requirements. But legislative standards are not available to check the accuracy of the reported data.

The self-reported nature of the program and lack of regulatory monitoring raises questions about the accuracy of the reported data. Researchers and environmental groups have argued that there are potential for firms to overestimate or underestimate the TRI figures. Poje and Horowitz (1990) and US EPA (1993) survey analysis show that while half the changes in TRI figures came from real changes in toxic releases, the rest came from changes in reporting requirements, changes in production volume and changes in paperwork.

Site survey studies by EPA to verify the accuracy of the reported TRI data revealed that in the early years of the TRI program some establishments had difficulties in determining whether their chemical use surpassed the threshold or how to measure their chemical uses. In such instances, most establishments have used guesswork in reporting (US EPA 1990, US EPA 1998a, US EPA 1998b). Such guesswork may have led to an overestimate or underestimate of the reported figures, thereby introducing potential inaccuracies in the TRI data. EPA, in subsequent years, removed the 1987 TRI reports from the database.

Several research methods are available to check the accuracy of such self-reported data (Marchi and Hamilton 2006). A comparison of change in average TRI emissions in 1988-1990 with the same in 1998-2000 reveal that large reductions in firm-reported TRI chemicals, like nitric acid and lead, are not supported by EPA's chemical monitoring data (Marchi and Hamilton 2006). Despite the limitations in the data, the TRI database is the most comprehensive source of information about toxic releases and it has been extensively used by researchers. EPA conducts data quality audits on a regular basis that are helping to improve the quality of the TRI data.

Another weakness of the TRI program is that the listed chemicals and the way the toxic releases are reported in the database do not reflect the toxicity or the harmfulness of the chemicals (Daniels and Friedman 1999, Szasz and Meuser 1997). The total volume of toxic releases or changes in the volumes of toxic releases is not informative about the public health hazards. It would be more informative, for the general public, health officials and researchers, to have some idea about the toxicity of the chemicals or the risks associated with exposure to these listed chemicals. Also since reporting does not collect information about chemical use (to protect trade secrets), there is no incentive to reduce waste at the source, which is considered more efficient than "end-of-pipe" reductions (Graham and Miller 2001, Daniels and Friedman 1999, Poje and Horowitz 1990).

In highlighting some of the design limitations of the TRI, Graham and Miller (2001) points out that given the structure of the program, establishments may resort to quick fixes rather than finding permanent solutions to their pollution problems in order to stay off the list of top polluters and avoid negative publicity costs. Resorting to quick fixes in the face of external pressures may help explain some unfavorable environmental outcomes associated with this program.

Under the TRI program, firms are not restricted by the medium into which they release their toxic chemicals or how much each TRI facility can release. Firms, therefore, can release their toxic chemicals into the air, water, land or transfer them offsite. Such flexibility in the disposal of toxic releases can lead to unfavorable outcomes. Reports from the US Government Accounting Office (US GAO) and United

Christ of Church (UCC) in the early 80s showed that there was an unfavorable trend in the distribution of toxic releases. GAO and UCC not only document the trend in the distribution of toxic releases but the reports also show that poor and minority communities were associated with exposure to large volumes of toxic releases. The literature uses the term "environmental justice" to identify such occurrences.

1.4 Toxic Release Inventory, Environmental Justice and Media Attention

The roots of the environmental justice movement can be traced back to the Civil Rights Movement in the United States between 1950s and 1970s. The Civil Rights Movement pressed for social changes to abolish discrimination against the racial minorities through grassroots activism. Similar methods of persuasion were used to raise awareness about environmental issues related to the poor and racial minorities. The landmark event that laid the foundation of the environmental justice movement in the United States was the dumping of PCBs in a landfill in Warren County, North Carolina (Szasz 1994). Thousands of gallons of PCB-contaminated transformer oil that were well beyond the proposed landfill capacity were dumped along hazardous waste landfill in this county. The population of Warren County, who were predominantly poor African Americans, protested this continued landfill via organized meetings, lawsuits and protests that led to civil unrest and mass arrests in 1982. Similar grassroots environmental activism was experienced in the Love Canal disaster in New York in the late 1970s (Cole and Foster 2001). Protests following the discovery that houses were built on toxic waste dumps led to the evacuation and relocation of residents of Love Canal. These and similar other incidents at the grassroots grew from local conflicts to issues of national and international interest.

The leaders of these civil confrontations were longtime Civil Rights activists, were mainly church-based and had pioneered important findings about the unequal distribution of environmental damages among the minorities. In 1983, following the request of a leader of the Black Congressional Caucus, Walter Fauntroy (who was then a Warren County arrestee), the US Government Accounting Office (US GAO) conducted a study to examine the demographics of communities near large commercial hazardous waste landfills in the United States (Foster and Cole 2001). The GAO study revealed that three out of four landfills were located in predominantly black communities (US GAO 1983). Robert Bullard's work on land use patterns in Houston, Texas revealed that 21 out of 25 of Houston's garbage dumps were located in black neighborhoods in the late 1970s (Bullard 1983). United Church of Christ (UCC) published a report in 1987, *Toxic Wastes and Race in the United States*, which concluded that "indeed, race has been a factor in the location of commercial hazardous waste facilities in the United States" (p. 15, UCC 1987).

A review of the literature on environmental justice revealed that the above three works are typically listed as the seminal work that set the stage for future research in this field. It is mainly due to their relevance to the Warren County incidents in 1978 and also the timing of their publication. But some isolated studies conducted in the 1970s show that scholarly interest in environmental inequality existed even prior to the 1980s. These works, mostly conducted by economists, study the relationship between poverty and exposure to polluted air. Freeman (1972), Zupan (1973), Berry (1977), Asch and Seneca (1978), Gianessi et al. (1979), all show a consistent pattern in the relationship between social groups and their exposure to polluted air.

The findings of the three seminal works: the US GAO report (1983), Bullard (1983) and the UCC reports (1987), triggered broader scholarly interest in the area of environmental inequality. In 1990 a group of academicians, headed by Robert Bullard and Bunyan Bryant, organized a Conference on the Race and the Incidence of Environmental Hazards at the University of Michigan. The goal was to bring together and share the latest findings of researchers, professors, activists and state and federal officials on the issue of environmental inequality. In an article that reviews the studies presented at this conference, Bryant and Mohai (1992) conclude that the inequitable distribution of pollution can be attributed to both income level and racial composition, but race has been found to be major determinant of such inequitable distribution of pollution.

The discussions at this Michigan conference, and later correspondences between federal officials at the U.S Department of Health and Human Services, U.S Environmental Protection Agency and members of the conference led to the creation of EPA's Work Group on Environmental Equity. This work group was later renamed as the Office of Environmental Justice in 1993 (Cole and Foster 2001).

A significant body of scholarly work on environmental justice proliferated in the 1990s with parallel studies by economists, sociologists, demographers, political scientists and geographers. This period saw the emergence of a multi disciplinary interest in environmental inequality research. Some notable works in the field of sociology between 1987 and 1999 by Frey 1987, Frisbie and Kasarda 1988, Capek 1993, Massey and Denton 1993, Bullard 1995, Cable 1995, Pollock and Vittas 1995, Hurley 1995, Markham and Rufa 1997, Boer et al. 1997, and Ringquist 1997, Szasz and Meuser 1997, Daniels and Friedman 1999 provide in-depth discussions on the how the concept of environmental justice evolved over time, its historical background, and provide consistent evidence of environmental inequality through their empirical work and case studies.

During the same period, economists' interest in this topic can be witnessed from the works of Smith and Devousges 1986, Gregory and Smith 1990, Zimmerman 1993, Perlin et al. 1995, Kohlhase 1991, Hird 1993, Been 1994, Krieg 1995, Hamilton 1995b, Kriesel et al 1996, Been and Gupta 1997, Brooks and Sethi 1997, Arora and Cason 1999. Compared to the 70s work by economists, these studies were more sophisticated in their approach; partly due to the advances in the field and partly due to the availability of comprehensive datasets on pollution like the US EPA's Toxic Release Inventory. But the results on the evidence of environmental inequalities were consistent between the older and newer studies.

Studies by Stafford 1985, Langford and Unwin 1994, Bowen et al. 1995, Glickman et al. 1995, Pulido 1996, Pulido et al. 1996, Cutter et al. 1996, Chakraborty and Armstrong 1997, McMaster et al. 1997, Scott et al. 1997 show the growing interest among geographers and demographers in environmental justice. These studies emphasize the importance of geographical units in analyzing environmental inequality related issues, since studies conducted at different levels of spatial measures have revealed contrasting results.

While most studies in the 1980s showed a strong correlation between socio-economic characteristics and exposure to pollution, researchers in the 1990s started questioning the history of the host community at the timing of siting. It seemed rather important to explore this history as it is plausible that the demographics may have changed overtime (due to migration, market forces, job creation, cheaper amenities), since industrial activity started in the host community. The 1990s and the 2000s saw a surge in the number of studies that explored the question of time of siting, as it holds clues to why some communities are subject to inequitable distribution of pollution.

Prominent among such studies is a study by Been (1994), which re-examined the studies of Bullard (1983) and the GAO report (1983). His re-examination confirmed the results of both these studies, and also highlighted that at the time of the siting the host communities were predominantly non-white (Been 1994). In subsequent years, similar studies on the time of siting and prevalence of environmental justice find that racial composition of neighborhoods cannot explain firm location decisions, but this decision is often influenced by the income status and the political mobilization of the neighborhood (Wolverton 2009, Davidson and Anderton 2000, Been and Gupta 1997, Kriesel et al. 1996). This view is also supported by Hamilton (1995b) and Gamper-Rabindran (2006) who found that voter participation, and economic status, but not race influence broader measures of environmental outcomes. Arora and Cason (1999) and Fricker and Hengartner (2001), however, found that either racial composition or a combination of both race and income status might be important factors in determining the distribution of TRI emissions. They found significant increases in toxic releases in the South, and non-urban areas, with a pre-dominantly higher percentage of ethnic minorities.

Chapter 2 extends this literature on environmental justice and TRI with a focus on the role of the print media. One of the design limitations of the TRI is that firms may resort to quick fixes to avoid the costs associated with non-regulatory external pressures, like the press and media attention, instead of investing in more permanent solutions. I hypothesize that if media attention is associated with neighborhood characteristics, then firms may resort to fixes like redistributing their production (and hence, toxic releases) among the establishments to minimize the costs of public reaction. Firms may decide to pollute more in neighborhoods where the cost of external pressures, like media attention, are minimized.

This chapter explores the response of the national print media to the first wave of the Toxic Release Inventory (TRI) filings. It studies the degree to which neighborhood characteristics like racial composition and income status associate with the number of newspaper articles written about a polluting establishment, controlling for the volume of pollution, industry and observable establishment characteristics. The measure of media reports, gathered from the Lexis-Nexis database, identifies newspaper articles that mention specific polluting facilities in reference to the TRI program. Regression results, based on 1989 media reports that corresponded to the first release of TRI data, suggest that neighborhoods with a higher percentage of non-white population are more likely to be included in media reports, but the results are not consistently statistically significant across four different measures of media attention. Richer neighborhoods while positively associated with media attention are statistically significant.

1.5 Toxic Release Inventory and Firm Responses

External pressures under information-based environmental policies can manifest itself as community pressures, investor reaction, consumer reaction and media activity (Tietenberg 1995, 1998). These public pressures are expected to impose costs on the firms so that they alter their polluting behavior. The empirical literature on public disclosure programs has mainly focused on the capital market to evaluate the effectiveness of such programs. Capital market reaction to public disclosure of environmental performance shows that these markets are quite sensitive to environmental news. Capital markets respond positively or negatively depending on whether the environmental performances of the companies were superior or poor.

Empirical studies on the capital market reaction to environmental news or public disclosure show that it affects stock market prices. Hamilton (1995a) shows that public provision of TRI reports is "news" to both journalists and investors. Big TRI polluters caught the attention of media, and these big polluters also experienced significant losses at the stock market. According to this study, TRI firms experienced an estimated loss of $4.1 million on the day the TRI figures were published for the first time. Cañón-de-Francia et al. (2008) study the first European public disclosure program, European Pollutant Emission Register (EPER) and the effect of information disclosure under this program on the reaction of shareholders. They conclude that like the U.S TRI program, new pollution information under the EPER program has a significant negative impact on the market value of listed firms. LaPlante and Lanoie (1994) study how shareholders of Canadian firms update their expectations following the announcement of environmental incidences, lawsuits and settlement of lawsuits on the firm's equity value, and finds a shareholders react negatively to such incidences and equity values drop.

Stock market reactions can subsequently affect firm's pollution behavior. Khanna et al. (1998) examine the effect of investor reactions to environmental information on firm's subsequent performance. They find that repeated disclosure of environmental information results in significant losses to these firms and that they subsequently change the way they dispose toxic chemicals. Konar and Cohen (1997) finds that firms with the largest stock price decline on the day the TRI reports became public subsequently reduced emissions more than their industry peers. These studies highlight that external pressures like investor reaction can affect firm's output decisions.

While the focus has largely been on the stock market reaction to public disclosure, some studies explore the association between public disclosure and the goods market. Arora and Gangopadhyay (1995) find that firms under public disclosure programs may over-comply with regulations to attract "green consumers". Firms attempting to "to gain more contact with final consumers" have also been found to enroll in the 33-50 program under the TRI provision (Khanna and Damon 1999, Arora and Cason 1996).

Chapter 3 extends this literature that study how external pressures under information-based policies influence firm level polluting behavior. The role of the media in exerting external pressures to alter a firm's output decision is largely unexplored. Dasgupta et al. (2006b) is the only study to my knowledge that highlights the role of media attention on a firm's environmental performance. Using survey data from industrial facilities in South Korea, they show that environmental news and a firm's awareness of such media attention are important predictors of firm's performance. Media activity can impose negative publicity cost and such costs can alter a firm's behavior

Chapter 3 examines the relationship between media attention and pollution behavior of Toxic Release Inventory (TRI) firms. I find that firms with media attention are more likely to reduce emissions compared to those without media attention and the results are statistically significant. However, the results do not reveal any statistically significant causal effect of media attention. I find that firms with media attention might behave differently in reducing future toxic releases, but there is no evidence that such attention may cause reductions in releases.

1.6 Environmental Competitiveness and Porter Hypothesis

The conventional view of the relationship between environmental regulations and competiveness of firms is that regulations impose costs on firms which leads to a loss of competiveness. With a regulation, resources need to be diverted towards meeting environmental standards, thereby raising the direct expenditures on pollution reduction and the indirect cost of paying higher prices for inputs affected by regulation. These higher costs are reflected in higher prices of the firm's product and hence, a loss of competitiveness.

In an international trade setting, stringent regulatory standards for the domestic firm impose costs on domestic firms. These high costs result in higher prices for goods produced by domestic firms compared to other countries with lax environmental standards. This loss of competitiveness in the international markets is reflected in shifts of the trade flow, where exports of the regulated good decline over time and imports increase, thereby adversely affecting the net exports of the domestic country. Given the spatial nature of competition, strict regulation may also lead to a movement of production capacities from the domestic to foreign locales where the production costs are low and firms have a better access to markets (Jaffe et al. 1995).

Loss of competition can also be reflected in productivity losses in the exporting sectors. Since resources are now used to produce environmental quality, (not output) and typically environmental quality is not included in measures of productivity, it is expected that stringent regulations will lead to loss of competitiveness (Jaffe et al. 1995). Loss of U.S competiveness in the international market in the 1990s, especially in goods produced in the pollution-intensive sectors, led to concerns about the high environmental standards set by the United States. The conventional view was that relaxing the standards might help improve competitiveness. So, when it came to signing the Kyoto protocol, where the goal was to systematically reduce the emission of greenhouse gases, the U.S signed the amendment along with all other nations but failed to ratify it.

This conventional view on environmental competitiveness and regulations was challenged by Michael Porter, a business professor at Harvard University, in the early 1990s. In *Scientific America* (1991), he suggested that more stringent regulations can improve international competitiveness. His argument is that stringent regulations do impose costs and make firms less competitive, but only if the regulation involves "optimizing within fixed constraints" (Porter and van der Linde 1995). Instead, if the focus is on outcomes and not setting standards, firms will have greater flexibility in deciding how to control pollution. This flexibility, in turn, may help firms to locate new cost reducing or revenue improving opportunities.

According to Porter, pollution "is a manifestation of economic waste and involves unnecessary or incomplete utilization of resources… (hence) reducing pollution is often coincident with improving productivity with which resources are used." (p. 105, Porter and van der Linde 1995). If firms are given the flexibility to decide how to control pollution, then it may encourage firms to reduce expenditures on materials, energy and service usage, stimulate them to "re-engineer their technology" and such innovation may offset the cost of compliance and may even generate private benefits to firms (Porter 1991).

The environmental-competitiveness debate drew attention from leading environmental economists. A typical economic model assumes that firms maximize profits under the assumption of perfect information and all possible avenues of innovation have already been explored, at least to the point where a priori profitable innovations are identified. In such a scenario, stringent regulation will surely raise costs and hamper a firm's competitiveness. Palmer, Oates and Portney (1995), for example, illustrate this by using a simple theoretical model where they show that if new and efficient technologies are available to the firms before stringent regulations are imposed and they do not adopt such technologies, then stringency would not change the adoption decision and generate higher profits.

Porter argues that his view of competiveness is rather "dynamic" than "static". In a dynamic framework, there is "incomplete information, organizational inertia and control problems" which result in firms underutilizing their resources (Porter 1995). Thus, Porter claims that stringent regulations will push firms towards discovering ways to eliminate resource inefficiencies and improve organizational inertias which would lower production costs and improve competitiveness. He supports his conclusion with case studies which show that stricter standards force firms to explore new and efficient avenues to meet their environmental obligations and in the process generate benefits.

Case studies, both from Porter's examples and others, highlight the range of applicability of the hypothesis. Robbins Company, a jewelry company in Massachusetts, was facing violation charges for discharging dirty water beyond what permits allowed and was on the verge of a closure. The company adopted a zero-discharge system for handling water used in plating jewelry. This system not only reduced water discharge, but also improved the quality of its plating with fewer rejects (Berube et al. 1992). While implementing ISO 14001, General Motors managers at its Flint plant in Michigan realized that they could have saved approximately $250,000 by systematically shutting down machines during weekends or holidays (El Bizat 2006). With the switch to SO_2 allowance trading from technological standards, U.S firms not only experienced reduced compliance costs, but it also stimulated innovation and organizational changes and improved competition in their inputs market (Burtraw 2000).

Given that Porter's hypothesis was based on case studies, critics argued that a scenario consistent with the hypothesis could be an exception to the rule. While Porter's view was well received in the business community, it drew criticisms from economists mostly because they were opposed to the idea that firms operate sub-optimally and that a strict regulation would force them to explore such inefficiencies. In spite of the initially skeptical response by economists, several theoretical papers do show that regulations may improve competiveness by correcting more than one market failure at a time. These instances may be very restrictive, but they show that theoretically results consistent with the Porter hypothesis are plausible.

Barrett (1994) and Simpson and Bradford (1996) show that strategic behavior between firms or between firms and regulators in the face of strict environmental standards can produce results consistent with the hypothesis. Under restrictive conditions, they show that imposing strict environmental standards may provide strategic advantage to firms to invest in research and development to reduce marginal costs. These cost reduction avenues may generate profits.

Rege (2000) explores the possibility that addressing asymmetric information about the environmental quality of goods may result in a scenario consistent with the Porter hypothesis. She shows that regulations which force firms to provide credible information about the environmental quality of their products, like eco-labeling, can enhance competitiveness by increasing consumer's awareness about green products and enhancing their willingness to pay for such products. Ambec and Barla (2002) develop a similar principle-agent model where firm managers have private information about the outcomes of a research and development investment. In such a scenario shareholders must pay a rent to extract that information. Such "information rent" reduces the incentive to invest in research and development (Ambec and Barla 2002). Regulation is shown to reduce this rent and increase investment in research and development and create a scenario consistent with the Porter hypothesis.

Xepapadeas and Zeeuw (1999) examine the effect of emission tax on the composition of capital. They show that emission taxes may lead to a change in the composition of capital whereby old vintage capital may retire. This improves the average productivity of capital, a scenario conducive to generate results similar to the Porter hypothesis. Mohr (2002) points out that with accumulated experience firms may develop new environmental technologies that have non-excludible benefits. No single firm would be willing to adopt this new technology though, as the learning cost of the first adopter will be higher than the followers. A stringent regulation in such a scenario may force adoption and generate a scenario consistent with the Porter hypothesis.

Greaker (2006) points out that innovation will led to the development of new markets upstream in the supply chain, where the high cost of adoption will bar entry into these markets. With regulation and entry, the cost of adoption in these new, upstream markets will drop, thereby increasing the supply of abatement equipments and lowering its price to customers (firms) downstream. Andre´ et al (2009) uses a framework similar to Mohr (2002) where firms are strategically unwilling to adopt a technology to produce green goods, as the first-mover loses competition to producers of similar, non-green goods. But a regulation will force firms to adopt the technology, and at the same time, gain from the consumer's high willingness to pay for such products, a scenario similar to Rege (2000).

A common feature of these theoretical instances is that in order to generate a scenario consistent with the Porter hypothesis there should be presence of additional market failures, apart from pollution (Hart 2004). Chapter 4 uses the intuition behind the different theoretical examples discussed above and introduces market failures into the same model that critics used to refute the Porter hypothesis. The examples discussed in chapter 4 generate results consistent with the hypothesis. Adding a market failure, like imperfect competition, negative production externalities, asymmetric information and public goods, creates the possibility that firms benefit from regulations. While each example can be fully consistent with the Porter Hypothesis, Chapter 4 highlights that it is also possible that regulations benefit firms even without fostering innovation, a result that would be empirically difficult to distinguish from the Porter Hypothesis.

Although this dissertation does not explore the Porter hypothesis empirically, it sets the stage for future research in this direction. The empirical literature on the Porter hypothesis is growing rapidly. Most empirical papers that claim to be a test of the Porter hypothesis may not be a direct test of the hypothesis. Our definition of the Porter hypothesis in Chapter 4 rests on two important factors. First, a strict environmental standard should promote innovation. Second, such innovation should partly or fully offset the cost of complying with the regulation, thereby creating the possibility of generating profits.

Most of the empirical literature on the Porter hypothesis tests parts of these links or directly studies the effect of regulation on profitability. Ambec and Lanoie (2008) make this distinction clear and classify the empirical literature into two broad sets. One set studies the effect of environmental regulations on innovation, and the other set studies the effect of environmental regulations on firm's performance, using productivity or costs as a measure of a firm's financial performance. There are very few studies that test that full causal link of the Porter hypothesis.

Studies on the effect of environmental regulations on the innovation or innovation related activities find that stringent regulations enhance innovation. The degree of association between regulation and innovation may be weak but, in general, there is a positive link. Jaffe and Palmer (1997) find that environmental stringency measured by pollution abatement cost increased expenditures on total research and development. Brunnermeier and Cohen (2003), instead of looking at the total research and development expenditures focus on green patents, and find that regulations lead to an increase in environmental patenting. Carrion-Flores and Innes (2010) explore the casual link between regulation and innovation using a panel data of manufacturing firms and finds that strict regulation leads to environmental innovation, and such innovation leads to reduced pollution.

Studies on the performance of firms, especially productivity, in response to environmental regulations present mixed results. While Gollop and Roberts (1983) show that U.S. productivity growth slowed down following the SO_2 regulations, Berman and Bui (2001) show that stringent air pollution standard increased the productivity of oil refineries in Los Angeles compared to other oil refineries in the U.S. Alpay et al. (2002) find increases in productivity in the Mexican food processing industry in the face of stringent regulations. These studies, however, do not explore the exact mechanism of such productivity gains. For a direct test of the Porter hypothesis, productivity gains should result via innovation or innovation related activities.

To my knowledge, the only two studies that explore the full link are studies by Lanoie et al (2007) and Rassier and Earnhart (2010). Lanoie et al (2007) find that environmental regulation enhances spending on research and development, but net effect of such expenditures on a firm's performance is negative. Rassier and Earnhart (2010) study the effect of water regulation on the profitability of firms in the chemical manufacturing industries and find that profitability drops, as costs increase for a given level of sales.

1.7 Conclusions

The rest of the dissertation consists of four chapters. Chapter 2 explores the factors that determine media attention in the event of new pollution information being made publicly available via the TRI database. It specifically explores whether socio-economic variables like race and income status matter in pollution news, apart from pollution variables. Chapter 3 explores the association between external pressure, like TRI pollution-related media attention, and a firm's pollution behavior. Chapter 4 presents four theoretical examples where improved internal awareness of a firm in the face of a regulation can benefit firms. Chapter 5 presents extensions and future directions of the current research.

CHAPTER 2

NEIGHBORHOOD CHARACTERISTICS, MEDIA ATTENTION AND THE US-ENVIRONMENTAL PROTECTION AGENCY'S TOXIC RELEASE INVENTORY PROGRAM.

2.1 Introduction

The Environmental Protection Agency (EPA) eased its reporting requirements under its Toxic Release Inventory (TRI) program in November 2006. The TRI requires all polluting firms to publicly report their toxic releases annually. The revised policy proposed to raise the threshold of releases that trigger mandatory reporting and ease reporting requirements from annual reporting to biennial. The EPA justified this change, arguing that it would save millions in compliance costs in each non-reporting year. However, critics feared that this change would weaken the effectiveness of the program, arguing that relaxed reporting requirements would imply lesser accountability for the polluting firms, lesser public scrutiny, and unfavorable environmental outcomes. Even though the proposal was rescinded in 2009, the question still lingers as to what role public scrutiny plays in this unconventional regulation.

In order to understand the implications of these reforms, a clear understanding of how this program works is necessary. The general idea is that negative publicity imposes costs on polluting firms, which would provide incentives to modify polluting behaviors (Khanna et al. 1998, Arora and Cason 1999). This paper studies the role of the national print media activity in generating such negative publicity. Specifically, it studies how the media historically responded to the first wave of the TRI reports. With limited preconceived notions about the polluting behavior of facilities around the early years of TRI reporting, media responses to this report provide a rare opportunity to isolate and study the behavior of the media to pollution news. The results may help explain some findings associated with "environmental justice", the concept that environmental costs and benefits should be equitably distributed regardless of race, color, income, educational level or national origin. If the media are less likely to report about toxic releases in such neighborhoods, and firms perceive negative publicity as a cost, then firms in poor or minority neighborhoods have an incentive to pollute more (or abate less). This understanding of the behavior of the media, therefore, goes beyond environmental justice and sets the stage to explore firm responses to media attention in Chapter 3[6].

While prior studies highlight the behavior of the firm in explaining environmental justice outcomes, none to my knowledge explore the role of media as a potential explanation for disproportionate environmental harms on poor and minority neighborhoods. Media reporting plays an important role in providing

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[6] The link between media attention and incentives to pollute is explored in more details in Chapter 3. The existing literature shows that media attention related to toxic releases does appear to impose costs on firms. The fear of negative publicity can explain financial market outcomes (Hamilton 1995a, Konar and Cohen 1997) and influence corporate environmental decisions (Arora and Cason 1999, Khanna and Anton 2002, Anton et al. 2004, Gamper-Rabindran 2006).

information to the public and thereby influencing both "individual and collective decisions" (Baron 2006). If a lower probability of media attention provides incentives to firms to pollute more in poor neighborhoods, then "environmental justice" outcomes may partly be attributed to media practices. And there are reasons to believe that media reports may have some bias in reporting. It could arise from the supply-side and demand-side of news reporting.

There are a number of reasons to believe that neighborhood characteristics like income or racial composition will affect the media's decision to report on a particular polluting establishment. A number of authors (Bennett (1988), Wilson and Gutiérrez (1995), Entman and Rojeck (2000) Baron (2006), and Groseclose and Milyo (2005)) provide supply-side explanations of media bias where news content reflects the preferences and worldviews of reporters, editors and the newspaper owner. Bias may reflect ideological positions on public policy issues. Journalists working for such profit maximizing newspaper companies may even bias their stories to reflect the ideological beliefs of the news organization (Baron 2006). A newspaper organization with a liberal stand on public policy issues may have greater news coverage on issues related to the poor and racial minorities.

While ideological bias might make news organizations more likely to report on poor or minority neighborhoods, the motive of profit maximization might lead them to report less on these neighborhoods. News organizations are profit-maximizing firms that cater to the demands of their clienteles. News is a business that sells its audience to advertisers. A larger audience generates more television revenue via advertising. Since demographically the largest audience in the U.S. has been the white and middle-class (Larson 2006, Shirley 1992), reporting about poor and minority neighborhoods may not appeal to readers. Furthermore, the costs of reporting about pollution in high-income neighborhoods might be lower. If higher income neighborhoods are more vocal about their disamenities (and therefore more responsive to reporters) and lower income neighborhoods attach less weight to environmental quality, it is likely that pollution in higher income neighborhoods will get more attention.

Based on these conceptual ideas, I hypothesize that apart from observable firm-level characteristics like the volumes of toxic discharges; the industrial classification and its geographical location, media attention is also a function of a facility's neighborhood characteristics like income status and racial composition. This paper uses national print media reports from 1989 to explore this idea. Even though this first TRI report is now considered unreliable, this report created a media buzz in response to such categorized pollution information[7]. I take advantage of this activity to study the response of the media to pollution information.

The results suggest that the media reports disproportionately more about pollution in higher income neighborhoods, and the results are statistically significant. Neighborhoods with a higher percentage of non-white/non-Hispanic population are also more likely to be included in media reports, and the results are

[7] For more details on the limitations and drawbacks of the Toxic Release Inventory datasets refer to Chapter 1.

statistically significant in two out of the four different measures of media attention. Even though the percent of Hispanics residing in the neighborhood is positively associated with media attention, they are never statistically significant.

In the following sections, I first present a background of the TRI program. Second, I discuss the background of the environmental justice movement. Later sections discuss the hypotheses, describe the data, lay out the empirical strategy, analyze the results and finally, conclude.

2.2 TRI and the Media

The TRI program was formulated under the Emergency Planning & Community Right-To-Know Act (EPCRA) of 1986, in the backdrop of a chemical accident at a Union Carbide's chemical plant in Bhopal, India in 1984. The program was designed to help "increase the public's knowledge and access to information on chemicals at individual facilities, their uses, and releases into the environment. States and communities, working with facilities, can use the information to improve chemical safety and protect public health and the environment"[8]. It decreed that all U.S. manufacturing facilities, with at least 10 employees and producing more than 500 lbs of each of the 320 listed chemicals, must annually report to the EPA. The EPA collects this information and catalogs it for public dissemination via its TRI database.

[8] From the EPA website on EPCRA summary at http://www.epa.gov/emergencies/content/lawsregs/epcraover.htm (as viewed in June 2010)

The first wave of TRI reports were made publicly available on 19th June, 1989, which reported about pollution in 1987. Shortly thereafter, the Natural Resources Defense Council (NRDC 1989) and the National Wildlife Federation (NWF) published two specialized reports on the top polluters in 1987. These publications, along with the original TRI reports, generated some media activity including articles in major newspapers like *The Wall Street Journal, USA TODAY, The Boston Globe, The LA Times, The Washington Post* and *The New York Times*. Much of this activity appears closely linked to the publication of the specialized reports by NWF and the NRDC. Of the 370 facilities in my dataset that received some sort of media attention, 130 facilities come from the top 500 establishments reported in NWF's "Toxic 500" (Dean 1989) report.

The exposure of polluting TRI facilities accompanied by the print media activity impacted several local communities, interest groups, consumers and shareholders. For example, *The New York Times* reports that citizens in New Jersey, Ohio, California and Texas protested against the practices of polluting establishments in order to reduce their risks of being in another chemical accident like the Bhopal incident (Suro 1989). Herrmann et al. (1997) estimates a 40 to 60 percent drop in apple consumption due to concerns about Alar. Alar, a pesticide used in prolonging the ripening of apples was found in the 1987 TRI reports, even though EPA banned this chemical use for being a "probable human carcinogen". Financial market reactions to the TRI reports show that publicly traded TRI firms experienced negative abnormal returns on the day following the first TRI release (Hamilton 1995a). Konar and Cohen (1997) further show that firms with largest negative abnormal returns reduced their toxic emissions by a greater amount than their industry peers.

2.3 Environmental Justice

Environmental justice is related to the finding that disadvantaged neighborhoods are exposed to disproportionately high environmental harms and those harms should be equitably distributed across racial, income, regional and educational classifications. Reports from the U.S. Government Accountability Office (GAO) in 1983 and later from the United Church of Christ (UCC) in 1987 showed a correlation between siting of hazardous waste sites, and poor and minority communities. Recurring evidence of such "environmental injustice" since the early 80's and the burgeoning of it since the inception of the TRI program, led EPA to declare environmental justice a national priority. EPA set up an Office of Environmental Justice in 1993, with the mission to address these concerns. According to the EPA, environmental equity is the "fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies[9]".

Hamilton (1995b) provides an economic explanation based on Coasian bargaining, on why firms might locate in minority and poor communities. This explanation posits that residents in poor neighborhoods attach less importance to environmental quality, so firms find it profitable to locate to neighborhoods where

[9] From the EPA website on Environmental Justice at http://www.epa.gov/environmentaljustice/index.html (as viewed in June 2010)

the cost of collective bargaining is low. It is equally plausible that polluting firms attract the poor. Lower income households migrate to neighborhoods with waste sites in the hope to find suitable jobs or affordable housing (Cameron and McConnaha 2006).

The empirical literature since the GAO and UCC reports has found mixed evidence of "environmental injustice". Studies on the time of siting and prevalence of "environmental injustice" find that racial composition of neighborhoods cannot explain firm location decisions, but this decision is often influenced by the income status and the political mobilization of the neighborhood (Wolverton 2009, Davidson and Anderton 2000, Been and Gupta 1997, Kriesel et al 1996). This finding is also supported by Hamilton (1995b) and Gamper-Rabindran (2006) who found that voter participation, and economic status, but not race influence broader measures of environmental outcomes. Arora and Cason (1999), on the other hand, found that both income status and racial composition might be an important factor in determining emissions pattern. They found significant increases in toxic releases in the South, and non-urban areas, with a pre-dominantly higher percentage of ethnic minorities.

2.4 Data

This study uses pollution data from the TRI database, socio-economic characteristics from the 1990 Census and media attention data from the LEXIS-NEXIS Academic Universe database.

The TRI database contains detailed information about toxic releases of all U.S manufacturing facilities eligible to report under the TRI regulation. There is a two year gap between the data-reporting date and the date EPA publicly disseminates this information. The first TRI report was available on 19th June, 1989 and contained information about the toxic releases of almost 24,000 polluting facilities in 1987. This dataset was later found to be unreliable as many facilities were unaware how to measure the toxic releases and the 1987 data were removed from the TRI database. However, since this study focuses on media attention to reported releases (regardless of the accuracy of the underlying reports), the 1987 data are nonetheless most appropriate for this research. These data, while no longer available in the TRI database, were collected from EPA's Office of Pollution Prevention and Toxics library.

Media attention data are collected from the news archives at the LEXIS-NEXIS Academic Universe database. The LEXIS-NEXIS Academic Universe database is the most extensive database on newspaper-related research. It archives a wide variety of news sources: international and national newspapers, newswires, magazines and trade journals, and broadcast media transcripts. It archives newspapers from the early 1970s and provides full coverage of more than 1000 U.S. newspapers. It has several same day publications and fully archives major national newspapers like *The New York Times* and *The Washington Post* which are archived dating back to 1980 and 1977, respectively.

Although two other data sources, ProQuest and NewsLibrary could have also been used for this study, LEXIS-NEXIS has several advantages. Comparing the availability of top 30 U.S newspapers in the LEXIS-NEXIS database to NewsLibrary and ProQuest, shows that more newspapers are covered in the LEXIS-NEXIS. Table 2.1 shows that of the top 30 newspapers in 2010 only two newspapers are not archived in the LEXIS-NEXIS compared to NewsLibrary and ProQuest. Using LEXIS-NEXIS also allows comparisons to studies by Hamilton (1995a) and Konar and Cohen (1997), which explore similar research questions (firm responses to TRI news), and use the LEXIS-NEXIS database. LEXIS-NEXIS also has a wide collection of newswires, which other competing news databases do not archive so extensively. In the absence of regular indexing of smaller local and regional newspapers, these newswires can be used as a proxy for local news coverage. LEXIS-NEXIS covers respected wire services such as the *Associated Press*, *Business Wire* and *PR Newswire*, which are updated several times a day, full-text articles are provided and have very few vendor restrictions.

There are, however, drawbacks to the LEXIS-NEXIS data. Several major newspapers, like *The Los Angeles Times* and *The San Francisco Chronicle,* have vendor restrictions that require newspaper articles to be removed from the LEXIS-NEXIS database. As a result of such restrictions, several prominent newspapers which reported about the TRI proceedings in the late 1980s did not show up in my database search.[10] In addition to vendor restrictions, other news sources are not archived back to 1989. Articles from newspapers, like *The Chicago Tribune* and *The Long Island Newsday,* are provided to the LEXIS-NEXIS database by other newspaper services like Global News Wire and Newstex Blogs, respectively, which in turn are archived from a much later year than 1989. Regional and local newspapers have low to no coverage archived back to 1989.

These limitations mean that LEXIS-NEXIS represents only a fraction of the potential news coverage in 1989. To get a better sense for this limitation, I compare the coverage dates of the top 30 newspapers that are currently in circulation in the US in each of the competing databases: NewsLibrary, ProQuest and LEXIS-NEXIS, to see which one covers most of my study period. NewsLibrary does not cover most of the top 30 U.S newspapers. Between ProQuest and LEXIS-NEXIS, ProQuest is preferred for news articles from *The Houston Chronicle, The Philadelphia Inquirer, The Plain Dealer, The Denver Post* and *The Orange County Register* as these newspapers are archived from an earlier year than 1989. However, they may have the similar vendor restrictions like the LEXIS-NEXIS. Ten out of the top 30 newspapers in the LEXIS-NEXIS database cover my study period with varying restrictions.

The media reported about 1987 TRI releases in June, 1989. To identify newspaper articles related to the TRI, I used a combination of keywords for the

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[10] Other prominent newspapers, like *The Wall Street Journal,* are archived by the LEXIS-NEXIS but provide only abstracts through its database. Since the articles are still identifiable with keyword searches, such papers are included in my dataset.

database search: 'Toxic Release Inventory' or 'worst polluters' or 'pollution' or 'Toxic 500' or 'National Wildlife Federation' for the time period June, 1989 to April, 1990. The aim was to gather as much information as possible about the TRI facilities that polluted in 1987. The database search included major U.S. newspapers as well as all U.S regional newspapers. This search identified around 1,000 articles from major newspapers and newswire reports. It, however, did not identify any articles from regional newspapers.

To narrow search results further, I read each article. Given that the first TRI report was closely followed by the publication of the *"Toxic 500"* by the National Wildlife Federation and the *"A Who's Who of American Toxic Air Polluters"* by the Natural Resources Defense Council, most of the newspaper and newswire reports made references to these reports. In most cases, the newspapers covered the top 500 polluting facilities under the TRI program. Some articles, instead of reporting about any particular facility talked mostly about the counties or the states in which these facilities are located. News coverage on the TRI program are usually on toxic releases, the toxic nature of the releases, the likely health effects of these releases on children and the elderly, the relative ranking of the facilities in the TRI list, a geographic analysis of the polluting facility, the regulatory fines imposed on companies for non-reporting and the legal proceedings on the TRI firms. The reports are, more often than not, negative in tone.

Reading the articles allowed me to identify those that had specific information about TRI facilities[11]. Because this study is at the facility level, articles discussing TRI only at the parent company level or at the state and county levels were dropped. This selection left me with 84 articles from major newspapers including *USA TODAY, The Boston Globe, The Washington Post, The Wall Street Journal, The New York Times* and newswires like *The Associated Press, United Press International, States News Service.* These 84 articles identified 378 facilities that polluted in 1987. Compared to prior research, this set of articles represents a substantial increase in information about media responses to the initial wave of TRI reporting in part because the search uses the full population of over 19,000 TRI establishments. Hamilton (1995a), for example, found 50 out of the top 500 facilities received media attention for polluting in 1987. The distribution of media reports in my dataset by facility is shown in Figure 2.1.

I collected data on the neighborhood characteristics of the TRI facilities from the 1990 U.S Census at the U.S. zip code level[12]. After merging the datasets, my dataset has 18,769 observations (TRI facilities) of which 311 facilities received media attention in 272 zip codes. Note that in merging these datasets, I lost information about 67 facilities with media attention. Zip codes reported by plants in older TRI data and zip codes used in Census data on community characteristics

[11] For *The Wall Street Journal* abstracts, I read the corresponding microfiche using the Wall Street Journal indices. The articles did not provide any facility level information about the TRI companies.

[12] The 1990 Census dataset did not have information about the population density at the zip-code level, which is one of the control variables in my estimations. So I calculated it separately, using information about total population from Census 1990 and land area in square miles from the 2000 Zip Code Tabulation Areas.

suffer from mismatches due to frequent changes to the zip codes made by the postal service (Gamper-Rabindran 2006). Most these missing zip codes are located in the middle of a larger zip-code and represent locations where the U.S postal service allocates a separate zip-code to a company for ease of delivering mail. Given that media attention is a rare event, a loss of 67 facilities with media attention out of 378 is a substantial loss in the number of observations. I, therefore, recover information about 59 such missing zip codes by replacing the existing zip code with zip code that envelopes it.

Table 2.2 shows the distribution in the number of articles written per facility with and without the zip code replacements. The table shows that with replacement I retrieve information about several establishments that were rigorously reported about, but would otherwise remain unaccounted for. For example, there are two additional establishments that were covered by four different articles, or three more establishments that were mentioned in eleven different newspaper articles. Being reported in four or eleven different articles represents an intense level of media reporting especially with the limited number of facilities that received media attention in all. Replacing the missing zip codes help restore this invaluable information in my dataset. One should, however, be aware that this replacement strategy introduces some potential bias. In replacing the missing zip code information I concentrated only on those establishments that received media attention. There are, however, several other TRI establishments with no media attention located in zip codes which did not find a corresponding match in the Census files and hence dropped out from my final dataset.

For the rest of the analysis, both in this chapter and the next, I will use the dataset where information about the missing zip codes has been replaced using the above criteria. The final dataset for this essay, therefore, contains 19,082 observations of which 370 facilities received media attention in 1989 for polluting in 1987.

2.5 Measures and Empirical Strategy

This section describes the measures of pollution, income, race, control variables, and media attention. It also outlines an empirical strategy using the alternate measures of media attention. I estimate the following model:

$$MEDIA\_ATTENTION = f(X_i^P, X_i^I, X_i^R, X_i^S) + \varepsilon_i \qquad (1)$$

In equation (1), X_i^P is the vector of pollution measures, X_i^I is the vector of industry classification variables, X_i^R is the vector of regional dummy variables, and X_i^S is the vector of socio-economic characteristics of the *i*-th facility. The pollution vector includes variables *AIR, WATER, UNDER, LAND, OFFSITE* and FORMR. The vector on industry classification includes *CHEMICALS, PAPER, PRIMARY, PETROLEUM, TRANSPORTATION* and *OTHERMANU.* The regional vector introduces *NORTHEAST, SOUTH, MIDWEST* and *WEST* as dummy variables. Lastly, the socio-economic characteristics vector consists of *INCOME, HISPANIC* and *NONWHITE.* I test the null hypothesis that media attention is non-discriminatory with respect to income status (*INCOME*) and racial composition (*HISPANIC* and *NONWHITE*) of the neighborhood.

There is no standard measure or index for media attention, the dependent variable in equation (1). So I construct four different measures to check for the robustness of my results. These measures, which are summarized in Table 2.3, include the number of articles mentioning a facility (*ARTICLES*), the number of words (*WORDS)*, weighted hits (*WARTICLES*), and weighted words (*WWORDS*).

ARTICLES measure the number of articles that identify each facility. The distribution of *ARTICLES* is reported in Table 2.2. Given the large number of zero counts and an over-dispersed distribution of *ARTICLES*, I use a zero-inflated negative binomial regression, to estimate equation (1) (Demaris 2004). By using the zero-inflated binomial regression, I assume that the excess zeroes in my dataset may have been generated by two different processes. While some facilities received no media attention due to low emissions, it is possible that some facilities with high emissions, which could have received attention, eventually did not. This distinction in the generation of excess zeroes is not accounted for in a standard negative binomial regression. The choice of the zero-inflated negative binomial regression is supported by Vuong likelihood ratio tests for model selection on the dispersion parameter, which is significantly different from zero.

The second measure of media attention is the total number of words in articles (*WORDS*) that mention a given facility. Since a facility can be mentioned in more than one article, I added these word counts across articles. Given that *WORDS* is a count variable and there is a large proportion of zeroes in my dataset, I use zero-inflated negative binomial regression again in estimating equation (1). The assumption behind the generation of excess zeroes remains the same as *ARTICLES*. This choice of model is again supported by Vuong likelihood ratio tests for model selection on the dispersion parameter.

One issue with *ARTICLES* and *WORDS* as a measure of media attention is that the measure attaches equal weight to all facilities. If several facilities were mentioned in one article the measure treats this as identical to an article reporting exclusively about a single facility. In order to make sure that I do not treat these two types of media reporting equally, I construct two weighted measures of media attention, weighted hits (*WARTICLES*) and weighted words (*WWORDS*). If one article lists n different facilities, then each facility gets a weighted article measure of $(1/n)$. Similarly, if n facilities are mentioned in one article with m words, then each facility is assigned a weighted word measure of (m/n) words per facility. These two measures of media attention are continuous and strictly non-negative. Hence, I use Tobit regression to estimate equation (1).

The key independent variables of interest are the income and race variables. The logarithm of the median household income (*INCOME*) measures the neighborhood income at the zip code level. I classify race into two major groups. One is the percentage of Hispanics (*HISPANIC*) in the neighborhood and the other is the percentage of non-whites who are not Hispanics (*NONWHITE*). The omitted category is non-Hispanic white.

A substantial proportion of the media reports in the dataset come from the major daily newspapers, like *The New York Times*, and *The Boston Globe*. It is likely that the readership of these papers is disproportionately urban and relatively wealthy. I include the logarithm of the population density (*POPN*) as a control variable since facilities in densely populated neighborhoods might be subject to increased reporting. I also include geographical classifications, *NORTHEAST, SOUTH, MIDWEST* and *WEST* to allow for the possibility that location of the facility matters in drawing media attention. *WEST* is treated as the omitted category in the estimations.

The measures of pollution include the amount of toxic wastes (in pounds) released in the air (*AIR*), water (*WATER*), injected underground (*UNDER*), released on land (*LAND*), and transferred offsite (*OFFSITE*). Although several of these measures are closely correlated (see Table 2.3), they are included separately (rather than as an index) since media attention might be sensitive to the type of pollution. The number of Form-R's (*FORMR*), a reporting form used to report about a particular toxic chemical or toxic category, proxies for risks associated with pollution. The greater the numbers of Form-R's, the more chemicals have been released.

Indicator variables for industry control for the possibility that facilities may draw attention by virtue of the industry to which they belong. The industry classifications are *CHEMICALS, PAPER, PRIMARY, PETROLEUM, TRANSPORTATION*, with "other manufacturing" (*OTHERMANU*) as the omitted category.

2.6 Descriptive Statistics

The dataset contains 19,082 observations of which 370 facilities received media attention in 1989 for polluting in 1987. Figure 2.1 shows the distribution of these facilities across different non-wire newspapers and newswires in my dataset. It shows that most of the facilities mentioned in the news articles came from the wire services. The most prominent among them is States News Service, which reported about 182 out of the 370 TRI facilities with media attention[13]. Among the major newspapers *USA Today*, which has a nationwide circulation, reported on 78 TRI facilities out of the total 370. This daily reported disproportionately more than any other newspaper in my dataset. As for the intensity of media attention, there are 37 facilities that were mentioned in both newspapers and newswires, and 274 facilities were covered by either of these forms of print media.

Table 2.2, which highlights the frequency distribution of *ARTICLES,* shows the limited variability in the dependent variable. There are only 370 facilities out of 19,082 TRI establishments that received media attention. Of these, an ALCOA facility at Port Comfort, Texas received the most media attention; 15 out of 84 different news articles from my database search reported about this particular TRI facility. This lack of variability in the dependent variable highlights the usefulness of a zero-inflated negative binomial regression. Correlation coefficients between *ARTICLES*, pollution, income and race variables are presented in Table 2.3. All types of pollution have a positive but weak correlation with media attention. Correlation

[13] States News Service is a national newswire service that provides Washington coverage and state and local bills in Congress.

between media attention and race is also weak, but while *HISPANIC* neighborhoods are negatively correlated, *NONWHITE* populations correlate positively to media attention. Income as an indicator of the economic status is very weakly correlated and the sign on the correlation coefficient suggests a negative association.

Table 2.4 shows the relative share of the TRI facilities by industry classification and region. Most facilities belong to the category, "other manufacturing," followed by the chemicals, and primary metals. Among the facilities that received media attention, 118 facilities belong to chemicals industry, and only 10 facilities belong to the petroleum industry. By region, most TRI facilities in the dataset are from the *MIDWEST* and *SOUTH*. Since the major newspapers in the dataset are located primarily in the northeastern part of the US, it is plausible that the newspapers report more on facilities located in this region.

Finally, Table 2.5 summarizes the income, race and population density variables as described in the 1990 Census, the full sample of TRI facilities used in this analysis and the subset of facilities that received media attention. Since *INCOME* is measured as the logarithm of the median household income, the table provides the value of the mean in equivalent dollars. The table shows that in 1990, an unweighted mean (across zip codes) of median household income in the U.S was $27,274. At $27,735, the average household income in the neighborhoods of the TRI establishments is a little higher than the national average and the average income ($27,876) of the neighborhoods that received media attention is higher still. It is suggestive that higher income neighborhoods may receive greater media attention.

Table 2.5 also highlights the distribution of the race measures, *NONWHITE* and *HISPANIC*. While Census reports an average of 14% non-whites residing at the zip-code level in 1990, the TRI establishments are located in neighborhoods with 22% of non-whites. An even higher percentage of non-whites reside in the neighborhoods that received media attention for polluting in 1987. As for the Hispanics, on an average lesser percentage resides in the neighborhoods that received any media attention. The average population density in the neighborhood of TRI facilities and in the neighborhood of facilities that received media attention is higher than the national average.

2.7 <u>Results</u>

Before presenting the regression results, it is worthwhile to discuss how the regression results would have differed had I used the dataset with missing information on a substantial number of facilities with media attention. Appendix Table 2.1A reports a comparison between results obtained from using the two datasets: one with missing zip codes and the other with the zip codes replaced with information from the "envelope" zip code. The table reports the coefficient estimates (and not the marginal effects) of the Zero-Inflated Negative Binomial (ZINB) regression using *ARTICLES* as a measure of media attention. The main difference is in the level of significance of the key variables of interest, *INCOME*, *NONWHITE* and *HISPANIC*. While the signs on *INCOME* and *NONWHITE* remain the same, the statistical significance of coefficient estimates improves significantly. Even though the sign on *HISPANICS* change, they are never statistically significant.

The stronger statistical significance along with an improved number of observations (from 18,769 to 19,082) justifies the replacement of missing zip codes information.

Tables 2.6 and 2.7 report the regression coefficients and the marginal effects of the Zero-inflated Negative Binomial (ZINB) estimations. These tables report the standard errors clustered by zip codes[14]. The variables of interest in these tables are *INCOME*, *NONWHITE* and *HISPANIC*. The results show that facilities located in higher income neighborhoods (*INCOME*) are more likely to receive media attention and they are statistically significant across both measures of media attention, *ARTICLES* and *WORDS*. The marginal effect of *INCOME* on media attention, as shown in Table 2.8, is positive and statistically significant, but small in magnitude. If the median household income in the neighborhood of a TRI facility doubles (that is, increases by 100%) approximately one more article will be written about that establishment. A similar increase in median household income will increase the total number of words by approximately 733 words,. The marginal effects are very small, but show that income is positively associated with media attention.

NONWHITE is also positive and highly significant (at 1% level) across all measures of media attention in Table 2.6. The marginal effects, as presented in Table 2.7, are also positive and suggest that if the percentage of non-whites residing in the neighborhood of a polluting facility double, then it is likely that 0.01 more articles or 10 more words will be written about such a TRI facility. The marginal effects are statistically significant for both *WORDS* and *ARTICLES*, are quantitatively

[14] There are 6965 zip code clusters in the full dataset of 19,082 facilities. However, the 370 facilities that received media attention were fairly dispersed among 272 zip code clusters (Table 2.5)

very small in magnitude, but they show that there is a positive association with media attention. The results on *HISPANIC* show a positive association with media attention, but the results are never statistically significant across both measures of media attention.

Table 2.8 reports the results of the Tobit regression, where the measures of media attention are *WARTICLES* and *WWORDS.* The coefficients on the income and race variables show that *INCOME* tends to be positively associated with media attention, *NONWHITE* is negatively correlated but the results are never statistically significant. The sign on *HISPANICS* is mixed with no statistical significance.

Across all regressions presented in the Tables 2.6 and 2.8, facilities located in the *NORTHEAST* are more likely to draw media attention than any other regional classifications. Since most newspapers in my dataset are disproportionately located in this region, this regional bias is not surprising. It is likely that they report mostly about their local polluting facilities in the TRI reports. Facilities in the petroleum industry are less likely to receive media attention, while firms in the paper and transportation industry are more likely to be reported. The coefficients on the population density measure (*POPN*) have negative sign across all measures of media attention and are never significant.

Across all regression models presented in Tables 2.6 and 2.8, measures of pollution are statistically significant (at 1% level), and while *AIR, LAND, UNDER* and *OFFSITE* are more likely to draw media attention, volumes of toxic chemicals released in the *WATER* are less likely to attract media attention. These results are similar to prior findings on the determinants of media attention where different mediums into which toxic wastes are released have a positive association with media attention (Hamilton 1995a). *FORMR,* a measure used as a proxy for the intensity of pollution has a positive sign on it and is statistically significant at 1% level. It suggests that as the number of chemicals reported by the facilities increase, it draws greater media attention.

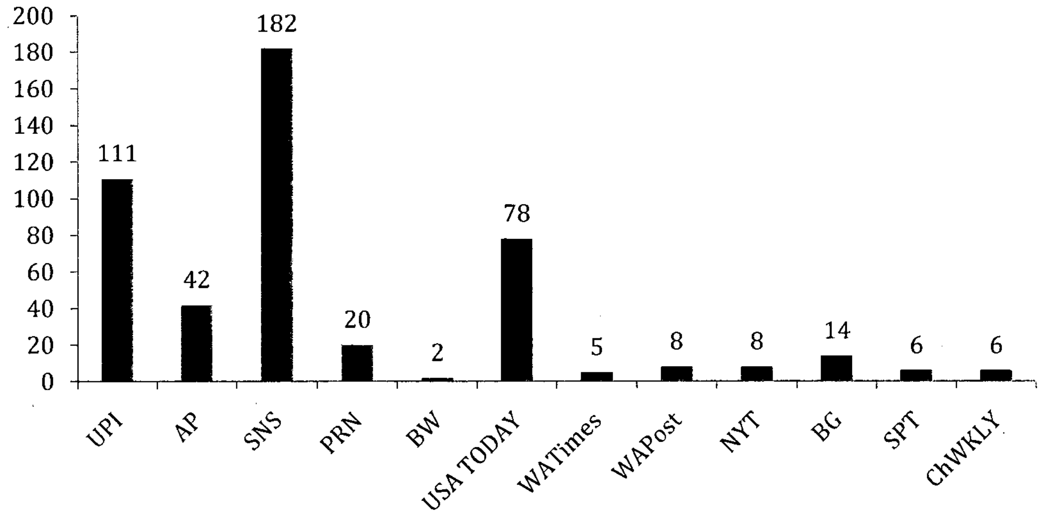
2.8 Conclusions

This study tests the hypothesis that media attention is non-discriminatory with respect to racial composition and income status of the neighborhood of a polluting facility, while controlling for pollution and observable firm characteristics like industry classification and location of the facility. Because other studies have found that media attention can influence firm behaviors, the aim of this work is to determine if income and race associate with media attention. If media reports less on pollution in poor and minority neighborhoods, then it can create incentives to polluting facilities to locate or pollute more in such neighborhoods, thereby providing an additional explanation to "environmental injustice" outcomes.

Regression results, based on 1989 national newspaper reports that corresponded to the first release of TRI data, suggest that neighborhoods with either a higher percentage of non-white population or higher incomes are more likely to be included in media reports, and the results are statistically significant. These findings are consistent with those in the literature on environmental justice. Wolverton (2009), Davidson and Anderton (2000), Been and Gupta (1997), Kriesel et al. (1996), Hamilton (1995b), and Gamper-Rabindran (2006) all fail to find evidence of "injustice" in terms of the racial composition of the neighborhoods, but these studies do show that the income status of the neighborhood matters in firm location decisions.

This study sets the stage for the next research question. If neighborhood characteristics associate with media attention, then it is worthwhile to investigate how the behavior of media imposes any costs on the polluting firms. One measure is to explore whether media attention leads to changes in future TRI emissions. This is the goal of Chapter 3.

Figure 2.1: Distribution of Facilities by Newswires and Newspapers.



Newswires: UPI = *United Press International*, AP = *Associated Press*, SNS = *States News Service*, PRN= *PR Newswire*, BW = *Business Wire*

Newspapers: *USA Today*, WATimes = *The Washington Times*, WAPost = *The Washington Post*, NYT = *The New York Times*, BG = *The Boston Globe*, SPT = *St.Petersburg Times*, ChWKLY = *Chemical Weekly*

Table 2.1: Coverage Dates of the Top 30 US Newspapers in the Three Databases: LEXIS-NEXIS, NewsLibrary and ProQuest.

Rank by Circulation	Top 30 U.S Newspapers (by circulation in 2010)	Lexis Nexis Coverage	NewsLibrary CoverageΔ	ProQuest CoverageΔ
1	USA Today	3-Jan-89#	1-Jul-87	1-Apr-87
2	The Wall Street Journal	1-May-73@	*NA*	2-Jan-84
3	New York Times	1-Jun-80	*NA*	1-Jun-80
4	Los Angeles Times	1-Jan-85*	*NA*	1-Jan-85
5	The Washington Post	1-Jan-77	1977 onwards	4-Dec-96
6	New York Daily News	1-Mar-95	16-Jan-95	21-Dec-92
7	The Chicago Tribune	1-Oct-98	2008 onwards	4-Dec-96
8	New York Post	5-Dec-97	21-Nov-99	3-Aug-98
9	Long Island Newsday	1-Jan-06	*NA*	*NA*
10	The Houston Chronicle	15-Sep-91	1-Jul-08	13-Feb-85
11	The San Francisco Chronicle	1-Oct-89*#	1985 Onwards	1-Jan-85
12	New York Newsday	2-Jan-88*	*NA*	*NA*
13	The Arizona Republic	Jan-97#	*NA*	*NA*
14	The Chicago Sun-Times	1-Jan-92#	24-Jan-06	*NA*
15	The Boston Globe	Jan-97	Dec-79	1-Jan-80
16	The Atlanta Journal-Constitution	*NA*	1985 onwards	1-Jan-95
17	The Star-Ledger	1-Jan-96	*NA*	*NA*
18	Minneapolis Star Tribune	1-Sep-91	12-Jun-08	*NA*
19	Detroit Free Press	11-Oct-96#	*NA*	1-Jan-95
20	The Philadelphia Inquirer	1-Jan-94	1-Apr-08	1-Jan-83
21	The Plain Dealer (Cleveland)	1-Jan-92	1991 Onwards	27-Mar-89
22	St.Petersburg Times	1-Jan-87	1987 Onwards	30-Jun-86
23	Portland Oregonian	Jan-97#	*NA*	*NA*
24	San Diego Union-Tribune	5-Dec-83*	4-Feb-04	2-Feb-92
25	The Denver Post	1-Dec-93#	27-Mar-05	1-Jun-89
26	Rocky Mountain News	*NA*	1-Jan-90	1-Jan-97
27	The Miami Herald	11-Oct-96	1-Aug-05	1-Dec-97
28	The Sacramento Bee	Jan-97#	1984 Onwards	11-Nov-88
29	The Orange County Register	11-Oct-96	1-Jan-87	15-Sep-86
30	St. Louis Post-Dispatch	Feb-81#*	1988 Onwards	1-Jan-92

Ψ Information on coverage dates obtained from http://www.newslibrary.com
Δ Information on coverage dates obtained from http://www.proquest.com
* Due to vendor restrictions there is limited access to this newspaper in the Lexis-Nexis.
# Certain freelance articles previously available in this newspaper has been removed by Lexis-Nexis.
@ Only abstracts available at the Lexis-Nexis.
NA stands for "Not Available"

Table 2.2: Frequency Distribution in the Number of *ARTICLES*.

Number of Articles Mentioning a Facility	Frequency With Missing Zip Codes	Frequency With Missing Zip Codes replaced
0	18,458	18,712
1	229	270
2	43	54
3	19	20
4	5	7
5	10	11
6	2	2
11	2	5
15	1	1

Table 2.3: Correlation Coefficients between Media Attention, Pollution, Income and Race.

Variables	*ARTICLES*	*AIR*	*LAND*	*UNDER*	*WATER*
AIR	0.377				
LAND	0.374	0.129			
UNDER	0.142	0.014	0.001		
WATER	0.129	0.034	0.004	0.962	
OFFSITE	0.138	0.055	0.007	0.003	0.006
INCOME	(-)0.001				
POPN	(-)0.013				
HISPANIC	(-)0.001				
NONWHITE	0.005				

Table 2.4: Distribution of Facilities According to SIC Industry Classification and US Regions.

Industry	*TRI Facilities*	*Facilities with Media Attention*
CHEMICALS	3,621	118
PRIMARY METALS	1,558	48
PAPER	659	31
PETROLEUM	325	10
TRANSPORTATION	966	27
OTHERMANU	11,953	136

Regions	*TRI Facilities*	*Facilities with Media Attention*
NORTHEAST	4,175	112
MIDWEST	6,488	67
SOUTH	5,635	155
WEST	2,784	36

Table 2.5: Descriptive Statistics on Measures of Media Attention, Income, Racial and Population characteristics.

Variable	Dataset	Observations	Unit of Measurement	Mean	Std. Dev.	Min	Max
ARTICLES	-	19,082	No. of articles per facility	0.03	0.32	0	15
WORDS	-	19,082	No. of words facility	26.63	248.82	0	10001
WARTICLES	-	19,082	-	0.01	0.09	0	7.11
WWORDS	-	19,082	-	11.67	564.05	0	64971.18
INCOME	All zip-codes in 1990 Census	29,420	Logarithm of median household income	10.21 ($27,274)	0.39	0.00	11.92
INCOME	Zip-codes containing TRI Facilities	6,965	Logarithm of median household income	10.23 ($27,735)	0.35	8.52	11.57
INCOME	Zip-codes containing Media Attention Facilities	272	Logarithm of median household income	10.23 ($27,876)	0.34	9.11	11.02
NONWHITE	All zip-codes in 1990 Census	29,290	Percentage of total population	14.11	21.47	0.00	100.00
NONWHITE	Zip-codes containing TRI Facilities	6,965	Percentage of total population	22.42	25.60	0.00	100.00
NONWHITE	Zip-codes containing Media Attention Facilities	272	Percentage of total population	22.60	24.18	0.00	98.95
HISPANIC	All zip-codes in 1990 Census	29,290	Percentage of total population	4.41	11.54	0.00	100.00
HISPANIC	Zip-codes containing TRI Facilities	6,965	Percentage of total population	7.74	15.53	0.00	97.50
HISPANIC	Zip-codes containing Media Attention Facilities	272	Percentage of total population	6.49	13.48	0.00	70.18
POPN	All zip-codes in 1990 Census	29,290	Logarithm of population density	3.45	0.72	0.00	5.05
POPN	Zip-codes containing TRI Facilities	6,965	Logarithm of population density	9.76	0.95	3.09	11.62
POPN	Zip-codes containing Media Attention Facilities	272	Logarithm of population density	9.58	13.48	3.52	11.45

Table 2.6: Zero Inflated Negative Binomial (ZINB) Regression Estimates.

VARIABLES	ZINB		ZINB	
	ARTICLES	inflate	*WORDS*	inflate
AIR (in pounds)	0.0716*** (0.016)	(-)6.0532*** (2.007)	0.0246*** (0 .005)	(-)0.5882*** (0 .061)
WATER (in pounds)	(-)0.0036** (0.002)	(-)0.1045* (0 .062)	(-)0.0008 (0.001)	(-)0.0119 (0.007)
LAND (in pounds)	0.0113*** (0.004)	(-)1.0631* (0 .545)	0.0036*** (0. 001)	(-)0.2191*** (0 .034)
UNDER (in pounds)	0.0107** (0 .004)	(-)0.1125 (0.162)	0.0027 (0. 002)	(-)0.0951*** (0 .027)
OFFSITE (in pounds)	0.0579*** (0 .017)	(-)0.4948*** (0 .154)	0.01791** (0. 007)	(-)0.2011*** (0 .031)
FORMR (Number of Form-Rs)	0.0329*** (0.011)	(-)0.0466 (0.029)	0.0017 (0. 004)	(-)0.0866*** (0 .008)
CHEMICALS (Dummy Variable)	0.0084 (0.168)		(-)0.0386 (0. 093)	
PRIMARY METALS (Dummy Variable)	0.1913 (0.213)		0.0936 (0. 115)	
PAPER (Dummy Variable)	(-)0.1623 (0.234)		(-)0.2341* (0. 132)	
PETROLEUM (Dummy Variable)	(-)1.2302*** (0.381)		(-)0.1567 (0. 225)	
TRANSPORTATION (Dummy Variable)	(-)0.1437 (0.238)		(-)0.1968 (0. 132)	
POPN (Logarithm of Population Density)	(-)0.0057 (0 .041)		(-)0.0101 (0. 023)	
INCOME (Logarithm of Median Household Income)	0.3956* (0 .221)		0.4766*** (0. 124)	
HISPANIC (Percentage of Total Population)	0.0018 (0 .005)		0.0016 (0. 003)	
NONWHITE (Percentage of Total Population)	0.0091*** (0.003)		0.0065*** (0. 002)	
NORTHEAST (Dummy Variable)	0.9413*** (0 .236)		(-)0.1046 (0. 147)	
MIDWEST (Dummy Variable)	-0.3345 (0.241)		(-)0.0161 (0. 153)	
SOUTH (Dummy Variable)	0.1341 (0.223)		(-)0.0104 (0. 138)	
Observations	19,082	19,082	19,082	19,082
*** p<0.01, ** p<0.05, * p<0.1. The table reports the ZINB regression coefficients. Robust (clustered by zip code) standard errors in parentheses. There are 6,965 zip code clusters. *WEST* and *OTHERMANU* are the base categories for the regional and industry vectors, respectively.				

Table 2.7: Marginal Effects of ZINB Estimations for *ARTICLES* and *WORDS.*

VARIABLES	*ARTICLES*	*WORDS*
AIR (in pounds)	0.0119*** (0.0047)	1.1679*** (0.1431)
WATER (in pounds)	0.0006* (0.0004)	0.0735 (0.0523)
LAND (in pounds)	0.0019** (0.0011)	0.3895*** (0.0667)
UNDER (in pounds)	0.0003 (0.0004)	0.2341*** (0.0689)
OFFSITE (in pounds)	0.0008*** (0.0003)	0.3158*** (0.0515)
FORMR (Number of Form-Rs)	0.0046*** (0.0012)	4.8661*** (0.5482)
CHEMICALS (Dummy Variable)	0.0001 (0.0028)	(-)0.5862 (1.4053)
PRIMARY METALS (Dummy Variable)	0.0035 (0.0042)	1.4979 (1.9158)
PAPER (Dummy Variable)	(-)0.0025 (0.0034)	(-)3.2366 (1.6771)
PETROLEUM (Dummy Variable)	(-)0.0122*** (0.0026)	(-)2.2376 (2.9762)
TRANSPORTATION (Dummy Variable)	(-)0.0023 (0.0036)	(-)2.7764 (1.7457)
POPN (Logarithm of Population Density)	(-)0.0001 (0.0007)	(-)0.1559 (0.3545)
INCOME (Logarithm of Median Household Income)	0.0067* (0.0037)	7.3313*** (2.0304)
HISPANIC (Percentage of Total Population)	0.0001 (0.0001)	0.0247 (0.0446)
NONWHITE (Percentage of Total Population)	0.0001*** (0.0001)	0.1005*** (0.0332)
NORTHEAST (Dummy Variable)	0.0216*** (0.0077)	(-)1.5636 (2.1569)
MIDWEST (Dummy Variable)	(-)0.0054 (0.0038)	(-)0.2475 (2.3345)
SOUTH (Dummy Variable)	0.0023 (0.0041)	(-)0.1599 (2.1217)
*** p<0.01, ** p<0.05, * p<0.1. Standard errors are in parentheses. Marginal effects for the dummy variables are discrete changes from 0 to 1. Marginal effects are computed at the mean.		

Table 2.8: Tobit Regression Results for *WARTICLES* and *WWORDS*.

VARIABLES	Tobit	Tobit
	WARTICLES	*WWORDS*
AIR (in pounds)	0.0713*** (0.027)	471.6000* (243.501)
WATER (in pounds)	(-)0.0001 (0.008)	(-)4.9521* (4.303)
LAND (in pounds)	0.0097*** (0.002)	71.3321*** (16.821)
UNDER (in pounds)	0.0052*** (0.002)	26.1140** (10.531)
OFFSITE (in pounds)	0.0520*** (0.011)	291.8715*** (83.657)
FORMR (Number of Form-Rs)	0.0401*** (0.008)	199.0491*** (58.510)
CHEMICALS (Dummy Variable)	0.0414 (0.057)	242.3238 (341.096)
PRIMARY METALS (Dummy Variable)	0.1101* (0.066)	449.2725 (394.529)
PAPER (Dummy Variable)	0.2931*** (0.081)	1518.1450*** (512.136)
PETROLEUM (Dummy Variable)	(-)0.4631** (0.220)	(-)2422.9150* (1258.067)
TRANSPORTATION (Dummy Variable)	0.2121** (0.085)	1065.2497** (501.115)
POPN (Logarithm of Population Density)	(-)0.0011 (0.014)	(-)5.9111 (76.977)
INCOME (Logarithm of Median Household Income)	0.0261 (0.077)	233.2221 (429.898)
HISPANIC (Percentage of Total Population)	(-)0.0002 (0.002)	0.3281 (9.424)
NONWHITE (Percentage of Total Population)	(-)0.0002 (0.001)	(-)0.9156 (6.533)
NORTHEAST (Dummy Variable)	0.2690*** (0.096)	1561.7150** (635.938)
MIDWEST (Dummy Variable)	(-)0.1090 (0.078)	(-)508.6580 (439.134)
SOUTH (Dummy Variable)	0.1351 (0.083)	871.4876 (532.794)
Observations	19,082	19,082

*** p<0.01, ** p<0.05, * p<0.1 The table reports the Tobit regression coefficients. Robust (clustered by zip code) standard errors in parentheses. There are 6,965 zip code clusters. *WEST* and *OTHERMANU* are the base categories for the regional and industry vectors, respectively.

APPENDIX

Table 2.1A: Comparing Zero Inflated Negative Binomial (ZINB) Regression Results With and Without Replacing Missing Zip-Codes.

VARIABLES	ZINB	ZINB
	HITS	*HITS*
AIR (in pounds)	0.0699*** (0.018)	0.0716*** (0.016)
WATER (in pounds)	(-)0.0737*** (0.019)	(-)0.0036** (0.002)
LAND (in pounds)	(-)0.0605*** (0.017)	0.0113*** (0.004)
UNDER (in pounds)	(-)0.0590*** (0.017)	0.0107** (0 .004)
OFFSITE (in pounds)	0.0568*** (0.018)	0.0579*** (0 .017)
FORMR (Number of Form-Rs)	0.0339** (0.015)	0.0329*** (0.011)
CHEMICALS (Dummy Variable)	0.1461 (0.188)	0.0084 (0.168)
PRIMARY METALS (Dummy Variable)	0.2555 (0.229)	0.1913 (0.213)
PAPER (Dummy Variable)	0.0086 (0.225)	(-)0.1623 (0.234)
PETROLEUM (Dummy Variable)	(-)1.2945** (0.557)	(-)1.2302*** (0.381)
TRANSPORTATION (Dummy Variable)	0.0759 (0.247)	(-)0.1437 (0.238)
POPN (Logarithm of Population Density)	(-)0.0192 (0.045)	(-)0.0057 (0 .041)
INCOME (Logarithm of Median Household Income)	0.3361 (0.258)	0.3956* (0 .221)
HISPANIC (Percentage of Total Population)	(-)0.0041 (0.007)	0.0018 (0 .005)
NONWHITE (Percentage of Total Population)	0.0081** (0.004)	0.0091*** (0.003)
NORTHEAST (Dummy Variable)	0.8430*** (0.271)	0.9413*** (0 .236)
MIDWEST (Dummy Variable)	(-)0.2612 (0.291)	(-)0.3345 (0.241)
SOUTH (Dummy Variable)	0.1891 (0.283)	0.1341 (0.223)
Observations	18,769	19,082

CHAPTER 3

FIRM'S RESPONSE TO MEDIA ATTENTION UNDER U.S-ENVIRONMENTAL PROTECTION AGENCY'S TOXIC RELEASE INVENTORY PROGRAM

3.1 Introduction

The United States Environmental Protection Agency's (US-EPA) Toxic Release Inventory (TRI) program is viewed as a complement to the standard command and control, and market-based environmental regulations. Implemented in 1988 following a chemical spill in Union Carbide's chemical plant in Bhopal, India, this program aims to keep the public aware of the chemical hazards in their neighborhoods via a publicly available database known as the Toxic Release Inventory database[15]. In addition to providing information about toxic chemicals to the public, the TRI also creates incentives that may affect firm behavior via active involvement of the general public, government agencies, advocacy groups, stakeholders and the media. The logic of the reporting requirement under this program is that negative publicity imposes a cost on polluting firms and provides incentives to modify polluting behaviors (Khanna, et al. 1998, Arora and Cason 1999, Terry and Yandle 1997).

[15] Manufacturing plants that emitted 500 lbs or more of the 320 listed chemicals under the TRI had to report to the US-EPA annually. Since its inception in 1988, the list of chemicals has doubled, some new industry sectors have been added and the reporting thresholds of some chemicals have changed overtime in order to accommodate information requirements from the public.

This essay focuses on the firm's response to media attention. Specifically, it studies the role the media played when the TRI program was implemented for the first time in the late 1980s. With limited preconceived notions about the polluting behavior of facilities around the early years of TRI reporting, media responses at this time provide a rare opportunity to isolate and study how firms responded to a sudden wave of media attention. If media attention imposes costs on the firm, the firm may have an incentive to change its subsequent behaviors.

A number of articles in the literature using the TRI data study firm behaviors. Some study how firms responded to TRI reporting requirements, while others focus on how stock market returns affect pollution behaviors (Hamilton 1995, Khanna 1998). While some study how the regulation may induce enrollment in voluntary environmental management programs (Arora and Cason, 1995, 1996, Khanna 2002, 1999), others study how the regulation may affect the location decisions of the firms (Wolverton 2009, Anderton et al. 1994, Boer et al. 1997, Sadd et al. 1999, Davidson and Anderton 2000). But none so far has comprehensively explored the relationship between TRI-related media attention and firm responses. This essay focuses on how media attention is associated with changes in toxic releases and explores the causal relationship between media attention and subsequent toxic releases.

Three different approaches are employed to understand this relationship. First, a difference-in-differences approach is used to study whether firms with media attention behave differently from those that do not. Results show that establishments receiving media attention reduce pollution more than those without. These results, however, should not be interpreted as causal due to the non-random nature of media attention. Second, in order to explore causality, a two stage instrumental variable approach has been adopted. Using three different instrumental variables for media attention, I find that the treatment effects are mixed in sign and the coefficient estimates are not statistically significant. Third, to check the consistency of the 2SLS results and to reduce the selection bias in our control group, I use propensity score matching to estimate the treatment effect of media attention. Results show that average treatment effect for the treated firms is negative but statistically insignificant, in general. Based on these results, I argue that although firms with media attention clearly behave differently, we cannot isolate the causal effect of media attention on changes in toxic releases.

The next three sections will first review the literature on firm responses to TRI regulations, followed by a description of the data used and the empirical strategies employed to estimate the treatment effect of media attention. The last two sections discuss the results and conclude.

3.2 Literature Review

Public disclosure programs like the Toxic Release Inventory program intend to impose costs on the polluting firms via public scrutiny, investor reactions in the capital markets, and peer-pressure. It is expected that such pressures have an adverse impact on a firm which might translate into improved environmental performance.

Studies by Hamilton (1995a), Konar and Cohen (1997), Afsah et al. (1997), Khanna et al. (1998), Lanoie et al. (1998), Dasgupta et al. (2001, 2006a), Doonan et al. (2006) explores the capital market reaction of firms to public disclosure of pollution information. These studies have shown that capital markets are sensitive to environmental information of firms or news about their environmental performances. Capital markets respond positively or negatively depending on whether the environmental performances of the companies were superior or poor. Khanna et al. (1998) examine investor reactions to environmental information of firms in the chemical industry and finds that repeated disclosure of environmental information results in significant losses to these firms and that they subsequently change the way they dispose toxic chemicals. Konar and Cohen (1997) finds similar evidence that TRI firms with significant abnormal returns following the first wave of TRI reports experienced improvements in their environmental performances. Doonan et al. (2005), unlike other prior studies, finds that managers of Canadian paper and pulp industries are not affected by capital market shocks.

While the stock market reactions are important factors in affecting a firm's output decisions, prior studies pay limited attention to the role of the print media in enhancing firm outcomes. Hamilton (1995a) shows that media attention is associated with firm characteristics and that media attention may generate stock market shocks. According to Hamilton's (1995a) study, TRI firms experienced an estimated loss of $4.1 million on the day the TRI figures were published for the first time. Dasgupta et al. (2006b) studies the role of media attention on a firm's environmental performance. Using survey data from industrial facilities in South Korea, they show that environmental news and a firm's awareness of such media attention are important predictors of a firm's performance.

The literature on firm responses to TRI program, apart from studying capital market reactions, has also explored other aspects of the program. An increasing number of studies focus on the association between local and community characteristics and patterns in toxic releases. While Arora and Cason (1999) finds that disproportionately high volumes of toxic chemicals are released in minority neighborhoods, Gamper-Rabindran (2006) and Wolverton (2009) find evidence otherwise. Another line of research that uses TRI data focus on specific instruments of the program that might influence environmental performances. Khanna and Damon (1999), Arimura et al. (2008), Anton et al. (2004), Vidovic and Khanna (2007) and Brouhle et al. (2009) all study the association between environmental management programs and firm performances. They find that either environmental assistance programs or a mix of regulatory threats and assistance programs can improve environmental outcomes.

This essay contributes to the existing literature on firm responses to information-based environmental regulations. My study extends the TRI literature by providing a comprehensive study of the relationship between media attention and firm responses. I, first, explore what determines TRI-related media attention (in Chapter 2), then show how differently firms with media attention may behave in releasing toxic chemicals, and lastly, investigate the causality between media attention and subsequent toxic releases. For this I use a dataset which allows me to control for several firm-level and neighborhood characteristics that influence toxic releases, thereby making my data more extensive than any prior work.

3.3 Data

This study uses media attention data from the LEXIS-NEXIS Academic Universe database, pollution data from the Toxic Release Inventory (TRI) database, company level information about the TRI establishments from Standard and Poor's COMPUSTAT North America database and socio-economic characteristics from the 1990 U.S. Population Census. Data on the structure of the media markets is collected from the 1989 Standard Rates and Data Services' (SRDS) Newspaper Circulation Analysis reports published by the Audit Bureau of Circulation.

Media attention data is collected from the news archives at the LEXIS-NEXIS Academic Universe database. The aim of the database search was to gather as much information as possible about the first time TRI related media attention in 1989[16]. This search identified around 1000 articles from major national newspapers and newswires. A thorough reading of these newspaper articles to identify specific information about TRI establishments (and not the parent company), generated 84 articles which contained information about 378 establishments that polluted in 1987. These major newspapers includes *USA TODAY, The Boston Globe, The Washington Post, The Wall Street Journal, The New York Times* and newswires like *The Associated Press, United Press International, States News Service.* After merging

[16] I used a combination of keywords for the database search: 'Toxic Release Inventory' or 'worst polluters' or 'pollution' or 'Toxic 500' or 'National Wildlife Federation' for the period June, 1989 to April, 1990, media reported about 1987 TRI releases in June, 1989. For a more detailed discussion on the database search, refer to the data section in Chapter 2.

the 1987 TRI dataset with the 1990 Census data and adjusting for the missing zip code information, I am left with 370 establishments with media attention[17].

The TRI database contains detailed information about toxic releases of all U.S manufacturing facilities eligible to report under the TRI regulation. There is a two year gap between the data-reporting date and the date EPA publicly disseminates this information. The first TRI report was available on 19th June, 1989 and contained information about the toxic releases of almost 24,000 polluting facilities in 1987. I ranked the 1987 TRI facilities by their overall onsite and offsite toxic releases. I, then, limit my focus to the top 500 facilities and follow their emissions for every year starting from 1987 to 1995. It is important to note that the 1987 dataset was later found to be unreliable as many establishments were inexperienced in measuring their toxic releases[18]. I, therefore, disregard the 1987 toxic releases, as the focus is on firm responses and accuracy of the releases matter. The study, therefore, uses the top 500 polluting establishments of 1987, but follow their emissions data from 1988 to 1995 as the response variable.

Like prior literature, I limit my focus to the top 500 polluting establishments. Out of the 370 establishments that received media attention in 1989, 138 establishments are in the top 500 list. The remaining 232 establishments with media attention are distributed haphazardly in low polluting establishments. Figure 3.1 shows the distribution of media attention among the TRI establishments. There

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[17] For more details on the missing zip code adjustments, refer to the data section of Chapter 2.

[18] For more details on the limitations of the TRI data, refer to Section 1.3.2 in Chapter 1.

are 53 establishments in the top 100 TRI establishments that received media attention. In the following sets of 100 establishments, establishments with media attention steadily decrease. Between 500 and 1000 establishments there 54 media hits and an additional 500 establishments (between 1000 and 1500 establishments) adds only 31 establishments with media attention. The frequency of media attention becomes sparse in low polluting establishments. I am aware that by limiting the dataset to the top 500 I lose important information about media attention, but this subset contains larger number of media hits than those identified in a prior study by Hamilton (1995)[19]. Also limiting the focus to the top 500 establishments allows me to analyze the polluters who are comparable in all other aspects except media attention[20].

While this intuition to limit the dataset to the top 500 establishments is necessary to be able to accurately merge establishment and parent company level data it, nonetheless, raises concerns of sample selection bias. Limiting our analysis to the top 100 or top 200 polluters only generates estimates that have larger coefficients in absolute value. My final dataset, therefore, uses the top 500 establishments which contain 138 establishments with media attention in 1989. The treatment year is 1989, the first year of media reports. 1988 is the pre-treatment year and years 1990 to 1995 are the post-treatment years.

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[19] Hamilton (1995a) identified 50 facilities with media attention in the top 500 list.

[20] I have experimented with other sets of treatment and control groups based on the industry and geographic classifications. In all cases, there is very little to no variability in media attention within those subsets and a large amount of valuable information about media attention is lost in such categorizations.

I use the COMPUSTAT North America from Standard and Poor's database to collect financial information about TRI facilities[21]. I collected data on the neighborhood characteristics of the TRI facilities from the 1990 U.S Population Census at the U.S. zip code level. The 1990 Census dataset did not have information about the population density at the zip-code level, which I calculated separately, using land area in square miles from the 2000 Zip Code Tabulation Areas.

I collected data on the structure of the media markets from the 1989 SRDS Newspaper Circulation Analysis reports published by the Audit Bureau of Circulation. These reports contain data on the market penetration rates of major newspapers at the U.S. county level and maps that depict the number of radio stations, television stations and newspaper companies in each county.

3.4 Empirical Strategy

This section describes the measures of pollution, socio-economic control variables, and media attention used for the empirical analysis in this chapter. It also outlines the empirical strategies used in estimating how firm responses associate with media attention. I use a difference-in-differences approach, a two stage least squares (2SLS) estimation method and propensity score matching (PSM) to explore the relationship between media attention and firm responses. This section explains them in details.

[21] Even though the TRI database provides information about the parent company, there is no unique identifier common to the TRI files and the COMPUSTAT database to merge the datasets digitally. So the data was manually entered.

I estimate a difference-in-differences model with year effects to isolate how firms that received media attention pollute differently from those that did not.

$$RELEASES_{it} = \alpha + \sum_{j=1990}^{1995} \beta_j * YEAR_j + \beta_2 * MEDIA\_ATTENTION_i + \beta_3 * AFTER_t * MEDIA\_ATTENTION_i + X\beta + \varepsilon_{it} \qquad (1)$$

In equation (1), the dependent variable, $RELEASES_{it}$, is the logarithm of i-th facility's toxic releases in period *t*. $YEAR_j$, is an indicator variable for each post-treatment year to capture which one of them has a greater effect on reducing toxic releases[22]. $MEDIA\_ATTENTION_i$ is the binary treatment variable. The pre and post-treatment years are captured by the dummy variable $AFTER_t$. The coefficient of the interaction term (β_3), captures the treatment effect of media attention on future toxic releases.

The vector *X*, is a set of control variables that includes industry classification variables (*CHEMICALS, PAPER, PRIMARY, PETROLEUM,* and *TRANSPORTATION*) and the establishment's geographical location (*NORTHEAST, SOUTH, MIDWEST* and *WEST*). It also includes socio-economic characteristics like *INCOME,* the logarithm of the median household income at the zip code level, *HISPANIC,* the percentage of Hispanics in the neighborhood and *NONWHITE,* the percentage of non-whites who are not Hispanics. I also include the logarithm of the population density (*POPULATION DENSITY*) since facilities in densely populated, urban neighborhoods

[22] Typically, the *AFTER* variable is used to capture the time trend in the control group in a difference-in-differences estimation. Following Dave and Kaestner (2009), I have introduced, *YEAR,* a dummy variable for each post treatment year to capture this time trend.

may be more cautious about their annual toxic releases than sparsely populated neighborhoods.

In addition, vector *X* also includes measurable firm characteristics. Logarithm of the average cost of goods and services is used as a proxy for the input prices and other costs incurred by the firm (*AVG. COST OF INPUTS*); logarithm of total sales is used as a proxy for the output of the firm (*SALES*), and logarithm of research and development expenditures per unit sales (*RND INTENSITY)* proxies for the firm's innovativeness.

Ideally we want our treatment variable, $MEDIA\_ATTENTION_i$, to be randomly assigned and the treatment to be an unexpected shock to the facilities. In our case, media attention is clearly not randomly assigned. Prior studies like Hamilton (1995a) and my prior essay have shown that media attention is closely associated with neighborhood and establishment level characteristics, thereby making media attention more deterministic in nature. Non-randomness of media attention raises the possibility that there might be some unobservables that are correlated to both media attention and future toxic releases. Hence the results of the difference-in-differences estimations should not be interpreted as causal. The estimates are descriptive that will simply show the degree of association between media attention and future emissions.

While non-random, I argue that the treatment variable used in this analysis is likely to capture an unexpected shock to the establishments. Prior studies have shown that there was a significant drop in the stock prices of TRI companies and stockholders experienced abnormal negative returns following the first wave of the

TRI reports. Hamilton (1995a) translates this average loss to $4.1 million in stock values for TRI firms. If shareholders had expected the media attention following the first publication of the TRI reports and the negative publicity costs associated with it, then stock markets would not have experienced such abnormal negative returns on a single day and stock prices would not have dropped significantly. The news coverage and media attention took investors by surprise. This unexpected shock created by media attention is required so that its causal effect on toxic releases in not anticipated by the firms.

I use two-stage least squares (2SLS) estimation to address the endogeneity with media attention. Arora and Cason (1996) and Wolverton (2009) show that socio-economic characteristics like the distribution of non-whites and Hispanics, the income distribution of the neighborhood are associated with toxic releases of a TRI facility. And these characteristics are found to be closely associated with media attention as well. So there are some observables that not only influence media attention but are also correlated with toxic releases. While some of these factors can be controlled for, several others may remain unobserved and if left unaccounted for, would not allow me to isolate the direct effect of media attention on future toxic releases. An ideal instrumental variable would be strongly correlated to media attention, but would not influence future toxic releases. I have identified three such candidates[23]. Using these instruments, I estimate the following equation:

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[23] I also considered a fourth candidate for the instrumental variable, but it is not used in the estimations due to lack of sufficient number of observations. Media tend to report more about companies that spend heavily on advertising as a company's advertising expenditures are revenues for the media houses. It is less likely that such expenditures would influence the output decisions of

$$\Delta RELEASES_{it+1} = \alpha + \beta_1 * MEDIA\_ATTENTION_{it} + X\beta + \varepsilon_{it} \quad (2)$$

$$\text{Where, } MEDIA\_ATTENTION_{it} = \gamma + I\delta + \varphi_{it} \quad (3)$$

The dependent variable in equation (2), $\Delta RELEASES_{it+1}$, measures the change in the logarithm of the toxic releases between 1990 and 1988. $MEDIA\_ATTENTION_{it}$ is the instrumented media attention as expressed in equation (3). The vector, *X*, in equation (2) contains the same list of variables as in equation (1) above. The vector, *I*, in equation (3) contains three instrumental variables.

The three instruments used in estimating equation (3) are based on the structure of the media markets. If a polluting facility is in close proximity to a media market that is very competitive, then newspapers or other types of media (like radio and television) would be competing with each other for readership or viewership or airtime. Such a competitive atmosphere would attract media attention irrespective of the establishment's toxic releases. According to Lacy (1989), the intensity of newspaper competition influences "the percentage of space in a newspaper given to news coverage and coverage of news in the city in which the newspaper is located." The structure of the media market is unlikely to directly affect decision-making about changes in toxic releases. News coverage in this case is not necessarily meant to impose a negative publicity cost on the polluting establishments, but to sell news. In order to capture competitiveness in the media markets, I gather data to create three variables which serve as instrumental variables.

the company and hence its toxic releases. Advertisement expenditure figures collected from COMPUSTAT have substantial amount of missing observations.

The first one is a dummy variable, *RADIO DUMMY,* for the presence of radio stations and television stations in a given county. The idea here is that there will be a greater sense of competition in a particular county if it has at least one of the two other types of media offices apart from newspaper. These other types of media are expected to compete for airtime or viewership. Such competition may correlate with the likelihood of TRI-related media attention but may not directly affect the volumes of toxic chemicals released by the TRI establishments located in that county. So I expect that there will be a positive correlation between *RADIO DUMMY* and *MEDIA ATTENTION*. This data for *RADIO DUMMY* is collected from the maps in the 1989 SRDS Newspaper Circulation Analysis reports published by the Audit Bureau of Circulation.

The next instrumental variable is constructed based on a different concept of competitiveness in media markets. In media economics, competitiveness in the media markets is explained with the help of a model known as "umbrella competition[24]" (Lacy et al. 2002). "Umbrella competition" refers to newspapers headquartered in different cities with different publication cycles competing for circulation areas for news, readership and advertising (Lacy et al., 2002). Competition here is defined by the degree of substitutability between the different layers or cycles of newspapers circulated in a given area. For example, newspapers in different layers, like metropolitan dailies and suburban dailies, are substitutes of

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[24] "Umbrella competition" refers to newspapers headquartered in different cities with different publication cycles competing for circulation areas for news, readership and advertising (Lacy et al., 2002)

each other in a household in a particular county. Such substitutability is usually measured by the market penetration of a newspaper in a given area.

Market penetration is typically expressed as a percentage of households that receive a copy of the newspaper against the total number of households in the paper's market area. Several newspapers are circulated in each county and the SRDS's publications report market penetration of each of these newspapers. But I am interested in one composite measure of competiveness that would be representative of the media market surrounding the polluting establishment. So, I use the market penetration, *MARKET PENETRATION,* of the largest newsgroup as identified by the Audit Bureau of Circulation's Newspaper Circulation Analysis of 1989/90, as my instrumental variables. I expect that the there will be a positive correlation between this instrument and media attention.

The last instrumental variable is the average distance of a facility from the newspaper headquarters that covered the TRI reports. One would expect that the farther away the polluting establishment is from the newspaper headquarters, the less likely it is going to be reported about. So the average distance may determine whether the establishment is reported about or not, but this distance does not influence the output decisions of the firm. So I expect that the correlation between average distance and media attention would be negative. There are 12 newspapers and newswires in my dataset. I identified the zip codes of the 7 newspaper offices (excluding newswires) and calculated the average distance, *AVERAGE DISTANCE*, of each TRI establishment from these media houses as an instrumental variable.

For a causal interpretation, the difference-in-differences approach requires that media attention is randomly assigned. I try to address the endogeneity issue with media attention by using two stage instrumental variables estimation. But I find that the instruments are underidentified and weak, thereby making my estimates inconsistent. The literature provides solutions that can help overcome the problem with weak instruments. One solution is to look for more valid instruments and/or to adopt use lagged values of the instruments to overcome the problem with weak instruments[25]. But given the nature of the data used in this study, these solutions cannot be adopted. Another solution is to adopt an estimation technique that might help reduce the selection bias in the sample. Such a bias is a common problem when using observational data where the treatment and control groups are not randomly assigned.

Matching is an estimation technique that is useful when treatment and control groups are not randomly assigned. In order to measure the treatment effect of media attention on changes in future emissions I employ propensity score matching (PSM). By using propensity score matching I can create a counterfactual control group based on the predicted probabilities of getting a treatment. The predicted probabilities, or propensity scores, are created using several characteristics that are common between treatment and control groups.

Propensity scores are typically obtained from Logit regressions that predict the likelihood of being treated, in our case, getting media attention. These

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[25] For more discussion on ways to deal with weak instruments refer to Murray (2006), Dufour (2003), and Staiger and Stock (1997).

propensity scores are then used to split the sample into several equally spaced blocks. These blocks should be created in such a way that the average propensity scores between groups in each block do not differ. It is also necessary that the blocks pass the balancing test before estimating the average treatment effect. To check that the blocks are balanced, we test whether the mean of each of the characteristics that are used to generate the propensity scores do not differ between groups within each block. Once the balancing properties are met, various matching techniques are used to estimate the average treatment effect of the treated. I use nearest neighbor matching, radius matching and kernel matching to estimate the average treatment effect of media attention on changes in future toxic releases between 1988 and 1990.

The Logit specification used to generate the propensity scores is shown in equation (4). Here I assume that the probability of getting media attention depends on the volumes of toxics released into the air (*AIR*), water (*WATER*), underground (*UNDER*), landfills (*LAND*), and offsite transfers (*OFFSITE*). I also include their square terms and some neighborhood characteristics as determinants of media attention. I estimate the following equation:

$$\begin{aligned} Prob(MEDIA\_ATTENTION_i) &= \alpha + X_i^P \beta_{P1} + (X_i^P)^2 \beta_{P2} + X_i^I \beta_{I1} \\ &+ (X_i^I)^2 \beta_{I2} + X_i^R \beta_R + X_i^S \beta_S + \varepsilon_i \end{aligned} \tag{4}$$

In equation (4) the pollution vector in the above specification is denoted by. X_i^P The vector X_i^I includes socio-economic characteristics like the percentage of Hispanics (*HISPANIC*) and non-whites (*NONWHITE)* residing in the neighborhood, the logarithms of median income levels and the population density. Equation (4) also uses the squares of all variables, except income and population density. Vectors X_i^R and X_i^S used in equation (4) represent the region and industry classifications as described in equation (1).

3.5 Media Attention and Firm Response

3.5.1 Descriptive Statistics

The dataset used for estimating equation (1) contains 500 establishment level observations, of which 138 received media attention. Facilities are distributed in 426 zip codes clusters, 125 of which include facilities with media attention. In constructing the dataset, I have limited my focus on the top 500 polluters of 1987 and followed there pollution patterns up to 1995. While none of the establishments with media attention dropped out of the list of the top 500 polluters, their relative ranks have changed over the years. For example, the rank of the largest TRI polluting facility in 1987 with media attention, Kerr-McGee Chemical Corporation's Trona facility in California, dropped to 245 in 1988, 257 in 1989, 222 in 1990, and finally 316 in 1995.

Figure 3.2 plots the annual mean emissions of the top 500 TRI firms between 1988 and 1995. It shows the annual emissions pattern between firms with media attention and those without. The vertical line indicates the treatment year, 1989. Annual toxic releases for both types of establishments have been steadily decreasing and visually there seems to be no distinctive change in the rate of decline in toxic releases for facilities with media attention after 1989. The graph shows that emissions for establishments with media attention started declining even before the treatment shock in 1989. Even though graphically there seems to be no evidence of the treated establishments to significantly change their rate of decline in toxic releases following the first wave of media reporting, a well-controlled regression like equation (1) may capture such a change.

Figure 3.3 shows the annual trends in the toxics releases of TRI establishments by regions. Establishments located in the Northeast and Midwest experienced steady declines toxic releases over the years. While establishments located in the South demonstrate a significant decrease in toxic releases in the post-treatment years, establishments in the West tend to experience an increase in toxic releases following the first wave of media attention in 1989.

Figures 3.4 takes a closer look at the annual release patterns by industry classification of the TRI establishments. All industries show mild declines in toxic releases between 1988 and 1995. Chemicals, primary metals and petroleum industries show rapid declines in the pre-treatment periods. These industries are generally highly polluting and heavily regulated than any other industries.

The rapid decline in toxic releases in chemicals, primary metals and petroleum between 1988 and 1989 may well reflect direct regulation correlated to the TRI or technological progress. However, it is also possible that establishments in these industries were expecting some form of attention to their volumes of pollution even before the first TRI reports came out, and this may help explain part of the pre-treatment year declines in toxic releases that we notice in Figure 3.1. The distribution of media attention by industry classification, as shown in Figure 3.5, shows that establishments in the chemical industry indeed received the most number of media hits. Of the 138 media hits that are present in the top 500 polluting TRI facilities, 72 belong to the chemical industry, followed by petroleum, paper and primary metals. This justifies why we need to control for industry classification in our regression analysis.

3.5.2 Results of Difference-in-Differences (DID) approach

Table 3.1 presents the estimates of the difference-in-differences model as described in equation (1). The variable of interest here is the interaction term (*MEDIA ATTENTION * POST1989).* This term measures the difference in the changes in toxic releases over time. Results show that there has been a statistically significant decrease in the toxic releases of facilities with media attention in the years following the first publication of the TRI report. Compared to the pre-treatment years, facilities with media attention have experienced a 40.3% decrease in releases over and above the decrease experienced by facilities without media attention. These estimates, which are surprisingly large, clearly show that facilities with media attention behave differently from the ones that did not receive any media attention. Since I was concerned about the sample size, I also report the difference-in-differences results using different sample sizes in Appendix Table 3.1A.

In addition to the declines in toxic releases, Table 3.1 also highlights which post-treatment year had a greater decline in toxic releases. It shows that decline in releases were more pronounced in later years than the years immediately following the treatment. Reducing toxic releases involves adjustments to the production processes and it may take some time. The year dummies exhibit this effect of time on reduction in toxic releases. Toxic releases decline incrementally till 1994, after which the declines seem to be less pronounced.

Table 3.1 also shows that neighborhoods with a higher percentage of non-white and Hispanics populations have experienced greater reductions in toxic releases. Richer neighborhoods and neighborhoods with high population density have also experienced reductions in toxic releases over the period of time 1988 to 1995. The magnitudes of these reductions are not large, but the estimates are statistically significant. These results give a reason to think that firms in non-white areas may respond more to media coverage because such coverage could more easily result in other non-profitable actions such as law suits. Hence, I try interacting *MEDIA ATTENTION* with the different measures of race, *NONWHITE* and *HISPANIC*. The results (only the variables of interest) are presented in Appendix Table 3.2A. It shows that facilities with media attention are more likely to decrease toxic releases in Hispanic neighborhoods, but are less likely to decrease releases in non-white/non-Hispanic neighborhoods.

3.5.3. Results of Two Stage Least Squares (2SLS) Estimation

Tables 3.2 - 3.4 present the results of the 2SLS estimations. Table 3.2 shows the first stage coefficients of the 2SLS estimations. The first three columns show the results of individually using market penetration of the major newspaper (*MARKET PENETRATION*), presence of radio stations (*RADIO DUMMY*) and average distance of the establishment from the media headquarters (*AVERAGE DISTANCE*) as instruments. The last column uses all the three instruments to estimate media attention. The coefficients on the instrumental variables show a very weak correlation and in the case of *RADIO DUMMY*, the sign on the coefficient is not as expected.

Table 3.3 reports the tests of underidentification and weak instrument identification, weak instrument robust inferences and the over-identification test (when all instruments are used). The second column reports the tests of underidentification. The null hypothesis under this test is that the excluded instruments are not relevant. I report the Kleibergen-Paap rk Wald statistic along with the p-values in the first column. In all cases, I fail to reject the null hypothesis, which suggests that the instruments are underidentified. The third column reports the results of the weak instrument identification tests. Instruments are considered weak when their correlation with the endogenous regressors is insufficient to allow inference on the variable of interest. The null hypothesis of the weak identification test is that the equation is weakly identified. The third column reports the Kleibergen-Paap Wald rk F statistic from the first stage and I fail to reject the null hypothesis. My instruments are weak. Table 3.3 also reports the Anderson and Rubin (1949) test of structural parameters, which tests the joint significance of our endogenous regressor, *MEDIA ATTENTION,* given that the instruments are weak. The results show that none of the estimates reported in Table 3.4 are statistically significant.

Table 3.4 reports the second stage of the 2SLS estimations, along with robust standard errors. The sign on our variable of interest, *MEDIA ATTENTION*, is mixed and never are statistically significant. Across all regressions, except when using *RADIO DUMMY* and all instruments, media attention may reduce toxic releases in 1990 compared to 1988, but the results are still not significant.

The 2SLS regression approach tried to address the endogeneity issue of media attention. The regression results do not find definitive evidence that media attention may affect a firm's polluting behavior. One explanation for such results is that the instruments used for the estimations are weak and underidentified, both of which lead to inconsistent estimates. It is also likely that the large effects suggested by the difference-in-differences in part reflect the influence of some unobserved characteristics that correlate with media attention and have not been fully captured by the instruments used here. There may be some other regulatory tools or unobservables that are strongly correlated with media attention. Such strong correlation with media attention hinders isolating the treatment effect of media attention on changes in toxic releases. I have controlled for some obvious firm-level characteristics, like industry and regional classifications. For example, the chemicals, primary metals and petroleum industries which show rapid declines in toxic releases could have been heavily regulated at the same time that the media was reporting about them. Even though I controlled for the industry classifications, there are still some unobserved factors that make it unlikely to tease out the treatment effect of media attention.

3.5.4 Results of Propensity Score Matching

The last sets of results are the propensity score estimates. In order to implement the matching technique, the first step is to obtain the propensity scores. For the propensity scores, I estimate equation (4) using a simple Logit specification. The Logit specification uses the squared terms of pollution and socio-economic variables[26]. Table 3.5 presents the results of the Logit regression. In generating these propensity scores, 5 final blocks are created to ensure that the mean propensity scores in each block do not differ for the control and treated groups in each block. A descriptive summary of the propensity scores in the 5 blocks are presented in Table 3.6.

Table 3.7 presents results of the across group t-tests of each of the five blocks created. It tests whether there is any difference in the mean propensity scores in each block. The balancing property requires that there is no difference in the mean of the propensity scores within groups in each block. The groups are labeled as "With Media Attention" and "Without Media Attention" in the table. The table shows that across all blocks, we have failed to reject the null hypothesis thereby ensuring that the blocks are balanced in terms of the propensity scores. The balancing property of each characteristic within each block is also satisfied. A synopsis of the test results is presented in Table 3.8, where the null hypothesis of no difference

[26] In generating the propensity scores, I have experimented with the interaction terms between the several socio-economic and pollution variables. The results show that general the average treatment effect is negative but not significant. A summary of the results are presented in Appendix Table 3.3A and Appendix Table 3.4A.

between the means of each characteristic between groups in each block is never rejected.

Finally, Table 3.9 reports the average treatment effect for the treated establishments with media attention using three common matching techniques: the nearest neighbor matching, radius matching (with a radius of 0.05) and kernel matching. Nearest neighbor matching finds 83 matches out of the 138 treated firms and 40 matches out of the 362 controls in my dataset. The estimate of the average treatment effect of media attention shows that these firms would tend to reduce their future toxic releases. The results are not statistically significant. For the nearest neighbor matching, there are only 63 matches found from the treatment group and 144 matches from the control group. The average treatment effect using this matching technique suggests that establishments with media attention would on an average reduce their future toxic releases by almost 25% between 1988 and 1990 and this result is significant at the 5% level. Results of the kernel matching technique show statistically insignificant reduction in future emissions by the treated establishments. In general, the average treatment effects for the treated show that media attention has a negative effect on the future toxic releases, and the results are not consistently statistically significant.

3.6 Conclusions

The unconventional nature of the TRI program and the success attributed to it in reducing toxic emissions over two decades have made it a popular complement to traditional environmental regulations. Nonetheless, the proposals to change the reporting requirements of the TRI program remind us that we don't fully understand how the program works. This essay adds to that understanding by providing a comprehensive study on the role of media attention under this program, and allows us to investigate the role played by TRI-related media responses in affecting firm behavior.

The difference-in-differences results reported here show that firms with media attention reduce toxic releases far more than the similar untreated firms. The reductions are more so in minority and poor neighborhoods. However, results on the causality between media attention and future emissions do not show any definitive evidence that media attention may impose costs on firms to affect their future emissions. A two-stage instrumental variable estimation does not generate statistically significant results. Propensity score matching results support decreases in future toxic releases, but the results are not consistently significant across all matching techniques.

There could be several plausible explanations for not finding any definitive evidence on the causality of media attention on firm behavior. There was a drop in the TRI emissions even before the treatment year and it could be due to the combined effect of several unobserved factors. First, for example, figure 3.4 which plots the distribution of media attention among industry classifications shows that more than half of the establishments with media attention belong to the chemical industry. The chemical industry also tends to be heavily regulated. So it is possible that a certain subsection of establishments in the chemical industry were subject to regulatory stringency that was also subject to media attention. Although industry classifications have been controlled for, other unobservables may be correlated with media attention.

Second, it is possible that once firms submitted their first TRI reports, they anticipated a negative publicity even before they received media attention. So they started reducing their emissions even prior to 1989, the treatment year. Third, it is possible that firms may have overstated their toxic releases prior to 1989. In fact, firms under public disclosure type programs like the TRI have often been found to voluntarily over-comply (Arora and Gangopadhyay 1995, Wu 2009). So it is also plausible that firms were overstating their toxic releases in the pre-treatment period, even before they received media attention. While instruments are used to isolate the treatment effect of media attention, these unobserved factors among others could not be controlled for to estimate the direct effect of media attention on future emissions.

The results of this study provide useful insights for both the supporters and critics of changing the reporting requirement under the TRI program. Those who support more rigorous reporting requirements might appreciate the fact that facilities with media attention are more likely to decrease toxic releases in some minority neighborhoods, like Hispanic neighborhoods, than those without media attention. While this paper does not find a causal link between media attention and future emissions, these results suggest that the EPA should carefully consider potential impacts on environmental justice before scaling back TRI reporting requirements.

Those who support more lax reporting requirements would, however, appreciate that media attention in itself does not impose significant external pressure on the firm to influence its polluting behaviors. So the reductions in toxic releases over a period of two decades may have been the result of other significant regulatory costs imposed on the firm, or the complementary effect of several other regulatory tools experienced by these firms. It is plausible that media attention may have an indirect effect on the polluting behavior of the firm. For example, media attention may provide incentives to enroll in voluntary environmental management programs, which in turn might affect subsequent toxic releases (Arora and Cason 1995, 1996, Arimura 2008, Brouhle 2009). Therefore, the fear raised by critics that lax reporting requirement may weaken the effectiveness of the program, it may lead to lesser accountability, lesser public scrutiny, and unfavorable environmental outcomes does not seem all that serious. In fact, such a policy reform may save some administrative costs for the EPA and information gathering costs for the firms, and also provide flexibility to the firms to choose alternate ways of reducing toxic releases.

Figure 3.1: Distribution of Media Attention in the Top 500 TRI Facilities.

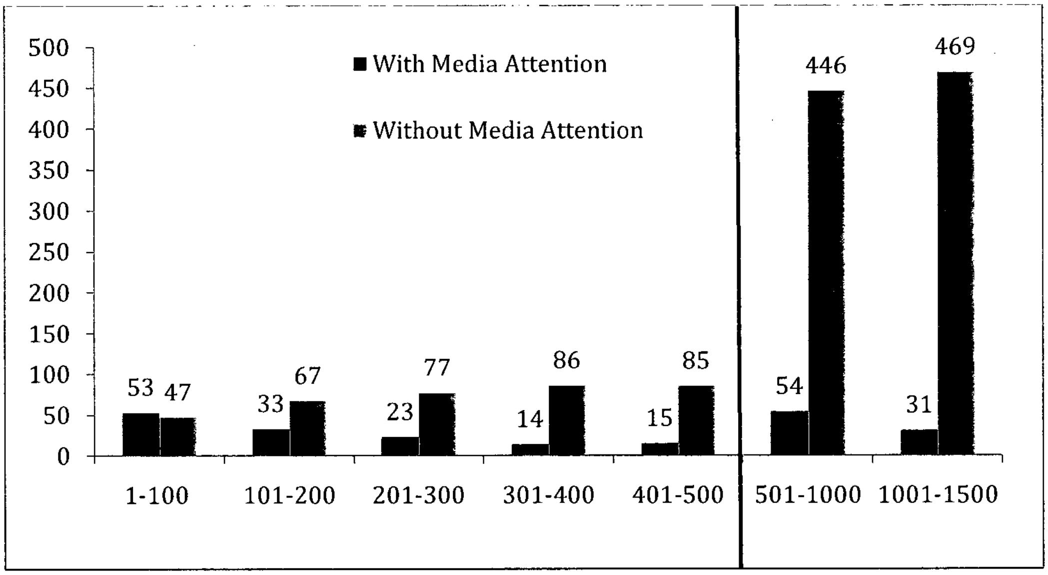


Figure 3.2: Annual Mean Emissions of Top 500 TRI Facilities by Media Attention (MA), 1988-95.

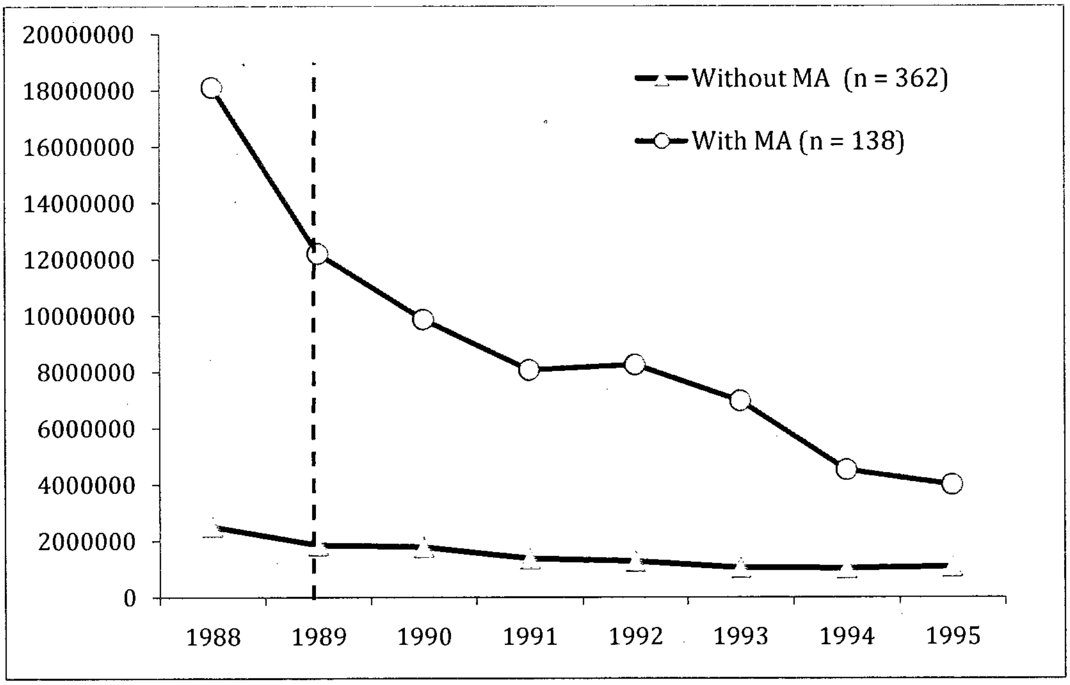


Figure 3.3: Annual Mean Emissions of Top 500 TRI Facilities by REGION, 1988-95.

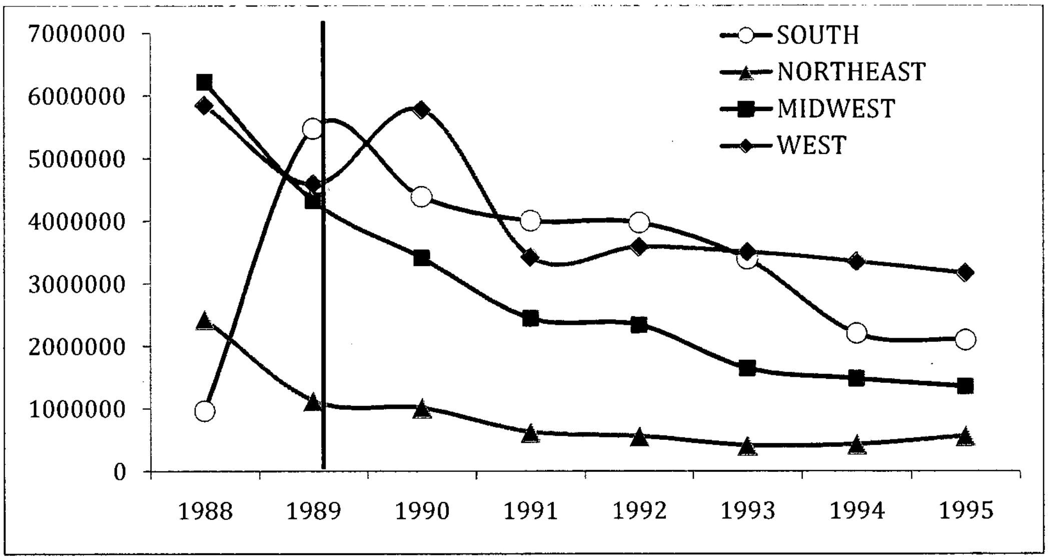


Figure 3.4: Annual Mean Emissions of Top 500 TRI Facilities by INDUSTRY, 1988-95.

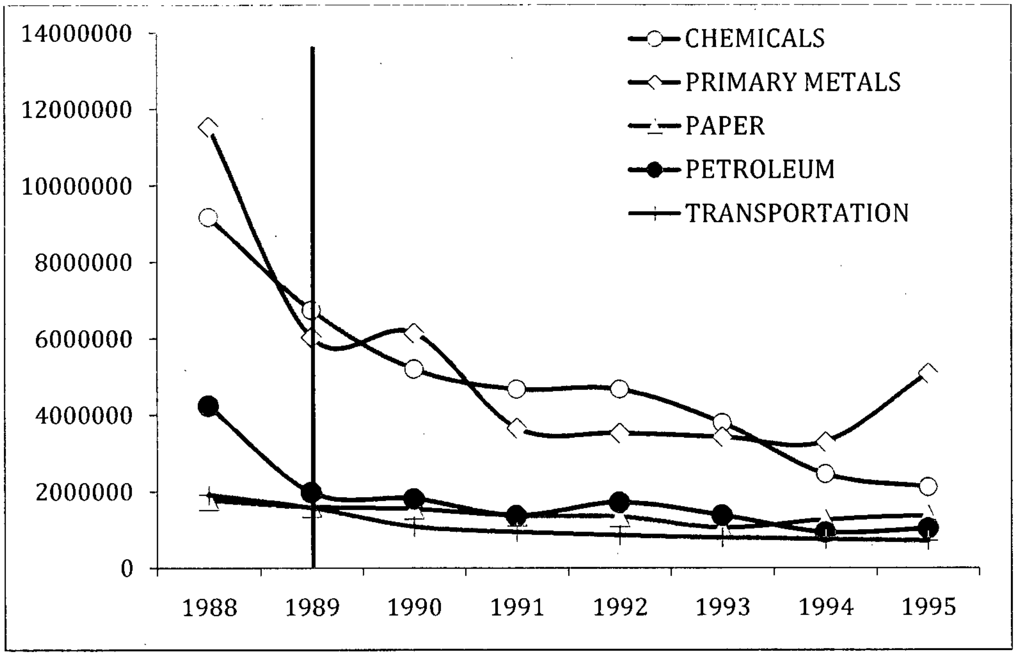


Figure 3.5: Distribution of Media Attention in the Top 500 TRI Facilities by INDUSTRY classification.

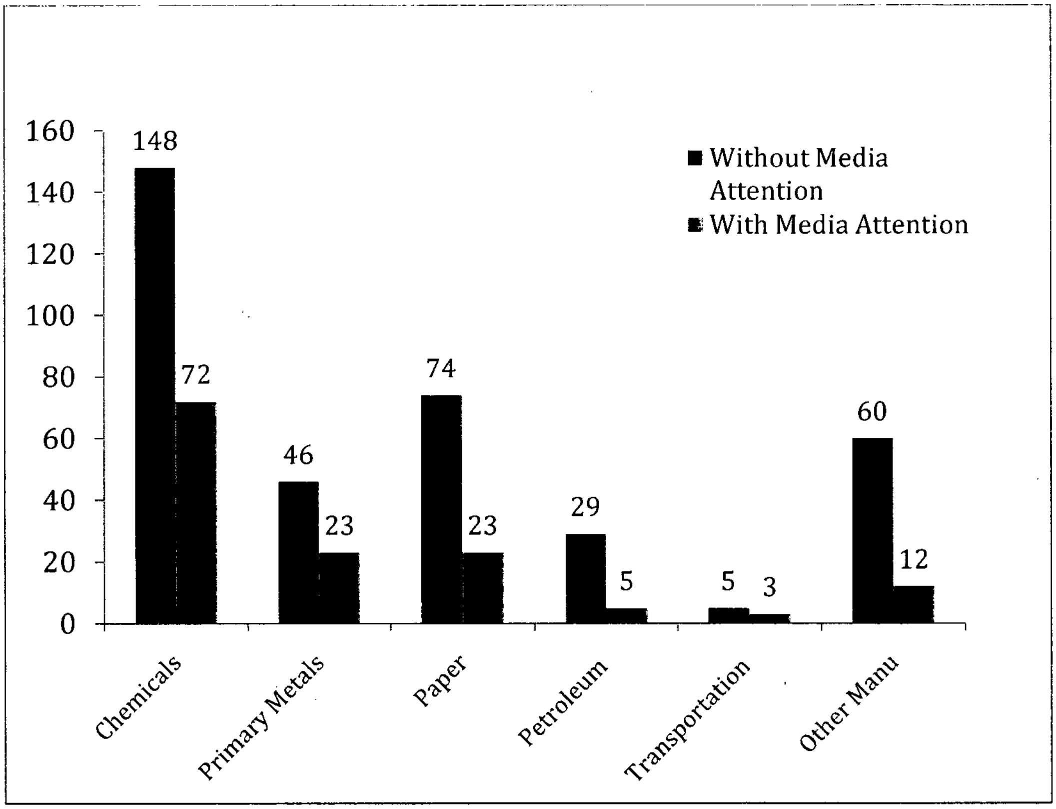


Table 3.1: Difference-in-Differences Estimation Results.

VARIABLES	*RELEASES* (Log of Total Releases)
MEDIA ATTENTION (Dummy Variable)	1.605*** (0.142)
YEAR1990 (Dummy Variable)	(-)0.310 (0.115)
YEAR1991 (Dummy Variable)	(-)0.443** (0.115)
YEAR1992 (Dummy Variable)	(-)0.579*** (0.116)
YEAR1993 (Dummy Variable)	(-)0.809*** (0.116)
YEAR1994 (Dummy Variable)	(-)0.943*** (0.115)
YEAR1995 (Dummy Variable)	(-)0.826*** (0.115)
*MEDIA ATTENTION * POST1989* (*POST1989:* Dummy variable)	(-)0.403** (0.162)
NONWHITE (Percentage of Total Population)	(-)0.011*** (0.002)
HISPANIC (Percentage of Total Population)	(-)0.002 (0.003)
INCOME (Log of Median Household Income)	(-)0.303** (0.124)
POPULATION DENSITY (Log of Population Density)	(-)0.180*** (0.021)
CHEMICALS (Dummy Variable)	0.699*** (0.096)
PRIMARY METALS (Dummy Variable)	0.941*** (0.121)
PAPER (Dummy Variable)	0.969*** (0.112)
PETROLEUM (Dummy Variable)	1.543*** (0.159)
TRANSPORTATION (Dummy Variable)	0.867*** (0.268)
NORTHEAST (Dummy Variable)	(-)0.702*** (0.136)
MIDWEST (Dummy Variable)	0.184 (0.118)
SOUTH (Dummy Variable)	0.400*** (0.109)
SALES (Log of Total Sales per year)	0.134*** (0.029)
AVG. COST OF INPUTS (Log of Average Cost of Goods and Services per year)	0.433** (0.198)
RND INTENSITY (Log of R&D expenditures per unit sales per year)	0.082 (0.052)
Observations	3920
R-Squared	0.207

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3.2: First-stage of 2SLS Estimation with Mean Substitution for Missing Values.

Dependent Variable: *MEDIA ATTENTION* (Dummy Variable)				
	Excluded Instrumental Variable			
	MARKET PENETRATION	*RADIO DUMMY*	*AVERAGE DISTANCE*	All Instruments
NONWHITE (Percent of Total Population)	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)	0.002** (0.001)
HISPANIC (Percentage of Total Population)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)
INCOME (Log of Median Household Income)	0.040 (0.073)	0.038 (0.072)	0.039 (0.074)	0.044 (0.074)
POPULATION DENSITY (Log of Population Density)	(-)0.042*** (0.013)	(-)0.040*** (0.013)	(-)0.042*** (0.013)	(-)0.041*** (0.014)
CHEMICALS (Dummy Variable)	0.112** (0.056)	0.111* (0.056)	0.114** (0.055)	0.109** (0.056)
PRIMARY METALS (Dummy Variable)	0.186*** (0.072)	0.185** (0.072)	0.186** (0.072)	0.184** (0.072)
PAPER (Dummy Variable)	0.023 (0.065)	0.024 (0.065)	0.024 (0.065)	0.025 (0.066)
PETROLEUM (Dummy Variable)	(-)0.068* (0.087)	(-)0.758 (0.087)	(-)0.064* (0.088)	(-)0.077 (0.088)
TRANSPORTATION (Dummy Variable)	0.248 (0.162)	0.247 (0.162)	0.252 (0.162)	0.247 (0.163)
NORTHEAST (Dummy Variable)	0.265*** (0.078)	0.261*** (0.079)	0.238* (0.137)	0.233* (0.135)
MIDWEST (Dummy Variable)	0.056 (0.063)	0.053 (0.063)	0.035 (0.107)	0.032 (0.105)
SOUTH (Dummy Variable)	0.093 (0.062)	0.089 (0.062)	0.074 (0.099)	0.072 (0.097)
SALES (Log of Total Sales per year)	0.023 (0.021)	0.024 (0.021)	0.024 (0.019)	0.024 (0.021)
AVG. COST OF INPUTS (Log of Average Cost of Goods and Services per year)	(-)0.139 (0.141)	(-)0.133 (0.141)	(-)0.143 (0.141)	(-)0.137 (0.141)
RND INTENSITY (Log of R&D expenditures per unit sales per year)	(-)0.030 (0.034)	(-)0.028 (0.034)	(-)0.032 (0.034)	(-)0.029 (0.034)

MARKET PENETRATION (Instrumental Variable)	0.000 (0.001)			0.000 (0.001)
RADIO DUMMY (Instrumental Variable)		(-)0.069 (0.085)		(-)0.072 (0.085)
AVERAGE DISTANCE (Instrumental Variable)			0.000 (0.000)	0.000 (0.000)
CONSTANT	(-)1.151 (0.818)	(-)1.015 (0.808)	(-)1.105 (0.805)	(-)1.077 (0.822)
Observations	500	500	500	500

Notes: Robust (clustered by zip code) standard errors in parentheses. There are 426 zip code clusters.
*** p<0.01, ** p<0.05, * p<0.1

Table 3.3: Test Statistics of First-Stage Results of the 2SLS Estimations.

Excluded Instrumental Variable	Underidentification Test: Kleibergen-Paap rk Wald statistic	Weak Identification Test: Kleibergen-Paap Wald rk F statistic[a]	Weak Instrument-robust inference: Anderson-Rubin Wald (chi-square) test statistic	Overidentification test of all instruments
MARKET PENETRATION	0.18 (0.67)	0.17	1.00 (0.31)	-
RADIO DUMMY	0.63 (0.42)	0.60	0.02 (0.87)	-
AVERAGE DISTANCE	0.06 (0.81)	0.06	0.05 (0.81)	-
All Instruments	1.01 (0.79)	0.33	1.06 (0.78)	1.876 (0.59)

Notes: p-values reported in brackets.

[a] Stock and Yogo weak ID test critical values:

10% maximal IV size:	16.38
15% maximal IV size:	8.96
20% maximal IV size:	6.66
25% maximal IV size:	5.53

Table 3.4: Second Stage of the 2SLS Estimations.

Dependent Variable:				
	Excluded Instrumental Variables			
	MARKET PENETRATION	*RADIO DUMMY*	*AVERAGE DISTANCE*	*All Instruments*
MEDIA ATTENTION (Dummy Variable)	(-)10.868 (25.455)	0.679 (4.595)	2.343 (14.451)	(-)1.136 (3.594)
NONWHITE (Percentage of Total Population)	0.029 (0.061)	0.015 (0.011)	(-)0.002 (0.034)	0.006 (0.009)
HISPANIC (Percentage of Total Population)	0.003 (0.032)	(-)0.007 (0.008)	(-)0.009 (0.015)	(-)0.005 (0.007)
INCOME (Log of Median Household Income)	0.665 (1.226)	0.231 (0.304)	0.168 (0.611)	0.299 (0.291)
POPULATION DENSITY (Log of Population Density)	(-)0.514 (1.074)	(-)0.031 (0.211)	0.038 (0.608)	(-)0.107 (0.167)
CHEMICALS (Dummy Variable)	0.779 (2.895)	(-)0.527 (0.542)	(-)0.716 (1.672)	(-)0.322 (0.439)
PRIMARY METALS (Dummy Variable)	0.854 (4.774)	(-)1.307 (0.944)	(-)1.619 (2.759)	(-)0.967 (0.726)
PAPER (Dummy Variable)	0.292 (0.902)	0.025 (0.254)	(-)0.012 (0.426)	0.067 (0.243)
PETROLEUM (Dummy Variable)	(-)1.494 (2.153)	(-)0.703 (0.439)	(-)0.589 (1.042)	(-)0.827 (0.433)
TRANSPORTATION (Dummy Variable)	2.332 (6.596)	(-)0.056 (1.208)	(-)0.976 (3.693)	(-)0.105 (0.973)
NORTHEAST (Dummy Variable)	3.091 (6.661)	0.045 (1.273)	(-)0.393 (3.829)	0.524 (0.981)
MIDWEST (Dummy Variable)	0.913 (1.497)	0.276 (0.384)	0.184 (0.827)	0.376 (0.334)
SOUTH (Dummy Variable)	1.046 (2.372)	(-)0.008 (0.465)	(-)0.161 (1.357)	0.157 (0.384)
SALES (Logarithm of Total Sales per year)	0.286 (0.643)	0.011 (0.136)	(-)0.029 (0.363)	0.053 (0.117)

AVG. COST OF INPUTS (Log of Average Cost of Goods and Services per year)	(-)1.841 (3.926)	(-)0.223 (0.743)	0.009 (2.131)	(-)0.478 (0.627)
RND INTENSITY (Log of R&D expenditures per unit sales per year)	(-)0.431 (0.908)	(-)0.076 (0.161))	(-)0.025 (0.472)	(-)0.132 (0.146)
CONSTANT	(-)16.199 (29.067)	(-)3.469 (5.778)	(-)1.635 (16.246)	(-)5.471 (4.847)
Observations	500	500	500	500

Notes: Robust (clustered by zip code) standard errors in parentheses. There are 426 zip code clusters. *** p<0.01, ** p<0.05, * p<0.1

Table 3.5: Results of the Logit regression for the Propensity Scores.

MEDIA ATTENTION	Coefficients
AIR	5.21e-08 (2.81e-08)
AIR_SQUARE	3.00e-16 (2.30e-16)
WATER	(-)2.59e-08 (3.21e-08)
WATER_SQUARE	(-)6.94e-16 (3.87e-16)
UNDER	(-)9.49e-09 (5.56e-08)
UNDER_SQUARE	4.90e-16 (8.90e-16)
LAND	1.53e-07*** (4.97e-08)
LAND_SQUARE	(-)7.31e-16 (4.72e-16)
OFFSITE	5.85e-08 (8.02e-08)
OFFSITE_SQUARE	3.12e-15 (4.00e-15)
FORMR	0.013 (0.035)
FORMR_SQUARE	0.001 (0.001)
NONWHITE	0.017 (0.018)
NONWHITE_SQUARE	(-)0.000 (0.000)
HISPANIC	0.002 (0.028)
HISPANIC_SQUARE	(-)0.000 (0.000)
INCOME	(-)0.204 (0.476)
POPULATION DENSITY	(-)0.083 (0.084)
NORTHEAST	2.326*** (0.617)
MIDWEST	0.729 (0.603)
SOUTH	0.898 (0.579)
CHEMICALS	0.006 (0.317)
PRIMARY METALS	(-)0.332 (0.475)
PETROLEUM	(-)1.759** (0.713)
TRANSPORTATION	1.169 (0.849)
CONSTANT	(-)2.151 (5.115)

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3.6: Description of Estimated Propensity Scores and Distribution of Treated and Control across Each Block.

The region of common support is [0.0025, 1]
Mean propensity score: 0.276
Standard Deviation: 0.235
Number of observations: 500

Blocks of the pscore for treatment, *MEDIA ATTENTION*	*MEDIA ATTENTION*		Total
	0	1	
1	227	31	258
2	109	36	145
3	18	27	45
4	5	14	19
5	3	30	28
Total	362	138	500

Table 3.7: Two-sample t-test with Equal Variances for Each Block.

Blocks	Groups[Ψ]	Observations	Mean	Difference[B] (T)	Fail to reject null?
Block 1	WOMA	227	0.113 (0.003)	(-)0.024 (0.009)	YES
	WMA	31	0.138 (0.009)		
Block 2	WOMA	109	0.289 (0.005)	(-)0.020 (0.011)	YES
	WMA	36	0.311 (0.008)		
Block 3	WOMA	18	0.462 (0.012)	(-)0.002 (0.015)	YES
	WMA	27	0.464 (0.009)		
Block 4	WOMA	5	0.635 (0.014)	(-)0.053 (0.024)	YES
	WMA	14	0.689 (0.013)		
Block 5	WOMA	3	0.864 (0.026)	(-)0.087 (0.031)	YES
	WMA	30	0.952 (0.011)		

Notes: Standard errors are reported in brackets.
Ψ Groups are labeled as WOMA: Without Media Attention and WMA: With Media Attention.

B Difference = Mean (WOMA) – Mean (WMA).
Ho: Difference = 0;
Ha: Difference < 0; Ha: Difference != 0; Ha: Difference > 0

Table 3.8: Testing the Balancing Property for Each Variable in All Five Blocks.

Block Number	Variables in each block±	Groups within each variable	Fail to reject null for all variables in each block?[C]
1	*AIR, AIR_SQUARE, WATER, WATER_SQUARE, UNDER, UNDER_SQUARE, LAND, LAND_SQUARE, OFFSITE, OFFSITE_SQUARE, FORMR, FORMR_SQUARE, NONWHITE, NONWHITE_SQUARE, HISPANIC, HISPANIC _SQUARE, INCOME, POPULATION DENSITY, NORHTEAST, MIDWEST, SOUTH, CHEMICALS, PRIMARY METALS, PETROLEUM, TRANSPORTATION*	WOMA	Yes
		WMA	
2	*Same as above*	WOMA	Yes
		WMA	
3	*Same as above*	WOMA	Yes
		WMA	
4	*Same as above*	WOMA	Yes
		WMA	
5	*Same as above*	WOMA	Yes
		WMA	

Notes: ± Groups are labeled as WOMA: Without Media Attention and WMA: With Media Attention

C Difference = Mean (WOMA) – Mean (WMA).
Ho: Difference = 0;
Ha: Difference < 0; Ha: Difference != 0; Ha: Difference > 0

Table 3.9: Estimates of the Average Treatment Effect of the Treated.

Matching Algorithms	Number treated used	Number controls used	Average treatment effects on the treated
Nearest Neighbor Matching	83	40	(-)0.067 (0.234)
Radius Matching (Radius = 0.05)	63	144	(-)0.249** (0.146)
Kernel Matching (Bandwidth = 0.06)	83	144	(-)0.169 (0.222)

Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

APPENDIX

Table 3.1A: Difference-in-differences Results for Different Sample Sizes.

VARIABLES	*Top 100*	*Top 200*	*Top 300*	*Top 400*
MEDIA ATTENTION	1.910*** (0.299)	1.970*** (0.191)	1.704*** (0.172)	1.679*** (0.153)
YEAR1990	-0.188 (0.288)	-0.189 (0.182)	-0.242 (0.156)	-0.252* (0.131)
YEAR1991	-0.194 (0.293)	-0.264 (0.183)	-0.316** (0.157)	-0.344*** (0.131)
YEAR1992	-0.316 (0.293)	-0.354* (0.183)	-0.403** (0.157)	-0.455*** (0.131)
YEAR1993	-0.531* (0.291)	-0.596*** (0.183)	-0.647*** (0.157)	-0.700*** (0.131)
YEAR1994	-0.562* (0.290)	-0.657*** (0.182)	-0.731*** (0.156)	-0.822*** (0.130)
YEAR1995	-0.434 (0.287)	-0.523*** (0.182)	-0.635*** (0.156)	-0.733*** (0.131)
*MEDIA ATTENTION * POST1989*	-0.845*** (0.319)	-0.669*** (0.215)	-0.554*** (0.194)	-0.504*** (0.174)
NONWHITE	0.003 (0.004)	-0.002 (0.003)	-0.012*** (0.002)	-0.012*** (0.002)
HISPANIC	-0.005 (0.007)	-0.006 (0.004)	-0.003 (0.004)	-0.002 (0.003)
INCOME	-0.056 (0.318)	0.069 (0.201)	-0.231 (0.178)	-0.276* (0.145)
POPULATION DENSITY	-0.131** (0.054)	-0.165*** (0.034)	-0.155*** (0.028)	-0.148*** (0.024)
CHEMICALS	-0.743 (0.731)	0.369* (0.195)	0.943*** (0.153)	0.697*** (0.118)
PRIMARY METALS	-1.227 (0.757)	0.439* (0.231)	1.065*** (0.181)	1.008*** (0.143)
PAPER	-0.464 (0.721)	0.694*** (0.197)	0.971*** (0.157)	0.976*** (0.131)
PETROLEUM	-0.467 (0.818)	1.307*** (0.281)	1.756*** (0.226)	1.606*** (0.186)
TRANSPORTATION	Dropped	Dropped	Dropped	1.679*** (0.503)
NORTHEAST	-1.992*** (0.384)	-1.491*** (0.226)	-0.893*** (0.187)	-0.940*** (0.153)

MIDWEST	-0.821*** (0.281)	0.052 (0.184)	0.103 (0.160)	0.173 (0.136)
SOUTH	-0.952*** (0.244)	-0.105 (0.157)	0.046 (0.141)	0.218* (0.122)
SALES	0.625 (0.791)	0.525* (0.296)	0.256 (0.259)	0.085 (0.219)
AVG. COST OF INPUTS	0.158** (0.068)	0.173*** (0.045)	0.175*** (0.039)	0.135*** (0.034)
RND INTENSITY	0.563*** (0.144)	0.330*** (0.084)	0.0962 (0.068)	0.056 (0.057)
Observations	760	1552	2320	3120
R-Squared	0.165	0.214	0.193	0.194

Notes: Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.2A: Results of the Interaction between *MEDIA ATTENTION* and *NONWHITE and HISPANICS.*

Variables of interest	Coefficients
*MEDIA ATTENTION * POST1989* *(POST1989:* Dummy variable*)*	(-)0.403** (0.162)
NONWHITE (Percentage of Total Population)	(-)0.0139*** (0.002)
*MEDIA ATTENTION * NONWHITE*	0.0104*** (0.003)
HISPANIC (Percentage of Total Population)	0.00593* (0.003)
*MEDIA ATTENTION * HISPANIC*	(-)0.0265*** (0.006)

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3.3A: Description of Estimated Propensity Scores, and Distribution Of Treated and Control across Each Block.

The region of common support is [0.00093678, 1]
Mean propensity score: 0.276
Standard Deviation: 0.268
Number of observations: 500

Blocks of the pscore for treatment, *MEDIA ATTENTION*	*MEDIA ATTENTION*		Total
	0	1	
1	240	20	260
2	91	38	129
3	23	21	44
4	6	19	25
5	2	40	42
Total	362	138	500

Table 3.4A: Estimates of the Average Treatment Effect of the Treated.

Matching Algorithms	Number treated used	Number controls used	Average treatment effects on the treated
Nearest Neighbor Matching	83	37	0.056 (0.356)
Radius Matching (Radius = 0.05)	63	107	(-)0.101 (0.563)
Kernel Matching (Bandwidth = 0.06)	83	107	(-)0.004 (0.295)

Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

CHAPTER 4

DISTRIBUTION OF ENVIRONMENTAL COSTS AND BENEFITS, ADDITIONAL DISTORTIONS AND THE PORTER HYPOTHESIS.

4.1 Introduction

Michael Porter and Claas van der Linde argue that, "properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with them" (Porter and van der Linde 1995, 98). They claim that regulations can lead to innovation and those innovations can generate profits. This is the Porter Hypothesis. Leading environmental economists reject this idea, arguing that regulations do impose costs and that those costs should be weighed against the benefits of improved environmental quality. Portney, for example, states, "I disagree fundamentally with a message... [that] we can avoid painful choices..." (Portney 1994, 22), while Smith and Walsh maintain that "there are no painless environmental policies" (Smith and Walsh 2000, 74).

This paper derives a series of theoretical examples that are consistent with the Porter Hypothesis. Our main point is that the debate surrounding the Porter Hypothesis has ignored the distribution of benefits and costs and has largely viewed markets as being initially undistorted with perfect competition, perfect information, purely private goods and no externalities, apart from pollution itself. The examples presented here include some of these elements in order to add new insights into the contrasting views that surround the hypothesis. Each example highlights either the distribution of costs and benefits or the introduction of a market failure, other than pollution itself, in order to add new insights into the contrasting views that surround the hypothesis. Collectively, the examples make a number of contributions. First, by highlighting the distribution of environmental costs and benefits, they show that Porter's hypothesis, that firms benefit from regulation, does not necessarily contradict the idea that regulations have costs. Second, the paper argues that inclusion of an additional market failure in a standard economic model can lead to results consistent with the hypothesis. Numerous such scenarios are possible. Third, Porter argues that firms will benefit from regulation only when they innovate. Each of the examples here shows such a scenario. In some cases, it is also possible that regulations can benefit firms even without fostering innovation. This clarifies a distinction that needs to be addressed in empirical work. Fourth, the paper makes a policy point. In several of the examples, benefits arise because the policy addresses two distortions. The implication, therefore, is that it would be preferable to use different policies to separately correct for each distortion.

The different examples presented here also help to organize much of the existing literature on the Porter Hypothesis; previously published research inspires the examples in this paper. In fact, our point is that while the mechanics of each example is well understood, the concepts have either not been linked to the Porter Hypothesis, or been presented as narrowly defined special cases. For instance, our first example discusses scarcity rents, using a framework similar to Fullerton and Metcalf (2001) and Fullerton (2001). These papers show that environmental regulations might benefit existing firms, but they do not link this idea to the Porter Hypothesis. Similarly, our next example, a production externality, is also well understood (Yin 2003) but not previously discussed in the context of the Porter Hypothesis. The existing literature also provides several specific illustrations of regulation correcting two distortions, simultaneously benefiting firms and improving environmental quality. These papers, which discuss the Porter Hypothesis explicitly, cannot individually show that numerous such possibilities exist.[27] Our third example discusses imperfect information, the market failure central to Ambec and Barla (2001) and Rege's (2000) discussions of the Porter Hypothesis. Our final example, which argues that new environmental technologies might have non-excludible benefits, generalizes an idea first presented by Mohr (2002).

The examples presented here also generalize another result from several previously published articles: some models produce results that may be empirically difficult to distinguish from the Porter Hypothesis, even though the mechanisms of the models do not support Porter's argument. Brown and Wilcoxen (2003) and Xepapadeas and de Zeeuw (1999) show that strict regulation may lead to premature restructuring of a firm's capital stock producing a productivity increase. Popp (2005) shows that even if R&D efforts have a negative expected return, innovation induced by regulation might increase profits with significant frequency. These results are inconsistent with Porter's argument – here regulations do have real costs

[27] Hart (p,1079, 2004) indicates in a footnote that models consistent with the Porter Hypothesis may generally require more than one market failure.

– but would require careful empirical work to distinguish from the hypothesis that innovation offsets exceed the cost of the regulation.

The next section of this paper describes the model that critics used to refute the Porter Hypothesis and identifies several possible outcomes of regulation. Section II presents four examples that produce results consistent with the Porter Hypothesis. The final section concludes by discussing how these examples might inform the existing debate on the Porter Hypothesis.

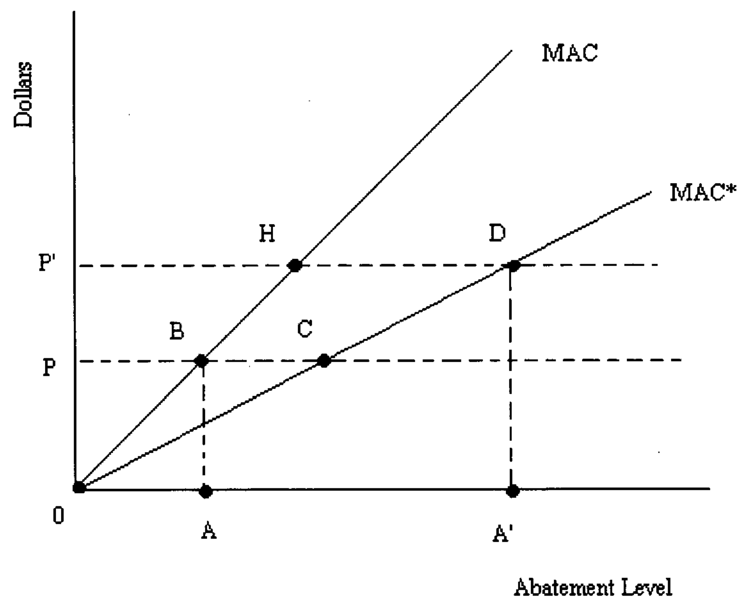
4.2 Theoretical Framework

The most considered criticism of the Porter Hypothesis comes from Palmer, Oates and Portney (1995), who use a simple model to show that increasing the stringency of incentive-based environmental regulations results in reduced profits for the firm.[28] This section presents that model. Its figure 1 (Palmer, Oates and Portney 1995, 123), partially reproduced here, explains the basic framework. The horizontal axis measures pollution abatement, the vertical axis measures costs, and the model makes the common assumption that marginal abatement costs (MAC) are increasing. The horizontal lines through P and P' represent two possible choices of emission fees imposed by regulators on the polluting firms. Given MAC and effluent charge P, the firm's optimal level of abatement is A. The model also assumes that the firm has information about a potential innovation that would allow it to innovate and reduce the MAC for any given level of abatement. Graphically,

[28] Their model is based on an extensive literature in the tradition of Magat (1978), Downing and White (1986), and Milliman and Prince (1989).

this is represented by $MAC*$, which lies everywhere below MAC. Innovation requires some fixed cost, so the firm's decision depends on comparing the fixed cost of innovation to the benefits of reduced abatement costs.

Figure 4.1: Incentive to Innovate under Regulation



The model shows that while a regulation may encourage innovation, it does not increase profits. To see this, suppose that the firm faces an emissions charge of *P*, chooses *MAC*, and therefore abates *A*. The firm has chosen not to innovate, which would allow it to abate at lower marginal cost, reduce its effluent charges by increasing abatement, and thus reducing its costs by the area of triangle ΔOBC. This implies that the fixed cost of innovation exceeds ΔOBC, and that the firm earns higher profits without innovation. Letting *B* and *C* represent combinations of abatement level and technology and π represent profits, this means that $\pi(B) > \pi(C)$.[29]

The model allows for the possibility that a firm innovates in response to a stricter environmental regulation. Suppose the emission fee is raised to P'. If the firm continues to operate on *MAC*, technology remains unchanged and abatement costs rise, which implies that profits fall, so $\pi(B) > \pi(H)$. It is also possible that the firm innovates in response to regulations, as the Porter Hypothesis suggests, and therefore chooses the technology described by *MAC**. However, even if the firm does innovate, it still prefers a lax standard to a stricter one, so $\pi(C) > \pi(D)$. Palmer, Oates and Portney use this insight to highlight the logical inconsistency in Porter's argument. If $\pi(B) > \pi(C)$ (given that the firm does not innovate when the charge is *P*), and $\pi(C) > \pi(D)$, then $\pi(B) > \pi(D)$ (by transitivity). If innovations have a net cost with low emission charges, they must still have a net cost with strict regulations.

While the model highlights a logical inconsistency in the Porter Hypothesis, it is also useful for carefully defining the hypothesis. One condition for results consistent with the Porter Hypothesis is $\pi(B) < \pi(D)$. That is, the Porter Hypothesis says that the combination of innovation and tightened regulations generates higher profit. In our view, this condition is consistent with the Porter

[29] Like Palmer, Oates and Portney (1995), we treat higher abatement costs as synonymous with lower profits when discussing the model. While this is true in a partial equilibrium setting with no distortions other than environmental externality, our examples will highlight cases where these assumptions are relaxed and profits increase even though regulations increase abatement costs.

Hypothesis, but not sufficient. The three profit points identified in our discussion of the model highlight this. Recall that $\pi(B)$ denotes the level of profit when the firm faces a low level of regulation and does not innovate, $\pi(H)$ denotes the level of profit when the firm faces a strict environmental regulation but does not innovate, and $\pi(D)$ denotes the level of profit where the firm faces both a strict environmental regulation and innovates. Porter's hypothesis has two separate criteria: fostering innovation and increasing profits. A situation fully consistent with Porter's hypothesis requires that profits arise because of innovation, so $\pi(H) < \pi(B) < \pi(D)$.

The profit points also allow us to consider the possibility that tightening environmental regulation may prove beneficial to the firm, even without innovation, so $\pi(B) < \pi(H)$. Finally, it is also possible that regulation induces innovation and that the firm earns higher profits, but that the firm would have benefited even without adopting the cleaner technology. In this case, $\pi(B) < \pi(H) < \pi(D)$. Table 4.1 summarizes all of these possible linkages between environmental regulation, innovation and profits.

Table 4.1: Possible Links between Environmental Regulation, Innovation and Profits.

Statements	Links	Interpretations
"Static" model (without innovation)	$\pi(H) < \pi(B)$	Firm does not innovate, and regulations impose costs on the firm.
Insight from model presented by Palmer, Oates and Portney (1995)	$\pi(H) < \pi(B)$ & $\pi(D) > \pi(H)$, but $\pi(D) < \pi(B)$	Regulations impose costs on firms, and firms can offset only a portion of those costs through innovation.
Firms benefit, but not through the mechanism (innovation) that Porter suggests	$\pi(B) < \pi(H)$ or $\pi(B) < \pi(H) < \pi(D)$	Regulation itself is beneficial even without innovation. Firms may get additional benefit from innovation.
Porter Hypothesis	$\pi(H) < \pi(B) < \pi(D)$	Regulations impose costs that can be fully offset via induced innovation.

$\pi(B)$ denotes profit when the firm faces lax regulation and does not innovate.
$\pi(H)$ denotes profit when the firm faces a strict regulation but does not innovate.
$\pi(D)$ denotes profit where the firm strict regulation and innovates.

4.3 Four examples consistent with the Porter Hypothesis

Having defined both Porter's hypothesis and other conditions where firms benefit from regulation, we now turn to explaining these additional sources of profits within a standard economic framework. To do so, we develop a series of examples that highlight either the distribution of environmental benefits and costs or the presence of some additional market failure, other than pollution. To emphasize that numerous such scenarios exist, we organize our examples according to a typical list of market failures: imperfect competition, externalities, asymmetric information and public goods. Adding any one of these features to a simple economic model creates the possibility that environmental regulations induce innovation and benefit firms.

In order to maintain continuity between our examples, we retain the same underlying assumptions and notations. In each case, we start with N identical, competitive firms. Each firm has rising marginal costs and views itself as too small to affect market price.[30] To model emissions as simply as possible, we assume that emissions, e, are directly proportional to output, y, so that $e = \gamma y$, where γ is a parameter. Lowercase letters represent variables at the level of the firm, whereas capital letters represent aggregate measures, so $Y = Ny$ represents aggregate output and E represents the externality from aggregate emissions[31]. We assume that firms have knowledge about two alternate technologies that differ in γ. For the "dirty" technology, we define our units so that $\gamma = 1$. For the "clean" technology,

[30] Allowing firms to treat price as exogenous significantly simplifies the exposition of the model and ensures that the highlighted outcomes are not necessarily a consequence of imperfect competition. Each of the examples could also be supported in a model with imperfect competition.

[31] The externality from aggregate emission, under restrictive circumstances, can be assumed to be the sum total of all the individual firms' emissions, so that we can define aggregate emissions as *E=Ne*. But, it is possible that aggregate emissions are less than *Ne,* due to differential concentrations of the pollutant between the source of pollution and the recipient of pollution. For example, carbon dioxide released by an upstream firm may get diluted by the time it reaches a firm located downstream. But this change in concentration affecting externality is not central to our present question.

$\gamma < 1$, but technology is available to the firm only with a fixed cost, f. Regulations come in the form of an emissions tax, t, where a portion, α, of per-firm tax revenues are refunded to the firm.

Individual refunds depend on the average tax payment of all firms and are not directly linked to the emissions of a particular firm. This assumption, that refunds are based on average tax payments and not individual tax payments, allows the firm to treat these refunds as exogenous when choosing its output and emissions. If a single firm were to increase emissions, that would raise its tax payment but would not (noticeably) raise the average tax of all firms and hence not the rebate. The refund allows consideration of different distributional scenarios. A full refund (α=1) would have the same distributional consequences as a permit policy where permits are "handed out to the firm" and no refund (α=0) would be equivalent to auctioned permits (see Fullerton, 2001 for a discussion). With identical firms, who make identical output decisions, the result is that each firm receives a refund directly proportional to its tax payment.

These features are fully consistent with the model outlined earlier. Here, the marginal cost of abatement is the opportunity cost of forgone production, which is increasing in abatement for each technology. Innovation, as represented by γ, means that for any level of abatement, this opportunity cost is lower for the clean technology. Furthermore, modeling innovation in this way is very general; it only requires reduced emissions per unit of output. This might be accomplished either with an "end of pipe" change that filters a larger proportion of effluents, or it might be accomplished through a process change where potentially-damaging production byproducts are instead reused to increase productivity. While Porter and van der Linde argue that benefits from environmental regulation come only from the latter form of innovation, our results suggest that such a restriction is not necessary for constructing a model where firms benefit from regulation.

In order to highlight the intuition behind our examples, we also add some restrictions to the model, all of which could be relaxed without any loss of generality. We assume that the number of firms is fixed at N and that all firms initially use the dirty technology. Limiting the number of firms ensures that we do not assume away even the possibility of profits by having both identical firms and easy entry. However, the intuition supporting our examples does not rely on a fixed number of firms and could be generalized. For example, with grandfathered permits, scarcity rents benefit existing firms, even when entry and exit is possible. Because profits accrue only once for the N firms (or in a model with generations of firms, profits accrue only to the initial set of grandfathered firms), one can also think of these profits as a short run benefit.

The firm, therefore, chooses output and emissions so that $c'(y) = P + t$ and $e = y$, where $c'(y)$ and P respectively represents marginal cost and market price. In the first three examples, we assume that the tax is initially set at zero. In these cases, we can also assume that the fixed cost of adopting clean technology, f, is arbitrarily small. In such a scenario, environmental regulation must induce innovation, so the model produces an outcome consistent with one criterion of Porter's hypothesis. We can therefore focus on the second, more controversial aspect of Porter's argument: that because of this innovation, regulation benefits the firms.

For each of the examples, we also follow the same analytical steps. Porter and van der Linde argue that firms benefit only after they innovate. Therefore we analyze the response to regulation in two distinct steps. We start by looking at the response of an individual firm before it has the opportunity to innovate. Next, we allow the firm to innovate and therefore reduce its marginal cost of abatement. In some cases we also highlight how this differs from the effect of the entire industry innovating. For each of the examples, we construct a scenario fully consistent with the Porter's hypothesis, as defined in the last row of Table 1. In other words, if the regulated firm does not innovate, profits decline. However, the firm benefits when regulations induce innovation.

4.3.1 Example 1: Scarcity Rents

Regulations might benefit firms by creating scarcity rents. We start with this example for several reasons. First, it is familiar. Policy discussions on the allocation of pollution permits often point out that resistance to environmental regulations might be mitigated by giving away permits to existing polluters, free of charge. Permit recipients benefit from the acquisition of scarce, and therefore valuable, permits. Therefore, this example provides an important link between the literature on the Porter Hypothesis and the literature in firm appropriation (or granting to firms) of scarcity rents created by environmental regulation. Second, the example highlights the importance of distributional outcomes. When Palmer, Oates and

Portney and others reject the Porter Hypothesis, they do so on the basis of the assertion that regulations have costs. However, if those costs can be distributed away from firms, it is possible that firms nonetheless benefit from environmental regulations. A claim that firm's benefit from regulation is not necessarily a claim that regulations have no costs. Third, this example highlights the distinctions made in Table 1. With scarcity rents, it is possible to develop a scenario where regulations induce innovation and where firms are better off. The outcomes would appear to support Porter's hypothesis, but the mechanism is different. It is the ability to shift costs to the consumer, rather than innovation, which drives profits.

In order to illustrate scarcity rents, we add a downward-sloping market demand curve, $P(Y)$, to our framework. If taxes are initially set to zero and firms are perfectly competitive, then $c'(y) = P$, and $\frac{dy}{dt} = \frac{1}{NP'(Y) - c''(y)} < 0$. Given that the individual firm uses the dirty technology, its profit function is described by:

$$\pi(t) = P(Y(t))y(t) - c(y(t)) - (1-\alpha)te(t) \tag{1}$$

Since each firm chooses $y = e$, the introduction of an emissions' tax results in reduced individual output, decreased market supply and a higher market price. Evaluating $\frac{\partial \pi(t)}{\partial t}$ at the competitive output when $t = 0$ produces:

$$\left.\frac{\partial \pi(t)}{\partial t}\right|_{t=0} = [NP'(Y)y'(t) - (1-\alpha)]y(t) \qquad (2)$$

The first term in the brackets is the scarcity rent; it reflects the benefits from rising prices.[32] The second term measures the marginal cost of unrefunded tax liabilities. If the firm receives a full tax refund, so $\alpha = 1$, the second term drops out and $\left.\frac{\partial \pi(t)}{\partial t}\right|_{t=0,\alpha=1} > 0$. Regulation makes the firm better off: $\pi(B) < \pi(H)$.

It is also possible that the firm does not immediately benefit from scarcity rents, unless it innovates. If tax revenues are not fully returned to the firm, so $\alpha < 1$, then the sign of (2) is ambiguous. Regulation can hurt firms if scarcity rents do not offset its entire tax burden. Consider the case where $\frac{\partial \pi(t)}{\partial t} < 0$, but the magnitude of the effect is very small. Recall that the clean technology is almost free of cost to the firm (f is assumed to be arbitrarily small). As the regulation binds, the firm's willingness to pay for the alternate technology increases and, for the individual firm, innovation becomes profitable. The clean technology allows the firm to increase output and reduce its tax burden, so it may be that $\pi(H) < \pi(D)$. Such a scenario is consistent with the Porter's prediction. When scarcity rents don't fully offset the cost of unrefunded taxes, regulations initially impose costs. These remaining costs can be fully offset via induced innovation.

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[32] In a setting with perfect collusion, where a single agent maximizes joint industry profits the term NP'*(Y) y'(t)* would then be eliminated from equation 2.

Our example has generated a scenario that is empirically identical to the Porter Hypothesis. Regulations generate innovation, firms benefit, and it is possible that the increased profits would not have occurred without the innovation. While the outcome matches Porter's hypothesis, the mechanism is quite different: scarcity rents, not innovation offsets, drive the result. The regulation does have a cost; it is just passed along to the consumer in the form of a higher price. To see this more clearly, consider the consequences when not just one firm, but the entire industry innovates. With widespread innovation, output of each firm increases, raising market supply and hence lowering the market price back towards the initial competitive level. Extensive technology adoption reduces industry profits relative to limited adoption.

4.3.2 Example 2: Negative Production Externality

The prior example shows that results consistent with Porter's hypothesis can arise if costs are distributed away from firms. This example makes an analogous point about the distribution of environmental benefits. We now assume that total industry emissions impose a negative externality on the individual firm's costs. One example is the prophylactic use of antibiotics in livestock. Such usage protects individual herds from disease, but may produce antibiotic-resistant bacteria that may be transmitted to other farms (McEwen and Fedorka-Cray 2002).[33] In such cases, where firms are imposing negative externality on one another rather than on

[33] Common access resource problems, like fisheries, can also be thought of as a form of production externality. The harvest of a single fishing vessel affects the costs of all other vessels.

the public, regulation can reduce the externality and yield a benefit to individual firms. This result is important to understand as the example can be constructed to produce an outcome that appears fully consistent with the Porter Hypothesis. For some regulations, firms can achieve a net benefit only through innovation.

In order to rule out the scarcity rents discussed in the prior example, we now assume that the market demand curve is horizontal. The externality is measured by the total emissions of the N identical firms in the industry and each firm is so small that it considers this externality to be exogenous, unaffected by its own emissions. Letting E denote the external cost, which depends on aggregate emissions, we now define the individual firm's cost function as $c(y,E)$, where $c'(E)>0$. We make no further assumptions about how the external cost relates to individual emissions, except that the use of an emission's tax will reduce the externality, so that $E'(t)<0$. [34] Assuming that the individual firm initially uses the dirty technology, the profit function is described by:

$$\pi(t) = py(t) - c(y(t), E(t)) - (1-\alpha)ty(t) \tag{3}$$

Differentiating with respect to the tax rate, t, applying an envelope condition, and evaluating at $t=0$ produces:

$$\left.\frac{\partial \pi(t)}{\partial t}\right|_{t=0} = -c'(E)E'(t) - (1-\alpha)y(t) \tag{4}$$

[34] With perfect mixing, *E=Ne*.

If tax revenues are refunded $(\alpha = 1)$, then $\left.\frac{\partial \pi(t)}{\partial t}\right|_{t=0, \alpha=1} = -c'(E)E'(t) > 0$, so $\pi(H) > \pi(B)$. As the tax increases, each firm reduces emissions, which reduces the total external cost, and increases profits. When firms bear the external cost of pollution, they benefit from environmental regulation.

It may be that environmental regulation benefits the firm only if it innovates, consistent with the Porter Hypothesis. If taxes are not fully refunded, the sign on $\frac{\partial \pi(t)}{\partial t}$ is ambiguous. Just like in the prior example, it is possible that a tax and partial rebate initially leaves each firm with small costs that can be fully offset through innovation. If environmental benefits cannot fully offset the tax burden of the regulation, then the firm is hurt by the regulation as long as it does not innovate. However, once the tax is imposed, the clean technology offers an opportunity for the individual firm to reduce emissions and hence its tax burden. With innovation, the firm benefits. As in the prior section, the effect of regulation differs in the case where only one firm innovates, from the case where the entire industry innovates. If all firms adopt the clean technology, the profits of each firm will be even larger, as adoption will both offset tax burdens and further reduce the overall externality cost.

4.3.3 Example 3: Asymmetric Information

This example assumes that consumers have a preference for goods that are produced using "green" production techniques and are willing to pay a premium for such goods, but cannot observe the production process. For example, U.S.

consumers cannot easily distinguish genetically modified organisms and advocates suggest avoiding entire groups of crops. For example, advocates recommend avoiding all Hawaiian grown papaya, even though approximately half of Hawaiian papayas are not genetically modified. (cite 1, cite 2)[35] Similarly, the health of a fishery depends on the location, method, and even season of harvest. This level of detail may not be easily available.[36] In such cases, conservation groups therefore recommend that consumers avoid entire species of fish (cite). In the notation of our model, this suggests that consumers rely on total industry emissions as a proxy for environmental quality. Regulation can reduce industry emissions while firms benefit from the premium paid for such goods. Here, we define market demand as $P(E) = \hat{P} - h(E)$, so industry emissions negatively affect market price. The market demand curve is otherwise horizontal. Using the dirty technology, the firm's profit function is:

$$\pi(t) = P(E(t))y(t) - c(y(t)) - (1-\alpha)ty(t) \tag{5}$$

Differentiating with respect to the tax rate, applying an envelope condition, and evaluating at $t = 0$ produces:

$$\left.\frac{\partial \pi(t)}{\partial t}\right|_{t=0} = -y(t)h'(E)E'(t) - (1-\alpha)y(t) \tag{6}$$

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[35] This does not suggest that papaya farmers would benefit from regulation; it only illustrates the type of market failure studied in this example.

[36] In other cases, only inaccurate information may be available. *Consumer Reports* and the *New York Times* report that farm-raised salmon is frequently mislabeled as wild. (Consumer Reports, "Mislabeled Salmon: The Salmon Scam" (2006),cite 2).

Equation 6 is similar to equations 2 and 4 from the prior examples. More stringent regulation combined with a full refund of tax payments unambiguously improves the firm's profitability. Just as with scarcity rents, a tax encourages each firm to emit less, which in turn raises output price. The policy helps firms by solving the informational problem. If tax revenues are only incompletely refunded $(\alpha < 1)$, the effect on profits is ambiguous. Once again, it is possible to construct a scenario where regulation hurts the firm, unless it innovates. The example, too, can be consistent with the Porter Hypothesis.

Note that while the notation and mechanics of this example are similar to the scarcity rents example (in both cases the regulation creates profits by increasing price), the two scenarios are conceptually different. Scarcity rents reflect a purely distributional change. With asymmetric information, prices rise because consumers have a higher willingness to pay for goods produced with less emissions. The contrast between the two examples is clearer when comparing profitability of a single firm that innovates to industry-wide innovation. With scarcity rents, widespread innovation mitigates the initial gains, whereas in this example industry-wide innovation further increases profitability and simultaneously generates greater consumer surplus.

4.3.4 <u>Example 4: Public Good</u>

This example considers the case where adoption experiences with the clean technology are a public good. The fixed cost of adoption for the i^{th} firm, $f_i(j_{-i})$, now depends on, j_{-i}, the total number of other firms (not i) using the clean technology, where $f_i(j_{-i})$ decreases with more adopting firms. In cases where patent protections and other forms of intellectual property rights are imperfect, knowledge about the clean technology is a public good. As this knowledge increases with more users, the fixed cost of adopting the clean technology declines. In such a scenario, there may be a Nash Equilibrium where no individual firm adopts, although all firms would benefit through universal adoption of the technology.

To describe such a scenario, we must assume that the emissions' tax is initially positive, so $t_0 > 0$. Let $y_c(t, j_{-i})$ denote the firm's optimal choice of output when using the clean technology, let $y_d(t, j_{-i})$ denote the firm's optimal choice of output when using the dirty technology, and redefine N to count the number of other firms (not *i*). If all of the following three conditions hold, then we can create a scenario consistent with Porter's hypothesis:

if $t = t_0$, and $j_{-i} = 0$, $\quad \pi(y_c(t_0,0)) < \pi(y_d(t_0,0))$ (7a)

for any $t \geq t_0$, and $j_{-i} = N$, $\quad \pi(y_c(t,N)) > \pi(y_d(t,N))$ (7b)

There exists some $t_\eta > t_0$, so that, $\quad \pi(y_c(t_\eta,0)) > \pi(y_d(t_\eta,0))$ (7c)

The first condition indicates that if tax is t_0, no individual firm has the incentive to adopt the clean technology. The second condition indicates that if all firms were to adopt the technology, then they would each garner higher profits. For any level of emissions tax greater than or equal to t_0, correcting the market failure represented by the public good benefits the industry. The final condition indicates that if taxes are sufficiently high, a tax policy induces technology adoption and can correct the market failure. Any tax level higher than t_η induces all firms to adopt the clean technology.

As always, we first consider the effect of an increase in the emission tax rate on the profits before the firm has the opportunity to innovate. In this case, it is trivial to show thatan increase in taxes must unambiguously lower profits: $\frac{\partial \pi(t)}{\partial t} < 0$, so: $\pi(H) < \pi(B)$. Next, we consider the case where the policy induces innovation. If $t \geq t_\eta$, then all firms adopt the clean technology. From (7c), this lowers each firm's marginal cost of abatement and reduces its cost of complying with the regulation, making the action individually rational. From (7b), adoption also provides a public good, which benefits all other firms. If this second effect is sufficiently large, then regulated firms might find themselves better off than they were, even prior to the initial tax. In such a case:

$$\pi(y_c(t_\eta, N)) > \pi(y_d(t_0, 0)) \tag{8}$$

A simple numerical example can verify that (7a) – (7c) can be met simultaneously and satisfy Porter's hypothesis.[37]

[37] Assume that $P=30$, $N=100$, $c(y)=\frac{y^2}{2}+te+f$, $f=\frac{10}{j_{-1}+1}$, $\gamma=0.77$, $\alpha=0$ and taxes rise from $t_0=5$ to $t=5.2$. In this case, all three conditions are met: at $t_0=5$, no firm adopts, at $t=5.2$ all firms adopt and profits per firm rise from 312 to 318.

4.4 Conclusions

The four examples are simple to understand and build upon basic concepts. Nonetheless, each adds important insight to the debate surrounding the Porter Hypothesis. Palmer, Oates and Portney acknowledge only two possible situations where regulations may benefit regulated firms: strategic behavior and overlooked opportunities for profitable innovation (Palmer, Oates and Portney 1995, 125).[38] While both are important, this list is too narrow. They might have instead used a variety of scenarios to clarify how standard economic models might yield results consistent with Porter's observations. For example, Porter and van der Linde explicitly ignore social benefits and focus on "private costs" (Porter and van der Linde 1995, 98). They then use a series of case studies to highlight instances where individual firms benefit from environmental innovation. This focus on firms gives the impression that private costs are only those that accrue to the firm, and social benefits accrue only outside of the affected industry. Palmer, Oates and Portney clearly understand that private costs might be distributed away from firms or that the social benefits might be seen in production, but pass up the opportunity to highlight this point.[39] The distribution of costs or benefits can produce outcomes

[38] Simpson and Bradford (1996), Greaker (2003) and McAusland (2004) all explore the role of strategic behavior in generating results consistent with Porter's Hypothesis. Popp (2005) argues that with uncertainty, rational firms might overlook opportunities, which are profitable *ex-post* with a considerable frequency.

[39] In a footnote they point out that increased environmental stringency will induce firms to decrease output (Palmer, Oates and Portney 1995, 124), as in the example of scarcity rents. Production externalities are featured in the numerous textbooks, including Baumol and Oates (1988).

that appear similar to Porter and van der Linde's observations: regulations benefit firms, but only if they innovate.

The discussion of market failures introduces a second avenue through which a simple model can yield results consistent with Porter's observations. If the environmental regulation corrects two distortions, it might simultaneously benefit firms and improve environmental quality. While the existing literature provides several specific illustrations of this point, we argue that the results are general and can be derived even from a very simple model. Finally, the examples also point out that Porter's argument of innovation offsets leading to increased profits may be hard to distinguish empirically from other reasons that regulation might be correlated with increasing profits or productivity. In several examples firms might benefit, even without innovation.

While we have shown several reasons why firms may benefit from environmental regulations, we make no suggestion about the likelihood that such outcomes will actually be observed following the implication of policy. The empirical question remains: to what degree do firms experience higher profits after environmental regulations are imposed and innovation occurs? While this paper suggest some reasons that such outcomes are possible, it also highlights a reason that they may be unlikely. Even if an environmental regulation helps enforce a joint action that makes firms better off, neither Porter nor these examples fully explain why firms don't collectively make more of an effort to impose voluntary industry standards or actively advocate for regulation.[40] This insight remains central to the debate about the Porter Hypothesis. We only argue that if discussions about the Porter Hypothesis are reframed in this way, they will be considerably more nuanced than simple statements that the Porter Hypothesis is inconsistent with most economic models or merely about measuring costs. Such a more nuanced debate, in fact, requires empirical work. For example, the definitions (in Table 4.1) classify different routes in which regulations may generate profits. This implies that empirical work should clearly define their question. Are they looking for increased productivity, or increased profitability? Do regulations lead to innovation, but not profits, or regulation leading to innovation and profits? These distinctions, in turn, suggest that policy implications from the empirical studies should be interpreted carefully, as it depends on the type of distortion, under consideration. If the distortion arises from imperfect competition and inter-firm externalities, then a cost and benefit analysis should provide a picture of the benefits generated. This, however, doesn't imply that regulations do not have costs. There are costs involved, but they are either distributed away from the producers or borne by the consumers. Therefore, the results of a cost-benefit analysis will remain unaffected. But if the distortion arises from market failures like asymmetric information or public goods, then a policy that addresses both these distortions should realize/acknowledge that these benefits arise from correcting two distortions simultaneous, with one policy.

[40] Porter (1991) suggests that firms have a "Chicken Little mindset," meaning that they fail to have the foresight to take advantage of such opportunities.

The examples are straightforward, but make important points. First, the existing debate has largely ignored distributional effects or the possibility of distortions, other than pollution itself. Second, the examples presented here provide concrete examples of the distinctions made in Table 1. Regulations may simultaneously benefit firms and foster innovation. However, in some cases that are empirically difficult to distinguish from the Porter Hypothesis, regulations benefit firms for reasons other than innovation. Third, the examples contribute through their simplicity; a variety of intuitive scenarios might produce outcomes consistent with the Porter Hypothesis.

Finally, the examples highlight the general applicability of the results to not just market incentive based instruments, like emission taxes, grandfathered or tradable permits, but also to other forms of flexible environmental policies. The key here is that the regulation should be flexible enough to allow firms to internally adjust its production processes in order to mitigate regulatory costs. Information-based environmental policies, like the U.S. Toxic Release Inventory, are a good candidate. Porter argues that "information gathering often leads to environmental improvements without mandating pollution reductions, sometimes even at lower costs" (p. 100, Porter and van der Linde 1995). Hence this essay ties to the general theme of the dissertation which is to explore the unintended consequences of newer and non-traditional forms of environmental policies.

CHAPTER 5

EXTENSIONS AND FUTURE WORK

5.1 Introduction

The dissertation presents three essays that highlight how external pressures and internal awareness generated under information-based environmental policies may influence a firm's polluting behavior and improve its environmental performance. Chapters 2 and 3 assess the role of the print media in influencing a firm's pollution behavior. Chapter 2, specifically, shows that there is an association between media attention and socio-economic characteristics. Media reports are more likely to write about pollution in minority neighborhoods. Media attention also has a positive and statistically significant association with household income level. Chapter 3 shows that there is an association between media attention and a firm's toxic releases. But the results do not produce evidence of a causal relationship between the two. If media attention imposes reputation costs on the firm, then it may provide incentives to change their pollution behavior. But it was difficult to isolate this causal effect of media attention on subsequent changes in toxic releases. Chapter 4 presents four different scenarios where a strict environmental regulation can lead to outcomes consistent with the Porter hypothesis. The chapter concludes that there are different routes in which regulations may generate profits and that the results should be carefully interpreted in an empirical study. The results are applicable to information-based environmental policies, like the Toxic Release Inventory.

Collectively, the findings presented in chapters 2 to 4 highlight opportunities for many new areas of research. Among these, two merit particular attention. One research agenda is to extend our understanding of the role of the media in information-based regulations. The second agenda is to empirically extend the literature on the Porter hypothesis. This chapter provides a sketch of these two research avenues.

One avenue is to extend the empirical analysis of chapters 2 and 3. Chapter 2 uses cross-sectional data to study the association between media attention and socio-economic characteristics and makes inference about environmental justice based on income and racial composition at the zip code level. Some researchers argue that the geographic scale used is critical to the of study environmental justice .Zip codes are larger than Census tracts and it is preferable that environmental justice analysis be conducted at the Census tract or smaller spatial units. Anderton et al. (1994), for example, uses Census tracts data and finds no evidence of racial differences in the siting of hazardous waste facilities. Similar studies conducted at the zip-code level, however, found results contrary to the Anderton, et al. study. One way to extend Chapter 2 would be to analyze the association between media attention and socio-economic characteristics at the Census tracts level and compare the results to see whether geographical units of space matter in environmental justice studies.

Recall from Chapter 2 that the media attention data was collected for one year following the first publication of the TRI reports. Most of the media hits were received in the weeks immediately following the first announcement, after which the attention fades out in later months or weeks. The TRI reports were published along with the National Wildlife Federation's report on the Toxic 500 companies and the National Resources Defense Council's report on the top carcinogenic polluters in the TRI list. They were published in the same month, only a couple of days apart. It would be interesting to explore in future projects whether the timing of the TRI reports or other major national reports on the TRI firms play an important role in determining media attention. This, however, cannot be explored with the dataset that I have used in chapter 2 as number of media hits is not sufficient. It can be explored appropriately by expanding my current dataset to a panel where media attention is recorded for each facility for several years.

Chapter 3 explores the relationship between media attention and subsequent changes in toxic releases. The results did not produce evidence of a causal relationship between the two. One conclusion is that there might be some unobservables that are very strongly correlated with the treatment variable, media attention. Some of these unobservables could be time-invariant. Fixed-effects estimation model using panel data can help isolate the effect of these time invariant unobservables from media attention. In order to study the causal relationship between media attention and future toxic releases more rigorously, one option is to create a panel data where media attention and control variable information for each facility is recorded for each subsequent year. Constructing this panel would require conducting database searches, similar to the one in Chapter 2, to collect media attention measures for each year. The parent company-level information can be similarly collected from the COMPUSTAT database.

Beyond studying the causal relationship between media attention and a firm's pollution behavior, it would be worthwhile considering other channels through which media attention may affect firm behaviors. Three such channels are discussed in the following sections. The next four sections present new ideas that can be explored in future research. The first three sections present various firm responses to media attention, while the fourth section proposes how to empirically expand the theoretical exposition on the Porter hypothesis presented in Chapter 4.

5.2 Media Attention and Participation in Voluntary Agreements

The cost associated with negative publicity may provide firm's with incentives to enroll in voluntary agreements to reduce toxic releases. The literature on eco-labeling and green rating has a couple of studies (Afsah, et al, 2000, Liu, 2010) where firms have enrolled in targeted emission reduction programs to protect their reputation, and their relationship with stakeholders in the supply chain. In the context of the TRI program, a voluntary agreement policy that was introduced in 1990 is the 33/50 program. The aim was to systematically reduce toxic releases of participating firms by 1995. The literature on the 33/50 program shows that firms that participated in the program reduced their emission well beyond the standards set by the program and met their targets ahead of the deadline (Arora and Gangopadhyay, 1995). The literature also has evidence that investor's reaction to the public disclosure of toxic releases is an important factor in determining participation in the TRI program (Khanna and Damon, 1999). It would, therefore, be interesting to explore whether media attention determines participation in a voluntary agreement type program like the EPA's 33/50 program under TRI.

5.3 Media Attention and Analyst's Earning Forecasts

The TRI report generated media activity whereby national and regional newspapers reported about the pollution behaviors of companies listed in the TRI report. Prior research has shown that such media activity took TRI companies by surprise and was reflected in negative abnormal returns. Prior literature has also explored the effect of TRI-related media attention on stock prices. A step forward in investigating how public disclosure type programs work could be to study financial markets forecasts. More specifically, future studies can investigate the effect of media attention on analyst's earning forecasts of TRI firms, as media coverage of companies may affect analysts' estimates of environmental costs on the firm. In particular, analysts may adjust down their earnings forecasts for firms that receive media attention. Using analysts' earnings forecasts from Institutional Brokers' Estimate System (IBES) provided by Compustat North America and media attention information from the dataset that I have created for this dissertation, one can test the above hypothesis.

5.4 Media Attention and Firm Closure Decision

In a recent study, Kassinis and Vafeas (2009) explore the relationship between pressures from stakeholders and environmental performance of firms and how it translates into firms deciding to close their plants. Using data from U.S. manufacturing facilities, they find that closing facilities face strong community and regulatory pressures compared to surviving ones and that the closing facilities reduce their toxic release more than the surviving establishments. In line with this research, one can explore the effect of media attention as an external pressure on a firm's decision to close some of its polluting establishment. In other words, media attention may cause attrition from the TRI list. To do so, one may use duration or survival analysis that is used extensively in economics to model time to an event, which in our case is dropping out of the TRI list.

5.5 Voluntary Agreements and 'Green' Patenting

One way to contribute to the empirical literature on the Porter hypothesis would be to study the effect of flexible policies like the EPA's 33/50 program on the firm's innovative activities. The literature on EPA's 33/50 program shows that a firm's research and development intensity, measured by the R&D expenditures per unit of toxic emission, is an important factor in determining participation in the program (Khanna and Damon 1999). But one can hypothesize that participation in the program can also lead to activities like investing in R&D to meet the pollution targets.

This bi-directional relationship between participation in the 33/50 program and innovation is worth exploring in future research. Interestingly, one can analyze the effect of participation in the program on a firm's green patenting, rather than a broader measure like R&D expenditures (which captures all kinds of innovative activities at the firm level). This research will shed light on the distinctions that empirical studies on the Porter hypothesis should emphasize on. For a scenario consistent with the Porter hypothesis, a regulation should be flexible like the voluntary agreement under the 33/50 program, and the first step towards realizing benefits would be through innovation in the face of regulation. So a research project that studies the effect of participation in the 33/50 program on successful application for green patents would be an ideal test of the Porter hypothesis.

5.6 Conclusions

All of these additional avenues for research highlight the general theme in this dissertation. Voluntary, collaborative and information based environmental regulations have become popular in the last two decades as complements to the traditional regulatory tools. But the effectiveness of these new policies is not well understood. This dissertation fills this gap by focusing on the information based environmental regulations. The TRI program has been touted as one of the most successful environmental policies because toxic releases have declined significantly since its inception. This dissertation explored the role of media attention in explaining such declines and did not find evidence on the causal relationship between media attention and declining toxic releases. In fact, toxic releases had been declining even before media attention focused on emissions. Therefore, one has to be careful in evaluating the effectiveness of the TRI program in reducing toxics.

To my knowledge, environmental justice has not been explored through the behavior of the media. This dissertation presents results which show that media activities are associated with socio economic characteristics and that socio economic characteristics are associated with significant reductions in toxic releases in some minority neighborhoods. While we cannot define causality definitively, policy proposals on scaling back the reporting requirements should take into account the potential implications it may have on the distribution of toxic releases in minority neighborhoods.

Finally, this work sheds light on the controversy surrounding the Porter hypothesis; my research sets the stage for interesting future projects in the area of environmental regulation and competitiveness. It presents a classification of what a direct test of the Porter hypothesis must or must not include. This classification will serve as a guideline for any future empirical work in this area.

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